Review of Finance, 2018, 117–153
doi: 10.1093/rof/rfx009
Advance Access Publication Date: 13 March 2017

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

JEL classification: D83, G18, C78

Keywords: Disclosure, Transparency, Financial literacy, Limited attention, OTC markets

Received March 10, 2016; accepted December 3, 2016 by Editor Franklin Allen.

* We thank the Editor (Franklin Allen), an anonymous referee, Daron Acemoglu, Abhijit Banerjee, Nicholas Barberis, Bruno Biais, Milo Bianchi (discussant), Guillermo Caruana, Hui Chen, Kent Daniel, Darrell Duffie, Xavier Gabaix, Diego Garcia, Johan Hombert, Pab Jotikasthira, Andrey Malenko, Gustavo Manso, Meg Meyer, Andrea Prat, Barbara Rindi, Steve Ross, Ioanid Rosu (discussant), Andrei Shleifer, Peter Norman Sorensen, Xavier Vives, Liyan Yang (discussant), Hongkai Zhang, and seminar participants at the Econometric Society Meeting, the Barcelona GSE Summer Forum on Information and Market Frictions, the European Summer Symposium in Financial Markets, the EFA meeting, the SFS Finance Cavalcade, the FIRS meeting, the CREI-CEPR workshop on "Behavioral Decision Theory and its Applications to Economics and Finance," the CSEF-IGIER Symposium on Economics and Institutions, the XIV Madrid Finance Workshop, the 2015 Graz Workshop on "Accounting, Information, and Financial Crises," and seminars at MIT, Catholic University (Milan) and Science Po (Paris) for helpful comments and suggestions. We are grateful to Ding Yuan for providing excellent research assistance and to EIEF for financial support.

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 itis 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 article, we propose one solution to the puzzle: issuers do not necessarily gain from financial disclosure and market transparency if (i) it is costly to process financial information and (ii) not everyone is equally good at it. Under these assumptions, disclosing financial information may not be beneficial, because giving traders more information increases their information-processing costs and thus accentuates the informational asymmetry between more sophisticated and less-sophisticated investors, thus exacerbating adverse selection.

Specifically, we set out a simple model where the issuer of an asset places it with one of many competing dealers, who sells it to investors through a search market that randomly matches him with buyers. The price at which the issuer can initially place the asset with the dealer depends on the expected price on this search market. The sale of an asset-backed security (ABS) is one example: the ABS is placed by its originator (e.g., a bank wishing to offload a loan pool from its balance sheet) with an underwriter who searches for buyers via an over-the-counter (OTC) market. Another example is that of a company that hires a broker to sell its shares via a private placement or a Direct Public Offering (DPO) to investors, who can trade them on the Pink Sheet market or the OTC Bulletin Board.[2]

Before the asset is initially placed with investors, the issuer can disclose fundamental information about the asset, for example, 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, 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

1 For instance, Greenstone, Oyer, and Vissing-Jorgensen (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% 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 book-building 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 Securities and Exchange Commission and greater discretion regarding disclosure. For instance, more than 1 billion (dollar) of Facebook shares were sold on the secondary market introduced by SecondMarket in the year preceding the IPO.

better at understanding the price implications of new information, concluded that the asset is not worth buying. This depresses the price that unsophisticated investors are willing to pay; in turn the sophisticated investors, anticipating that the seller will have a hard time finding buyers among the unsophisticated, will offer a price below the no-disclosure level.

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

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

Hence, a key novelty of our setting is that it encompasses two notions of transparency that are naturally related: financial disclosure affects security prices, but the transparency of the trading process determines how and when the disclosed information is incorporated in market prices. We show that each of these two forms of transparency amplifies the other's impact on the security price. Interestingly, the recent financial crisis has brought both notions of transparency under the spotlight. The opacity of the structure and payoffs of structured debt securities—a form of low financial disclosure—has been blamed by some for the persistent illiquidity of their markets. But the crisis has also highlighted the growing importance of off-exchange trading, with many financial derivatives (mortgage-backed securities, collateralized debt obligations, credit default swaps, etc.) traded in opaque OTC markets—an instance of low-trading transparency.

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

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

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

First, we show that there can be either under- or over-provision of information, whenever the seller has less bargaining power in trading with speculators than with hedgers (which is realistic, as the former tend to have more continuous market presence and greater bargaining skills than the latter). In the opposite case, instead, there is never under-provision of information. Intuitively, when issuers know that trading with a speculator will entitle them to a smaller fraction of the bargaining surplus than trading with a hedger, they may prefer to deter trading by speculators by not disclosing information about the asset, even though this would be socially efficient. In this case, regulatory intervention for disclosure is required. This is likely to occur if, when the information is released, hedgers devote little attention to it: hence, releasing the information does not lead them to spend too many resources. When instead hedgers devote much attention to information, the issuer has either the same incentive to disclose as the regulator or even greater incentive to do so, as he does not give sufficient weight to the resources that hedgers spend to study the disclosed information.

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

These insights build on the idea that not all the information disclosed to investors is easily and uniformly digested—a distinction that appears to be increasingly central to regulators' concerns. For instance, in the USA 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, Matsumoto, and Miller (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

3 Bushee, Matsumoto, and Miller (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

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 discusses few extensions of the model. Section 6 investigates the role of regulation in the baseline model, and Section 7 concludes. Omitted proofs are presented in the Appendix.

1. Related Literature

This paper is part of a growing literature on costly information processing, initiated by Sims (2003) and Sims (2006), which argues that agents are unable to process all the information available, and accordingly underreact to news. Subsequent work by Peng and Xiong (2006), Van Nieuwerburgh and Veldkamp (2009), Van Nieuwerburgh and Veldkamp (2010), Davies (2014) and Woodford (2005) brought out the implications of information constraints for portfolio choice problems and monetary policy, whereas Pavan (2014) provides a general framework to shed light on the type of payoff interdependencies that contribute to inefficiency in the allocation of attention.[4] Whereas these papers analyze how the presence of investors with limited attention affects trading outcomes in competitive markets, we show that new insights emerge by considering OTC markets. Specifically, our main contribution is to explain how investors' attention allocation affects the issuer's incentives to release information to market participants. Furthermore, the difficulty to process this newly released information generates an information externality among investors, whose intensity crucially depends on the opacity of the OTC markets. This result parallels the findings of Duffie *et al.* (2014b), who highlight how herding by uninformed investors leads to learning externalities.

