Financial Disclosure with Costly Information Processing

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Abstract

We analyze a model where some investors ("hedgers") are bad at information processing, while other ("speculators") trade purely to exploit their superior information processing ability. Disclosure of signals about the asset's value induce an externality: as speculators understand the signals' pricing implications, their decision to abstain from trading will be imitated by hedgers, depressing the asset's equilibrium price compared to its no-disclosure level. Market transparency will reinforce this mechanism, by making speculators' trades more visible to hedgers. Hence asset sellers will oppose both disclosure and market transparency. This policy is socially inefficient whenever speculators are a large fraction of the market and hedgers' processing costs are low. In these circumstances, an alternative to mandating disclosure is forbidding hedgers access to the market.

1 Introduction

The transparency of financial markets has two quite different dimensions. The first concerns the amount and precision of fundamental information about assets' payoffs disclosed to investors via security listing prospectuses, the presentation of accounting data, the publication of credit ratings, etc. The second dimension of transparency instead has to do with security trading: how much investors know about recent trades or about the conditions at which a new order may execute. In a nutshell, the first dimension refers to asset fundamentals, the second to the trading process. While distinct – and analyzed as such by scholars in accounting and in market microstructure, respectively – these two notions of transparency are quite related in practice: information about fundamentals affects security prices, but the transparency of the trading process determines how and when it is priced into assets.

Thus, it is not surprising that the recent financial crisis has brought both of these notions of transparency under the spotlight. The opacity of the structure and payoffs of structured debt securities, as well as the lack of information regarding the amount of toxic assets in the balance sheets of banks, are blamed as key reasons for the freezing and persistent illiquidity of fixed income and interbank markets, respectively. These are examples of low transparency about fundamentals. But the crisis has also highlighted the growing importance of off-exchange trading, with many financial instruments such as mortgage-backed securities, collateralized debt obligations and credit default swaps being traded in very opaque over-the-counter (OTC) markets, where very little is known about the positions of traders and even about the execution prices of recent trades. These are examples of low transparency of the trading process, even though they often refer to the same securities that are also opaque in the first sense.

In this paper, we propose a tractable model where the effects on market prices and economic efficiency of both forms of transparency can be analyzed jointly, while taking into account two important features of real-world markets – that (i) financial information is costly to process and (ii) not everyone is equally good at processing it. Taking these two features into account produces quite novel results, compared to the received wisdom. Generally, increasing public information about security fundamentals is taken to be beneficial because it should reduce the adverse selection problems created by asymmetric information in securities markets. Many market microstructure models support a similar prediction regarding the transparency of the trading process: when more is known about the trading process, it is easier to gauge the presence and strategies of informed traders, hence adverse selection is reduced also on this account. These adverse selection costs should be priced into the initial price at which assets can be sold, so that both form of transparency should ultimately benefit the sell side of the market.

In contrast to these traditional insights, we show that in search markets (such as OTC ones) information disclosure might not always be beneficial, because not all market participants are able to incorporate the available information in the asset's valuation. In our model, when investors receive new fundamental information before trading, they must decide how much attention to pay in order to gauge its pricing implications, balancing the benefits of this understanding for their trading decisions with the costs of increased attention. We show that, when investors differ in their processing ability, releasing information tends to damage in for two reasons. First, it forces all investors to invest more resources to understand the pricing implications of the new information, updating their estimates of asset values. Second, disclosure *endogenously* generates adverse selection: in a search market: investors with limited processing ability will be naturally concerned that, if the asset has not been already traded by others, it might be because the more sophisticated investors, who had an informational advantage in predicting the asset's value, discovered that its value is too low to buy. This depresses the price that unsophisticated investors are willing to offer to the seller; but then sophisticated investors, anticipating that the seller will have a hard time finding a buyer among the unsophisticated, will in turn offer a price lower than that they would offer if they were the only buyers.

On both accounts, therefore, sellers should have little incentives to release information. However, releasing information also helps investors guarding against making costly mistakes in their trades, and under this respect it stimulates investors' demand for the asset. Hence, in deciding about information disclosure, sellers face a trade-off: on the one hand, disclosure encourages demand for the asset, because it protects unsophisticated investors from too large errors in trading; on the other hand, it leads to the possibility of selling to a speculator, who will appropriate a higher fraction of the expected surplus because he can exploit his superior processing ability and the pricing externality that this advantage entails.

Interestingly, the magnitude of the pricing externality set in motion by greater disclosure of fundamentals is crucially affected by the degree of transparency of the trading process, because this makes unsophisticated investors more keenly aware of the trades (or lack thereof) of more sophisticated investors, and therefore encourages the former to mimic the trades of the latter more closely. In equilibrium, this increases the price concession that sophisticated investors can inflict on asset sellers, so that the latter will be averse to trading transparency. Indeed, the interaction between the disclosure of fundamental information and trading transparency creates a *substitutability* between the two from the stand point of asset sellers: these will be more willing to disclose information about the asset's value if they can expect the trading process to be more opaque. In this case, the adverse selection caused by the disclosure of news is mitigated by the possibility that the order flow is not observed by investors.

Another departure from the previous literature is that in most market microstructure models opacity tends to redistribute wealth from uninformed to informed investors, while in our model it may damage both types of investors and improve the position of the seller. Sophisticated investors miss the chance to exploit their superior processing ability, and less sophisticated ones make more trading mistakes, both because they have less fundamental information and because they cannot observe previous trades to update their beliefs about the asset's value.

