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Financial Disclosure and Market Transparency with Costly Information Processing

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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. This is socially inefficient if a large fraction of market participants are speculators and hedgers have low processing costs. But in these circumstances, forbidding hedgers' access to the market may dominate mandatory disclosure.

Can the disclosure of financial information and the transparency of security markets be detrimental to issuers? One's immediate answer would clearly to 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.[1]

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 entrusts a dealer to search for a buyer in a market with sequential trading. The sale of an asset-backed security (ABS) is one example: the ABS is issued by its originator (e.g. a bank wishing to offload a loan pool from its balance sheet), who entrusts its placement to an underwriter that searches for buyers; later, these may retrade the security by searching for other 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 later can trade them on the Pink Sheet market or the OTC Bulletin Board.[2] A third example is that of the owner of a house who appoints a real estate agent to search for a buyer, who can later at some stage turn around and resell it.

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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[1] 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)).

[2] 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.

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 asset characteristics via the release of accounting data, listing prospectuses, credit ratings, and so on. But in choosing the degree of disclosure, the issuer must also consider the transparency of the security market, i.e. how much investors know about the trades of others. Market transparency amplifies the pricing externality triggered by financial disclosure, because it increases unsophisticated investors' awareness of the trading behavior of the sophisticated, and in this way fosters closer imitation of the latter by the former. In equilibrium, this increases the price concession that sophisticated investors require, and asset sellers will accordingly resist trading transparency. Hence, the interaction between financial disclosure and market transparency makes the two substitutes from the asset issuers' standpoint: they will be more willing to disclose information on cash flow if they can expect the trading process to be more opaque. The interaction between the two forms of transparency may even affect unsophisticated investors' willingness to trade: if market transparency increases beyond some critical point, financial disclosure might induce them to leave the market altogether, as they worry that the assets still available may have already been discarded by better-informed investors.

Hence, a key novelty of our setting is that it encompasses two notions of transparency that are generally analyzed separately by researchers in accounting and in market microstructure, even though they are naturally related: financial disclosure affects security prices, but the transparency of the trading process determines how and when the disclosed information is incorporated in market prices. We show that each of these two forms of transparency amplifies the other's impact on the security price. Interestingly, the recent financial crisis has brought

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both notions of transparency under the spotlight. The opacity of the structure and payoffs of structured debt securities – a form of low cash-flow transparency – 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, where at least they could process public information. As a result, the possibility of private information acquisition will elicit disclosure from issuers who would otherwise prefer no disclosure. Second, we allow sophisticated investors to retrade the securities in the secondary market. Interestingly, we show that this does not affect the equilibrium in the primary market because speculators will never buy in the primary market just to resell to hedgers in the secondary one. If speculators have a large enough informational advantage, hedgers will not want to purchase the asset in the secondary market for fear of losing out to better informed speculators. If instead speculators have a low information advantage, in the primary market the seller finds it optimal to refrain from trading with speculators and sells only to hedgers. 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 political economy of regulation, the model helps to address several pressing policy issues: if a regulator wants to maximize social welfare, how much information should be required when processing it is costly? When are the seller's incentives to disclose information aligned with the regulator's objective and when instead should regulation compel disclosure? How does mandatory disclosure compare with a policy that prohibits unsophisticated investors from buying complex securities?

First, we show that in general there can be either under- or over-provision of information. When there are many sophisticated investors, issuers fear their superior processing ability and

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therefore inefficiently prefer not to disclose. Hence, regulatory intervention for disclosure is required. This is likely to occur in markets for complex securities, such as asset-backed securities, where sophistication is required to understand the asset's structure and risk implications, so that sophisticated investors are attracted. But surprisingly, there is a region in which the seller has a greater incentive than the regulator for disclosure: this occurs when enough unsophisticated investors are in the market.

We also show that in markets where most investors are unsophisticated, it may be optimal for the regulator to license market access only to the few sophisticated investors present, as this saves the processing costs that unsophisticated investors would otherwise bear. Thus, when information is difficult to digest, as in the case of complex securities, the planner should allow placement only with the "smart money", not to all comers.

These insights build on the idea that not all the information disclosed to investors is easily and uniformly digested – a distinction that appears to be increasingly central to regulators' concerns. For instance, in the U.S. there is controversy about the effects of Regulation Fair Disclosure promulgated in 2000, which prohibits firms from disclosing information selectively to analysts and shareholders: according to Bushee et al. (2004), "Reg FD will result in firms disclosing less high-quality information for fear that [...] individual investors will misinterpret the information provided".[3] 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 two extensions of the model: one where speculators may obtain the private signal at a cost even when it is not publicly disclosed, and another where the acquirer of the asset can retrade it. Section 6 investigates the role of regulation in the baseline model, and Section 7 concludes.

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[3]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) and Woodford (2005) brought out the implications of information constraints for portfolio choice problems and monetary policy.[4] While in these papers limited cognition stems from information capacity constraints, in our setting it arises from the cost of increasing the precision of information.

The idea that information processing is costly squares with a large body of empirical evidence, as witnessed by surveys of studies in psychology (Pashler and Johnston (1998) and Yantis (1998)), in experimental research on financial information processing (Libby et al. (2002) and Maines (1995)), and in asset pricing (Daniel et al. (2002)).[5] In particular, there is evidence that limited attention affects portfolio choices: Christelis et al. (2010) investigate the relationship between household portfolio composition in 11 European countries and indicators of cognitive skills drawn from the Survey of Health, Ageing and Retirement in Europe, and find that the propensity to invest in stocks is positively associated with cognitive skills and is driven by information constraints, not preferences or psychological traits.[6] 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 accordingly be predicted by those of the latter (Cohen and Lou (2012)).

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

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[4]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.

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

[6]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.

on the issuers' incentive for disclosure information in the first place.

