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# ***Financial Disclosure and Market Transparency with Costly Information Processing***

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# ***Financial Disclosure and Market Transparency with Costly Information Processing***

**Marco Pagano\* and Marco di Maggio\*\***

### **Abstract**

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, issuers will oppose both the disclosure of fundamentals and trading transparency. Issuers may either under- or over-provide information compared to the socially efficient level if speculators have more bargaining power than hedgers, while they never under-provide it otherwise. When hedgers have low financial literacy, forbidding their access to the market may be socially efficient.

**Keywords:** disclosure, transparency, financial literacy, limited attention, OTC markets.

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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. If so, issuers should spontaneously commit to high disclosure and list their securities in transparent markets. This is hard to reconcile with the need for regulation aimed at augmenting issuers’ disclosure and improving transparency in off-exchange markets. Yet, this is the purpose of much financial regulation – such as the 1964 Securities Acts Amendments, the 2002 Sarbanes-Oxley Act and the 2010 Dodd-Frank Act.<sup>1</sup>

In this paper we propose one solution to the puzzle: issuers do not necessarily gain from financial disclosure and market transparency 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 model where the issuer of an asset places it with one of many competing dealers, who sells it to investors through a search market that randomly matches him with buyers. The price at which the issuer can initially place the asset with the dealer depends on the expected price on this search market. The sale of an asset-backed security (ABS) is one example: the ABS is placed by its originator (e.g. a bank wishing to offload a loan pool from its balance sheet) with an underwriter who searches for buyers via an Over-The-Counter (OTC) market. Another example is that of a company that hires a broker to sell its shares via a private placement or a Direct Public Offering (DPO) to investors, who can trade them on the Pink Sheet market or the OTC Bulletin Board.<sup>2</sup>

Before the asset is initially placed with investors, the issuer can disclose fundamental information about the asset, e.g. data about the loan pool underlying the ABS. If information is disclosed, investors must decide what weight to assign to it in judging its price implications,

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<sup>1</sup>For instance, [Greenstone et al. \(2006\)](#) document that when the 1964 Securities Acts Amendments extended disclosure requirements to OTC firms, these firms experienced abnormal excess returns of about 3.5 percent in the 10 post-announcement weeks. Similarly, several studies in the accounting literature document that tighter disclosure standards are associated with lower cost of capital and better access to finance for firms (see the survey by [Leuz and Wysocki \(2008\)](#)).

<sup>2</sup>Private placements and DPOs are increasingly common forms of stock offering that do not involve a centralized mechanism such as the bookbuilding process or the auction typical of Initial Public Offerings (IPOs). They allow a company to informally place its shares among investors with lighter registration requirements with the SEC and greater discretion regarding disclosure. For instance, more than \$1 billion of Facebook shares were sold on the secondary market introduced by SecondMarket in the year preceding the IPO.

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, issuers 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, issuers 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 about the asset via the release of accounting data, listing prospectuses, 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 issuers' standpoint: they will be more willing to disclose information on the asset's characteristics 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, a key novelty of our setting is that it encompasses two notions of transparency that 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 financial disclosure – has been blamed by some for the persistent illiquidity of their 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 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 learn the asset's value.

We extend the model in three directions. First, we allow the sophisticated investors to acquire a costly signal about the asset's payoff when no public information is disclosed by the issuer. We show that this possibility increases the issuer's incentives to disclose. Intuitively, if in the absence of disclosure only speculators can acquire information privately, less sophisticated investors will be totally uninformed and therefore less eager to bid for the asset than under disclosure, which would at least allow them to process public information. As a result, the possibility of private information acquisition elicits disclosure from issuers who would otherwise prefer no disclosure. Second, we explore whether the seller might avoid the informational externality by committing to sell only to hedgers, since the externality is triggered by speculators. However, we show that such a commitment by the seller may not be credible. Third, we extend the model to the case in which the seller has private information about the value of the asset, and show that model is robust to this change in assumptions.

Besides providing new insights about the effects of financial disclosure on issuers, 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 there can be either under- or over-provision of information, whenever the seller has less bargaining power in trading with speculators than with hedgers (which is realistic, as the former tend to have more continuous market presence and greater bargaining skills than the latter). In the opposite case, instead, there is never under-provision of information. Intuitively, when issuers know that trading with a speculator will entitle them to a smaller fraction of the bargaining surplus than trading with a hedger, they may prefer to deter trading by speculators by not disclosing information about the asset, even though this would be socially

efficient. In this case, regulatory intervention for disclosure is required. This is likely to occur if, when the information is released, hedgers devote little attention to it: hence, releasing the information does not lead them to spend too many resources. When instead hedgers devote much attention to information, the issuer has either the same incentive to disclose as the regulator or even greater incentive to do so, as he does not give sufficient weight to the resources that hedgers spend to study the disclosed information.

We also show that in markets where the information-processing costs of unsophisticated investors are high, so that issuers may engage in over-provision of information, 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”.<sup>3</sup> 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 \(2012\)](#)).

The rest of the paper is organized as follows. Section 1 places it in the context of the literature. Section 2 presents the model. Section 3 derives the equilibrium under the assumption of complete transparency of the security market. Section 4 relaxes this assumption and explores the interaction between financial disclosure and market transparency. Section 5 considers four extensions of the model. Section 6 investigates the role of regulation in the baseline model, and Section 7 concludes.

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<sup>3</sup>[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).

# 1 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 \(2010\)](#), [Davies \(2014\)](#) and [Woodford \(2005\)](#) brought out the implications of information constraints for portfolio choice problems and monetary policy, whereas [Pavan \(2014\)](#) provides a general framework to shed light on the type of payoff interdependencies that contribute to inefficiency in the allocation of attention.<sup>4</sup> Whereas these papers analyze how the presence of investors with limited attention affects trading outcomes in competitive markets, we show that new insights emerge by considering OTC markets. Specifically, our main contribution is to explain how investors' attention allocation affects the issuer's incentives to release information to market participants. Furthermore, the difficulty to process this newly released information generates an information externality among investors, whose intensity crucially depends on the opacity of the OTC markets. This result parallels the findings of [Duffie et al. \(2014\)](#), who highlight how herding by uninformed investors leads to learning externalities.

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. \(2002\)](#)).<sup>5</sup> In particular, there is evidence that limited attention affects portfolio choices: [Christelis et al. \(2010\)](#) document that the propensity to invest in stocks is positively associated with cognitive skills and is driven by information constraints, not preferences or psychological traits.<sup>6</sup> 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 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

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<sup>4</sup>See 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.

<sup>5</sup>See [Carlin \(2009\)](#) for a model of strategic complexity, and [Gennaioli and Shleifer \(2010\)](#), [Jehiel and Bianchi \(2012\)](#) and [Gennaioli et al. \(2012\)](#) for studies of different investors' behavioral limitations in processing information.

<sup>6</sup>The 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.

accordingly be predicted by those of the latter (Cohen and Lou (2012)).<sup>7</sup>

Several recent papers show that investors may overinvest in information acquisition. For instance, in Glode et al. (2012) 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 to disclose information in the first place.

Our result that issuers may be damaged by financial disclosure parallels Pagano and Volpin (2012), 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 our present setting differs in other important respects. First, since in Pagano and Volpin (2012) trading is not sequential, less sophisticated investors have no chance to learn from the more sophisticated ones, which precludes information externalities. Second, here we show that issuers do not always opt for opacity, since they will trade off the costs of disclosure (strategic interaction among investors) against its benefits (greater willingness to pay for the asset). Moreover, unlike Pagano and Volpin (2012), this paper shows that the level of disclosure chosen by issuers may either exceed or fall short of the socially efficient level, and is affected by the degree of trading transparency.<sup>8</sup>

Finally, 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 models where it can exacerbate externalities among market participants, as in our model: Morris and Shin (2012) 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; Goldstein and Yang (2014) show that disclosing public information is beneficial only when it improves the overall learning quality of relevant decision makers, which is more likely to occur when the information being disclosed is about something that decision makers already know much, or when the market does not aggregate traders' private information effectively.<sup>9</sup> As in these papers, also in

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<sup>7</sup>Other related papers include Klibanoff et al. (1998), Hong et al. (2007) and Hirshleifer et al. (2011).

<sup>8</sup>Recently, Dang et al. (2012) and Yang (2012) 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.

<sup>9</sup>In a similar vein, Gao and Liang (2011) show that on one hand, disclosure narrows the information gap between informed and uninformed traders and improves the liquidity of firm shares; on the other hand, it reduces the informational feedback from the stock market to real decisions as it dampens the investors' incentive to

our model disclosure creates externalities and strategic behavior; but being chosen by issuers, it may be set at a socially inefficient level.<sup>10</sup>

## 2 The Model

The issuer of an asset wants to sell it to investors: he might be the issuer of a new asset-backed security (ABS) or a firm looking to offload its risk exposure to interest rates or commodity prices. The price at which the issuer can sell the asset depends on its expected price on the secondary market: whoever initially buys the asset can resell it through a search market that randomly matches him with buyers. Before the initial sale, the issuer can commit to a disclosure regime, whereby a noisy signal will be released about the value of the asset. This signal reflects information that is still unavailable to the issuer at the time of the initial sale, but will become available during secondary market trading. An example arises when the initial owner of a company decides whether to list it in a stock market with strict periodic disclosure requirements or rather on an OTC Bulletin Board with no such requirements.

To understand the pricing implications of the disclosed information, 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 to buy for non-informational reasons, such as to hedge some risk: we accordingly call them “hedgers”. By contrast, sophisticated investors are assumed to trade purely to exploit their superior information-processing ability, and are accordingly labeled “speculators”.

### 2.1 Information

The asset is indivisible, and has a common value that for simplicity is standardized to zero, and a private value  $v$  that differs between the investors and the seller: investors value the asset at either  $v_g$  or  $v_b$ , where  $v_b < 0 < v_g$ , depending on whether the asset has good or bad risk characteristics, which is equally likely, so that the unconditional mean of the asset’s value is  $\bar{v} \equiv (v_g + v_b)/2$ . In contrast, the issuer’s private value is zero. To fix ideas, we can think of the

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acquire information. Another negative feedback of disclosure on real decisions is that it may lead managers to strive to increase the amount of hard information at the expense of soft, by cutting investment, as shown by [Edmans et al. \(2013\)](#).

<sup>10</sup>Other related papers include [Ho and Michaely \(1988\)](#), [Boot and Thakor \(2001\)](#) and [Fishman and Hagerty \(2003\)](#). [Ho and Michaely \(1988\)](#) consider costly information collection by equating the marginal information cost across all firms. [Boot and Thakor \(2001\)](#) studies what kind of information and how much of it should firms voluntarily disclose, when it can either substitute or complement the information that investors can privately acquire. [Fishman and Hagerty \(2003\)](#), instead, provides a model in which issuers may choose a socially inefficient level of disclosure because some customers fail to grasp the meaning of the information disclosed by the seller.

asset as a derivative that might provide valuable hedging to investors, but these do not know precisely how good a hedge it is. Conversely, the issuer places no value on the asset’s hedging properties, being already perfectly hedged against the relevant risk.