The model can also be used to address a number of pressing policy questions: how much information should be released when processing it is costly? Are seller's incentives to disclose information aligned with those of regulators? When should regulators force disclosure? How does mandatory disclosure compare with a policy where only qualified investors are licensed to buy complex securities?

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

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

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

These insights build upon the difference between the information disclosed to the market and that digested by market participants. This difference naturally arises in many situations and has already drawn the attention of the regulator. For example, U.S. the information that U.S. disclose to analysts and shareholders is subject to *Regulation Fair Disclosure*, promulgated by the SEC in 2000, which prohibits firms from disclosing it selectively. The effect of this regulation is not obvious: some have argued that they may be perverse: Bushee, Matsumoto, and Miller (2004) argue that "Reg FD will result in firms disclosing less high-quality information for fear that [...] individual investors will misinterpret the information provided".[1] We provide a rationale for why selective disclosure may be attractive for sellers, yet socially detrimental. In our model the seller has an incentive to disclose information only to sophisticated investors, because this would maximize their participation to the market and, at the same time, would not induce the endogenous adverse selection problem discussed above. But the policy maker also cares about the trading errors incurred by unsophisticated investors, which would inevitably become larger if they do have access to fundamental information.[2]

This paper is related to a growing literature on costly information processing by economic agents, started by Sims (2003) and Sims (2006) who

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

[2] Related issues arise in central banking, where the quest for transparency about the transcripts of policy committee meetings must be balanced with the danger that the arguments behind policy decisions may be misinterpreted by some market participants. See for example Woodford (2005). Winkler (2000) and Carpenter (2004) argue that the potential for misunderstanding by the market greatly affects the effectiveness of a central bank's policies and central banks are therefore naturally concerned about the risks involved in disclosing information.

argue that agents are unable to process all the available information, explaining in this way the observed inertial reaction to external information. Subsequent work by Peng and Xiong (2006), Van Nieuwerburgh and Veldkamp (2009) and Van Nieuwerburgh and Veldkamp (2010) have analyzed various information constraints in monetary policy as well as in portfolio choice problems.[3] Our model differs in many respects. Instead of assuming information capacity constraints we propose a simpler model of limited cognition where investors can increase the precision of the available information, but at a cost. Moreover, we focus on the strategic interactions triggered by information disclosure and on its policy implications.

The assumption that information processing is costly squares with a large body of empirical evidence both in psychology, economics and accounting. Pashler and Johnston (1998), for example, summarize supporting evidence that the central cognitive processing ability of the human brain has limits. Yantis (1998) reviews the psychological studies, that suggest that attention can be directed by people's deliberate strategies and intentions. Moreover, Libby, Bloomfield, and Nelson (2002) and Maines (1995) provide surveys of experimental research on financial information processing, whereas Daniel, Hirshleifer, and Teoh (2002) survey the evidence consistent with limited attention affecting securities prices. There is also evidence that limited attention affects portfolio choices: Christelis, Jappelli, and Padula (2010) investigate the relationship between household portfolio composition in 11 European countries and indicators of cognitive abilities drawn from the Survey of Health, Ageing and Retirement in Europe (SHARE), and find that the propensity to invest in stocks is strongly associated with cognitive abilities and is driven by information constraints, rather than by features of preferences or psychological traits. Also the accounting literature recognizes a discrepancy between the information released to the market and the information digested by market participants: Barth, Clinch, and

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

Shibano (2003) and Espahbodi, Espahbodi, Rezaee, and Tehranian (2002), among others, distinguish between information disclosure and recognition, and observe that the latter has a larger empirical impact than the former, presumably a reflection of a better understanding of the disclosed information.

Just as in Tirole (2009), our model does not assume bounded rationality: in his framework information processing costs rationally lead to incomplete contracts, which impose costs on them; similarly, in our setting unsophisticated investors rationally decide how much information they wish to process, being aware that choosing a low level of attention may lead to mistakes in their trading strategies.

The detrimental effects of news releases have been recently recognized by Morris and Shin (2010). They argue that even a small amount of adverse selection in asset markets can lead to the total breakdown of trade. Moreover, they argue that "When common understanding is important [...] if the greater precision of information leads to an exacerbation of externalities in the use of information that detracts from overall welfare". Our model provides a framework to understand under which conditions information disclosure may exacerbate these externalities, although in our setting the implication is not market freeze but underpricing.

Our result that financial disclosure might have perverse effects for asset sellers also parallels the finding by Pagano and Volpin (2010), who show that financial disclosure has two opposite effects on the initial sale price of an asset: on one hand, disclosure increases the informational disadvantage of unsophisticated investors, inducing them to require a price concession in the primary market; on the other hand, once the information is out, the secondary market for these securities will become more liquid, which is valuable for investors who need to resell them. Thus, in that setting the sellers' incentive to disclose depends on the balance between the effects of disclosure on primary market underpricing and those on secondary market liquidity. In contrast, in the present setting the tradeoff does not require retrading of the security: the costs of disclosure arise from the information processing costs that it imposes on investors as well as from the strategic interaction among them, while its benefits arise from its contribution to avoiding mistaken portfolio choices. Moreover, our current setting models how different types of investors rationally choose their level of attention as a function of their information processing costs, and these costs play a key role in the design of regulation.

Finally, Dang, Gorton, and Holmstrom (2009) have also noted that opacity may have beneficial insofar as it reduces informational asymmetries, but they mainly concentrate on the security design implications of this insight: they observe that debt, being less information sensitive than other assets, provides least incentive to private information production and therefore is less exposed to adverse selection problems, except in bad aggregate states of the world, where information production may becomes worthwhile even for debt. In contrast, in this paper we focus on the effect that investors' heterogeneous processing ability has on the costs and benefits of transparency about fundamentals and about the trading process, and on the extent to which the incentives of sellers in the choice of transparency differ from those of a benevolent regulator.