Several authors have suggested possible reasons why limiting disclosure may be efficient, starting with the well-known argument by Hirshleifer (1971) that revealing information may destroy insurance opportunities. The detrimental effect of disclosure has been shown in settings where it can exacerbate externalities among market participants, as in our setting: Morris and Song 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 real decision makers, which is more likely to occur when the information being disclosed is about something that real decision makers have already known much, or when the market does not aggregate traders' private information effectively.[7] In our model too, disclosure creates trading externalities and strategic behavior, which are exacerbated by transparency about the trading process; but as disclosure is decided by issuers, this may produce an inefficiently low level of transparency.[8]

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. Our present setting shares with Pagano and Volpin (2012) the idea that disclosure may aggravate adverse selection if investors have different information processing ability, but we differ in other important respects. First, in Pagano and Volpin (2012) trading is not sequential, and in particular 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.[9]

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[7]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 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).

[8]Another related paper is Boot and Thakor (2001), which 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.

[9]Recently, Dang et al. (2012) and Yang (2012) have also noted that opacity may be beneficial insofar as

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

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

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), a firm looking to offload its risk exposure to interest rates or commodity prices, or a household seeking a buyer for its house. 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 already available to the issuer at the time of the initial sale, or that will become available at a later stage, during secondary market trading. An example of the former occurs when the issuer of an ABS chooses between

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it reduces informational asymmetries, but they mainly concentrate on the security design implications of this insight.

a registered securitization, which requires detailed disclosures in the issuance process, and Rule 144a, which exempts the issuer from these disclosure requirements. An example of the latter 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; in contrast, the seller's private value is zero, as he assigns no weight to the asset's risk characteristics, for instance because he is well diversified and therefore perfectly hedged against the asset's risk. The unconditional mean of the value is $v^e \equiv (v_g + v_b)/2$. 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 probability of correctly estimating the probability distribution of the asset's value: $\Pr(\sigma = v|v) = \frac{1+a_i}{2}$. 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 $C_i(a, \theta)$, with $\partial C_i / \partial a > 0$ and $\partial^2 C_i / \partial a^2 > 0$, where the shift parameter θ_i measures inefficiency in processing, i.e. the investor's "financial illiteracy".[10] To simplify the analysis, we posit a quadratic cost function: $C_i(a, \theta) = \theta_i a^2 / 2$. The greater θ_i, the harder for investor i to measure the asset's price sensitivity to factors like interest rates, commodity and housing

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

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: $\theta_s = 0$.[11] 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.

2.2 Trading

The investor who initially purchased the asset from the issuer (henceforth, "seller") can resell it on a secondary market where trading occurs via a matching and bargaining protocol: the seller is initially matched with a hedger with probability μ, 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.[12] 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 $v - \omega_i$. 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, although the information structure described here is not essential for our results, it greatly simplifies their exposition. 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 Ω_i is buyer i's information set. The seller makes a take-it-or-leave-it offer with probability β.[13]

The outcome of bargaining is given by the generalized Nash solution under symmetric information: the trade occurs at a price such that the seller captures a fraction β and the investor a fraction $1 - \beta$ of this expected surplus, where β measures the seller's bargaining power. As in the search-cum-bargaining model of Duffie et al. (2005), the seller can observe

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[11] 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.

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

[13] One can allow hedgers and speculators to have different bargaining power β with no significant change to our qualitative results.

the investor's type.[14] Real-world examples of such a setting are OTC and housing markets, where matching via search gives rise to a bilateral monopoly at the time of a transaction. For instance, 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 non-financial company seeking to hedge operating risks (a "hedger").

We impose the following restrictions on the parameters:

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

Hence, the two types of investors differ in their outside options. Hedgers have a comparatively low outside option, and therefore view the asset as a good investment on average ($v^e > \omega_h > 0$). Say, they are farmers who see the asset as a hedge against the price risk of their crops. In contrast, speculators are in the market only to exploit their information processing ability, because they have no intrinsic need to invest in the asset: $\omega_s = v^e$. For example, they may be hedge funds or investment banks with strong quant teams. 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 $\omega_s < v^e$, 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 θ implies that his information processing cost is high enough to deter him from achieving perfectly precise information; that is, they 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 β 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:

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[14]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.

1. The issuer decides on the disclosure regime, i.e. $d \in \{0, 1\}$, and sells the asset to one of a set of competing investors.[15]

2. Depending on the disclosure regime, the signal σ is released or not, and the seller is randomly matched with investor i, who is type h with probability μ, and type s with probability $1 - \mu$.

3. Investor i chooses his attention level a_i and forms his expectation of the asset value $\widehat{v}_i(a_i, \sigma)$.[16]

4. If he decides to buy, buyer and seller bargain over the expected surplus.

5. If he does not buy, the other investor, upon observing the outcome of stage 4, is randomly matched to the seller and bargains with him over the expected surplus.

This means that in this baseline version, the final stage of the game posits complete market transparency, previous trades being observable to all market participants. In Section 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. 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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[15]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 dislcosure or full opacity. Notes describing the analysis for this case are available from the authors.

[16]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:

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

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 $\widehat{v}$ over and above the price paid to the seller, and his outside option ω_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 σ, is

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

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.[17] This probability is an increasing function of the investor's attention a: in the limiting case $a = 0$, the estimate $\widehat{v}$ would be the unconditional average v^e, 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 $a_h^* \in [0, 1)$.[18] Thus, in equilibrium speculators know the value of the asset and hedgers hold a belief $\widehat{v}\left(a, \sigma\right)$ whose precision depends on the attention level they choose.

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

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

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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[17]To see why, recall that the conditional probability that the signal is correct given an attention level a is $\Pr\left(\sigma = v_j | a, v = v_j\right) = \frac{1+a}{2}$, 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

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

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

is released.[19] 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*

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

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

$$p_h^{nd} = \beta \left(v^e - \omega_h \right). \tag{4}$$

When the signal is disclosed ($d = 1$), an initial match with the speculator leads to trade only if the asset value is high, because the speculator's reservation value ω_s exceeds the low 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 $\widehat{v} \left(a_h, v_g \right) > v_b$).[20]

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

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

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[19]The relevant condition is derived in the proof of Proposition 3.