As already mentioned, initially the issuer may commit to a disclosure regime ( $d = 1$ ) or not ( $d = 0$ ). If he does, investors will observe a signal  $\sigma \in \{v_b, v_g\}$  correlated with the value that they place on the security. In this case, before trading each investor  $i$  must decide the level of attention  $a \in [0, 1]$  to be devoted to the signal. The greater the attention, the higher the probability of correctly estimating the probability distribution of the asset’s value:  $\Pr(\sigma = v|v, a_i) = \frac{1+a_i}{2}$ . So by paying more attention, investors read the signal more accurately. The choice of  $a$  captures the investors’ effort to understand, say, the risk characteristics of a new ABS based on the data disclosed about the underlying asset pool.

However, greater precision comes at an increasing cost: the cost of information processing is  $C_i(a_i, \theta_i)$ , with  $\partial C_i/\partial a_i > 0$  and  $\partial^2 C_i/\partial a_i^2 > 0$ , where the shift parameter  $\theta_i$  measures inefficiency in processing. Hence, we can think of  $1/\theta_i$  as a gauge of the investor’s “financial literacy”. To simplify the analysis, we posit a quadratic cost function:  $C_i(a_i, \theta) = \theta_i a_i^2/2$ . The greater  $\theta_i$ , 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:  $\theta_s = 0$ .<sup>11</sup> The differences between hedgers and speculators can also capture the differences between retail and institutional investors. However, it is important to realize that our unsophisticated investors are not at all naive: they realize that they have higher information processing costs than the speculators, and take this rationally into account in their market behavior. Like [Tirole \(2009\)](#), [Van Nieuwerburgh and Veldkamp \(2009\)](#) and [Van Nieuwerburgh and Veldkamp \(2010\)](#) we do not assume bounded rationality. 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.

## 2.2 Trading

After acquiring the asset from the issuer, the dealer (henceforth, “seller”) resells it on a secondary market where trading occurs via a matching and bargaining protocol.<sup>12</sup> The seller is

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<sup>11</sup>The model easily generalizes to the case where speculators too have positive information-processing costs or where there are more than two types of investors.

<sup>12</sup>In principle the issuer and the dealer can be the same player without significantly affecting our analysis. However, we want to allow for this interpretation because in reality the issuer chooses the disclosure regime,

initially matched with a hedger with probability  $\mu$ , and with a speculator with probability  $1 - \mu$ . If the initial match produces no trade, the seller is contacted by the other type of investor. The parameter  $1 - \mu$  can be interpreted as the fraction of speculators in the population: if investors are randomly drawn from a common distribution, in a securities market that attracts more speculators, one of them is more likely to deal with the issuer.

Each investor  $i$  has a reservation value  $\omega_i > 0$ , which is the investor's opportunity cost of holding the asset, and does not depend on  $v$ . The net value from purchasing the asset for investor  $i$  is  $v - \omega_i$ , for  $i = \{h, s\}$ . The seller places no value on the asset and is uninformed about  $v$ : he does not know which signal value will increase the investors' valuation of the asset, possibly because he ignores investors' trading motives or risk exposures. This allows us to focus on the endogenous information asymmetry among investors and greatly simplifies their exposition, although the information structure described here is not essential for our results (as shown by an extension). Once the seller is matched with a buyer, they negotiate a price and the trade occurs whenever the buyer expects to gain a surplus:  $\mathbb{E}_i(v - \omega_i \mid \Omega_i) > 0$ , where  $\Omega_i$  is buyer  $i$ 's information set. The seller makes a take-it-or-leave-it offer with probability  $\beta$ .

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  $\beta_i$  of this expected surplus when selling to investor  $i$ , where  $\beta_i$  measures the seller's bargaining power vis-à-vis hedgers ( $i = h$ ) and speculators ( $i = s$ ), respectively. The buyer  $i$  gets the remaining portion  $1 - \beta_i$  of the expected surplus. For most results of the model, it makes no substantive difference whether the seller has different bargaining power vis-à-vis the two types of investors or not. The only results where this assumption matters are those regarding the social efficiency of disclosure, i.e. whether issuers over- or under-provide information, when left to themselves. Therefore, for expositional simplicity in most of the analysis we assume  $\beta_h = \beta_s = \beta$ , and relax this assumption only in Section 6.2, where it matters for the efficiency of mandatory disclosure.

As in the search-cum-bargaining model of [Duffie et al. \(2005\)](#), the seller can observe the investor's type.<sup>13</sup> Real-world examples of such a setting are OTC markets, where matching via search gives rise to a bilateral monopoly at the time of a transaction: in OTC markets sellers can typically observe or guess the type of their counterparty – e.g. distinguish the trader calling from an investment bank (a “speculator” in our model) from the CFO of a

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while the dealer trades with investors in secondary markets.

<sup>13</sup>Notice that 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.



non-financial company seeking to hedge operating risks (a “hedger”). There is also empirical evidence that this is in fact the case. [Linnainmaa and Saar \(2012\)](#) show that broker identity can be used as a signal about the identity of investors who initiate trades and that the market correctly processes this information.

We impose the following restrictions on the parameters:

**Assumption 1**  $\omega_s = \bar{v} > \omega_h > 0$ .

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 ( $\bar{v} > \omega_h > 0$ ). For instance, they are farmers who need to hedge against the price risk of their crops, and due to their limited access to financial markets expect the asset to be a valuable hedge. Instead, speculators place no intrinsic value on the asset, because they have access to other hedging strategies ( $\omega_s = \bar{v}$ ): they are in the market only to exploit their information processing ability. For example, they may be hedge funds or investment banks with strong quant teams. This assumption is made just for simplicity, but it could be relaxed without affecting the qualitative results of the model: if it were assumed that  $\omega_s < \bar{v}$ , the only change would be that speculators will trade also when information is not disclosed, but in this case they would behave similarly to the hedgers.

**Assumption 2**  $\theta > (1 - \beta)(v_g - v_b)/4$  and  $\beta < 1$ .

These two parameter restrictions ensure that the attention allocation problem of the hedger has an interior solution. The assumption on  $\theta$  implies that his information processing cost is high enough to deter him from achieving perfectly precise information; that is, he will choose an attention level  $a_h^* < 1$ . Otherwise, in equilibrium hedgers would have the same information as speculators ( $\Omega_h = \Omega_s$ ). The assumption on  $\beta$  ensures that the hedger chooses an attention level  $a_h^* > 0$ , because he captures a part of trading surplus: if instead the seller were to appropriate all of it ( $\beta = 1$ ), the hedger would have no incentive to process information.

## 2.3 Timeline

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

1. The issuer decides on the disclosure regime, i.e.  $d \in \{0, 1\}$ , and sells the asset to one of several competing dealers.<sup>14</sup>

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<sup>14</sup>We have also examined the case in which the issuer can choose a continuous disclosure rule  $d \in (0, 1)$ : due to the linearity of the issuer’s payoff, our results are unaffected, as in equilibrium the issuer will always choose either full disclosure or full opacity.



2. Depending on the disclosure regime, the signal  $\sigma$  is released or not, investors decide whether to enter the market or not, and if they do they are matched with the dealer via random matching: if they both enter, the dealer is matched with the hedger with probability  $\mu$ , and with the speculator with probability  $1 - \mu$ .<sup>15</sup>
3. Investor  $i$  chooses his attention level  $a_i$  and forms his expectation of the asset value  $\hat{v}_i(a_i, \sigma)$ .<sup>16</sup>
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 this way we highlight the information externality among investors. In Section 4 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 by determining the intensity of this externality. In Section 5, we also extend the model to analyze the case in which speculators can purchase the asset to resell it later to other market participants.

### 3 Equilibrium

We solve the game backwards to identify the pure strategy *perfect Bayesian equilibrium* (PBE), 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; and (iv) investors' beliefs are updated using Bayes' rule. 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.

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<sup>15</sup>In equilibrium, under the no-disclosure regime  $\mu = 1$ , because speculators abstain from entering the market as they obtain no gains from trade.

<sup>16</sup>So we posit that investors choose their level of attention after matching with the seller: they do not analyze the risk characteristics of a security, say, until they have found a security available for purchase. The alternative is to assume that buyers process information in advance, before matching. But this would entail 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.

### 3.1 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:

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

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 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  $\omega_h$ .

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

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

where  $\frac{1+a}{2}$  is the conditional probability of the asset being high-value when the investor chooses attention  $a$  and receives a high-value signal.<sup>17</sup> This probability is an increasing function of the investor's attention  $a$ : in the limiting case  $a = 0$ , the estimate  $\hat{v}$  would be the unconditional average  $\bar{v}$ , whereas in the polar opposite case  $a = 1$ , the investor's 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  $a_h^* \in (0, 1)$ .<sup>18</sup> 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:

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

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

We focus on the parameter region where the hedger purchases the asset only if a good signal

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<sup>17</sup>To see why, recall that the conditional probability that the signal is correct given an attention level  $a$  is  $\Pr(\sigma = v_j|a, v = v_j) = \frac{1+a}{2}$ , for  $j = b, g$ , and that the prior probability of a high asset value is  $\Pr(v = v_g) = \frac{1}{2}$ . Therefore, the conditional probability that the investor assigns to  $v = v_g$  is

$$\Pr(v = v_g|a, \sigma = v_g) = \frac{\Pr(\sigma = v_g|a, v = v_g)\Pr(v = v_g)}{\Pr(\sigma = v_g|a, v = v_g)\Pr(v = v_g) + (1 - \Pr(\sigma = v_g|a, v = v_g))(1 - \Pr(v = v_g))} = \frac{1+a}{2}.$$

<sup>18</sup>In the next section we solve the attention allocation problem and show that this conjecture is correct.

is released.<sup>19</sup> By solving problems (1) and (2), we characterize the bargaining solution:

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

$$p_h^d = \beta (\widehat{v}(a_h, v_g) - \omega_h) + (1 - \beta) p_s^d \frac{1 + a_h}{2} \text{ and } p_s^d = \beta (v_g - \omega_s), \quad (3)$$

*while when  $\sigma = v_b$  the hedger never trades. If instead the signal is not disclosed at stage 1, the trade occurs only with the hedger at the price*

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

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  $\omega_s$  exceeds the low 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  $\widehat{v}(a_h, v_g) > v_b$ ). This is reminiscent of the "ringing-phone curse" analyzed by [Zhu \(2012\)](#). In his words: "the fact that the asset is currently offered for sale means that nobody has yet bought it, which, in turn, suggests that other buyers may have received pessimistic signals about its fundamental value. Anticipating this 'ringing-phone curse,' a buyer may quote a low price for the asset, even if his own signal indicates that the asset value is high."

As we show below, 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  $a_h$ .

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<sup>19</sup>The relevant condition is derived in the proof of Proposition 2.

By contrast, the price offered by the speculator is affected only by his own bargaining power: he captures a share  $1 - \beta$  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. The information externality generated by the issuer’s disclosure decision is related to that recently modeled by [Duffie et al. \(2014\)](#), who study how information percolates in markets. In our setting, it crucially depends on the differences in processing ability between hedgers and speculators.