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

2 The Model

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

The value of the asset, v, can take one of two equally likely values $v \in \{v_b, v_g\}$ where $v_b < 0 < v_g$ and $v^e \equiv (v_g + v_b)/2$.[4] Each investor i has a reservation value ω_i that is independent from v. Therefore, the net value from purchasing the asset for investor i is $v - \omega_i$.

Once the seller is matched with a buyer, they negotiate a price and trade will occur whenever the buyer expects to gain a surplus: $\mathbb{E}(v - \omega_i \mid \Omega_i) > 0$, where Ω_i is the buyer i's information set. Let $\beta_i \in (0, 1)$ be the probability the seller makes the offer. If an offer is rejected, the traders part and the seller continues searching; if the offer is accepted, exchange occurs.[5] This bargaining protocol is equivalent to the generalized Nash solution. Then, trade occurs at a price such that the seller captures a fraction β_i and the

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

[5]Note that in this bargaining problem, we assume that there is complete information about a buyer's valuation for the asset. This assumption simplifies the analysis because bargaining under incomplete information is a hard problem to deal with in a search-and-matching model. The same assumption is adopted by Miao (2006).

investor a fraction $1 - \beta_i$ of this expected surplus, where β_i measures the seller's bargaining power, which in turn may be taken to reflect the seller's impatience relative to that of buyers. Real-world examples of this setting are over-the-counter (OTC) markets and housing markets, where matching via search gives rise to a bilateral monopoly at the time of a transaction.[6]

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

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

We assume that there are two types of investors, i.e. $i \in \{h, s\}$. A fraction μ of them are unsophisticated ("hedgers"), who face a cost $\theta_h = \theta > 0$ in information processing, whereas the remaining $1 - \mu$ are sophisticated "speculators" who face no such costs: $\theta_s = 0$. (The model easily generalizes to the case where also speculators have positive information-processing costs or there are more than two types of investors.) The two types of in-

[6]See Duffie, Garleanu, and Pedersen (2005).for a search-cum-bargaining model of trading in OTC markets.

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

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

The timing of the game is the following:

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

2. An investor is randomly matched to the seller.

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

4. The investor decides whether to trade or not.

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

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

Note that at the final stage of the game we assume complete market transparency, since trades are observed by all market participants. However, one of the main results of the paper is obtained precisely by relaxing this assumption: in section 3.4 we shall assume that trades can be imperfectly observed by other investors, so that we shall be able to explore how reducing market transparency affects the equilibrium outcome.

3 Analysis

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

3.1 Bargaining

Let p_i and p_{ij} be the prices offered by investor i when he is the first bidder and when he bids after a type-j investor already dealt with the seller. For example, p_{hs} is the price offered by a hedger when the seller has been matched with a speculator in the previous stage. Since investors of type i are homogeneous, the only case to consider at stage 6 is that of an investor of a different type j being matched with the seller, because this is the only scenario where a trade might be profitable.[7]

The price offered by hedgers when they meet the seller solves the fol-

[7]This would be the case also if the seller could target investors: since investors of the same type have the same valuations, if the seller could not sell the asset to a type-i investor, he will seek a type-j investor, since no other type-i investor will offer a positive price for it.

lowing program:

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

where

$$p_{sh}(\sigma) = \begin{cases} \beta_s a \left(v_g - \omega_s\right) \text{ if } \sigma = \sigma_g, \\ \beta_s (1-a) \left(v_g - \omega_s\right) \text{ if } \sigma = \sigma_b \end{cases} \tag{2}$$

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

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

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

The weight assigned to the signal σ disclosed by the seller depends on the amount of attention a devoted by investors to the signal. In what follows, we conjecture that since processing the available information is costless for speculators, they choose $a_s^* = 1$, whereas hedgers's optimal choice is interior, i.e. $a_h^* \in [0,1)$.[8] Thus in equilibrium the speculators know the value of the asset, while hedgers hold a belief $\widehat{v}$ whose precision depends on the attention they devote to the available information.

Similarly, the price offered by speculators solves the following bargaining problem

$$p_s(v) \in \arg\max \left(p_s - p_{hs}(v)\right)^{\beta_s} \left(v - \omega_s - p_s\right)^{1-\beta_s} \tag{3}$$

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

where $p_{hs}(v)$ is the price offered by hedgers once speculators refuse to buy the asset. This refusal provides valuable information to hedgers, as they will use it to update their estimate of the asset's value, revising it down to v_b. Hence, they will themselves be unwilling to purchase the asset: their offer price will be $p_{hs}(v) = 0$. This information externality will in turn weaken the seller's bargaining position when dealing with the speculators, because it lowers his outside option. As a result, the speculators can buy the asset more cheaply than they could if hedgers do not observe their trading decision. In other words, even when $\beta_h = \beta_s$, the speculators' superior processing ability allows them to capture a higher fraction of the trading surplus due to the effect that their trading decision has on the hedgers' valuations.

Conversely, speculators do not learn from hedgers: since in equilibrium they have better information, they do not make any inference regarding the asset's value if they observe the hedgers not buying it. So observing past trades is irrelevant for them.