[20]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."

makes the take-it-or-leave-it offer. This outside option is weighted by the probability $\frac{1+a_h}{2}$ that the hedger attaches to the asset value being high, and therefore is increasing in the hedger's level of attention a_h.

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

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

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

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, the externality 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. Furthermore, for some parameter values the seller cannot even credibly precommit not to trade with the speculator, upon receiving an offer from him:

Proposition 2 (No precommitment by the seller) *It is never optimal for the seller to reject the speculator's offer if the difference in outside options between speculators and hedgers is low enough, namely:*

$$v_g - \widehat{v}(a_h, v_g) > \omega_s - \omega_h. \tag{5}$$

Intuitively, the condition (5) 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, $(1-a)/2$.

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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.

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 σ to guard against two possible types of errors. First, they might buy the asset when its value is lower than the outside option: if so, by investing attention a they save the cost $|v_b - \omega_i|$. Second, they may fail to buy the asset when it is worth buying, i.e. when its value exceeds their outside option ω_i: in this case, not buying means forgoing the trading surplus $v_g - \omega_i$.

In principle there are four different outcomes: the hedger may (i) never buy, (ii) always buy, irrespective of the signal realization; (iii) buy only when the signal is v_g or (iv) buy only when the signal is v_b. Proposition 3 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:

$$\max_{a_i \in [0,1]} (1 - \beta) \left(\frac{1 + a_i}{2} v_g + \frac{1 - a_i}{2} v_b - \omega_i - \bar{\omega}_i (a_i) \right) - \theta_i \frac{a_i^2}{2}, \text{ for } i \in \{h, s\}, \tag{6}$$

which shows that the seller's outside option is a function of the attention choice. The solution to problem (6) is characterized as follows:

Proposition 3 (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 financial illiteracy θ and in the seller's bargaining power β, and increasing in the asset's volatility $v_g - v_b$. The hedger buys the asset if and only if the realized signal is v_g when the asset's volatility is sufficiently high. Otherwise, the hedger chooses $a_h^* = 0$ and always buys the asset.

The first part of Proposition 3 captures the speculator's optimal choice of attention, which confirms the conjecture made in deriving the bargaining solution: as he has no processing costs,

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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. β is large), the hedger spends less on analyzing the information, because he expects to capture a smaller fraction of the gains from trade.[21] 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.

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

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,

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[21]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 v^e.

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

$$\mathbb{E}\left[\pi^{nd}\right] = p_h^{nd} = \beta\left(v^e - \omega_h\right), \tag{7}$$

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

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

$$\mathbb{E}\left[\pi^d\right] = \mu\mathbb{E}\left[\pi_h^d\right] + (1 - \mu)\mathbb{E}\left[\pi_s^d\right]. \tag{8}$$

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

$$\mathbb{E}\left[\pi_h^d\right] = \frac{1}{2}p_h^d + \frac{1 - a_h^*}{4}p_s^d, \tag{9}$$

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^* being defined by Proposition 3. 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

$$\mathbb{E}\left[\pi_s^d\right] = \frac{1}{2}p_s^d. \tag{10}$$

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 (9) and (10), the expression (8) for the seller's expected profits under disclosure becomes:

$$\mathbb{E}\left[\pi^d\right] = \frac{\mu}{2}(p_h^d - a_h^* p_s^d) + \frac{1}{2}p_s^d. \tag{11}$$

To choose between disclosure ($d = 1$) and no disclosure ($d = 0$), the seller compares the expected profits (11) and (7) 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 4 (Choice of financial disclosure) *The issuer's net benefit from disclosing the signal σ is increasing in the fraction μ of hedgers and in the asset's volatility $v_g - v_b$, and decreasing in the hedgers' financial illiteracy θ.*

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

The cost arises with probability $1 - \mu$, which is the likelihood of the seller being matched initially with the speculator. Conversely, the higher the chance μ of trading immediately with the hedger, the less the seller worries that disclosure may trigger the informational externality: this explains why the issuer's willingness to disclose is increasing in μ.

The benefits of disclosure for the seller are increasing in the asset's volatility: first, a more volatile asset induces the hedger to pay more attention to its valuation (Proposition 3), 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.

Proposition 4 also highlights that the issuer is less inclined to disclosure when the parameter θ is high, i.e. when the financial literacy of investors is low and/or the asset is complex, as in these circumstances the issuer anticipates that disclosure will fail to elicit a high level of attention by investors and accordingly not raise their valuation of the asset significantly.

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.[22] 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 γ. Hence the parameter γ can be taken as a measure of transparency, and conversely $1 - \gamma$ as a measure of opacity. In practice, market transparency also refers to the visibility of existing quotes: for instance, even in some OTC markets, major participants can access electronic trading platforms (ETPs), which allow them to post quotes on screens visible to other ETP market participants, even though they eventually still trade via bilateral negotiations via an inter-dealer broker (Duffie et al. (2010)). Our setting can capture also this form of transparency if failed trades are equivalent to investors placing very low bids for the asset, which later would-be buyers will consider as bad quality signals about the asset.

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

However, opacity also has a more subtle – and potentially countervailing – effect: even if the hedger does not observe that a previous match has failed to result in a trade, he might still suspect that such a match did occur, and that he should accordingly refrain from buying. If the market is very opaque (γ very low), this suspicion may lead the hedger to withdraw from the market entirely: in other words, market opacity may generate a "lemons problem". Hence, we shall see that, although opacity attenuates information externalities between traders, if it becomes too extreme it may lead to no trade. The latter result is closer than the former to typical market microstructure models.

Let us analyze the first effect in isolation, taking the hedger's participation and pricing decision as given. Suppose the 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

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

offer if $\gamma < 1$, we have to take into account that now two situations can arise: with probability γ, 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 willing to offer. When the speculator knows that he is the first to trade, he is willing to offer the price $p_s^{o_1}$, 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 $\frac{1+a_h}{2}$):

$$p_s^{o_1} = \beta \left(v_g - \omega_s \right) + \left(1 - \beta \right) \frac{1 + a_h}{2} p_h^o. \tag{12}$$

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

$$p_s^o = \eta p_s^{o_1} + \left(1 - \eta \right) \beta \left(v_g - \omega_s \right), \tag{13}$$

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 (12) $p_s^{o_1} > \beta \left(v_g - \omega \right)$.