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:  $\bar{v} - \omega_s = 0$ . 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  $\bar{v}$ , and will always be willing to buy it at a price that leaves the seller with a fraction  $\beta$  of his surplus  $\bar{v} - \omega_h$ .

### 3.2 Attention Allocation

So far we have taken investors’ choice of attention as given. Now we characterize it as a function of the model parameters: treating their attention level as given may lead to mistaken comparative statics results: for instance, parameter changes that deepen the hedgers’ information disadvantage may trigger a countervailing increase in their attention level. In general, investors process the signal  $\sigma$  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  $\omega_i$ : 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  $v_g$  or (iv) buy only when the signal is  $v_b$ . [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  $v_g$ , that is, if the seller discloses “good news”.

Investors choose their attention level  $a_i$  to maximize expected utility:

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

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*

$$a_h^* = (v_g - v_b) \frac{(1 - \beta)(1 - \beta/2)}{4\theta},$$

*which is decreasing in the seller's bargaining power  $\beta$ , and increasing in the asset's volatility  $v_g - v_b$  and in the hedger's financial literacy  $1/\theta$ . The hedger buys the asset if and only if the realized signal is  $v_g$  and only if the asset's volatility is sufficiently high. Otherwise, the hedger chooses  $a_h^* = 0$  and always buys the asset.*

The first part of Proposition 2 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 thus learns the true value of the asset.

The second part characterizes the choice of attention by the hedger, for whom processing the signal is costly. First, his 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.  $\beta$  is large), the hedger spends less on analyzing the information, because he expects to capture a smaller fraction of the gains from trade.<sup>20</sup> Similarly, when the seller has high bargaining power 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.

Moreover, the optimal choice  $a_h^*$  is increasing in the range of values  $v_g - v_b$  that the asset can take, because a larger volatility of its value increases the magnitude of the two types of errors that the hedger must guard against. Hence the hedgers' informational disadvantage, as measured by  $(1 - a)(v_g - v_b)/2$  (see end of the previous section), is not monotonically increasing in the asset volatility: when volatility is large enough, hedgers will increase their attention  $a$  so much as to more than compensate the implied informational disadvantage.

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<sup>20</sup>Recall that Assumption 2 rules out the extreme case  $\beta = 1$ , where – as shown by the expression for  $a_h^*$  – the hedger would exert zero attention, and behave simply as an unsophisticated investor, who never bears any information processing costs and estimates the value of the asset at its unconditional mean  $\bar{v}$ .

As one would expect, the hedger’s optimal attention  $a_h^*$  is also increasing in his financial literacy  $1/\theta$ , because the lower is the cost of analyzing the signal  $\sigma$ , the more worthwhile it is to do so. Alternatively, one can interpret  $1/\theta$  as a measure of the “simplicity” of the asset – the pricing implications of information being easier to grasp for plain-vanilla bonds than for complex assets such as asset-backed securities.

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 (the relevant threshold being stated in the proof). 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 its value.

### 3.3 Disclosure Policy

To determine what incentive the issuer has to commit to disclosure, consider that the price at which he initially sells the asset is nothing but the expected price at which the asset will later trade on the secondary market. Recall that, according to the timeline of the game, the initial sale of the asset occurs before the signal is released, and therefore still in a situation of symmetric information. Hence, competition between investors in the primary market will allow the issuer to capture any surplus that may accrue to them in secondary market trading. Therefore, the initial of disclosure by the issuer depends on the comparison between the expected profits in the disclosure and no-disclosure regime. Based on the previous analysis, in the no-disclosure regime the seller’s expected profit is simply

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

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  $\mu$ , 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

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

To choose between disclosure ( $d = 1$ ) and no disclosure ( $d = 0$ ), the seller compares the expected profits (7) and (6) in the two regimes, evaluated at the equilibrium prices defined by Proposition 1. Using this comparison, we characterize the issuer’s incentive to disclose information:

**Proposition 3 (Choice of financial disclosure)** *The issuer’s net benefit from disclosing*

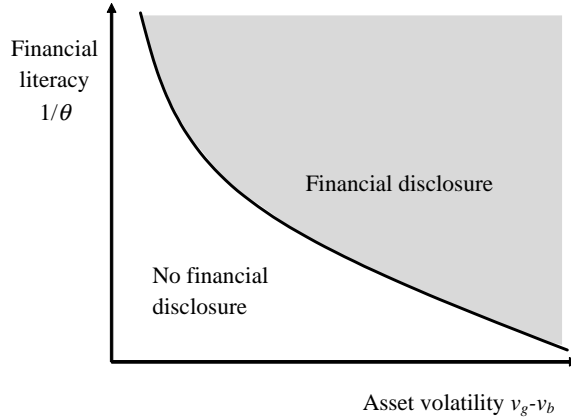


Figure 1: Financial disclosure as function of literacy and volatility

the signal  $\sigma$  is increasing in the asset's volatility  $v_g - v_b$  and in the hedgers' financial literacy  $1/\theta$ , and decreasing in the hedgers' relative appetite for the asset  $\omega_s - \omega_h$ .

To intuit the reason for these results, consider that in this model financial disclosure has both benefits and costs for the issuer. 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 of disclosure stems from enabling the speculator to deploy his information-processing skills, triggering an information externality that depresses the price.

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. By the same token, the issuer is more inclined to disclosure when  $1/\theta$  is high, i.e. when investors have high financial literacy and/or the asset has a simple payoff structure, as in these circumstances disclosure will elicit a high level of attention by investors and accordingly raise their valuation of the asset significantly. This comparative statics is illustrated in Figure 1, where financial disclosure occurs in the shaded region where either financial literacy or asset volatility is sufficiently high, or both.

Proposition 3 also highlights that the issuer is less willing to disclose information when hedgers have a low reservation value compared to speculators, and therefore bid aggressively for the asset irrespective of the information available to them. In this case, the seller will be less dependent on the speculators for the sale of the asset, and accordingly will be less inclined

to release the public signal that is a prerequisite for speculators to bid.

Recently, [Duffie et al. \(2014\)](#) argue that similar effects play a role in the publication of benchmarks in OTC markets, which might be interpreted as the disclosure of more information in our model. Specifically, they show that the publication of a benchmark can raise total social surplus as it facilitates more efficient matching between dealers and customers, and even if the improvement in market transparency caused by benchmarks may lower dealer profit margins, dealers may nevertheless introduce a benchmark to encourage greater market participation by investors. The latter effect is similar to our insight that disclosing information also encourages speculators to participate in the market by bidding for the asset, which benefits the issuer by increasing the competition among investors. However, in our setting their presence also generates a negative externality as speculators induce hedgers not to bid for the asset when its value is low. Next section shall show how this externality crucially depends on the market transparency.

## 4 The Effect of Market Transparency

In analyzing issuers' 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 post-trade transparency, the extent to which information on previous trades is disseminated to actual and potential participants.<sup>21</sup> Accordingly, we now generalize to examine how the results are affected by less than perfect market transparency. We model market transparency as investors' ability to observe previous trades – or absence of them. To this purpose, we assume that at stage 5 players observe the outcome of the match that occurred at stage 4 only with probability  $\gamma$ . Hence the parameter  $\gamma$  can be taken as a measure of transparency, and conversely  $1 - \gamma$  as a measure of opacity.

Hence, in our setting market transparency is more precise knowledge that a former trade could have occurred but did not. As is well-known, it is often the case that the absence of news as time passes often contains information (“no news is news”), and increased transparency can make such absence of news more salient for investors. For instance, consider the increase in post-trade transparency brought about by the introduction of the TRACE system in the bond market (a typical OTC trading venue), which enables investors to observe if there have been previous trades for the same bond. Then, absence of previous trades can be an important piece

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<sup>21</sup>For 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.



of “no news” that other investors will want to take into account in their trading decisions. In the model, changing  $\gamma$  makes the absence of news and the passage of time more visible and salient for investors. This logic applies also to other financial markets. In the market for corporate control, Giglio and Shue (2014) have formally tested how investors take into account the absence of information and find that, in the year after a merger announcement, the passage of time is informative about the probability that the merger will ultimately complete. Similarly, in the housing market the introduction of websites such as Zillow.com have increased transparency by providing more detailed information about current listings (greater disclosure), while also enabling house hunters to access the number of days a listing has been active, namely, for how long the house went unsold (greater trade transparency). With this additional information, potential buyers will bid more conservatively for houses that were on the market longer.

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  $\gamma$ ) 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 ( $\gamma$  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 no trade.<sup>22</sup>

Let us analyze the first effect in isolation, taking the hedger’s participation and pricing decision as given. Suppose the issuer discloses the signal  $\sigma = v_g$  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 ( $\gamma = 1$ ) where the hedger is never willing to buy the asset when he comes second. To compute the price that the speculator is willing to offer if  $\gamma < 1$ , we have to take into account that now two situations can arise: with probability  $\gamma$ , the speculator knows that he is the first to be matched with the seller, and with probability  $1 - \gamma$  he does not know whether he is the first or not.

To compute the seller’s expected profits, we start with the price that the speculator is

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<sup>22</sup>Our model can easily account for the case in which the hedgers are naive: this countervailing effect of opacity would be absent.

willing to offer. When the speculator knows that he is the first to trade, he is willing to offer the price  $p_s^{o1}$ , which is a weighted average of his surplus  $v_g - \omega_s$  and the seller's outside option  $p_h^o$ , i.e. the price that the hedger is willing to pay in the opaque market when he does not see the previous match and believes that the asset has high value (which occurs with probability  $\frac{1+a_h}{2}$ ):

$$p_s^{o1} = \beta (v_g - \omega_s) + (1 - \beta) \frac{1 + a_h}{2} p_h^o. \quad (8)$$

When instead the speculator does not know whether a previous match with the hedger failed, he is willing to offer the following price:

$$p_s^o = \eta p_s^{o1} + (1 - \eta) \beta (v_g - \omega_s), \quad (9)$$

where  $\eta = \frac{1-\mu}{(1-\mu)+\mu\frac{1-a}{2}}$  is the speculator's belief that he is the first to be matched with the seller. The greater the probability  $1 - \eta$  that the speculator assigns to a previous match between seller and hedger having failed (in which case the seller's outside option is zero), the lower the price that he is willing to offer: this can be seen by noticing that by (8)  $p_s^{o1} > \beta (v_g - \omega)$ .

Hence, the price that the seller expects to receive when he is matched with a speculator is the average of the prices in (8) and (9), respectively weighted by the probabilities  $\gamma$  and  $1 - \gamma$ :

$$\bar{p}_s^o(\gamma) = \gamma p_s^{o1} + (1 - \gamma) p_s^o. \quad (10)$$

Since  $p_s^{o1} < p_s^o$ , the average price  $\bar{p}_s^o(\gamma)$  paid by a speculator is decreasing in  $\gamma$ : market transparency heightens the information externality, to the speculators' benefit.

However, this result has been obtained taking the price  $p_h^o$  offered by hedgers as given. In fact, 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, we modify the bargaining protocol when opacity generates information asymmetry between the seller and the hedger: 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.