By solving problems (1) and (3), we obtain:

Lemma 1 *The prices offered by the two types of investors are*

$$p_h(\sigma) = \begin{cases} \beta_h \left(a v_g + (1-a) v_b - \omega_h\right) + (1-\beta_h) \beta_s a \left(v_g - \omega_s\right) & \text{if } \sigma = \sigma_h \\ \beta_h \left((1-a) v_g + a v_b - \omega_h\right) + (1-\beta_h) \beta_s (1-a) \left(v_g - \omega_s\right) & \text{if } \sigma = \sigma_l \end{cases}$$

and

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

It is important to realize that the price concession that speculators obtain as a result of hedgers imitating their behavior arises the hedgers' awareness of the speculators' superior information processing ability, which exposes hedgers to adverse selection. But this adverse selection effect is made possible by the public announcement made by the seller at the initial stage, since without such announcement speculators would lack the very opportunity to exploit their information processing advantage. Indeed, if there is no signal disclosure ($d = 0$), speculators do not participate to the market, because once they are matched to the seller their expected gains from trade are negative: $v^e - \omega_s < 0$. That is, it pays for them to be in the market only for information reasons. In this case, absent both the signal and the adverse selection problem, the price offered by hedgers will simply be a fraction of the unconditional expectation of their gains from trade:

$$p_h^{ND} = \beta_h \left(v^e - \omega_h \right).$$

3.2 Attention Allocation

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

In principle there are four different outcomes: the hedger may (i) never purchase the asset, (ii) always buy it, irrespective of the signal realization; alternatively, he can choose to buy the asset (iii) only when the signal is σ_g or (iv) only when the signal is σ_b. Proposition 1 characterizes the optimal attention allocation choice and shows that hedgers find it profitable to buy if and only if the realized signal is σ_g, that is, if the seller discloses "good news".

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

$$\max_{a \in [0,1]} a \left(v_g - \omega_h - p_h \left(\sigma_g, a \right) \right) + (1-a) \left(v_b - \omega_h - p_h \left(\sigma_g, a \right) \right) - \theta a^2, \quad (4)$$

where we bring out that the price that hedgers will offer at the bargaining stage is function of the attention choice. The solution to problem (4) is characterized as follows:

Proposition 1 (i) *Speculators choose* $a_s^* = 1$ *and trade takes place if and only if* $v = v_g$*, with payoffs* $\beta_s (v_g - \omega_s)$ *and* $(1 - \beta_s)(v_g - \omega_s)$ *for the seller and the speculator respectively.*

(ii)*The hedgers' optimal attention is*

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

Hedgers trade if and only if $\sigma = \sigma_g$ *and* $\widehat{v}(a^*, \sigma_g) > \omega_h$*, the seller's payoff is* $\beta_h (\widehat{v}(a^*, \sigma_g) - \omega_h)$ *whereas the hedger's payoff is* $(1 - \beta_h)(v - \omega_h)$.

(iii) *The hedgers' optimal attention is decreasing in* θ*,* β_h*,* β_s *and increasing in* ω_s *and* $v_g - v_b$.

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

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

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

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

3.3 Disclosure Policy

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

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

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

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

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

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

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

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

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

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

In this case, with probability $\frac{1}{2}$ the signal reveals to the speculators that the asset's value is higher than their outside option, so that they will bargain offering the price p_s. But with probability $\frac{1}{2}$ the asset's value turns out to be v_b, which induces both speculators and hedgers not to trade, which in the hedgers' case is due to their negative inference from observing speculators not buying the asset.

To build up intuition about the disclosure decision, consider first of all the two polar cases in which there are no speculators ($\mu = 1$) or no hedgers ($\mu = 0$). If $\mu = 1$, disclosure requires $\mathbb{E}\left[\pi_h^D\right] > \mathbb{E}\left[\pi^{ND}\right]$, which is always satisfied: if the seller were to deal at the first stage only with hedgers he would always disclose his available information. This is because disclosing information in our model hurts the seller only when this new piece of information is interpreted differently by different (types of) investors, and therefore creates adverse selection via the interaction of their trading strategies.

In the polar opposite case in which $\mu = 0$, so that the seller is certain to be matched with a speculator, he will not want to disclose the signal if

$$\mathbb{E}\left[\pi_s^D\right] < \mathbb{E}\left[\pi^{ND}\right]. \tag{6}$$

Condition (6) will hold when the seller can appropriate only a small fraction of the trading surplus in trading with speculators (low β_s) or if speculators have high outside option (high ω_s) and therefore have a weak demand for the asset. This indicates that there are situations in which the seller would prefer to trade with uniformed hedgers (if there were any available to trade with) rather than with informed speculators. Accordingly, as we shall see next, condition (6) is a more general prerequisite for the seller to ever prefer opacity.

Compared to the two polar opposite cases just considered, the intermediate cases where $\mu \in (0, 1)$ bring out another reason why the seller may want not to disclose the signal: as explained in the previous sections, under disclosure the interaction between the two types of investors creates an adverse selection problem that depresses the price offered to the seller. Indeed μ naturally captures the likelihood that disclosing information will generate this information externality among investors, damaging the seller. This brings us to the first main positive result of the paper:

Proposition 2 *If condition (6) holds, the seller prefer no disclosure when μ is sufficiently high or v^e is low. If condition (6) does not hold, the seller always discloses his signal σ.*

This result shows that opacity can pay for the seller, but not always does. As shown by Figure 1, the seller prefers to disclose information when the security's expected payoff v^e is low, because otherwise the asset would not be attractive enough to induce hedgers to offer a high price. In the limiting case where the asset has zero expected value, the seller must disclose information because otherwise he would stand no chance to profitably sell the asset, because otherwise investors would be afraid of making too large errors in their trading decisions. Then, this proposition predicts that more information should be disclosed by sellers when their assets are not much sought-after.