Hence, the price that the seller expects to receive when he is matched with a speculator is the average of the prices in (12) and (13), respectively weighted by the probabilities γ and $1 - \gamma$:

$$\bar{p}_s^o(\gamma) = \gamma p_s^{o_1} + \left(1 - \gamma \right) p_s^o. \tag{14}$$

Since $p_s^{o_1} < p_s^o$, the average price $\bar{p}_s^o(\gamma)$ paid by a speculator is decreasing in γ: 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 γ, the hedger will then offer the expected price that the speculator would bid if the match fails. With probability γ, 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:

$$p_h^o = \gamma\beta(v_g - \omega_s) + (1 - \gamma)p_s^o, \tag{15}$$

which is decreasing in market transparency γ, 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 μ 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 μ drops below a threshold level $\underline{\mu}$, this concern leads them to leave the market, as stated in the following proposition:

Proposition 5 (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 (15) 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 (14) or to the hedger at the price p_h^o in (15). 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 $\mu < \underline{\mu}$,
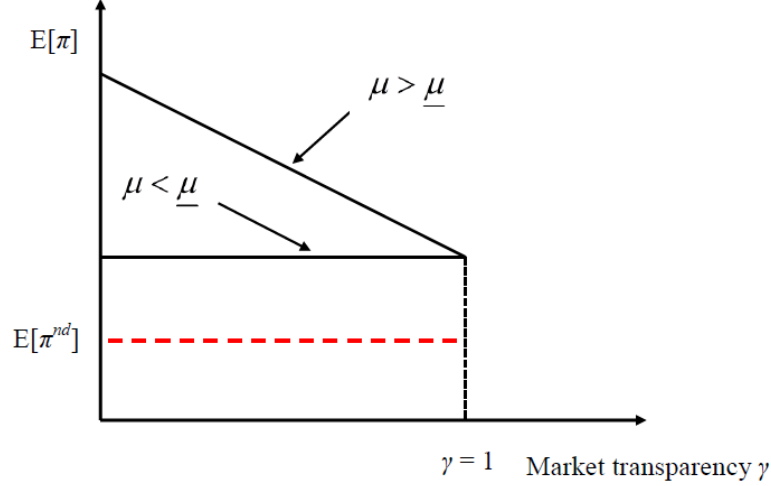
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Figure 1: Financial disclosure and market transparency: case (a)

the asset can be sold only to the speculator in the good state at price $\beta\left(v_g - \omega_s\right)$. Therefore, when the market is not fully transparent, under disclosure the seller's expected profit is:

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

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 γ 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 γ by the two solid lines in Figures 1 and 2. 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 (7). This level of expected profit is shown as the dashed line in Figures 1 and 2. The two figures illustrate two different
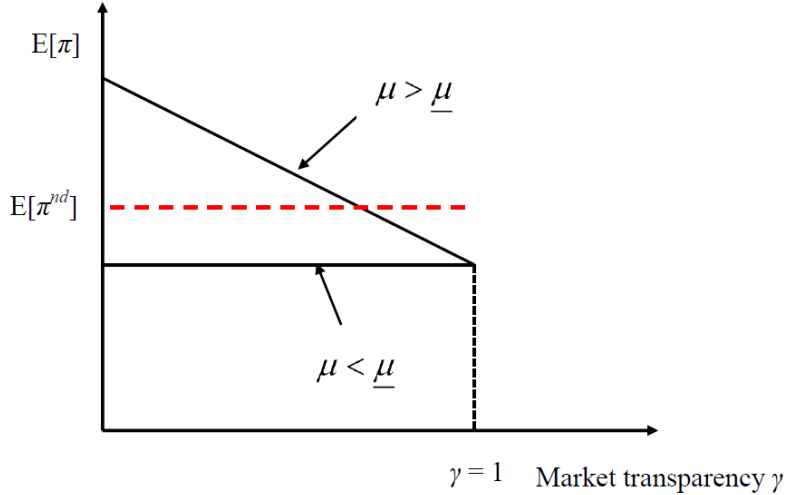
Figure 2: Financial disclosure and market transparency: case (b)

cases. Figure 1 shows the case in which 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: in this case, the issuer will always opt for disclosure ($d = 1$). Figure 2 shows the case in which if transparency γ is low and $\mu \geq \underline{\mu}$, the issuer prefers to disclose, but if transparency is high the issuer prefers not to disclose.

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

Proposition 6 (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 γ. (ii) Otherwise ($\mu < \underline{\mu}$), the issuer's benefit from disclosure are independent of the degree of market transparency γ.*

Proposition 6 shows that the issuer considers financial disclosure and market transparency as substitutes: he will always disclose more information in more opaque than in a more transparent market.

Our results differ considerably from the mainstream literature on market transparency (Glosten and Milgrom (1985), Kyle (1985), Pagano and Roell (1996), Chowhdry 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.[23] Speculators cannot fully ex-

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[23]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))

ploit 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 γ) increases hedgers' ability to infer the asset value. Finally, Foucault et al. (2007) find that in the Euronext market uninformed traders are more aggressive when using anonymous trading systems, which parallels our result that hedgers are willing to offer a higher price when $\gamma = 0$.

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 analyze the case in which the speculators can resell the asset to other market participants at a later stage. Third, we extend the model to the case in which the seller has private information about the value of the asset, and 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 $\gamma = 1$.[24] The speculator, knowing the specific realization of his information acquisition cost, will acquire the signal σ^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 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

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

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

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

The gains from trade between the seller and the uninformed hedger are given by $v^e - \omega_h$, and the seller appropriates a fraction β 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 7 (Information acquisition and disclosure) *(i) When speculators can acquire information privately, the seller's expected profits are always lower than under disclosure, i.e. $\mathbb{E}\left[\pi^{ia}\right] < \mathbb{E}\left[\pi^d\right]$. (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,

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[24]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.