Due to his informational advantage in the trading process, the seller extracts a rent from the hedger. When this rent is not so high as to deter him from making an offer, the hedger will offer the seller his outside option. If he knows to be the first to trade, which happens with probability  $\gamma$ , the hedger will then offer the expected price that the speculator would bid if the match fails. With probability  $\gamma$ , the speculator will know that the previous match with the hedger failed, and therefore will offer  $\beta(v_g - \omega_s)$ , while with probability  $1 - \gamma$  he will not know whether a previous match failed, and therefore will offer  $p_s^o$ . Hence, when he trades, in expectation the hedger will offer the following price:

$$p_h^o = \gamma\beta(v_g - \omega_s) + (1 - \gamma)p_s^o, \quad (11)$$

which is decreasing in market transparency  $\gamma$ , recalling that  $\beta(v_g - \omega_s) < p_s^o(\gamma)$ : a more transparent market allows also the hedger to bid less aggressively for the asset.

But the seller's informational rent may be so high as to deter the hedger from trading. This happens when the hedger's likelihood  $\mu$  of being the first to contact the seller is sufficiently low: 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  $\mu$  drops below a threshold level  $\underline{\mu}$ , this concern leads them to leave the market, as stated in the following proposition:

**Proposition 4 (Hedgers' participation decision)** *When the market is opaque, i.e.  $\gamma < 1$ , if the fraction of hedgers is high enough ( $\mu \geq \underline{\mu}$ ), the hedger offers the price (11) and the seller accepts it. Otherwise ( $\mu < \underline{\mu}$ ), the hedger does not trade.*

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, the asset is sold to the speculator at the expected price  $\bar{p}_s^o(\gamma)$  in (10) or to the hedger at the price  $p_h^o$  in (11). Specifically, the speculator manages to buy if he is the first to be matched with the seller and the asset value is high (which occurs with probability  $\frac{1-\mu}{2}$ ) or if he comes second but the hedger mistakenly refrained from buying the asset (which happens with probability  $\frac{\mu(1-a_h^*)}{4}$ ). The hedger instead buys only if he comes first and judges the asset value to be high (which happens with probability  $\frac{\mu}{2}$ ). If instead  $\mu < \underline{\mu}$ , the asset can be sold only to the speculator in the good state at price  $\beta(v_g - \omega_s)$ . Therefore,

when the market is not fully transparent, under disclosure the seller's expected profit is:

$$\mathbb{E}(\pi^{o,d}) = \begin{cases} \left[ \frac{1-\mu}{2} + \frac{\mu(1-a_h^*)}{4} \right] \bar{p}_s^o(\gamma) + \frac{\mu}{2} p_h^o & \text{if } \mu \geq \underline{\mu}, \\ \frac{1}{2}\beta(v_g - \omega_s) & \text{if } \mu < \underline{\mu}. \end{cases}$$

Recalling that both the expected price offered by the speculator  $\bar{p}_s^o(\gamma)$  and the expected price  $p_h^o$  bid by the hedger are decreasing functions of market transparency, the seller's profit is also decreasing in  $\gamma$  when the hedger trades ( $\mu \geq \underline{\mu}$ ). When instead the hedger refrains from trading ( $\mu < \underline{\mu}$ ), the seller's profit does not depend on market transparency, but coincides with his lowest profit when the hedger is active.

The expected profits under disclosure for the case  $\mu \geq \underline{\mu}$  and for the case  $\mu < \underline{\mu}$  are plotted as a function of market transparency  $\gamma$  by the two solid lines in Figures 2 and 3. The negative relationship between average asset price and transparency for  $\gamma \in [0, 1)$  highlights that in our setting market transparency exacerbates the externality between hedger and speculator, which damages the seller. Notice that in both cases when the market achieves full transparency ( $\gamma = 1$ ), the seller's expected profit is the one he would achieve if the hedger could capture the entire trading surplus by making a take-it-or-leave-it bid ( $\beta = 0$  in Proposition 1).

We are now in a position to investigate whether the issuer opts for disclosure, and how this decision is affected by market transparency. First, notice that the expected profit with no disclosure  $\mathbb{E}(\pi^{nd})$  is not affected by market transparency, since the speculator refrains from trading and the expected profit is accordingly given by expression (6). This level of expected profit is shown as the dashed line in Figure 2. The two graphs in the figure illustrate two different cases. In case (a), shown in the graph on the left, the expected profit under disclosure  $\mathbb{E}(\pi^{o,d})$  exceeds that under no disclosure  $\mathbb{E}(\pi^{nd})$  for *any* degree of market transparency, so that the issuer will always opt for disclosure ( $d = 1$ ). In case (b), shown in the graph on the right, the issuer prefers to disclose if transparency  $\gamma$  is low and  $\mu \geq \underline{\mu}$ , while he prefers no disclosure otherwise. Hence, going back to Figure 1, an increase in market transparency moves the boundary between the two regions outward, shrinking the shaded disclosure region.

The following proposition summarizes the effects of market transparency on the issuer'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 issuer's net benefit from disclosure is decreasing in the degree of market transparency  $\gamma$ .* (ii) *Otherwise ( $\mu < \underline{\mu}$ ), the issuer's benefit from disclosure is independent of the degree of market transparency  $\gamma$ .*

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

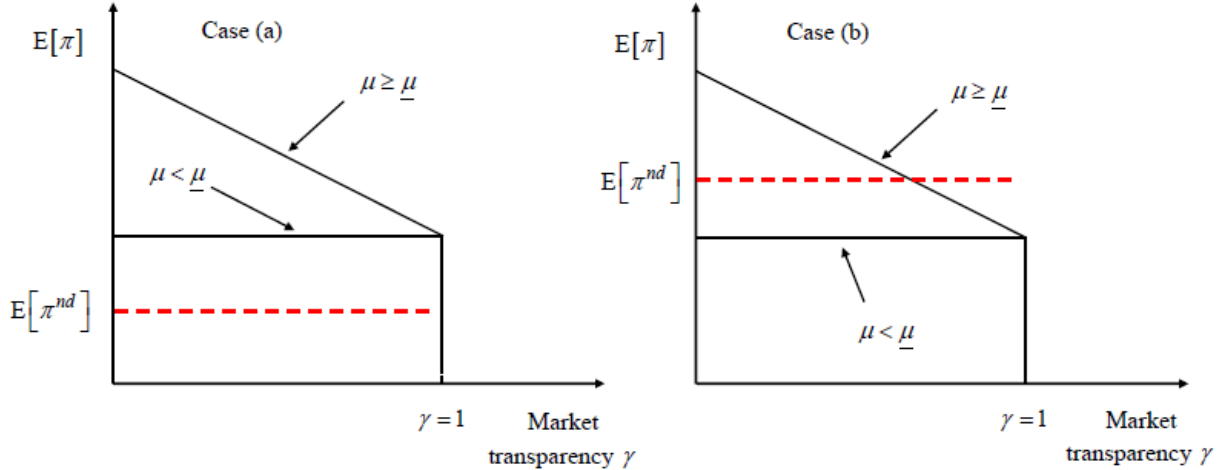


Figure 2: Financial disclosure and market transparency

transparent one. It is important to emphasize that for these results we do not need to assume that the investors observe a failed transaction: the mere *absence* of a past transaction conveys information to investors about the willingness to pay of other potentially more sophisticated market participants.

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 speculators and hedgers to the benefit of seller.<sup>23</sup> Speculators cannot fully exploit their superior processing ability, while the hedgers 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 speculators 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  $\gamma$ ) 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

<sup>23</sup>Note 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))

anonymous trading systems, which parallels our result that hedgers are willing to offer a higher price when  $\gamma = 0$ .

## 5 Extensions

This section extends the previous analysis in two distinct directions. First, we allow for the possibility that the speculators can acquire a private signal about the asset's value when the issuer does not disclose it. Second, we also ask whether the seller could avoid the winner's curse by committing to trade only with hedgers. In the appendix, we extend the model to the case in which the seller has private information about the value of the asset to investigate the robustness of the model's results to this change in assumptions.

### 5.1 Information Acquisition

In the previous section, the only information about the asset is that released by the issuer. However in practice investors, particularly sophisticated ones, may privately acquire information about the value of the asset, *especially* when there is no public news released by the issuer. The main point of this section is to investigate how the issuer's disclosure policy is influenced by the possibility that the sophisticated investors have access to private information about the asset's value.

To capture this possibility, we allow the speculators to acquire a private signal  $\sigma^p \in \{v_b, v_g\}$  about the asset payoff at a cost  $c$  cross-sectionally distributed according to the cumulative distribution function  $F(\cdot)$ . For simplicity, we assume that the signal is perfect, that is,  $\Pr(\sigma^p = v|v) = 1$ , that the decision to acquire the signal is not publicly observed by the hedgers, and that the market is fully transparent  $\gamma = 1$ .<sup>24</sup> The speculator, knowing the specific realization of his information acquisition cost, will acquire the signal  $\sigma^p$  if and only if on balance he benefits from it:

$$\frac{(1 - \beta)(v_g - \omega_s)}{2} - c > 0,$$

that is, if the expected payoff of purchasing the asset when the value is  $v_g$  exceeds the cost  $c$  of acquiring the signal. Then, a speculator can be expected to acquire the signal with probability  $F(c^*)$ , where  $c^* = (1 - \beta)\frac{v_g - v_b}{4} > 0$  is the threshold above which acquiring information becomes too expensive, and is increasing in the asset volatility  $v_g - v_b$ .

Now, even in the absence of disclosure by the seller, in equilibrium hedgers know that, if speculators are expected to possess private information about the asset value and refuse

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<sup>24</sup>It is straightforward to extend the analysis to the case in which  $\Pr(\sigma^p = v|v) \in (1/2, 1)$  and  $\gamma < 1$ , but the exposition becomes more cumbersome.

to purchase the asset, then it must be because they observed a negative private signal. In other words, when the speculators have an incentive to acquire private information, the market features a winner's curse even with no disclosure.

Let us now investigate how this possibility affects the seller's expected profits (using the superscript  $ia$  as a mnemonic for "information acquisition"). The expected profits for the seller when he is matched with a speculator are given by

$$\mathbb{E} [\pi_s^{ia}] = \frac{F(c^*)}{2} \beta (v_g - \omega_s),$$

that is, the probability of acquiring positive information,  $F(c^*)/2$ , multiplied by the price the speculators are willing to offer. Instead, the seller's expected payoff when he is matched with a hedger is

$$\mathbb{E} [\pi_h^{ia}] = \beta (\bar{v} - \omega_h) + (1 - \beta) \frac{F(c^*)}{2} \beta (v_g - \omega_s).$$

The gains from trade between the seller and the uninformed hedger are given by  $\bar{v} - \omega_h$ , and the seller appropriates a fraction  $\beta$  of them; in addition, the hedger is willing to compensate the seller for the possibility of being matched with an informed speculator, which occurs with probability  $F(c^*)/2$ . Comparing the seller's expected profits under information acquisition with those obtained in the previous section, one obtains the two results in the following proposition:

**Proposition 6 (Information acquisition and disclosure)** *(i) When speculators can acquire information privately, the seller's expected profits are always lower than under disclosure, i.e.  $\mathbb{E} [\pi^{ia}] < \mathbb{E} [\pi^d]$ . (ii) An issuer who opts no disclosure when speculators can acquire information privately, will switch to disclosure if speculators can acquire it.*

Intuitively, when only speculators have access to a private signal about the asset's value, hedgers are even more disadvantaged relative to the speculators than in the baseline model, and will bid more cautiously even when they are the first to be matched with the seller, their estimate of the asset's value being the unconditional expectation  $\bar{v}$  and not  $\hat{v}(a_h, v_g)$ , which conditions on the public signal  $\sigma$ . This explains the first result in the proposition, namely that the seller's expected profits are greater under disclosure than under private information acquisition.