The idea that information processing is costly squares with a large body of empirical evidence, as witnessed by surveys of studies in psychology (Pashler, Johnston and James 1998; Yantis, 1998), in experimental research on financial information processing (Libby, Bloomfield, and Nelson, 2002; Maines, 1995), and in asset pricing (Daniel, Hirshleifer, and Teoh, 2002).[5] In particular, there is evidence that limited attention affects portfolio choices: Christelis, Jappelli, and Padula (2010) document that the propensity to invest in stocks is

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, Gorton, and Madureira (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).

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), Bianchi and Jehiel (2015), and Gennaioli, Shleifer, and Vishny (2012) for studies of different investors' behavioral limitations in processing information.

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; 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).[7]

Several recent papers show that investors may overinvest in information acquisition. For instance, in Glode, Green, and Lowery (2012) traders inefficiently acquire information as more expertise improves their bargaining positions. In Bolton, Santos, and Scheinkman (2011), too many workers choose to become financiers compared to the social optimum, due the rents that informed financiers can extract from entrepreneurs by cream-skimming the best deals. In these papers, the focus is on the acquisition of information. Our focus is instead on information processing, and its effects on the issuers' incentive to disclose information in the first place.

Our result that issuers may be damaged by financial disclosure parallels Pagano and Volpin (2012), who show that when investors have different information-processing costs, transparency exposes the unsophisticated to a winners' curse at the issue stage: to avoid the implied underpricing, issuers prefer opacity. But our present setting differs in other important respects. First, since in Pagano and Volpin (2012) trading is not sequential, less-sophisticated investors have no chance to learn from the more sophisticated ones, which precludes information externalities. Second, here we show that issuers do not always opt for opacity, since they will trade off the costs of disclosure (strategic interaction among investors) against its benefits (greater willingness to pay for the asset). Moreover, unlike Pagano and Volpin (2012), this article 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.[8]

Finally, several authors have suggested possible reasons why limiting disclosure may be efficient, starting with the well-known argument by Hirshleifer (1971) that revealing information may destroy insurance opportunities. The detrimental effect of disclosure has been shown in models where it can exacerbate externalities among market participants, as in our model: Morris and Shin (2012) analyze a coordination game among differentially informed traders with approximate common knowledge; Vives (2011) proposes a model of crises with strategic complementarity between investors and shows that issuing a public signal about weak fundamentals may backfire, aggravating the fragility of financial

6 The accounting literature too sees a discrepancy between the information released to the market and the information digested by market participants: Barth, Clinch, and Shibano (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.

7 Other related papers include Klibanoff, Lamont, and Wizman (1998), Hong, Torous, and Valkanov (2007), and Hirshleifer, Lim, and Teoh (2011) .

8 Recently, Dang, Gorton, and Holmstrom (2012) and Yang (2012) have also noted that opacity may be beneficial insofar as it reduces informational asymmetries, but they mainly concentrate on the security design implications of this insight.

intermediaries; Goldstein and Yang (2014) show that disclosing public information is beneficial only when it improves the overall learning quality of relevant decision makers, which is more likely to occur when the information being disclosed is about something that decision makers already know much, or when the market does not aggregate traders' private information effectively.[9] As in these papers, also in our model disclosure creates externalities and strategic behavior; but being chosen by issuers, it may be set at a socially inefficient level. [10]

2. The Model

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

To understand the pricing implications of the disclosed information, potential buyers must devote some attention to analyzing the signal. But investors face different costs: understanding financial news is more costly for unsophisticated investors than for professionals with expertise, better equipment, and more time. Unsophisticated investors may still want to buy for noninformational reasons, such as to hedge some risk: we accordingly call them "hedgers." In contrast, sophisticated investors are assumed to trade purely to exploit their superior information-processing ability, and are accordingly labeled "speculators."

2.1 Information

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

9 In a similar vein, Gao and Liang (2011) show that on the 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, Heinle, and Huang (2013).

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

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

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

However, greater precision comes at an increasing cost: the cost of information processing is $C_i(a_i, \theta_i)$, with $\partial C_i/\partial a_i > 0$ and $\partial^2 C_i/\partial a_i^2 > 0$, where the shift parameter θ_i measures inefficiency in processing. Hence, we can think of $1/\theta_i$ as a gauge of the investor's "financial literacy." To simplify the analysis, we posit a quadratic cost function: $C_i(a_i, \theta) = \theta_i a_i^2/2$. The greater θ_i, the harder for investor i to measure the asset's price sensitivity to factors like interest rates, commodity and housing price changes, possibly because of its complexity: as the recent financial crisis has made apparent, understanding the price implications of a collateralized debt obligation'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] The differences between hedgers and speculators can also capture the differences between retail and institutional investors. However, it is important to realize that our unsophisticated investors are not at all naive: they realize that they have higher information-processing costs than the speculators, and take this rationally into account in their market behavior.[12] Like Tirole (2009), Van Nieuwerburgh and Veldkamp (2009), and Van Nieuwerburgh and Veldkamp (2010) we do not assume bounded rationality. In our setting, unsophisticated investors decide how much information they wish to process rationally, in the awareness that a low level of attention may lead to mistakes in trading.

2.2 Trading

After acquiring the asset from the issuer, the dealer (henceforth "seller") resells it on a secondary market where trading occurs via a matching and bargaining protocol.[13] The seller is initially matched with a hedger with probability μ, and with a speculator with probability

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

12 We assume that good and bad news are equally costly to process. However, in some settings bad news may be costlier to process for hedgers than good news. In this case, hedgers would make more mistakes (i.e., buy the asset when it is of low quality), and thus increase the expected profit of the seller both directly (when he trades with a hedger) and indirectly (by raising the seller's outside option when trading with the speculator). Moreover, if the hedger also has trouble in processing the "bad news" generated by observing the speculators refusing to purchase the asset, then the information externality in the market would weaken, which again would increase the seller's expected profits.

13 In principle, the issuer and the dealer can be the same player without significantly affecting our analysis. However, we want to allow for this interpretation because in reality the issuer chooses the disclosure regime, while the dealer trades with investors in secondary markets.

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

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

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

As in the search-cum-bargaining model of Duffie, Garleanu, and Pedersen (2005), the seller can observe the investor's type.[14] Real-world examples of such a setting are OTC markets, where matching via search gives rise to a bilateral monopoly at the time of a transaction: in OTC markets sellers can typically observe or guess the type of their counterparty—for example, distinguish the trader calling from an investment bank (a "speculator" in our model) from the chief financial officer of a nonfinancial company seeking to hedge operating risks (a "hedger"). There is also empirical evidence that this is in fact the case. Linnainmaa and Saar (2012) show that broker identity can be used as a signal about the identity of investors who initiate trades and that the market correctly processes this information.