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 v^e and not $\hat{v}(a_h, v_g)$, which conditions on the public signal σ. 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. $\mathbb{E}\left[\pi^{nd}\right] > \mathbb{E}\left[\pi^d\right]$. Now, if speculators are allowed to privately acquire such information, the no-disclosure outcome can no longer be attained, and by the previous result $\mathbb{E}\left[\pi^d\right] > \mathbb{E}\left[\pi^{ia}\right]$ the issuer will prefer to disclose the signal σ. Hence, Proposition 7 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   Retrading

Up to this point, both speculators and hedgers have been assumed to be buy-and-hold investors: they hold the asset until it yields its final payoff. But the analysis can be extended to a setting where speculators may purchase the asset in the primary market just to resell it later to other market participants in the secondary market, by adding a retrading stage before the asset-payoff stage in the time line of the game.

We posit that retrading may occur only before the asset's final payoff is realized. For clarity of exposition, we refer to a speculator who purchased the asset in the primary market as the asset's "owner", and to an investor who bids for it in the secondary market as a "non-owner". The latter is assumed to make a take-it-or-leave-it bid to purchase the asset: this assumption simplifies the bargaining stage in the secondary market and ensures that trade occurs even when the owner has private information about the asset's value.

We consider two candidate pure-strategy PBE, in neither of which the owner trades with a speculator, as there are no gains from trade between them. In the first candidate equilibrium, the speculator is assumed to purchase the asset only if he learns that its value is v_g and tries to resell it to a hedger for a profit in the secondary market. This would be a *certification equilibrium*, where the speculator profits from his information advantage by rubber-stamping high-value assets and reselling them to less informed hedgers. We denote the secondary market price offered by the hedger as p_h^r (where the superscript "r" is a mnemonic for retrading): as in this candidate equilibrium the hedger believes that the owner is reselling only high-value assets, he expects his bid to be acceptable to the owner if $p_h^r - v_g + \omega_s > 0$.

However, to rule out profitable deviations from this candidate equilibrium, we need to

analyze the owner's incentives to buy the asset and resell it even when the asset's value is v_b. This is a profitable deviation, because the hedger would still pay the hypothetical price p_h^r, due to his belief, while the speculator's surplus would be higher since

$$p_h^r - v_b + \omega_s > p_h^r - v_g + \omega_s > 0.$$

Hence, this is not a PBE: the speculator has the incentive to deviate from the strategy to purchase the asset only if it is high-valued and resell it in the secondary market to hedgers.

A second candidate equilibrium is one where speculators purchase the asset in the primary market irrespective of their information and of the asset value, to retrade it later on to other investors. We call this equilibrium the *intermediation equilibrium*, as speculators might profit from the higher appetite that hedgers have for the asset. Since hedgers expect the owner to resell the asset irrespective of its value, their valuation of the asset is $\hat{v}(a_h, v_g)$ as in the baseline version of the model. The lowest secondary market price that a hedger can bid is $v_g - \omega_s$, which just compensates the owner for his outside option of keeping the asset until maturity. It is optimal for the hedger to trade at such a price only if

$$\hat{v}(a_h, v_g) - \omega_h > v_g - \omega_s, \tag{16}$$

which ensures that the hedger's expected payoff is positive. But, by Proposition 5, condition (16) ensures that the initial seller prefers to refrain from trading with speculators and sells only to hedgers in the primary market. This establishes the following result:

Proposition 8 (Secondary market) *Retrading between speculators and hedgers never occurs in equilibrium. If $\hat{v}(a_h, v_g) - \omega_h < v_g - \omega_s$, hedgers are not willing to purchase the asset in the secondary market. If instead, $\hat{v}(a_h, v_g) - \omega_h > v_g - \omega_s$ then the initial seller does not trade with speculators in the primary market.*

This proposition shows that the results of the baseline model are unaffected by allowing for retrading among investors. Specifically, if the speculators' informational advantage $v_g - \hat{v}(a_h, v_g)$ is large enough, it is not profitable for the hedgers to purchase the asset in the secondary market, even when they have all the bargaining power. This is because even when they have higher appetite for the asset ($\omega_h < \omega_s$), they still lose out to better informed speculators. If instead the speculators' information advantage is low enough, hedgers would be willing to purchase the asset in the secondary market, but this is exactly the parameter region where in the primary market the seller refrains from trading with speculators and sells only to hedgers. Thus, even when their informational advantage is not too high, speculators do not manage to intermediate trade with the hedgers.

In our model retrading would happen if we assumed that in the secondary market there is a new group of speculators with a different reservation value for the asset from the speculators who access the primary market: this would create gains from trade among equally informed investors. Alternatively, retrading would occur if speculators are subject to liquidity shocks which force them to liquidate their positions for reasons unrelated to the value of the asset. In this case, one can show that the information externality between investors that in our model arises in the primary market, also reappears in the secondary market between hedgers and speculators who participate in the secondary market.[25]

5.3   Privately Informed Seller

In the previous sections, 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 6.

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 ($d = 1$).[26] Interestingly, this extension allows us to explore the possibility that the seller could signal his information by refusing to trade with the speculator. Specifically, when the seller negotiates with the speculator ahead of the hedger, 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 in the first match, so that even a seller with a bad asset might be able to trade with the 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 (5) 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,

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[25]Details about this different way of modeling retrading in the secondary market are available from the authors.

[26]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.

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

$$\widehat{v}\left(\underline{a}_h, v_g\right) - \omega_h \geq v_g - \omega_s \geq (1 - \gamma)\left(\widehat{v}\left(\underline{a}_h, v_g\right) - \omega_h\right), \tag{17}$$

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.

Proposition 9 (Privately Informed Seller) *If $v_g - \omega_s \geq \widehat{v}\left(\underline{a}_h, v_g\right) - \omega_h$, 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 $\widehat{v}\left(\underline{a}_h, v_g\right) - \omega_h \geq v_g - \omega_s \geq (1 - \gamma)\left(\widehat{v}\left(\underline{a}_h, v_g\right) - \omega_h\right)$, 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 π^{nd} are given by expression (7). 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 9. 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

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

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 π^{nd} from expression (7), 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 μ, while they are decreasing in the degree of market transparency γ, so that there is substitutability between disclosure and market transparency. These results mirror those described by Proposition 6 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.