The second result follows immediately. Consider a situation where, absent private information acquisition, the issuer would prefer not to disclose information, i.e.  $\mathbb{E} [\pi^{nd}] > \mathbb{E} [\pi^d]$ . Now, if speculators are allowed to privately acquire such information, the no-disclosure outcome can no longer be attained, and by the previous result  $\mathbb{E} [\pi^d] > \mathbb{E} [\pi^{ia}]$  the issuer will prefer to disclose the signal  $\sigma$ . Hence, Proposition 6 shows that introducing private information collection

by speculators heightens the issuer’s incentive to disclose: he always discloses information if he expects speculators to have access to the same information privately.

## 5.2 Seller’s Precommitment

Could the seller avoid the winner’s curse by committing to trade only with hedgers? Doing so would allow him to disclose information without attracting the speculators. However, for such commitment to eliminate the externality, the seller would need to (i) communicate it to all potential buyers, and (ii) stick to his word once a speculator were to bid for the asset.

Consider first a situation where, irrespective of the seller’s gains from trade with hedgers and speculators, he is unable to communicate his trading intentions to all comers: then, even when the seller announces that he will not trade with speculators, a speculator may still approach him with some probability. In this case, the information externality that generates the winner’s curse will still be present, because it 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.

Next, even if the seller can communicate to all potential buyers that he will not trade with speculators, he may still be unable to credibly precommit to do so, for some parameter values:

**Proposition 7 (No precommitment by the seller)** *It is never optimal for the seller to reject the speculator’s offer if and only if the difference in outside options between speculators and hedgers is low enough, namely:*

$$v_g - \widehat{v}(a_h, v_g) > \omega_s - \omega_h. \tag{12}$$

Intuitively, the condition (12) states that a speculator can make the seller “an offer that he cannot refuse” whenever his informational advantage over hedgers,  $v_g - \widehat{v}(a_h, v_g)$ , more than compensates his lower appetite for the asset arising from preferences,  $\omega_s - \omega_h$ . The speculators’ informational advantage on the left-hand side equals  $(1 - a)(v_g - v_b)/2$ , and therefore is increasing in the probability that hedgers make mistakes in purchasing the asset,  $(1 - a)/2$ . When this condition holds, the gains from trade with the speculator are high enough that the seller will not be able to precommit to trade only with the hedger.

## 6 Regulation

So far we have analyzed the issuer’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  $\gamma$ ), (ii) make disclosure compulsory (set  $d = 1$ ) and (iii) restrict market participation (for instance, ban hedgers from trading, setting  $\mu = 0$ ). We use the expected aggregate trade surplus as welfare metric.

## 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  $\gamma$ .

As Figure 3 shows, the issuer’s incentive to disclose the signal  $\sigma$  is decreasing in transparency  $\gamma$ . Hence, if the regulator increases  $\gamma$  beyond the intersection of the dashed line with the decreasing solid line, the seller will decide to conceal the signal  $\sigma$ , 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  $\gamma$  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 when the market is fully transparent, i.e.  $\gamma = 1$ . 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. In this section, we relax the assumption maintained so far that the seller has the same bargaining power when trading with hedgers and with speculators, because – as we shall see below – the relative magnitudes of  $\beta_h$  and  $\beta_s$  are key in determining whether issuers over- or under-provide information, in the absence of any policy intervention.

We compute the expected social surplus when information is disclosed and when it is not. When no information is disclosed, the gain from trade is simply

$$\mathbb{E} [S^{nd}] = \bar{v} - \omega_h, \quad (13)$$

while under disclosure it is

$$\mathbb{E} [S^d] = \mu \mathbb{E} [S_h^d] + (1 - \mu) \mathbb{E} [S_s^d], \quad (14)$$

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

$$\mathbb{E} [S_h^d] = \left[ \frac{1 + a_h^*}{4} (v_g - \omega_h) + \frac{1 - a_h^*}{4} (v_b - \omega_h) + \frac{1 - a_h^*}{4} (v_g - \omega_s) \right] - \frac{\theta a_h^{*2}}{2}. \quad (15)$$

The first term is the surplus if the asset value is  $v_g$  and the realized signal is  $v_g$ , 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  $v_g$ , 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

$$\mathbb{E} [S_s^d] = \frac{v_g - \omega_s}{2}, \quad (16)$$

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

Using expressions (13), (14), (15) and (16), one can compute the net social benefit from

disclosure  $\Delta = \mathbb{E}[S^d] - \mathbb{E}[S^{nd}]$ , and characterize its determinants. Clearly, the higher is the unconditional expectation of the asset's value, the lower is the net benefit that society gains from disclosure and the implied learning, as can be immediately seen from the fact that the expected surplus under no disclosure  $\mathbb{E}[S^{nd}]$  is increasing in  $\bar{v}$ . Conversely, disclosure increases the gains from trade insofar as it induces both the hedger and the speculator to bid more aggressively for high-valued assets. This occurs when the hedgers' financial literacy  $1/\theta$  and the asset volatility  $v_g - v_b$  are high, so that hedgers choose to devote high attention  $a_h^*$  to the signal  $\sigma$ ; high asset volatility also increases the speculators' willingness to pay for high-quality assets. To summarize:

**Remark 1 (Determinants of the social benefit of disclosure)** *The net social benefit from disclosure is decreasing in the asset's expected value  $\bar{v}$ , and increasing in hedgers' financial literacy  $1/\theta$  and in the asset volatility  $v_g - v_b$ .*

Clearly, depending on parameters, the net social benefit from disclosure  $\Delta$  may be positive or negative. The interesting issue is whether  $\Delta$  has the same or the opposite sign of issuers' private gain from disclosure  $G = \mathbb{E}[\pi^d] - \mathbb{E}[\pi^{nd}]$ , i.e. the difference between their expected profit under disclosure (25) and under no disclosure (6). When the net social surplus  $\Delta$  and the private gain  $G$  from disclosure are both positive or both negative, the disclosure choice made by issuers is aligned with social efficiency; if instead  $\Delta > 0$  and  $G < 0$ , issuers under-provide information, while if  $\Delta < 0$  and  $G > 0$ , they over-provide it compared to what a regulator would want. There are three reasons why the regulator's gain from disclosure may differ from the seller's. First, the planner ignores the distributional issues driven by the bargaining protocol, so bargaining power does not affect the expected social gain directly: it does so only indirectly via the attention level chosen by hedgers. 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  $\omega_h$ , and instead the asset is sold to a speculator.

It turns out that the difference between the seller's bargaining power with hedgers and speculators is a key determinant of the social efficiency of issuers' disclosure decisions:

**Proposition 8 (Optimal disclosure policy)** *If the seller has greater bargaining power when trading with hedgers than with speculators ( $\beta_h > \beta_s$ ), then both under- and over-provision of information can occur in equilibrium; otherwise ( $\beta_h \leq \beta_s$ ), under-provision cannot occur.*

The fact that under-provision of information can only occur when the seller's has greater bargaining power with hedgers than with speculators, i.e.  $\beta_h > \beta_s$ , is explained as follows.

When issuers anticipate that trading with a speculator will entitle them to a smaller fraction of the bargaining surplus than trading with a hedger, they may prefer to deter trading by speculators by not disclosing information about the asset. But this may be socially inefficient: the total gains from trade may be larger with disclosure, even though the fraction accruing to issuers is smaller. If so, regulatory intervention for disclosure is required. Instead, if  $\beta_h \leq \beta_s$ , there is never under-provision of information in equilibrium: when the seller has at least as much bargaining power with speculators than with hedgers, in the issuer's eyes the negative price externality triggered by the speculator under disclosure tends to be compensated by his small portion in the expected surplus. Hence, the issuer incentive to disclose is either well aligned with that of the regulator, or it exceeds it, leading to disclosure of the signal  $\sigma$  even though it would be socially efficient to withhold it.

What determines whether issuers under- or over-provide information when  $\beta_h > \beta_s$ ? Here the attention level  $a_h^*$  chosen by hedgers plays a key role: if they devote little attention to the signal  $\sigma$ , releasing it does not lead them to spend too many resources. Hence the regulator will be more inclined to favor disclosure, even if the issuer does not. Recalling that the optimal attention  $a_h^*$  is increasing in hedgers' financial literacy  $1/\theta$  and asset volatility  $v_g - v_b$ , under-provision will occur for low values of these parameters. Hence, mandating disclosure by issuers is warranted in situations where unsophisticated investors devote little attention to the securities in which they invest, because of their poor financial education, the complexity of the securities or their low unconditional risk. In the opposite case, in which unsophisticated investors devote much attention to information, the issuer has greater incentive to disclose than the regulator, because he does not give sufficient weight to the resources that hedgers spend to study the disclosed information: then, over-provision will occur.

### 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.<sup>25</sup> A step in this direction has already been taken in the

<sup>25</sup> *Financial Times*, June 16 2010 available at <http://cachef.ft.com/cms/s/0/a55d979e-797b-11df-b063-00144feabdc0.html#axzz1JDvAWQa2>.

contest of securitization instruments: issuers of Rule 144a instruments, which require a high degree of sophistication, can place them with dealers who can resell them only to Qualified Institutional Buyers, while registered instruments can be traded by both retail and institutional investors.

To analyze this policy, let us revert to the assumption earlier in the paper that the seller has the same bargaining power when trading with hedgers and with speculators, i.e.  $\beta_h = \beta_s = \beta$ . By Proposition 8, we know that under this assumption there is never a rationale to mandate disclosure, as issuers either provide information efficiently or even over-provide it. But in this case it may be efficient for the regulator to adopt a different policy: allow disclosure but limit market access to speculators who, upon getting the signal  $\sigma$ , forecast the asset's value perfectly and incur no processing costs. Limiting access to speculators is socially efficient when the expected surplus generated by trading with them (16) exceeds the expected gain (14) generated by the participation of all types of investors. The relevant condition is

$$\frac{v_g - \omega_s}{2} > \mu \left[ \frac{1 + a_h^*}{4} v_g + \frac{1 - a_h^*}{4} v_b - \frac{\omega_h}{2} + \frac{1 - a_h^*}{4} (v_g - \omega_s) - \frac{\theta a_h^{*2}}{2} \right] + (1 - \mu) \frac{v_g - \omega_s}{2}, \quad (17)$$

which leads to the following proposition:

**Proposition 9 (Banning hedgers from trading)** *Making market access exclusive to speculators is welfare-improving when financial literacy  $1/\theta$  is low and the expected value  $\bar{v}$  of the asset is low.*

Proposition 9 indicates that it may be socially efficient to limit access to speculators alone, because this saves hedgers 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 even hedgers are financially skilled or the asset is simple (high  $1/\theta$ ) and has high expected value (high  $\bar{v}$ ): 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 four main contributions.