We impose the following restrictions on the parameters:

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, Garleanu, and Pedersen (2005) to justify the adoption of the Nash bargaining solution in their matching model.

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

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

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

These two parameter restrictions ensure that the attention allocation problem of the hedger has an interior solution. The assumption on θ implies that his information-processing cost is high enough to deter him from achieving perfectly precise information; that is, he will choose an attention level $a_h^* < 1$. Otherwise, in equilibrium hedgers would have the same information as speculators ($\Omega_h = \Omega_s$). The assumption on 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:

1. The issuer decides on the disclosure regime,that is, $d \in \{0, 1\}$, and sells the asset to one of several competing dealers.[15]
2. Depending on the disclosure regime, the signal σ is released or not, investors decide whether to entry the market or not, and if they do they are matched with the dealer via random matching: if they both enter, the dealer is matched with the hedger with probability μ, and with the speculator with probability $1-\mu$.[16]
3. Investor i chooses his attention level a_i and forms his expectation of the asset value $\hat{v}_i(a_i, \sigma)$.[17]
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.

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 disclosure or full opacity.

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

17 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.

This means that in this baseline version, the final stage of the game posits complete market transparency, previous trades being observable to all market participants. In this way, we highlight the information externality among investors. In Section 4, we relax this assumption, and allow investors to fail to observe previous trades: this enables us to explore how less trading transparency affects the equilibrium outcome by determining the intensity of this externality. In Section 5, we also extend the model to analyze the case in which speculators can purchase the asset to resell it later to other market participants.

3. Equilibrium

We solve the game backwards to identify the pure strategy perfect Bayesian equilibrium (PBE), that is, the strategy profile (d, a_s, a_h, p_s, p_h) such that (i) the disclosure policy d maximizes the seller's expected profits; (ii) the choice of attention a_i maximizes the typical buyer i's expected gains from trade; (iii) the prices p_s bid by speculators and p_h bid by hedgers solve the bargaining problem specified above; and (iv) investors' beliefs are updated using Bayes' rule. Specifically, each type of investor pays a different price depending on the disclosure regime, and possibly on whether he is matched with the seller at stage 4 (when he is the first bidder) or 5 (when he bids after another investor elected not to buy). Each of the following sections addresses one of these decision problems.

3.1 The Bargaining Stage

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

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

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

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

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.[18] This probability is an increasing

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

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

function of the investor's attention a: in the limiting case $a = 0$, the estimate $\hat{v}$ would be the unconditional average $\overline{v}$, whereas in the polar opposite case $a = 1$, the investor's estimate would be perfectly precise. In what follows, we conjecture that speculators, who have no information-processing costs, will choose $a_s^* = 1$, while hedgers choose a lower attention level $a_h^* \in (0, 1)$.[19] Thus, in equilibrium speculators know the value of the asset and hedgers hold a belief $\hat{v}(a, \sigma)$ whose precision depends on the attention level they choose.

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

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

where $\overline{\omega}_s$ 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 is released.[20] 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*

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

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

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

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: $\overline{\omega}_s = 0$. This information externality weakens the seller's initial bargaining position *vis-à-vis* the speculator, by producing a lower outside option than when the hedger comes first (and so is more optimistic about the asset value, his estimate being $\hat{v}(a_h, v_g) > v_b$). This is reminescent of the "ringing-phone curse" analyzed by Zhu (2012). In his words: "the fact that the asset is currently offered for sale means that nobody has yet bought it, which, in turn, suggests that other buyers may have received pessimistic signals about its fundamental value. Anticipating this 'ringing-phone curse,' a buyer may quote a low price for the asset, even if his own signal indicates that the asset value is high."

As we show below, in equilibrium the hedger buys only when he is the first to be matched, and only upon receiving good news. Hence, the price p_h at which he trades according to expression (3) is his expected surplus conditional on good news: the first term is the fraction of the hedger's surplus captured by the seller when he makes the take-it-or-

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

20 The relevant condition is derived in the proof of Proposition 2.

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

In 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. Consistent with the intuitive criterion, the hedger is assumed to believe that the asset is of high quality whenever he sees the speculator buying it, and low quality whenever the speculator does not purchase it (which off equilibrium might occur also for a high-quality asset).

It is important to see that the price concession that speculators obtain as a result of hedgers' emulation depends on the hedgers' awareness of the speculators' superior information-processing ability, which exposes hedgers to a "winner's curse." But this adverse selection effect itself depends on the seller's initial public information release, since without it speculators would lack the very opportunity to exploit their information-processing advantage. The information externality generated by the issuer's disclosure decision is related to that recently modeled by Duffie *et al.* (2014), who study how information percolates in markets. In our setting, it crucially depends on the differences in processing ability between hedgers and speculators.

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

3.2 Attention Allocation

So far we have taken investors' choice of attention as given. Now we characterize it as a function of the model parameters: treating their attention level as given may lead to mistaken comparative statics results: for instance, parameter changes that deepen the hedgers' information disadvantage may trigger a countervailing increase in their attention level. In general, investors process the signal 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,that is, 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 2 characterizes the optimal choice of attention allocation and shows that hedgers find it profitable to buy if and only if the realized signal is v_g, that is, if the seller discloses "good news."

Investors choose their attention level a_i to maximize expected utility:

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

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

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

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

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

The first part of Proposition 2 captures the speculator's optimal choice of attention, which confirms the conjecture made in deriving the bargaining solution: as he has no processing costs, the speculator chooses the highest level of attention, and thus learns the true value of the asset.

The second part characterizes the choice of attention by the hedger, for whom processing the signal is costly. First, his optimal choice is an interior solution, due to Assumption 2. And, when the seller extracts a larger fraction of the gains from the trade (i.e., 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 also increasing in his financial literacy $1/\theta$, because the lower is the cost of analyzing the signal σ, the more worthwhile it is to do so. Alternatively, one can interpret $1/\theta$ as a measure of the "simplicity" of the asset–the pricing implications of information being easier to grasp for plain vanilla bonds than for complex assets such as asset-backed securities.

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

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 $\bar{v}$.

3.3 Disclosure Policy

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

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

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

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

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

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

Proposition 3 (Choice of financial disclosure) The issuer's net benefit from disclosing the signal σ is increasing in the asset's volatility $v_g - v_b$ and in the hedgers' financial literacy $1/\theta$, and decreasing in the hedgers' relative appetite for the asset $\omega_s - \omega_h$.