The figure also shows that if there are few speculators (low μ) in the market, the seller will be more willing to disclose information, because he is less likely to pay adverse selection rents to speculators. Thus, from the seller's

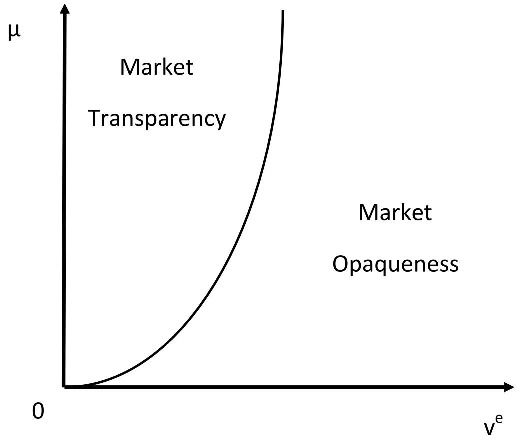

Figure 1: Seller's disclosure policy.

viewpoint, disclosing information generates a trade-off: on the one hand, it encourages hedgers to offer a higher price than they would otherwise, because it helps them avoiding too large errors in trading; on the other hand, it leads to the possibility of selling to a speculator, who will appropriate a higher fraction of the expected surplus not only because he has more bargaining power but especially because he can exploit his superior processing ability and the pricing externality that this advantage entails.

The next proposition characterizes the comparative statics with respect to the other parameters:

Proposition 3 *If condition (6) holds, then there exists a unique threshold $\mu^* \in (0,1)$ such that the seller discloses the signal σ if and only if $\mu \geq \mu^*$. The threshold μ^* is increasing in θ while it is decreasing in v_g.*

The processing cost θ affects the seller's incentives to disclose only through its effect on the optimal attention allocation a^*. A higher degree of financial illiteracy decreases the hedgers' processing ability, which in turn decreases the seller's incentives to disclose. Intuitively, the higher is the asset's value in the good state v_g, the more willing will the seller be to let speculators participate to the market, because he expects a higher profit by selling the asset to them. The comparative static with respect to the seller's bargaining power is instead less clear cut. On the one hand, an increase in β_s increases the seller's incentive to disclose because (1) the fraction captured by the seller when trading with the speculators is higher; (2) the seller expects hedgers to offer a better price, since p_h is increasing in β_s. On the other hand, a higher seller's bargaining power with the speculators also reduces the level of hedger's sophistication a^*, which in turn decreases the incentives to disclose the new piece of information.

3.4 Trading Transparency

Trading transparency refers to the public and timely transmission of information on past trades, including volume and price.[9] We can capture this notion of transparency assuming that investors observe the previous order flow only with probability γ. For example, a hedger matched with the seller knows that a speculator just declined trading with the seller only with probability γ, whereas with complementary probability he believes that he is the first investor who has the possibility to buy the asset.

Introducing this possibility modifies the previous analysis in two ways. First, the price that investors would offer to the seller will now be a function of market transparency:

$$p'_{hs}(\gamma) = (1-\gamma)\, p_h$$

that is, if hedgers do not observe the speculators' trade, which happens with probability $1-\gamma$, they will offer the same price that they would be willing

[9] 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) which analyze the effects of delayed trade reporting on the London Stock Exchange, whereas Porter and Weaver (1998) examine delayed reporting on the Nasdaq Stock Market.

to pay if they were the first to be matched with the seller. Similarly

$$p'_{sh}(\gamma) = \gamma\beta_s (v_g - \omega) + (1-\gamma) p'_s(\gamma)$$

where

$$p'_s(\gamma) = \left[\beta_s (v_g - \omega) + (1-\beta_s) \beta_h (1-\gamma) a (\hat{v} - \omega_h)\right]$$

is the price that the speculators would offer with less then a perfectly transparent market. With probability γ they observe a hedger who refuses to purchase the asset so that they do not need to compensate the seller for loosing his outside option. With complementary probability speculators are willing to pay $p'_s(\gamma)$, that is the price they would offer if they were the first to be matched with the seller. Notice that clearly these prices will be lower as γ increases, and we have that $p'_{hs}(1) = p_{hs}$ and $p'_{sh}(1) = p_{sh}$.

Intuitively, γ captures both market transparency and the weight assigned to other market participants' trading strategies. For example, if speculators are considered the ones that are better at processing information, the small investors are going to find their decisions more informative about the asset's value and then they will try to imitate their trading strategies more closely. This is in fact the case for the investors with highest visibility such as Warren Buffett or George Soros whose investment decisions are closely monitored by other market participants.

The inference that hedgers make based upon the speculators' decisions, relates our model also to the literature on herding (see Scharfstein and Stein (1990) and Banerjee (1992), among others). However, in our model hedgers always benefit from observing speculators' decisions, because there is no loss of valuable private information.

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

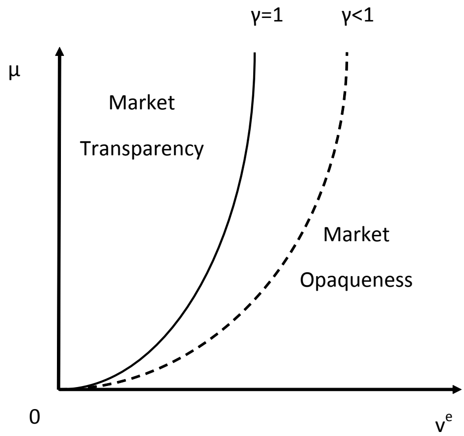

Figure 2: Seller's disclosure policy as a function of trading transparency.