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 γ), (ii) make disclosure compulsory (set $d = 1$) and (iii) restrict market participation (for instance, ban hedgers from trading, setting $\mu = 0$).

6.1 Market transparency

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

As Figure 2 shows, the issuer's incentive to disclose the signal σ is decreasing in transparency γ. Hence, if the regulator increases γ beyond the intersection of the dashed line with the decreasing solid line, the seller will decide to conceal the signal σ, making the policy ineffective. In this case, in fact, speculators will abstain from trading, and the heightened transparency will actually reduce the information contained in the price. This will affect the hedgers' trading decision adversely, as they will have no information on which to base their decisions.

This result, which follows from Proposition 6, is summarized in the following corollary:

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

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

6.2 Mandating disclosure

In this section we analyze the conditions under which the regulator should make disclosure compulsory 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.

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

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

while under disclosure it is

$$\mathbb{E}\left[S^d\right] = \mu \mathbb{E}\left[S_h^d\right] + (1 - \mu) \mathbb{E}\left[S_s^d\right], \tag{18}$$

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

$$\mathbb{E}\left[S_h^d\right] = \left[\frac{1 + a_h^*}{4}\left(v_g - \omega_h\right) + \frac{1 - a_h^*}{4}\left(v_b - \omega_h\right) + \frac{1 - a_h^*}{4}\left(v_g - \omega_s\right)\right] - \frac{\theta a_h^{*2}}{2}. \tag{19}$$

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

$$\mathbb{E}\left[S_s^d\right] = \frac{v_g - \omega_s}{2}, \tag{20}$$

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

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

Proposition 10 (Optimal disclosure policy) *The regulator's net benefit from disclosure is decreasing in the hedgers' financial illiteracy θ and in the asset expected value v^e, and increasing in the asset volatility $v_g - v_b$. It is also decreasing in the fraction μ of hedgers, if the speculators' informational advantage is sufficiently high. Both under- and over-provision of information can occur in equilibrium: under-provision is more likely to occur when the fraction μ of hedgers is low, over-provision when μ is high.*

The regulator's objective function differs from the seller's expected profits as computed earlier in three ways. First, the planner ignores the distributional issues driven by the bargaining protocol, so bargaining power does not affect the expected social gains. Second, the planner considers that disclosing information means the hedgers must investigate it, which is costly. Third, the regulator does not directly consider the externality generated by the speculators' superior processing ability and its effect on the seller's profit. This affects the social surplus only when it would be efficient for the seller to trade with the hedger, because of the latter's lower reservation value ω_h, and instead the asset is sold to a speculator. These differences generate the discrepancy between the privately and the socially optimal disclosure policy.

The fact that the over- or under-provision of information depends on information-processing costs and the seller's bargaining power is explained as follows. First, the social planner considers the total gains from trade, not the fraction accruing to issuers: on this account, the regulators' interest in disclosure is greater than the issuer's. At the same time, the issuer does not directly internalize the cost of processing information, which is instead taken into account by the regulator. Interestingly, there is a region in which the seller has a *greater* incentive than the regulator for disclosure. This happens when enough hedgers participate in the market (high

μ), where the issuer will disclose the signal σ even if it would be socially efficient to withhold it.

Conversely, in a market with a large share of speculators (low μ), the issuer will fear their superior processing ability, and so will not disclose even when it would be socially efficient. This is likely in the markets for complex assets, such as asset-backed securities, where considerable sophistication is required to understand the structure of the asset and its pricing implications, so that speculators are more likely to participate.[27] Hence, in such markets mandating information disclosure by sellers is warranted. This probably does not apply to markets for treasuries and simple corporate bonds, where the speculators' information-processing ability gives them a smaller advantage.

6.3   Licensing access

In practice, policy makers also have other instruments to regulate financial markets so as to maximize the expected gains from trade. Stephen Cecchetti, head of the BIS monetary and economic department, for example, has suggested that to safeguard investors "The solution is some form of product registration that would constrain the use of instruments according to their degree of safety." The safest securities would be available to everyone, much like non-prescription medicines. Next would be financial instruments available only to those with a licence, like prescription drugs. Finally would come securities available "only in limited amounts to qualified professionals and institutions, like drugs in experimental trials". Securities "at the lowest level of safety" would be illegal.[28] A step in this direction has already been taken in the 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.

Since speculators, when they get the signal σ, forecast the asset's value perfectly and incur no processing costs, it might be optimal to limit market participation to them, thereby inducing the seller to disclose information. Limiting access to speculators only is a socially efficient policy when the expected surplus generated by trading with them (20) exceeds the expected gain (18)

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[27]Related to our paper, Easley et al. (2013) propose a model where some traders (mutual funds) face ambiguity about the equilibrium trading strategies of other traders (hedge funds). This ambiguity limits the ability of mutual funds to infer information from prices and has negative effects on market outcomes. They show that increasing disclosure might have adverse effects on equity premium and welfare.

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

generated by the participation of all types of investors. The relevant condition is

$$\frac{v_g - \omega_s}{2} > \mu \left[\frac{1 + a_h^*}{4} v_g + \frac{1 - a_h^*}{4} v_b - \omega_h + \frac{1 - a_h^*}{4} \left(v_g - \omega_s \right) - \frac{\theta a_h^{*2}}{2} \right] + (1 - \mu) \frac{v_g - \omega_s}{2}, \quad (21)$$

which leads to the following proposition:

Proposition 11 (Banning hedgers from trading) *Making market access exclusive to speculators is welfare-improving when financial illiteracy* θ *is high and the expected value* v^e *of the asset is low. For the issuer this policy is never optimal.*

In this case too, therefore, the issuer's and the regulator's incentives are not aligned: in fact, issuers are always hurt by a policy that excludes hedgers, even when they deal with complex assets and unsophisticated investors. In contrast, Proposition 11 indicates that in these circumstances 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 the expected asset value v^e is high: in this case the expected gains from trade are greater when all investors participate and it is less likely that hedgers will buy the asset when it is not worth it. Finally, volatility $v_g - v_b$ has ambiguous effects on the regulator's incentive to exclude hedgers: on the one hand, it raises the costs associated with their buying a low-value asset, and hence the regulator's interest in keeping them out of the market; on the other hand, it induces hedgers to step up their attention level, making the regulator more inclined to let them in.[29]

7   Conclusion

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

First, we show that enhancing information disclosure may not benefit 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

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[29]Notice that it might be optimal to exclude the speculators even when their reservation value is greater than that of hedgers.