To intuit the reason for these results, consider that in this model financial disclosure has both benefits and costs for the issuer. The benefits are two-fold: 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 Equation (3) to p_h^{nd} in Equation (4)); second, it increases the speculator's willingness to pay in good states of the world. The cost of disclosure stems from enabling the speculator to deploy his information-processing skills, triggering an information externality that depresses the price.

The benefits of disclosure for the seller are increasing in the asset's volatility: first, a more volatile asset induces the hedger to pay more attention to its valuation (Proposition 2), which increases the price p_h^d he is willing to pay (from expression (3)); second, volatility increases the surplus that the seller can extract, under disclosure, from trading with the speculator, because it increases the latter's willingness to pay in the good state. By the same token, the issuer is more inclined to disclosure when $1/\theta$ is high, that is, when investors have high financial literacy and/or the asset has a simple payoff structure, as in these circumstances disclosure will elicit a high level of attention by investors and accordingly raise their valuation of the asset significantly. This comparative statics is illustrated in Figure 1, where financial disclosure occurs in the shaded region where either financial literacy or asset volatility is sufficiently high, or both.

Proposition 3 also highlights that the issuer is less willing to disclose information when hedgers have a low-reservation value compared to speculators, and, therefore, bid

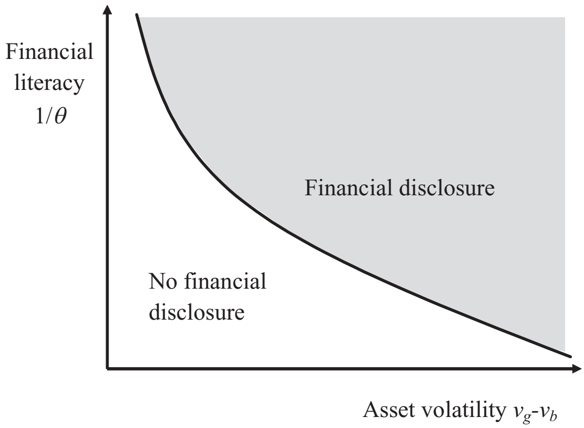

Figure 1. Financial disclosure as function of literacy and volatility.

aggressively for the asset irrespective of the information available to them. In this case, the seller will be less dependent on the speculators for the sale of the asset, and accordingly will be less inclined to release the public signal that is a prerequisite for speculators to bid.

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

4. The Effect of Market Transparency

In analyzing issuers' choice of disclosure, so far we have assumed that the market is fully transparent; that is, that subsequent buyers perfectly observe whether a previous trade has occurred or failed. This need not always be the case, however: securities markets differ in their post-trade transparency, the extent to which information on previous trades is disseminated to actual and potential participants.[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

22 For empirical studies on the effect of post-trade transparency on market quality, see Naik, Neuberger, and Viswanathan (1994), Gemmill (1996), Board and Sutcliffe (1995), and Saporta, Trebeschi, and Vila (1999) who 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.

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.

Hence, in our setting market transparency is more precise knowledge that a former trade could have occurred but did not. As is well-known, it is often the case that the absence of news as time passes often contains information ("no news is news"), and increased transparency can make such absence of news more salient for investors. For instance, consider the increase in post-trade transparency brought about by the introduction of the TRACE system in the bond market (a typical OTC trading venue), which enables investors to observe if there have been previous trades for the same bond. Then, absence of previous trades can be an important piece of "no news" that other investors will want to take into account in their trading decisions. In the model, changing γ makes the absence of news and the passage of time more visible and salient for investors. This logic also applies to other financial markets. In the market for corporate control, Giglio and Shue (2014) have formally tested how investors take into account the absence of information and find that, in the year after a merger announcement, the passage of time is informative about the probability that the merger will ultimately complete. Similarly, in the housing market the introduction of websites such as Zillow.com have increased transparency by providing more detailed information about current listings (greater disclosure), while also enabling house hunters to access the number of days a listing has been active, namely, for how long the house went unsold (greater trade transparency). With this additional information, potential buyers will bid more conservatively for houses that were on the market longer.

In this model, market opacity attenuates the information externality between speculators and hedgers: the less likely hedgers are to know whether a previous match between seller and speculator failed, the less frequently they themselves will refrain from buying, thus depressing the price. In turn, since speculators' failure to buy may go unobserved by hedgers, they will be able to obtain less of a price concession. Hence, greater market opacity (lower 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.[23]

Let us analyze the first effect in isolation, taking the hedger's participation and pricing decision as given. Suppose the issuer discloses the signal $\sigma = v_g$ at stage 1 and is matched with a speculator at stage 4. If the market is opaque, the seller might be able to place the asset even if bargaining with the speculator broke down, since the hedger might still be willing to buy. Hence, the speculator must offer a price that compensates the seller for this outside option, which did not exist under full transparency ($\gamma = 1$) where the hedger is never willing to buy the asset when he comes second. To compute the price that the speculator is willing to offer if $\gamma < 1$, we have to take into account that now two situations can arise:

23 Our model can easily account for the case in which the hedgers are naive: this countervailing effect of opacity would be absent.

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_b^o, that is, 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 $\frac{1+a_b}{2}$):

$$p_s^{o_1} = \beta(v_g - \omega_s) + (1-\beta)\frac{1+a_b}{2}p_b^o. \tag{8}$$

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

$$p_s^o = \eta p_s^{o_1} + (1-\eta)\beta(v_g - \omega_s), \tag{9}$$

where $\eta = \frac{1-\mu}{(1-\mu)+\mu\frac{1-a}{2}}$ is the speculator's belief that he is the first to be matched with the seller. The greater the probability $1-\eta$ that the speculator assigns to a previous match between seller and hedger having failed (in which case the seller's outside option is zero), the lower the price that he is willing to offer: this can be seen by noticing that by Equation (8) $p_s^{o_1} > \beta(v_g - \omega)$.