Proposition 4 *The seller's incentives to disclose the signal σ increases as trading transparency γ decreases, that is, he discloses if and only $\mu \geq \mu^{**}(\gamma)$, where $\mu^{**}(\gamma) < \mu^{*}$.*

This result depicted in figure 2 shows that there exists a *substitutability* between disclosure and trading transparency. The seller will be more willing to disclose information about the asset's value, when the market is more opaque, that is, when the endogenous adverse selection effect caused by the disclosure of the signal σ is mitigated by the possibility that the order flow is not observed by the hedgers, which happens with probability $1 - \gamma$.

In contrast to the existing theoretical literature on transparency (see Glosten and Milgrom (1985), Kyle (1985), Pagano and Roell (1996), Chowhdry and Nanda (1991), Madhavan (1995) and Madhavan (1996) among others) in which opacity tends to redistribute wealth from uninformed to informed investors, here instead it damages both and improves the position of the seller.[10] The speculators are not able to fully exploit their superior processing ability, and the hedgers lose the possibility to employ the previous order flow to update their beliefs about the asset's value.

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

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

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

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

This is also consistent with the evidence in Bloomfield and O'Hara (1999). They use laboratory experiments to determine the effects of trade disclosure on market efficiency. They find that trade transparency increases the informational efficiency of transaction prices. This is exactly what our model predicts, in fact, a more transparent market as captured by a higher γ, allows the hedgers to infer the value of the asset.[11] Finally, Foucault, Moinas, and Theissen (2007) using data from Euronext (the French Stock Exchange) find that uninformed dealers are more aggressive when using anonymous systems, which is reflected in our model by a higher price that the hedgers

[11] See also Biais, Glosten, and Spatt (2005) for a survey on some of these issues

are willing to offer when $\gamma = 0$. We can conclude that in a more transparent market where investors observe the order flow more easily, the seller's incentives to disclose information about the asset's value are lower.

4 Regulation

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

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

4.1 Mandate Disclosure

We can assume that the regulator aims to maximize the sum of market participants' payoffs:

$$S = \pi + u$$

where u is the investors' utility.[12]

We compute the expected gains from trade when new information is made available to the market and when this is not the case. The social wel-

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

fare when no information is disclosed is simply given by

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

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

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

The expected gains from trade when the seller meets a hedger are

$$\mathbb{E}\left[S_h^{D}\right] = \frac{a}{2}\left(v_g - \omega_h - \frac{\theta a^2}{2}\right) + \frac{1-a}{2}\left(v_b - \omega_h - \frac{\theta a^2}{2}\right) + \frac{1-a}{2}\left(v_g - \omega_s\right), \tag{7}$$

where the first term captures the surplus in the case in which the asset's value is v_g and the realized signal is σ_g, when the hedgers buy the asset and the realized surplus is positive. With probability $\frac{1-a}{2}$ instead the asset's value is v_b but the hedgers are willing to purchase the asset because the realized signal is σ_g. The realized surplus in this case is negative. Finally, the last term capture the possibility that hedgers do not buy the asset even if it was actually worth buying, and then the asset is allocated to the speculators.

It can also be rewritten as follows:

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

In fact, if the asset's value is v_g disclosing the signal σ allows for the possibility of selling the object and realize the maximum surplus $v_g - \omega_h$. However, disclosing has also a direct cost captured by the costly effort exerted by the hedgers. Finally, when hedgers have the opportunity to purchase the asset, this choice may also happen to be the wrong one due to the noise that remain after they have processed the information about the asset. Hence, with probability $\frac{1-a}{2}$ the realized surplus will be negative. As the recent financial crisis shows, some real investment decisions such as the building of entire new residential areas might be linked to the issuance and pricing of financial products. This suggests that a regulator cares about the correctness of the investors' beliefs about asset values, because on those depend other relevant decisions.

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

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

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

Notice that withholding information is worse than disclosing it when the speculators are the first to be able to bid for the asset, i.e. $\mathbb{E}\left[S^{ND}\right] < \mathbb{E}\left[S_s^D\right]$ if and only if the following condition holds

$$\omega_s < 2\omega_h - v_b \tag{8}$$

that is, if the speculators's outside option is not excessively high then the planner would prefer disclosing the new piece information if the speculators are able to purchase it first. This is because when the speculators are too picky (high ω_s) the realized gains from trade are very low. This possibility represents the only social inefficiency generated by selling to speculators.

Moreover if

$$\mathbb{E}\left[S_s^D\right] \geq \mathbb{E}\left[S_h^D\right] \tag{9}$$

then the regulator would prefer disclosing but giving priority to the speculators, then we can now characterize the optimal disclosure policy as follows

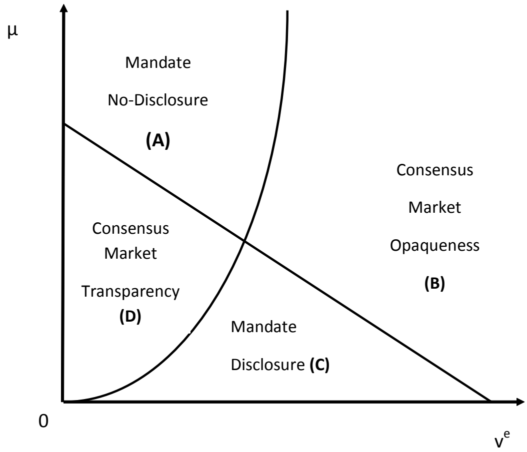

Figure 3: Socially optimal disclosure policy.