First, we show that enhancing information disclosure may not benefit hedgers, but can actually augment the informational advantage of the speculators. 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, we show that issuers have more incentives to disclose when, absent disclosure, speculators can privately acquire a signal about the asset's value. Intuitively, this is a consequence of the more severe information disparity among investors that emerge in this case.

Finally, in general the issuer's incentives to disclose are not aligned with social welfare considerations, thus warranting regulatory intervention. For instance, mandating disclosure can be efficient when sellers have less bargaining power in trading with speculators than with hedgers, and hedgers have low financial literacy or face complex securities. Under the latter condition, it may alternatively be optimal to exclude hedgers from the market.

## 8 Appendix A: Privately Informed Seller

In the main text, we assumed that the seller is uninformed about the value of the asset, or equivalently, he is as informed as the hedger. However, the analysis can be extended to a setting where the seller becomes perfectly informed about the asset's value  $v \in \{v_g, v_b\}$  after the signal is disclosed to the market. Thus, this extension introduces asymmetric information between the seller and the hedgers, on top of the asymmetry between hedgers and speculators. We can show that even in this case the issuer's optimal disclosure policy is very similar to the one described in Proposition 5.

To simplify the analysis, we assume that the seller has all the bargaining power and that the level of attention of the hedger is exogenously fixed at  $\underline{a}_h > 0$  when the issuer opts for disclosure ( $d = 1$ ).<sup>26</sup> This extension allows us to explore the possibility that the seller could signal his information by refusing to trade with the speculator. Specifically, there are two cases that must be considered. First, the seller might strictly prefer trading with the speculator, even if he is initially matched with a hedger. If so, a seller with a good asset always trades with the speculator: then, the hedger will refuse to trade, as he expects to be able to do so only when the value of the asset is low. Alternatively, a seller with a good asset prefers to trade with the hedger if he initially matched with him, so that even a seller with a bad asset might be able to trade with a hedger who did not observe the previous failed trade.

The first case arises only when the seller with  $v = v_g$  prefers trading with the speculator rather than with the hedger. This is the case when condition (12) holds, that is, when the gains from trade with the speculator ( $v_g - \omega_s$ ) exceed those with the hedger ( $\widehat{v}(\underline{a}_h, v_g) - \omega_h$ ). The second case arises when the seller with a good asset strictly prefers trading with the speculator, rather than dealing with a hedger in the subsequent match, but prefers dealing with the hedger if he meets him first. This is true only if

$$\widehat{v}(\underline{a}_h, v_g) - \omega_h \geq v_g - \omega_s \geq (1 - \gamma) (\widehat{v}(\underline{a}_h, v_g) - \omega_h), \quad (18)$$

that is, if the gains from trade with a speculator exceed those with the hedger if the hedger did not observe the previous failed trade, which occurs with probability  $1 - \gamma$ . Hence, in this case only a seller with a bad asset fails to trade with the speculator and deals with the hedger in the subsequent match. This is consistent with the hedger's posterior belief  $\Pr(v = v_g | \text{second}) = 0$ , which must hold in a Perfect Bayesian Equilibrium. The following proposition characterizes the equilibrium in the two parameter regions.

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<sup>26</sup>The analysis of a more general model, in which we relax these assumptions, and the derivation of all potential equilibria that can arise in that setting are outside the scope of this section. However, it is available upon request from the authors.

**Proposition 10 (Privately Informed Seller)** *If  $v_g - \omega_s \geq \widehat{v}(\underline{a}_h, v_g) - \omega_h$ , then the seller with a good asset always trades with the speculator, even if he is initially matched with a hedger, while the seller with a bad asset cannot trade with any investor. If instead  $\widehat{v}(\underline{a}_h, v_g) - \omega_h \geq v_g - \omega_s \geq (1 - \gamma)(\widehat{v}(\underline{a}_h, v_g) - \omega_h)$ , then the seller with a bad asset only trades with the hedger who did not observe the previous failed trade, while the seller with a good asset trades with the hedger only if he is initially matched with him.*

Finally, we characterize the optimal disclosure policy of the seller. Let us first consider the case in which the seller with a good asset prefers to trade with the speculator both in the first and in the second match. In this case, the expected profits of the seller equal

$$\pi^d = \frac{v_g - v_b}{4},$$

that is, they equal the expected gains from trade with the speculator when the asset value is high. Then, the issuer will disclose only if  $\pi^d > \pi^{nd}$ , where the no-disclosure profits  $\pi^{nd}$  are given by expression (6). Hence, he will have a higher incentive to disclose as the asset's volatility  $v_g - v_b$  increases.

Next, consider the equilibrium characterized in the second part of Proposition 10. In this equilibrium, the seller with a bad asset only trades with the hedger who did not observe a previous failed trade, while the seller with a good asset trades with the hedger when he is matched to him first. The expected payoff of the seller if  $d = 1$  is then equal to

$$\begin{aligned} \pi^d = & \frac{1}{2} \left[ \mu (\widehat{v}(\underline{a}_h, v_g) - \omega_h) + (1 - \mu) \frac{(v_g - v_b)}{2} \right] + \\ & \frac{1}{2} [\mu (\widehat{v}(\underline{a}_h, v_g) - \omega_h) + (1 - \mu)(1 - \gamma) (\widehat{v}(\underline{a}_h, v_g) - \omega_h)], \end{aligned}$$

where the first term is the expected profit if the value of the asset is good, while the second term is the seller's expected profit if the asset is bad. Comparing this expression with the no-disclosure profits  $\pi^{nd}$  from expression (6), it is immediate that the seller's incentives to disclose are increasing in the asset volatility  $v_g - v_b$ , as in the previous case, and in the proportion of hedgers  $\mu$ , while they are decreasing in the degree of market transparency  $\gamma$ , so that there is substitutability between disclosure and market transparency. These results mirror those described by Proposition 5 for the case where the seller has no private information.

In conclusion, even when we allow the seller to have private information about the asset's value, we are able to characterize the equilibrium of the game and the seller's disclosure decision, and the results are similar to those obtained in the previous section.



## 9 Appendix B: Omitted Proofs

### Proof of Proposition 1 (Bargaining outcome)

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:

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

Solving for  $p_i$ , we obtain

$$p_i = \beta (\hat{v} - \omega_i - \bar{\omega}_i) + \bar{\omega}_i, \tag{19}$$

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  $\beta$  of the total surplus. The investor's expected payoff is

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

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  $0 < a_h^* < 1$ . 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 (19) yields the price paid by the speculator:

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

Now suppose the seller is initially matched with a hedger who has observed a positive signal  $v_g$ . As shown in footnote 17, the hedger's belief about the asset being of high value is

$$\Pr(v = v_g | a = a_h, \sigma = v_g) = \frac{\frac{1+a_h}{2} \frac{1}{2}}{\frac{1}{2}} = \frac{1 + a_h}{2}.$$

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

$$\bar{\omega}_h = \begin{cases} \beta \frac{1+a_h}{2} (v_g - \omega_s) & \text{if } \sigma = v_g, \\ \beta \frac{1-a_h}{2} (v_g - \omega_s) & \text{if } \sigma = v_b. \end{cases} \quad (20)$$

Substituting (20) into expression (19) yields the equilibrium price paid by the hedger:

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

as stated in the proposition.

### Proof of Proposition 2 (Choice of attention)

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

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

where expression (20) 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

$$a_h^* = \frac{[(v_g - v_b) - \beta (v_g - \omega_s)] (1 - \beta)}{4\theta} = (v_g - v_b) \frac{(1 - \beta) (1 - \beta/2)}{4\theta},$$

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

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

$$\theta > (v_g - v_b) (1 - \beta) (1 - \beta/2) / 4,$$

which is implied by 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:

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

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  $v_g$  is revealed. The hedger trades only when good news is released if the following condition holds:

$$\frac{1 - \beta}{2} \left[ \bar{v} - \omega_h - \frac{1 + a}{2} \frac{v_g - v_b}{2} \beta + \frac{a}{2} (v_g - v_b) \right] - \theta \frac{a^2}{2} > (1 - \beta) (\bar{v} - \omega_h), \quad (21)$$

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 (21) can be re-written as follows:

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

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 (21) being positive (since  $\bar{v} - \omega_h > 0$ ).

### Proof of Proposition 3 (Choice of financial disclosure)

Let us consider the two terms in expression 7. The first refers to the case in which the seller first meets the hedger, and is equal to

$$\mathbb{E} [\pi_h^d] = \frac{1}{2} p_h^d + \frac{1 - a_h^*}{4} p_s^d, \quad (22)$$

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  $v_g$ , while with probability  $(1 - a_h^*)/4$  the value of the asset is  $v_b$  but the hedger observes the incorrect signal  $v_g$  where the probability  $a_h^*$  is defined by Proposition 2. Hence, the hedger finds it profitable to buy the asset at the price  $p_h^d$  with probability 1/2. With probability  $(1 - a_h^*)/4$ , instead, the

asset's value is  $v_g$  but the signal received by the hedger is  $v_b$ , 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

$$\mathbb{E} [\pi_s^d] = \frac{1}{2} p_s^d. \quad (23)$$

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 (22) and (23), the expression (7) for the seller's expected profits under disclosure becomes:

$$\mathbb{E} [\pi^d] = \frac{\mu}{2} (p_h^d - \frac{1 + a_h^*}{2} p_s^d) + \frac{1}{2} p_s^d. \quad (24)$$