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

$$\overline{p}_s^o(\gamma) = \gamma p_s^{o_1} + (1-\gamma)p_s^o. \tag{10}$$

Since $p_s^{o_1} < p_s^o$, the average price $\overline{p}_s^o(\gamma)$ 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_b^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_b^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, Cramton, and Deneckere, 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_b^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:

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

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

Having characterized the hedger's trading strategy, we can calculate the seller's expected profit under disclosure ($d=1$) when the market is less than fully transparent ($\gamma < 1$). Since the seller places no value on the asset, his profit coincides with the selling price. If $\mu \geq \underline{\mu}$, so that the hedger is present in the market, the asset is sold to the speculator at the expected price $\overline{p}_s^o(\gamma)$ in Equation (10) or to the hedger at the price p_h^o in Equation (11). Specifically, the speculator manages to buy if he is the first to be matched with the seller and the asset value is high (which occurs with probability $\frac{1-\mu}{2}$) or if he comes second but the hedger mistakenly refrained from buying the asset (which happens with probability $\frac{\mu(1-a_h^*)}{4}$). The hedger instead buys only if he comes first and judges the asset value to be high (which happens with probability $\frac{\mu}{2}$). If instead $\mu < \underline{\mu}$, the asset can be sold only to the speculator in the good state at price $\beta(v_g - \omega_s)$. Therefore, when the market is not fully transparent, under disclosure the seller's expected profit is:

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

Recalling that both the expected price offered by the speculator $\overline{p}_s^o(\gamma)$ 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 the two graphs shown in Figures 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

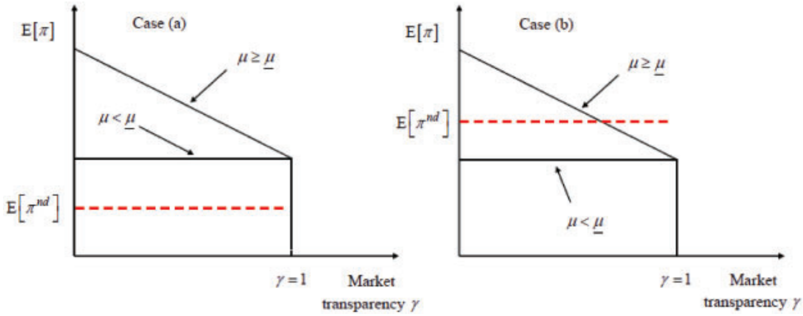

Figure 2. Financial disclosure and market transparency.

could capture the entire trading surplus by making a take-it-or-leave-it bid ($\beta = 0$ in Proposition 1).

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

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

Proposition 5 (Financial disclosure and market transparency) (i) When the fraction of hedgers is sufficiently high ($\mu > \underline{\mu}$), the issuer's net benefit from disclosure is decreasing in the degree of market transparency γ. (ii) Otherwise ($\mu < \underline{\mu}$), the issuer's benefit from disclosure is independent of the degree of market transparency γ.

Proposition 5 shows that the issuer considers financial disclosure and market transparency as substitutes: he will always disclose more information in a more opaque market than in a more transparent one. It is important to emphasize that for these results we do not need to assume that the investors observe a failed transaction: the mere absence of a past transaction conveys information to investors about the willingness to pay of other potentially more sophisticated market participants.

Our results differ considerably from the mainstream literature on market transparency (Glosten and Milgrom, 1985; Kyle, 1985; Chowhdry and Nanda, 1991; Madhavan, 1995, 1996; Pagano and Roell, 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.[24] Speculators cannot fully exploit their

24 Note that this result also differs from those of the existing models of the primary market, where opacity damages the seller (see, e.g., Rock, 1986).

superior processing ability, whereas 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 nonanonymous 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 nonanonymous 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, Moinas, and Theissen (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 discusses how the previous analysis can be extended in three different directions. The Online Appendix of this article analyzes in detail these extensions and proves some of the results discussed below.

Information acquisition: In practice investors, particularly sophisticated ones, may privately acquire information about the value of the asset, especially when the issuer releases no public news about the asset. We find that when speculators can acquire information privately, the seller's expected profits are always lower than they are under disclosure, that is, $\mathbb{E}[\pi^{ia}] < \mathbb{E}[\pi^{d}]$. Moreover, the issuer has a greater incentive to disclose information in the first place (see Section A of the Online Appendix). Intuitively, when only speculators have access to a private signal about the asset's value, hedgers are even more disadvantaged relative to speculators than in the baseline model, and will bid more cautiously even when they are the first to be matched with the seller. This explains why the seller's expected profits are greater under disclosure than under private information acquisition.

Market structure: While the model assumes a single seller, it can be used to explore how the equilibrium would change with competition between sellers. The model can capture more competition between sellers by increasing the parameter β that captures investors' bargaining power. In a perfectly competitive market, where for instance two sellers try to sell the same asset to investors and compete à la Bertrand, β would equal 1, so that all the gains from trade would be captured by investors.

Market structure may also feature segmentation, whereby one seller might find it optimal to cater to the institutional investors in the market (speculators) and the other seller might deal with exclusively the retail investors (the hedgers). In this way, they would both reduce competition and avoid the information externality. However, for this to be an equilibrium it must be true that the sellers have an incentive to focus on one part of the market or the other, that is, they may credibly precommit to serve only one type of trader: this turns out to be true only when the reservation values of the two investors are not too far apart, that is, when the expected profits in the two segments are similar (see Section B of the Online Appendix).

Privately informed seller: In the model, the seller is assumed to be uninformed about the value of the asset, or equivalently, be 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 $v \in \{v_g, v_b\}$ before the signal is disclosed to the market. This extension introduces asymmetric information between the seller and the hedgers, on top of the asymmetry between hedgers and speculators. One can show that even in this case the issuer's optimal disclosure policy is very similar to the one described in Proposition 5, in that there is still substitutability between disclosure and market transparency (see Section C of the Online Appendix).

In this setting, the very choice of disclosure may serve as a signal about the asset's quality if it is a costly decision. In fact, the equilibrium would unravel as the investors could infer the quality of the asset by observing the disclosure choice rather than processing the signals directly.

Finally, if the dealer is not only privately informed about the value of the asset but also has an incentive to retain it, there is adverse selection in the market, because buyers know that on average they would end up with a low-quality asset more frequently than when the dealer does not want to retain the asset. Thus, in this case disclosing a signal about the value of the asset would dampen the adverse selection in the market rather than exacerbate it as in our model, which means that the buyers would make fewer mistakes, increasing their willingness to pay and the seller's expected price. Therefore, in this case disclosure might be welfare improving.

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 $\mu = 0$). We use the expected aggregate trade surplus as welfare metric.