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. We also allow speculators to retrade the security on a secondary market, and show that our results are robust to this possibility.

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

8 Appendix

8.1 Proofs of Propositions

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:

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

Solving for p_i, we obtain

$$p_i = \beta \left(\hat{v} - \omega_i - \bar{\omega}_i\right) + \bar{\omega}_i, \tag{22}$$

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

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

Next, we investigate the possible strategies of the hedger in a second match following a first match between seller and speculator that results in no trade. We conjecture that in equilibrium $a_s^* = 1$ and $a_h^* < 1$. Since the outcome of the seller's negotiation with the speculator is observable, if the hedger sees that no trade occurred he infers that the asset is of low quality, so that the seller's outside option after being matched with the speculator is zero: $\bar{\omega}_s = 0$. Substituting this into expression (22) yields the price paid by the speculator:

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

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

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

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

$$
\bar{\omega}_h = \begin{cases} \beta \frac{1+a_h}{2} \left(v_g - \omega_s \right) & \text{if } \sigma = v_g, \\ \beta \frac{1-a_h}{2} \left(v_g - \omega_s \right) & \text{if } \sigma = v_b. \end{cases}
\tag{23}
$$

Substituting (23) into expression (22) yields the equilibrium price paid by the hedger:

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

as stated in the proposition.

Proof of Proposition 2 (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

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

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

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

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

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

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 Proposition 3 (Choice of attention)

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

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

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where expression ([23](#)) is used in the last step.

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

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

The solution is

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

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

Clearly $a_h^* > 0$. The condition for a_h^* to be interior, $a_h^* \le 1$, 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:

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

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 $\frac{1}{2} u\left(a_s\right)$, 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:

$$\frac{1 - \beta}{2}\left[v^e - \omega_h - \frac{1 + a}{2}\frac{v_g - v_b}{2}\beta + \frac{a}{2}\left(v_g - v_b\right)\right] - \theta\frac{a^2}{2} > (1 - \beta)\left(v^e - \omega_h\right), \tag{24}$$

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 ([24](#)) can be re-written as follows:

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

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 (24) being positive (since $v^e - \omega_h > 0$).

Proof of Proposition 4 (Choice of financial disclosure)

To prove this proposition, we compute total expected profits under disclosure ($d = 1$):

$$
\begin{aligned}
\mathbb{E}\left[\pi^d\right] &= \frac{\mu}{2}\left(p_h^d - a p_s\right) + \frac{1}{2}p_s && (25) \\
&= \frac{\mu}{2}\left[\beta\left(\hat{v} - \omega_h\right) + (1-\beta)\frac{1+a}{2}p_s - a p_s\right] + \frac{1}{2}p_s \\
&= \frac{\mu}{2}\left[\beta\left(v^e - \omega_h\right) + \beta\frac{v_g - v_b}{2}a + (1-\beta)\frac{1+a}{2}p_s - a p_s\right] + \frac{1}{2}p_s \\
&= \frac{\mu}{2}\left[\beta\left(v^e - \omega_h\right) + \left((1-\beta)\frac{1+a}{2}\beta\right)\frac{v_g - v_b}{2}\right] + \frac{1}{2}p_s > 0,
\end{aligned}
$$

where in the first two steps we have substituted the expressions for the prices and imposed the restriction $\omega_s = v^e$ on the speculator's outside option, and in the third we have used the fact that $p_s = \beta(v_g - v_b)/2$. The issuer's choice on disclosure depends on the expected profit under disclosure (25) and under no disclosure (7). In this comparison, the only terms involving the parameters $\{\mu, v_g - v_b, \theta\}$ mentioned in Proposition 3 appear in expression (25). The issuer's expected benefit from disclosure is clearly increasing in μ, because $p_h^d > p_s$, as shown. Volatility of value has two effects: first, a direct positive effect via prices, as shown by the terms inside the parenthesis in (25); and second, an indirect positive effect via the attention allocation a_h^*, recalling that $\frac{\partial a_h^*}{\partial(v_g - v_b)} > 0$ from Proposition 2. Finally, the financial illiteracy parameter θ affects the issuer's expected profit only through its effect on the optimal choice of attention a_h^*: since $\frac{\partial a_h^*}{\partial \theta} < 0$ by Proposition 2, an increase in θ reduces the issuer's benefit from disclosing.

Proof of Proposition 5 (Hedgers' participation decision)

In the case in which the market is transparent, which occurs with probability γ, 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 $p_h^o \geq p_s^o = \eta p_s^{o_1} + (1-\eta)\beta(v_g - \omega_s)$, as with probability $1 - \eta$ the speculator will know to be the second one to be matched with the seller, while with

complementary probability η 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

$$
\widehat{\mu} = \begin{cases} \frac{\mu}{\mu+(1-\mu)/2} & \text{if } p_h^o \geq p_s^o, \\ 0 & \text{if } p_h^o < p_s^o, \end{cases} \tag{26}
$$

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

Hence, the hedger faces a new adverse selection problem: if his bid price is below 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 he 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 Γ is increasing in his probability μ of being the first match. Thus his surplus is zero if μ is low enough to make the belief $\widehat{\mu}$ 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 6 (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

$$\mu \mathbb{E}[\pi_h^o] + (1 - \mu) \mathbb{E}[\pi_s^o] = \mu \frac{1 + a_h}{2} p_h^o(\gamma) + \left(\frac{(1 - \mu)}{2} + \mu \frac{1 - a_h}{2}\right) \bar{p}_s^o(\gamma)$$

$$= \mu \frac{1 + a_h}{2} \frac{\beta(v_g - \omega_s)}{(1 - \theta)(1 - \beta)^{\frac{1 + a_h}{2}}} + \left(\frac{(1 - \mu)}{2} + \mu \frac{1 - a_h}{2}\right) [\gamma p_s^{o_1} + (1 - \gamma) p_s^o],$$

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 γ 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 $p_s^{o_1} > p_s^o$. 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 γ. Then, point (ii) of the Proposition follows immediately.