To complete the proof of this proposition, we compute total expected profits under disclosure ( $d = 1$ ):

$$\begin{aligned} \mathbb{E} [\pi^d] &= \mu \left( \frac{p_h^d}{2} + \frac{1 - a_h^*}{4} p_s^d \right) + (1 - \mu) \frac{1}{2} p_s^d \quad (25) \\ &= \frac{\mu}{2} \left[ \beta(\hat{v} - \omega_h) + (1 - \beta) \frac{1 + a_h^*}{2} p_s^d + \frac{1 - a_h^*}{2} p_s^d \right] + (1 - \mu) \frac{1}{2} p_s^d \\ &= \frac{\mu}{2} \beta \left[ (\omega_s - \omega_h) + a_h^* \frac{v_g - v_b}{2} \right] + \left[ \frac{\mu}{2} (1 - \beta) \frac{1 + a_h^*}{2} + \frac{\mu}{2} \frac{1 - a_h^*}{2} + \frac{1 - \mu}{2} \right] p_s^d \\ &= \frac{\mu}{2} \beta (\omega_s - \omega_h) + \left[ \frac{\mu}{2} a_h^* + \frac{\mu}{2} (1 - \beta) \frac{1 + a_h^*}{2} + \frac{\mu}{2} \frac{1 - a_h^*}{2} + \frac{1 - \mu}{2} \right] \beta \frac{v_g - v_b}{2} \\ &= \beta \left\{ \frac{\mu}{2} (\omega_s - \omega_h) + \left[ (1 - \mu) + \mu \left( 1 - \frac{\beta}{2} \right) (1 + a_h^*) \right] \frac{v_g - v_b}{4} \right\} \end{aligned}$$

where in the second step we have substituted the expressions for the price  $p_h^d$ , in the third we have used the expression for  $\hat{v}$  and imposed the restriction  $\omega_s = \bar{v}$  on the speculator's outside option, in the fourth we have used the expression  $p_s = \beta (v_g - v_b) / 2$ , and in the fifth we have rearranged the expression. The issuer's choice on disclosure depends on the difference between

the expected profit under disclosure (25) and under no disclosure (6):

$$\mathbb{E} [\pi^d] - \mathbb{E} [\pi^{nd}] = \tag{26}$$

$$\begin{aligned} &= \beta \left\{ \frac{\mu}{2} (\omega_s - \omega_h) + \left[ (1 - \mu) + \mu \left( 1 - \frac{\beta}{2} \right) (1 + a_h^*) \right] \frac{v_g - v_b}{4} \right\} - \beta(\bar{v} - \omega_h) \tag{27} \\ &= \beta \left\{ \left[ (1 - \mu) + \mu \left( 1 - \frac{\beta}{2} \right) (1 + a_h^*) \right] \frac{v_g - v_b}{4} - \left( 1 - \frac{\mu}{2} \right) (\omega_s - \omega_h) \right\}, \end{aligned}$$

where we have again imposed the restriction  $\omega_s = \bar{v}$ . Expression (26) is clearly increasing in the volatility parameter  $v_g - v_b$  and in the hedger's choice of attention  $a_h^*$ , which by Proposition 3 is increasing in volatility  $v_g - v_b$  and in financial literacy  $1/\theta$ . Hence, volatility has two effects: first, a direct positive effect via prices, as shown by the fraction multiplying the term in the square parenthesis; and second, an indirect positive effect via the attention allocation  $a_h^*$ . The financial literacy measure  $1/\theta$  affects the issuer's expected profit only through its positive effect on the optimal choice of attention  $a_h^*$ . Finally, expression (26) is decreasing in the difference between the speculator's and the hedger's reservation values,  $\omega_s - \omega_h$ , which is a measure of the hedger's relative appetite for the asset.

#### **Proof of Proposition 4 (Hedgers' participation decision)**

In the case in which the market is transparent, which occurs with probability  $\gamma$ , the hedger always participate to the market as he knows if a seller has been previously matched with a speculator or not. Then, to understand the hedger's participation decision we can restrict attention to the case of an opaque market, which occurs with probability  $1 - \gamma$ . 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  $p_h^o \geq p_s^o = \eta p_s^{o1} + (1 - \eta) \beta (v_g - \omega_s)$ , as with probability  $1 - \eta$  the speculator will know to be the second one to be matched with the seller, while with complementary probability  $\eta$  he will be willing to offer a higher price as to compensate the seller for the possibility to trade with a hedger in the future. 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

$$\hat{\mu} = \begin{cases} \frac{\mu}{\mu + (1 - \mu)/2} & \text{if } p_h^o \geq p_s^o, \\ 0 & \text{if } p_h^o < p_s^o, \end{cases} \tag{28}$$

where it is easy to see that the belief  $\hat{\mu}$  is increasing in the hedger's probability  $\mu$  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  $p_s^o$ , 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  $p_s^o$  would be wasteful. Hence, the hedger will offer

$$\begin{aligned}
p_h^o &= p_s^o = \eta p_s^{o1} + (1 - \eta) \beta (v_g - \omega_s) \\
&= \eta \left( \beta (v_g - \omega_s) + (1 - \beta) \frac{1 + a_h}{2} p_h^o \right) + (1 - \eta) \beta (v_g - \omega_s) \\
&= \beta (v_g - \omega_s) + \eta (1 - \beta) \frac{1 + a_h}{2} p_h^o \\
&= \frac{\beta (v_g - \omega_s)}{1 - \eta (1 - \beta) \frac{1 + a_h}{2}},
\end{aligned}$$

where in the second line we have substituted the expression for the price  $p_s^{o1}$  and then solved the expression for the price  $p_h^o$ . 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:

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

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  $\widehat{v} > v_b$ , and  $\frac{\partial p_h^o}{\partial \mu} < 0$  (since  $\frac{\partial \eta}{\partial \mu} < 0$ ) the hedger's expected surplus  $\Gamma$  is increasing in his probability  $\mu$  of being the first match. Thus his surplus is zero if  $\mu$  is low enough to make the belief  $\widehat{\mu}$  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  $\Gamma(1) = \widehat{v} - \omega_h - p_h^o$ , 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  $\mu > \underline{\mu}$ .

Following the proof of Proposition 3, it is possible to compute the hedger's optimal attention level when the market is less than fully transparent.

### **Proof of Proposition 5 (Financial disclosure and market transparency)**

Point (i) of the Proposition follows from the fact that when  $\mu > \underline{\mu}$  the issuer's expected profit

is

$$\begin{aligned} \mu \mathbb{E} [\pi_h^o] + (1 - \mu) \mathbb{E} [\pi_s^o] &= \mu \frac{1 + a_h}{2} p_h^o(\gamma) + \left( \frac{(1 - \mu)}{2} + \mu \frac{1 - a_h}{2} \right) \bar{p}_s^o(\gamma) \\ &= \mu \frac{1 + a_h}{2} \frac{\beta (v_g - \omega_s)}{1 - \eta (1 - \beta)^{\frac{1 + a_h}{2}}} + \left( \frac{(1 - \mu)}{2} + \mu \frac{1 - a_h}{2} \right) [\gamma p_s^{o1} + (1 - \gamma) p_s^o], \end{aligned}$$

where in the second step the hedger's equilibrium price  $p_h^o$  from Proposition 5 and the expected price of the speculator  $\bar{p}_s^o$  has been substituted in.

It is straightforward to verify that the degree of market transparency  $\gamma$  decreases the seller's expected profits, that is:

$$\frac{d\mathbb{E} [\pi^o]}{d\gamma} < 0,$$

as  $\frac{d\mathbb{E} [\pi_s^o]}{d\gamma} < 0$  since  $p_s^{o1} > p_s^o$ . This proves point (i) of the proposition.

When the hedgers do not participate to the market, that is when  $\mu < \underline{\mu}$ , the speculators always offer  $\beta (v_g - \omega_s)$ , which means that the issuer's benefits from disclosure are independent of the degree of market transparency  $\gamma$ . Then, point (ii) of the Proposition follows immediately.

### **Proof of Proposition 6 (Information acquisition and disclosure)**

To show point (i) of the proposition notice that: (a)  $\hat{v} - \omega_h > \bar{v} - \omega_h$ , that is, the seller always gains from disclosing when he meets a hedger; (b) the price that the speculators are willing to bid in the case of a privately acquired signal is always lower than the price he is willing under disclosure. This shows that  $\mathbb{E} [\pi^{ia}] < \mathbb{E} [\pi^d]$ .

To show that there exists a region of parameters under which the configuration proposed in the Proposition  $\mathbb{E} [\pi^{nd}] > \mathbb{E} [\pi^d] > \mathbb{E} [\pi^{ia}]$  is possible, we start by assuming that  $\mathbb{E} [\pi^{nd}] > \mathbb{E} [\pi^d]$ , that is, in the baseline version of the model it would not be optimal for the seller to disclose the signal  $\sigma$ . Notice that when the gains from trading with a speculator  $v_g - \omega_s$  tend to zero, the seller's expected profits when the speculators can acquire the private signal  $\sigma^p$  tend to  $\mu\beta (\bar{v} - \omega_h) + (1 - \mu)\varepsilon$ , where  $\varepsilon$  is a small positive constant. Hence, there exist parameters for which the following condition holds

$$\mathbb{E} [\pi^{nd}] = \beta (\bar{v} - \omega_h) > \mathbb{E} [\pi^d] > \mu\beta (\bar{v} - \omega_h) + (1 - \mu)\varepsilon = \mathbb{E} [\pi^{ia}].$$

This reflects the fact that if the seller is matched with a speculator, with probability  $1 - \mu$  his profits are small if the value of the asset is  $v_g$ , while due to the hedgers' adverse inference, he is not able to sell the asset to the hedgers after being matched with a speculator if the value of the asset is  $v_b$ . This does not occur when the speculators cannot acquire private information about the asset's value as speculators do not find it optimal to participate in this market.

**Proof of Proposition 7 (No precommitment by the seller)**

If the seller always refuses the speculators' offer, then the hedger does not infer any new information from past failed trades and always offers the price

$$p_h = \beta (\hat{v}(a_h, v_g) - \omega_h).$$

However, the seller has an incentive to accept the speculators' offer as long as the following condition holds

$$p_s = \beta (v_g - \omega_s) > \beta (\hat{v}(a_h, v_g) - \omega_h) = p_h,$$

which is equivalent to the condition in the proposition. By substituting the expression for  $\hat{v}(a_h, v_g)$  we can rewrite it as follows:

$$\frac{1-a}{2} (v_g - v_b) > \omega_s - \omega_h.$$

Then, the seller always accept the speculators offer as long as their informational advantage more than compensate for their lower appetite for the asset; and he is matched with a hedger if the speculator does not purchase the asset.

**Proof of Remark 1 (Optimal disclosure policy)**

From expressions (13), (14), (15) and (16), one obtains the following expression for the social net benefit from disclosure:

$$\begin{aligned} \Delta &= \mathbb{E}[S^d] - \mathbb{E}[S^{nd}] = \mu \mathbb{E}[S_h^d] + (1-\mu) \mathbb{E}[S_s^d] - \mathbb{E}[S^{nd}] \\ &= \mu \left[ \frac{v_g - v_b}{8} + \frac{a_h^*}{8} (v_g - v_b) - \frac{\theta a_h^{*2}}{2} \right] + \left( 1 - \frac{\mu}{2} \right) (\omega_h - \bar{v}) + (1-\mu) \frac{v_g - \omega_s}{2}. \end{aligned}$$

As the optimal attention level chosen by hedgers (when  $\beta_h \neq \beta_s$ ) is

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

the previous expression can be rewritten as follows:

$$\Delta = \mu \frac{(1 - \beta_h)(1 - \beta_s/2)}{32\theta} (v_g - v_b)^2 \left[ 1 - (1 - \beta_h) \left( 1 - \frac{\beta_s}{2} \right) \right] + \left( 1 - \frac{\mu}{2} \right) \left[ (\omega_h - \bar{v}) + \frac{v_g - v_b}{4} \right],$$

where we have also used the assumption  $\omega_s = \bar{v} = (v_g + v_b)/2$  and rearranged the expression. It is then immediate that the social net benefit from disclosure  $\Delta$  is decreasing in the asset's expected value  $\bar{v}$ , and increasing in hedgers' financial literacy  $1/\theta$  and in the asset volatility



$v_g - v_b$ .