Proposition 5 (i) *If conditions (8) and (9) hold then there exists a unique threshold $\mu^{OPT} \in (0,1)$ such that the regulator forces disclosure if and only if $\mu < \mu^{OPT}$, which is decreasing in θ.*

(ii) *The seller has a higher incentive to disclose the signal σ than the planner as β^i or θ increases.*

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

As depicted by regions (A) and (C) in Figure 3, Proposition 5 implies that in general we can have either over or under provision of information depending on the processing costs and the seller's bargaining power. This is mainly driven by the fact that on one hand the social planner takes into account the total gains from trade and this increases its incentives to disclose compared to the seller. On the other hand, the seller does not internalize the cost of processing information, which are instead taken into consideration by the regulator. Interestingly, there exists a region in which the seller has a *higher* incentive to disclose than the regulator. Intuitively, this happens when enough hedgers participate to the market and the expected asset's value is low as in region (A), where the seller will disclose the signal σ, even if the efficient thing to do is to withhold it. This is even more likely when the seller appropriates a high fraction of the expected gains from trade (high β^i).

Region (C) describes a situation in which there are enough speculators waiting for the information to be released that the seller fears to unleash their superior processing ability so that he does not disclose. In this case the regulator's intervention is required to mandate disclosure. This is likely to happen in very specialized markets, such as the ones for asset-backed securities, where the degree of financial sophistication required to fully understand the structure of the assets and its implications in terms of risks is higher so that it is more likely that speculators participate. Hence, in this market the regulator should intervene forcing the seller to make publicly available as much information as possible. This is probably not the case for markets where treasuries and simple corporate bonds are traded, because speculators do not expect to fully exploit their superior processing ability in those markets.

Regions (B) and (D), instead, capture situations in which the market configuration is such that the seller's incentive to disclose are perfectly aligned with regulator's. In region (B) the likelihood of selling to a hedger as well as the asset's expected value is low enough that disclosure is privately and socially optimal. The seller has an incentive to disclose because otherwise he would not be able to close a profitable deal with hedgers (due to low v^e), whereas the regulator is willing to disclose information because the processing costs generated by releasing σ are low (due to low μ). Finally, in region (D) the asset's expected value is so high that both the seller and the regulator do not find it optimal to disclose new information. The seller has no reason to induce the speculators to participate to the market and the regulator finds it optimal to save on the processing costs by withholding information.

Finally, proposition 5 also predicts that in markets where a high level of financial literacy is required (high θ), the regulator will be less likely to mandate disclosure to avoid bearing the processing costs.

4.2 Licensing Access

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

Stephen Cecchetti, head of the Basel-based body's monetary and economic department, for example, has suggested a solution to bring the vast OTC derivatives markets under closer supervision and to ensure they are traded and processed more transparently to safeguard the wider financial system: "The solution is some form of product registration that would constrain the use of instruments according to their degree of safety." He said that the "safest" securities would be available to everyone, much like non-prescription medicines. Next would be financial instruments available only to those with a licence, like prescription drugs. Finally would come securities available "only in limited amounts to qualified professionals and institutions, like drugs in experimental trials". Securities "at the lowest level of safety" would be deemed illegal.[13]

Since the speculators if endowed with the signal σ perfectly forecast the asset's value and they do not incur in any processing costs, it might be op-

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

timal for the regulator is limit market participation to the speculators, inducing in this way the seller to disclose his information. We analyze the conditions under which this constitutes a socially efficient policy to implement

$$\frac{v_g - \omega_s}{2} > \mu \left[\frac{\left(v_g - \omega_h\right)}{2} - \frac{\theta a^2}{4} - \frac{1-a}{2}\left(\omega_s - v_b\right) \right] + (1-\mu)\frac{v_g - \omega_s}{2} \quad (10)$$

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

Proposition 6 *Licensing access to speculators is optimal as θ increases and ω_s decreases.*

This proposition identifies the main trade-off the regulator is facing. Intuitively, θ increases the planner's incentive to license the access to the market exclusively to speculators, because in this way he can save the processing costs the hedgers would pay. That is, when information is difficult to digest, the planner prefers leaving the seller with the "sharks", than making the assets available to all investors. We can imagine this is indeed the case for more complex assets such as asset-backed securities and credit-default swaps that had a leading role in the recent financial crisis.

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

4.3 Trading Transparency

Up to now we have assumed that the policy maker can simply mandate the disclosure of the signal σ, but in many real situations the seller can easily withhold information. The regulator, in fact, might not verify that the seller possess information, this means that the seller can claim that the all the information about the asset's value has been made available to investors. This is relevant in region (C) of figure 3, that is, when the seller has no incentive to disclose. However, hiding relevant information about the assets' value can be costly, because the seller put his reputation and investors' trust at stake. Moreover, financial authorities such as the Securities and Exchange Commission might charge the seller significant fines.

We can formally consider this possibility and extend the model by allowing the seller to hide the signal σ at cost k, that is unknown to the regulator. The policy maker knows that the cost k is distributed according to the continuous cumulative distribution function $G(k)$ on the real line.