Proof of Proposition 7 (Information acquisition and disclosure)

To show point (i) of the proposition notice that: (a) $\hat{v} - \omega_h > v^e - \omega_h$, 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 σ. 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 σ^p tend to $\mu \beta(v^e - \omega_h) + (1 - \mu)\varepsilon$, where ε is a small positive constant. Hence, there exist parameters for which the following condition holds

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

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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 8 (Secondary market)

This follows from the discussion in the text.

Proof of Proposition 9 (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 (5), 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 (17), 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.

Proof of Proposition 10 (Optimal disclosure policy)

The regulator's net benefit Δ is the difference between the expected social surplus with and without disclosure:

$$
\Delta \equiv \mathbb{E}\left[S^d\right] - \mathbb{E}\left[S^{nd}\right] = \mu\left[\frac{1+a}{4}(v_g - \omega_h) + \frac{1-a}{4}(v_b - \omega_h) + \frac{1-a}{4}(v_g - \omega_s) - \theta\frac{a^2}{2}\right]
$$

$$
+ (1 - \mu)\left(\frac{v_g - \omega_s}{2}\right) - v^e + \omega_h
$$

$$
= \mu\left[\frac{v_g + v_b}{4} + a\frac{v_g - v_b}{4} - \frac{\omega_h}{2} + \frac{1-a}{4}\frac{(v_g - v_b)}{2} - \theta\frac{a^2}{2}\right] + (1 - \mu)\left(\frac{v_g - \omega_s}{2}\right) - v^e + \omega_h
$$

$$
= \mu\left[\frac{v_g - v_b}{8} + \frac{a}{8}(v_g - v_b) - \theta\frac{a^2}{2}\right] - v^e(1 - \frac{\mu}{2}) + \left(1 - \frac{\mu}{2}\right)\omega_h + (1 - \mu)\left(\frac{v_g - \omega_s}{2}\right).
$$

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

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

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where
$$\frac{da}{d\theta} = -\frac{(1-\beta)^2 (v_g - v_b)}{4\theta^2},$$

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

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

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

where the inequality follows from $\frac{(1-\beta)^2 (v_g - v_b)}{16\theta} > \frac{(1-\beta)^4 (v_g - v_b)}{16\theta}$ because $\beta \in (0,1)$.

Finally, the derivative of the regulator's net benefit from disclosing with respect to μ is

$$\frac{\partial \Delta}{\partial \mu} = -\frac{v_g - v_b}{8} + \frac{a (v_g - v_b)}{8} - \frac{\theta a^2}{2} + \frac{v^e}{2} - \frac{\omega_h}{2},$$

which is negative provided the speculator has a sufficiently high informational advantage on the hedger, i.e. if the following condition holds:

$$\frac{1-a}{4} (v_g - \omega_s) > v^e - \omega_h,$$

which is a stronger version of condition (5).

To show that there might be either under-provision and over-provision of information, we show that depending on parameter values there are cases in which the regulator would compel disclosure but the issuer would not want to disclose, and also the other way around, depending on the relative size of the social benefit from disclosure Δ and the issuer's corresponding gain $G = E(\pi^d) - E(\pi^{nd})$. In the following table we show two possible cases: in the first, the regulator finds disclosure optimal and the seller does not ($\Delta > 0 > G$), while in the second the issuer discloses the signal even though it is socially optimal to conceal it ($\Delta < 0 < G$).

	v_g	v_b	ω_h	μ	θ	β	a_h^*	Δ	G
Case 1: *Under-provision*	99.5	-26.5	5.1	0.4	20	0.99	0.0001	0.08	-0.3
Case 2: *Over-provision*	100	-30	0	0.7	100	0.9	0.017	-1.8	3.7

The first case, when the issuer does not gain from disclosing the signal, is more likely

to happen when μ is sufficiently small: to see why, recall that by Proposition 4 the issuer's expected net benefit from disclosure G is increasing in μ, while from the results presented above the social regulator's gain from disclosure Δ is decreasing in μ. Intuitively, when the asset is likely to be sold to the speculator, and the gains from trading with a speculator are small, the issuer refrains from disclosing the signal to avoid the implied underpricing. Conversely, the second case, where the issuer wishes to disclose the signal while the regulator would prefer it not to be disclosed, arises if the fraction of hedgers μ is sufficiently large. This is because when the probability of selling to a hedger is high, it becomes crucial for the regulator (but not for the seller) to minimize the costs of trading with a hedger, that is, his information processing cost.

Proof of Proposition 11 (Banning hedgers from trading)

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

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

The regulator, however, will want to restrict market participation to the speculators when the resulting expected loss $\mathbb{L}$ is negative; that is, from condition (21)

$$\mathbb{L} \equiv \frac{v^e}{2} - \omega_h + \frac{a}{8}\left(v_g - v_b\right) - \frac{v_g - v_b}{8} - \theta\frac{a^2}{2} < 0. \tag{27}$$

By the same steps as in the proof of Proposition 9, it can be shown that $\frac{\partial \mathbb{L}}{\partial \theta} < 0$, implying that the regulator's interest in barring hedgers increases as the complexity θ of the asset increases. From expression (27), it is straightforward to show that a higher expected asset value v^e reduces the regulator's interest in excluding hedgers. The effect of asset volatility $v_g - v_b$ on expression (27) is ambiguous.

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