### Proof of Proposition 8 (Optimal disclosure policy)

First of all, notice that from the proof of Remark 1, the social net benefit from disclosure can be rewritten as

$$\Delta = \left[ 1 - (1 - \beta_h) \left( 1 - \frac{\beta_s}{2} \right) \right] A + \frac{2 - \mu}{8} (v_g - v_b) - \frac{2 - \mu}{4} (v_g + v_b) + \frac{2 - \mu}{2} \omega_h,$$

where  $A \equiv \mu \frac{(1 - \beta_h)(1 - \beta_s/2)}{32\theta} (v_g - v_b)^2$ , which incidentally is increasing in the optimal attention level  $a_h^*$ .

The private expected gain from disclosure (when  $\beta_h \neq \beta_s$ ) instead is

$$\begin{aligned} G &= E(\pi^d) - E(\pi^{nd}) = \frac{\mu}{2} \left( p_h^d - \frac{1 + a_h}{2} p_s^d \right) + \frac{1}{2} p_s^d - \beta_h (\bar{v} - \omega_h) \\ &= (2 - \beta_s) \beta_h A + \frac{(2 - \mu \beta_h) \beta_s}{8} (v_g - v_b) - \frac{(2 - \mu) \beta_h}{4} (v_g + v_b) + \frac{(2 - \mu) \beta_h}{2} \omega_h \end{aligned}$$

To show that under-provision can arise, we need to find the region of parameters in which  $\Delta > 0$  and  $G < 0$ . These inequalities define the following interval for the hedger's outside option  $\omega_h$ :

$$\begin{aligned} \Delta > 0 &\Rightarrow \omega_h > \frac{v_g + v_b}{2} - \frac{v_g - v_b}{4} - \frac{2(\beta_h + \beta_s/2 - \beta_h \beta_s/2)A}{2 - \mu}, \\ G < 0 &\Rightarrow \omega_h < \frac{v_g + v_b}{2} - \frac{(2 - \mu \beta_h) \beta_s}{(2 - \mu) \beta_h} \frac{v_g - v_b}{4} - \frac{2(2 - \beta_s)A}{2 - \mu}. \end{aligned}$$

This interval is not empty only if the following condition is satisfied:

$$\begin{aligned} \frac{v_g + v_b}{2} - \frac{v_g - v_b}{4} - \frac{2(\beta_h + \beta_s/2 - \beta_h \beta_s/2)A}{2 - \mu} &< \frac{v_g + v_b}{2} - \frac{(2 - \mu \beta_h) \beta_s}{(2 - \mu) \beta_h} \frac{v_g - v_b}{4} - \frac{2(2 - \beta_s)A}{2 - \mu} \\ \Leftrightarrow \frac{1 - \frac{(2 - \mu \beta_h) \beta_s}{(2 - \mu) \beta_h}}{4} &> \frac{2(2 - 3\beta_s/2 - \beta_h + \beta_h \beta_s/2)}{2 - \mu} \frac{\mu(1 - \beta_h)(1 - \beta_s/2)}{32\theta} (v_g - v_b). \end{aligned}$$

First, notice that for  $\beta_s \geq \beta_h$  this condition is never satisfied. To see this, consider that under this condition the left-hand side is negative while the right-hand side is positive. Hence, when the seller's bargaining power with the speculator is at least as high as with the hedger, under-provision of information can never arise. Conversely, when  $\beta_s < \beta_h$ , this condition can be satisfied, so that under-provision of information can arise, as we show below with numerical examples. In fact, since the right-hand side is increasing in the hedgers' financial literacy  $1/\theta$  and in the asset's volatility  $v_g - v_b$ , under-provision of information is more likely to arise if

$1/\theta$  and  $v_g - v_b$  are low (and therefore the hedgers' attention level  $a_h^*$  is low), as stated in the comparative statics discussed in the text after Proposition 10.

To find the condition under which over-provision arises ( $\Delta < 0, G > 0$ ), we follow similar steps:

$$\Delta < 0 \Rightarrow \omega_h < \frac{v_g + v_b}{2} - \frac{v_g - v_b}{4} - \frac{2(\beta_h + \beta_s/2 - \beta_h\beta_s/2)A}{2 - \mu},$$

$$G > 0 \Rightarrow \omega_h > \frac{v_g + v_b}{2} - \frac{(2 - \mu\beta_h)\beta_s}{(2 - \mu)\beta_h} \frac{v_g - v_b}{4} - \frac{2(2 - \beta_s)A}{2 - \mu}.$$

These conditions can be jointly satisfied if the following parameter restriction holds:

$$\frac{v_g + v_b}{2} - \frac{v_g - v_b}{4} - \frac{2(\beta_h + \beta_s/2 - \beta_h\beta_s/2)A}{2 - \mu} > \frac{v_g + v_b}{2} - \frac{(2 - \mu\beta_h)\beta_s}{(2 - \mu)\beta_h} \frac{v_g - v_b}{4} - \frac{2(2 - \beta_s)A}{2 - \mu}$$

$$\Leftrightarrow \frac{1 - \frac{(2 - \mu\beta_h)\beta_s}{(2 - \mu)\beta_h}}{4} < \frac{2(2 - 3\beta_s/2 - \beta_h + \beta_h\beta_s/2)}{2 - \mu} \frac{\mu(1 - \beta_h)(1 - \beta_s/2)}{32\theta} (v_g - v_b).$$

Hence, over-provision is more likely to arise when the hedgers' financial literacy  $1/\theta$  and the asset volatility  $v_g - v_b$  are high.

We now provide a numerical example to show that, when  $\beta_s < \beta_h$ , both under- and over-provision may arise, depending on the asset volatility. Assuming low volatility:

$$v_g = 30, v_b = -5, \mu = 0.5, \theta = 20, \beta_s = 0.85, \beta_h = 0.9, \omega_h = 3.7, a_h = 0.025,$$

there is under-provision:

$$\Delta = 0.014 > 0, G = -0.12 < 0,$$

while for high enough volatility:

$$v'_g = 500, v'_b = -30, \mu = 0.5, \theta = 20, \beta_s = 0.85, \beta_h = 0.9, \omega_h = 86.5, a_h = 0.38,$$

there is over-provision of information:

$$\Delta = -0.107 < 0, G = 0.107 > 0.$$

Over-provision also obtains if one picks a lower value of the processing cost  $\theta$  (greater financial literacy), while leaving volatility as in the initial example, namely:

$$v_g = 30, v_b = -5, \mu = 0.5, \theta' = 1, \beta_s = 0.85, \beta_h = 0.9, \omega_h = 2.3, a_h = 0.503,$$

which entails:

$$\Delta = -0.05 < 0, G = 0.018 > 0.$$

### Proof of Proposition 9 (Banning hedgers from trading)

The regulator will want to restrict market participation to the speculators when the resulting expected loss  $\mathbb{L}$  is negative; that is, from condition (17)

$$\mathbb{L} \equiv \frac{\bar{v}}{2} - \frac{\omega_h}{2} + \frac{a_h^*}{8}(v_g - v_b) - \frac{v_g - v_b}{8} - \theta \frac{a_h^{*2}}{2} < 0. \quad (29)$$

Using the hedger's equilibrium attention level  $a_h^*$  in Proposition 2, the condition (29) can be rewritten as follows:

$$\mathbb{L} \equiv \frac{\bar{v}}{2} - \frac{\omega_h}{2} - \frac{v_g - v_b}{8} + \frac{(v_g - v_b)^2}{32\theta}(1 - \beta) \left(1 - \frac{\beta}{2}\right) \left[1 - (1 - \beta) \left(1 - \frac{\beta}{2}\right)\right] < 0,$$

which is clearly increasing in the expected asset value  $\bar{v}$  and in the hedgers' financial literacy  $1/\theta$ . Instead, the effect of asset volatility  $v_g - v_b$  on the regulator's expected loss is ambiguous.

### Proof of Proposition 10 (Privately Informed Seller)

We first show that there is no separating equilibrium in which the seller with a good asset offers a price different from the seller with a bad asset. Suppose by contradiction that there were such an equilibrium: then the seller with a bad asset would obtain a payoff of zero, because neither the hedger nor the speculator would trade with him; while the seller with a good asset would get a positive payoff. Thus, mimicking the strategy of the seller with a good asset is always optimal. Hence, we can restrict attention to a pooling equilibrium in which both types of seller offer the same price in every round of negotiation.

To show the first part of the proposition, we assign the hedger's belief on the equilibrium path as follows:

1. when the hedger is matched first with the seller, he believes  $Pr(v = v_g | \text{first}) = 0$ ;
2. when the hedger is matched second with the seller, he believes  $Pr(v = v_g | \text{second}) = 0$ .

First, consider the optimal strategy of the seller with a good asset. Based on the belief assignment on the equilibrium path and on condition (12), the seller's expected payoff from trading with the speculator is strictly higher than his share of gains from trade with the hedger. Hence, when  $v = v_g$  the seller strictly prefers trading with the speculator even if he is initially matched with a hedger, and the seller with a low-valued asset is then unable to trade with

any investor, because the hedger would not trade with him. Therefore, the belief assignment on the equilibrium path is consistent with the seller's strategy profile. To support this equilibrium, we assign an out-of-equilibrium belief such that the seller who makes any deviating offer is perceived as owning a low-valued asset with probability 1. This fully characterizes the Perfect Bayesian Equilibrium (PBE): the hedger does not trade in any matching order and the speculator trades only when  $v = v_g$ ; moreover, the strategy profile described above is optimal for the seller and the investors, given the hedger's beliefs.

To characterize the equilibrium in the second part of the proposition, fix any  $\gamma \in (0, 1)$ . We also assign the following posterior belief to the hedger: upon observing a failed trade with the speculator, he believes the asset value being low with probability 1, while if he is the first to be matched with the seller, he retains his prior belief.

When the seller of a good asset meets the hedger first, given the condition (18), he gets a higher payoff by trading with the hedger ( $\widehat{v}(\underline{a}_h, v_g) - \omega_h$ ) than with the speculator ( $v_g - \omega_s$ ). Thus, it is optimal for the good type to trade with the hedger in the first match. For the seller with a bad asset, this is trivially true as he would get zero profits when he negotiates with the speculator.

Next, consider the case in which the seller meets the speculator first. By assumption  $v_g - \omega_s \geq (1 - \gamma)(\widehat{v}(\underline{a}_h, v_g) - \omega_h)$  and, given the on-the-equilibrium-path belief assignment of the hedger, it is optimal for the good-type seller to trade with the speculator. By contrast, the seller with a bad asset always fails to trade with the speculator, but he can get positive expected gains by negotiating with the hedger in the second matching, when the hedger does not observe the previous failed match, which occurs with probability  $1 - \gamma$ . This strategy profile is consistent with the hedger's belief assignment on the equilibrium path. Finally, we assign an out-of-equilibrium belief to any deviating offer as coming from the seller with a bad asset with probability 1. This belief assignment characterizes a PBE as described above: the seller with any type of asset will not offer a deviating price; the hedger trades with the seller only if he believes being the first to be matched with the seller; and the speculator trades with the seller if and only if  $v = v_g$ , and he is the first one to be matched with the seller.

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