6.1 Market Transparency

There are several reasons why regulators might want to increase market transparency—to monitor the risk exposure of financial institutions, say, or to enable investors to gauge counterparty risk. Nevertheless, our analysis points to a surprising effect of greater transparency: it might reduce the issuer's incentive to divulge information. This effect stems from the endogeneity of the decision and the way in which it depends on market transparency 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 in the right-hand-side graph of Figure 2 (case b), the seller will decide to conceal the signal σ, making the policy ineffective. In this case, in fact, speculators will abstain from trading, and the heightened transparency will actually reduce the information contained in the price. This will affect the hedgers' trading decision adversely, as they will have no information on which to base their decisions.

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

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

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

6.2 Mandating Disclosure

In this section, we analyze the conditions under which the regulator should make disclosure compulsory when the market is fully transparent, that is, $\gamma = 1$. We assume the regulator wishes to maximize the sum of market participants' surplus from trading, defined as the difference between the final value of the asset and the reservation value placed on it by the relevant buyer. In this section, we relax the assumption maintained so far that the seller has the same bargaining power when trading with hedgers and with speculators, because—as we shall see below—the relative magnitudes of β_h and β_s are key in determining whether issuers over- or under-provide information, in the absence of any policy intervention.

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

$$\mathbb{E}[S^{nd}] = \overline{v} - \omega_h, \tag{12}$$

while under disclosure it is

$$\mathbb{E}[S^d] = \mu\mathbb{E}[S_h^d] + (1-\mu)\mathbb{E}[S_s^d], \tag{13}$$

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

$$\mathbb{E}\left[S_h^d\right] = \left[\frac{1+a_h^*}{4}\left(v_g-\omega_h\right) + \frac{1-a_h^*}{4}\left(v_b-\omega_h\right) + \frac{1-a_h^*}{4}\left(v_g-\omega_s\right)\right] - \frac{\theta a_h^{*2}}{2}. \tag{14}$$

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

$$\mathbb{E}\left[S_s^d\right] = \frac{v_g-\omega_s}{2}, \tag{15}$$

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

Using expressions (12–15), one can compute the net social benefit from disclosure $\Delta = \mathbb{E}[S^d] - \mathbb{E}[S^{nd}]$, and characterize its determinants. Clearly, the higher is the unconditional expectation of the asset's value, the lower is the net benefit that society gains from disclosure and the implied learning, as can be immediately seen from the fact that the expected surplus under no disclosure $\mathbb{E}[S^{nd}]$ is increasing in $\overline{v}$. Conversely, disclosure increases the gains from trade insofar as it induces both the hedger and the speculator to bid more aggressively for high-valued assets. This occurs when the hedgers' financial literacy $1/\theta$ and the asset volatility $v_g - v_b$ are high, so that hedgers choose to devote high attention a_h^* to the signal σ; high asset volatility also increases the speculators' willingness to pay for high-quality assets. To summarize:

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

Clearly, depending on parameters, the net social benefit from disclosure Δ may be positive or negative. The interesting issue is whether Δ has the same or the opposite sign of issuers' private gain from disclosure $G = \mathbb{E}[\pi^d] - \mathbb{E}[\pi^{nd}]$, that is, the difference between their expected profit under disclosure (Equation (A.7)) and under no disclosure (Equation (6)). When the net social surplus Δ and the private gain G from disclosure are both positive or both negative, the disclosure choice made by issuers is aligned with social efficiency; if instead $\Delta > 0$ and $G < 0$, issuers under-provide information, while if $\Delta < 0$ and $G > 0$, they over-provide it compared to what a regulator would want. There are three reasons why the regulator's gain from disclosure may differ from the seller's. First, the planner ignores the distributional issues driven by the bargaining protocol, so bargaining power does not affect the expected social gain directly: it does so only indirectly via the attention level chosen by hedgers. Second, the planner considers that disclosing information means the hedgers must investigate it, which is costly. Third, the regulator does not directly consider the externality generated by the speculators' superior processing ability and its effect on the seller's profit. This affects the social surplus only when it would be efficient for the seller to trade with the hedger, because of the latter's lower reservation value ω_h, and instead the asset is sold to a speculator.

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

Proposition 6 (Optimal disclosure policy) If the seller has greater bargaining power when trading with hedgers than with speculators ($\beta_h > \beta_s$), then both under- and over-provision of information can occur in equilibrium; otherwise ($\beta_h \leq \beta_s$), under-provision cannot occur.

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

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

6.3 Licensing Access

In practice, policy makers also have other instruments to regulate financial markets so as to maximize the expected gains from trade. Stephen Cecchetti, 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 license, 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.[25] 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.

To analyze this policy, let us revert to the assumption earlier in the article that the seller has the same bargaining power when trading with hedgers and with speculators, that is, $\beta_b = \beta_s = \beta$. By Proposition 6, we know that under this assumption there is never a rationale to mandate disclosure, as issuers either provide information efficiently or even over-provide it. But in this case it may be efficient for the regulator to adopt a different policy: allow disclosure but limit market access to speculators who, upon getting the signal σ, forecast the asset's value perfectly and incur no processing costs. Limiting access to speculators is socially efficient when the expected surplus generated by trading with them

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

(Equation (15)) exceeds the expected gain (Equation (13)) generated by the participation of all types of investors. The relevant condition is

$$\frac{v_g - \omega_s}{2} > \mu\left[\frac{1+a_b^*}{4}v_g + \frac{1-a_b^*}{4}v_b - \frac{\omega_b}{2} + \frac{1-a_b^*}{4}\left(v_g - \omega_s\right) - \frac{\theta a_b^{*2}}{2}\right] + (1-\mu)\frac{v_g - \omega_s}{2}, \tag{16}$$

which leads to the following proposition:

Proposition 7 (Banning hedgers from trading) Making market access exclusive to speculators is welfare-improving when financial literacy $1/\theta$ is low and the expected value $\overline{v}$ of the asset is low.

Proposition 7 indicates that it may be socially efficient to limit access to speculators alone, because this saves hedgers from the high processing costs incurred when information is difficult to digest.

However, restricting access is not always optimal. In particular, it is inefficient when even hedgers are financially skilled or the asset is simple (high $1/\theta$) and has high expected value (high $\overline{v}$): in this case, the expected gains from trade are greater when all investors participate and it is less likely that hedgers will buy the asset when it is not worth it. Finally, volatility $v_g - v_b$ has ambiguous effects on the regulator's incentive to exclude hedgers: on the one hand, it raises the costs associated with their buying a low-value asset, and hence the regulator's interest in keeping them out of the market; on the other hand, it induces hedgers to step up their attention level, making the regulator more inclined to let them in.

7. Conclusion

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

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

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

Third, we show that issuers have more incentives to disclose when, absent disclosure, speculators can privately acquire a signal about the asset's value. Intuitively, this is a consequence of the more severe information disparity among investors that emerge in this case.

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

Appendix: Omitted Proofs

Proof of Proposition 1 (Bargaining outcome). We first solve the bargaining stage of the game taking the seller's outside options as given. Then we compute these outside options to get the equilibrium prices. Let us restate the Nash bargaining problem of the two investors:

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

Solving for p_i, we obtain

$$p_i = \beta(\hat{v} - \omega_i - \overline{\omega}_i) + \overline{\omega}_i, \tag{A.1}$$

where $\hat{v}$ is the investor's estimate of the value of the asset and $\overline{\omega}_i$ 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

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

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

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

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

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

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

$$\overline{\omega}_h = \begin{cases} \beta\dfrac{1+a_h}{2}(v_g - \omega_s) \text{ if } \sigma = v_g, \\ \beta\dfrac{1-a_h}{2}(v_g - \omega_s) \text{ if } \sigma = v_b. \end{cases} \tag{A.2}$$

Substituting expression (A.2) into expression (A.1) yields the equilibrium price paid by the hedger:

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

as stated in the proposition.

Proof of Proposition 2 (Choice of attention). Given the bargaining protocol, the hedger captures only a fraction $1-\beta$ of the trading surplus, so his expected payoff is

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

where expression (A.2) is used in the last step.

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

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

The solution is

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

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

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

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

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

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

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

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

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

$$\frac{1-\beta}{2}\left[\overline{v} - \omega_h - \frac{1+a}{2}\frac{v_g - v_b}{2}\beta + \frac{a}{2}\left(v_g - v_b\right)\right] - \theta\frac{a^2}{2} > (1-\beta)(\overline{v} - \omega_h), \tag{A.3}$$

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, that is, make any effort to understand the signal: $a_h^* = 0$. Condition (A.3) can be re-written as follows:

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

which shows that for sufficiently high values of asset volatility $v_g - v_b$, it becomes optimal for the hedger to buy only upon seeing a positive signal. Notice that when this condition holds, the hedger will want to buy the asset, since he expects a positive payoff $u(a_h^*)$, the left-hand expression in inequality (Equation (A.3)) being positive (since $\overline{v} - \omega_h > 0$).

Proof of Proposition 3 (Choice of financial disclosure). Let us consider the two terms in expression (7). The first refers to the case in which the seller first meets the hedger, and is equal to

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

where p_h^d and p_s^d are the equilibrium prices defined by Proposition 1. With probability $(1+a_h^*)/4$ the value of the asset is v_g and the hedger observes a congruent signal v_g, while with probability $(1-a_h^*)/4$ the value of the asset is v_b but the hedger observes the incorrect signal v_g where the probability a_h^* is defined by Proposition 2. Hence, the hedger finds it profitable to buy the asset at the price p_h^d with probability 1/2. With probability $(1-a_h^*)/4$, instead, the asset's value is v_g but the signal received by the hedger is v_b, in which case he does not trade, so the asset ends up being bought by the speculator at price p_s^d.

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

$$\mathbb{E}\left[\pi_s^d\right] = \frac{1}{2}p_s^d. \tag{A.5}$$

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 (A.4) and (A.5), the expression (7) for the seller's expected profits under disclosure becomes:

$$\mathbb{E}\left[\pi^d\right] = \frac{\mu}{2}\left(p_h^d - \frac{1+a_h^*}{2}p_s^d\right) + \frac{1}{2}p_s^d. \tag{A.6}$$

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

$$\begin{aligned}
\mathbb{E}\left[\pi^d\right] &= \mu\left(\frac{p_h^d}{2} + \frac{1-a_h^*}{4}p_s^d\right) + (1-\mu)\frac{1}{2}p_s^d \\
&= \frac{\mu}{2}\left[\beta(\hat{v} - \omega_h) + (1-\beta)\frac{1+a_h^*}{2}p_s^d + \frac{1-a_h^*}{2}p_s^d\right] + (1-\mu)\frac{1}{2}p_s^d \\
&= \frac{\mu}{2}\beta\left[(\omega_s - \omega_h) + a_h^*\frac{v_g - v_b}{2}\right] + \left[\frac{\mu}{2}(1-\beta)\frac{1+a_h^*}{2} + \frac{\mu}{2}\frac{1-a_h^*}{2} + \frac{1-\mu}{2}\right]p_s^d \\
&= \frac{\mu}{2}\beta(\omega_s - \omega_h) + \left[\frac{\mu}{2}a_h^* + \frac{\mu}{2}(1-\beta)\frac{1+a_h^*}{2} + \frac{\mu}{2}\frac{1-a_h^*}{2} + \frac{1-\mu}{2}\right]\beta\frac{v_g - v_b}{2} \\
&= \beta\left\{\frac{\mu}{2}(\omega_s - \omega_h) + \left[(1-\mu) + \mu\left(1 - \frac{\beta}{2}\right)(1+a_h^*)\right]\frac{v_g - v_b}{4}\right\}
\end{aligned} \tag{A.7}$$

where in the second step we have substituted the expressions for the price p_h^d, in the third we have used the expression for $\hat{v}$ and imposed the restriction $\omega_s = \overline{v}$ on the speculator's outside option, in the fourth we have used the expression $p_s = \beta(v_g - v_b)/2$, and in the fifth we have rearranged the expression. The issuer's choice on disclosure depends on the difference between the expected profit under disclosure (Equation (A.7)) and under no disclosure (Equation (6)):

$$\mathbb{E}[\pi^d] - \mathbb{E}[\pi^{nd}] = \tag{A.8}$$

$$\begin{aligned} &= \beta\left\{\frac{\mu}{2}(\omega_s - \omega_h) + \left[(1-\mu) + \mu\left(1 - \frac{\beta}{2}\right)(1 + a_h^*)\right]\frac{v_g - v_b}{4}\right\} - \beta(\overline{v} - \omega_h) \\ &= \beta\left\{\left[(1-\mu) + \mu\left(1 - \frac{\beta}{2}\right)(1 + a_h^*)\right]\frac{v_g - v_b}{4} - \left(1 - \frac{\mu}{2}\right)(\omega_s - \omega_h)\right\}, \end{aligned} \tag{A.9}$$

where we have again imposed the restriction $\omega_s = \overline{v}$. Expression (A.8) is clearly increasing in the volatility parameter $v_g - v_b$ and in the hedger's choice of attention a_h^*, which by Proposition 3 is increasing in volatility $v_g - v_b$ and in financial literacy $1/\theta$. Hence, volatility has two effects: first, a direct positive effect via prices, as shown by the fraction multiplying the term in the square parenthesis; and second, an indirect positive effect via the attention allocation a_h^*. The financial literacy measure $1/\theta$ affects the issuer's expected profit only through its positive effect on the optimal choice of attention a_h^*. Finally, expression (A.8) is decreasing in the difference between the speculator's and the hedger's reservation values, $\omega_s - \omega_h$, which is a measure of the hedger's relative appetite for the asset.

Proof of Proposition 4 (Hedgers' participation decision). In the case, in which the market is transparent, which occurs with probability 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

$$\hat{\mu} = \begin{cases} \dfrac{\mu}{\mu + (1-\mu)/2} & \text{if } p_h^o \geq p_s^o, \\ 0 & \text{if } p_h^o < p_s^o, \end{cases} \tag{A.10}$$

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

Hence, the hedger faces a new adverse selection problem: if his bid price is below 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

$$\begin{aligned} p_h^o = p_s^o &= \eta p_s^{o_1} + (1-\eta)\beta(v_g - \omega_s) \\ &= \eta\left(\beta(v_g - \omega_s) + (1-\beta)\frac{1+a_h}{2}p_h^o\right) + (1-\eta)\beta(v_g - \omega_s) \\ &= \beta(v_g - \omega_s) + \eta(1-\beta)\frac{1+a_h}{2}p_h^o \\ &= \frac{\beta(v_g - \omega_s)}{1 - \eta(1-\beta)\frac{1+a_h}{2}}, \end{aligned}$$

where in the second line we have substituted the expression for the price $p_s^{o_1}$ 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:

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

where the first term refers to the expected value when the hedger is the first to be matched with the seller, and the second to the value when he is the second. Since $\hat{v} > v_b$, 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 $\hat{\mu}$ sufficiently pessimistic: denoting by $\underline{\mu}$ the threshold such that $\Gamma(\underline{\mu}) = 0$, for any $\mu < \underline{\mu}$ the hedger will not want to participate in the market. Such a cutoff $\underline{\mu}$ exists and is unique because $\Gamma(0) = v_b - \omega_h - p_h^o < 0$, and when $\mu = 1$ the expected payoff for the hedger is $\Gamma(1) = \hat{v} - \omega_h - p_h^o$, which is positive as long as there are gains from trade, that is, whenever the hedger observes a good signal. Then the strict monotonicity of $\Gamma(\mu)$ ensures that there exists a unique cutoff $\underline{\mu}$, defined by $\Gamma(\underline{\mu}) = 0$, such that trade occurs at a positive price whenever $\mu > \underline{\mu}$.

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

Proof of Proposition 5 (Financial disclosure and market transparency). Point (i) of the proposition follows from the fact that when $\mu > \underline{\mu}$ the issuer's expected profit is

$$\begin{aligned} \mu\mathbb{E}[\pi_h^o] + (1-\mu)\mathbb{E}[\pi_s^o] &= \mu\frac{1+a_h}{2}p_h^o(\gamma) + \left(\frac{(1-\mu)}{2} + \mu\frac{1-a_h}{2}\right)\overline{p}_s^o(\gamma) \\ &= \mu\frac{1+a_h}{2}\frac{\beta(v_g-\omega_s)}{1-\eta(1-\beta)\frac{1+a_h}{2}} + \left(\frac{(1-\mu)}{2} + \mu\frac{1-a_h}{2}\right)\left[\gamma p_s^{o_1} + (1-\gamma)p_s^o\right], \end{aligned}$$

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

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

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

as $\frac{\mathrm{d}\mathbb{E}[\pi_s^o]}{\mathrm{d}\gamma} < 0$ 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 Remark 1 (Optimal disclosure policy). From expressions (12–15), one obtains the following expression for the social net benefit from disclosure:

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

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

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

the previous expression can be rewritten as follows:

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

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

Proof of Proposition 6 (Optimal disclosure policy). First of all, notice that from the proof of Remark 1, the social net benefit from disclosure can be rewritten as

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

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

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

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

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

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

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

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

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

$$\iff \quad \frac{1 - \dfrac{(2-\mu\beta_h)\beta_s}{(2-\mu)\beta_h}}{4} > \frac{2(2 - 3\beta_s/2 - \beta_h + \beta_h\beta_s/2)}{2-\mu}\frac{\mu(1-\beta_h)(1-\beta_s/2)}{32\theta}(v_g - v_b).$$

First, notice that for $\beta_s \geq \beta_h$ this condition is never satisfied. To see this, consider that under this condition the left-hand side is negative, whereas the right-hand side is positive. Hence, when the seller's bargaining power with the speculator is at least as high as with the hedger, under-provision of information can never arise. Conversely, when $\beta_s < \beta_h$, this condition can be satisfied, so that under-provision of information can arise, as we show below with numerical examples. In fact, since the right-hand side is increasing in the hedgers' financial literacy $1/\theta$ and in the asset's volatility $v_g - v_b$, under-provision of information is more likely to arise if $1/\theta$ and $v_g - v_b$ are low (and, therefore, the hedgers' attention level a_h^* is low), as stated in the comparative statics discussed in the text after Proposition 10.

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

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

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

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

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

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

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

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

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

there is under-provision:

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

while for high enough volatility:

$$v_g' = 500, v_b' = -30, \mu = 0.5, \theta = 20, \beta_s = 0.85, \beta_b = 0.9, \omega_b = 86.5, a_b = 0.38,$$

there is over-provision of information:

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

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

$$v_g = 30, v_b = -5, \mu = 0.5, \theta' = 1, \beta_s = 0.85, \beta_b = 0.9, \omega_b = 2.3, a_b = 0.503,$$

which entails:

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

Proof of Proposition 7 (Banning hedgers from trading). The regulator will want to restrict market participation to the speculators when the resulting expected loss $\mathbb{L}$ is negative; that is, from condition (16)

$$\mathbb{L} \equiv \frac{\overline{v}}{2} - \frac{\omega_b}{2} + \frac{a_b^*}{8}\left(v_g - v_b\right) - \frac{v_g - v_b}{8} - \theta\frac{a_b^{*2}}{2} < 0. \tag{A.11}$$

Using the hedger's equilibrium attention level a_b^* in Proposition 2, the condition (A.11) can be rewritten as follows:

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

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

Supplementary Material

Supplementary data (the Online Appendix about the extensions in Section 5) are available at *Review of Finance* online.

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