We assume that the seller moves after the policy maker. This captures the idea that in financial markets issuers take financial regulation as given and optimally respond to it. Let us restrict attention to the region (C) which is the only relevant case. The seller will hide the available information if and only if the following condition holds

$$\mathbb{E}\left[\pi^{ND}\right] - k \geq \mathbb{E}\left[\pi^{D}\right]$$

that is, if the profits in the no-disclosure regime taking into account the hiding-cost k are greater than the profits in the disclosure regime. Recall that as showed in section 3.4 the seller's profits, as well as his incentives to disclose, crucially depend on the trading transparency parameter γ.

Mandating disclosure the regulator will expect the following expected gains

$$\left(1 - G\left(\bar{k}\right)\right)\left[\mathbb{E}\left[S^{D}\right] - \mathbb{E}\left[S^{ND}\right]\right]$$

where $\bar{k} = \mathbb{E}\left[\pi^{ND}\right] - \mathbb{E}\left[\pi^{D}\right]$. This means that the regulator expects the disclosure policy to be effective only with probability $\left(1 - G\left(\bar{k}\right)\right)$. The possibility for the seller to hide and withhold relevant information from the investors, even when regulation mandates disclosure, highlights the role that trading transparency might play in our model. Formally,

Proposition 7 *The policy maker finds it optimal to reduce trading transparency γ*

as the seller's hiding-cost k decreases.

As it becomes easier for the seller to hide the available information, the mandating disclosure policy becomes less effective. Hence, the policy maker might reduce trading transparency in order to increase the seller's expected profits in the case of disclosure so that to increase the possibility of *voluntary* disclosure.

The cost k also captures the fact that the policy maker might not be aware of the information required to correctly price a security. This is more likely for newly engineered assets, in fact, the seller can easily hide the information relevant for correctly price the asset, because the regulator cannot identify the signal σ that should be disclosed. During the recent financial crisis, most investors lacked data about the consequences on assets' values of a drop in housing prices, that was instead necessary, for example, to understand the risks implied by the CDO related to the subprime mortgages. Then, our model predicts that in markets where the policy maker has incomplete knowledge of the information needed to assess the securities' values, he would be willing to make these markets more opaque, because mandating disclosure is less effective.

5 Conclusion

[To be written]

Appendix

Proof of Lemma 1. The maximization with respect to p_h of (1) can be rewritten as follows

$$\max_{p_h} \beta^h \log\left(p_h - p_{sh}(\sigma)\right) + (1-\beta_h)\log\left(\widehat{v}(\sigma) - \omega_h - p_h\right)$$

then the first order condition is

$$\frac{\beta_h}{\left(p_h - p_{sh}(\sigma)\right)} = \frac{(1-\beta_h)}{\left(\widehat{v}(\sigma) - \omega_h - p_h\right)}$$

solving for p_h leads to the result. Problem (3) is solved similarly, and yields the above expression for $p_s(v)$. ■

Proof of Proposition 1. In principle we have four different cases to analyze. However, we can show that since $\bar{v} \geq \omega_h$ then as long as $a_h^* \geq 1/2$ it is never optimal to trade when the seller releases bad news, i.e. σ_b. The case in which he never trades can be ruled out because in that case the investor's profits are zero, while the expected profits when he trades are strictly positive. Then, the only other possibility is always trading irrespective of the realization of the signal. If this is the case, then problem (4) becomes

$$\max_{a\in[0,1]} \frac{1}{2}a\left(v_g - \omega - p_h\left(\sigma_g, a\right)\right) + \frac{1}{2}a\left(v_b - \omega - p_h\left(\sigma_b, a\right)\right)$$
$$+\frac{1}{2}(1-a)\left(v_b - \omega - p_h\left(\sigma_g, a\right)\right) + \frac{1}{2}(1-a)\left(v_g - \omega - p_h\left(\sigma_b, a\right)\right) - \frac{\theta a^2}{2},$$

which this is equivalent to

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

so that the optimal choice in this case would be $a_h^* = 0$. Intuitively, if the investor buys irrespective of the realized signal, he does not use the information disclosed; but since information processing is costly, it does not pay to process any information at all. However, if this is the case then the necessary condition for trading $\hat{v} > \omega_h$ becomes $v_b < \omega_h$, which means that this cannot be an equilibrium. Then, we can conclude that the investors will purchase the asset if and only if σ_g is disclosed. If this is the case, straightforward maximization of (4) leads to the expression for the optimal a^*. We have that $a_h^* > 1/2$ as long as $v_g - v_b > \frac{\theta}{(1-\beta_h)} + \beta_s\left(v_g - \omega_s\right)$. The assumptions on the processing cost function i.e. $C''(a) > 0$, guarantee that the second order condition is satisfied and then we made sure that there exists a unique solution a_h^*. Moreover, by the implicit function theorem it follows that $a^*(\theta, \beta_h)$ is decreasing in θ, β_s, β_h and ω_s. ∎

Proof of Proposition 2. Notice that since a_h^* does not depend on μ, we can find a threshold by solving the condition $\mathbb{E}\left[\pi^D\right] \geq \mathbb{E}\left[\pi^{ND}\right]$ which leads to $\mu \geq \mu^* \equiv \frac{\mathbb{E}\left[\pi^{ND}\right]-\mathbb{E}\left[\pi_s^D\right]}{\mathbb{E}\left[\pi_h^D\right]-\mathbb{E}\left[\pi_s^D\right]}$, substituting the expression for the seller's profits and after some algebra we get

$$\mu^* = \frac{\beta_h\left(v^e - \omega_h\right) - \frac{\beta_s}{2}\left(v_g - \omega_s\right)}{\frac{\beta_h}{2}a^*\left(a^*(v_g - v_b) + v_b - \omega_h\right) + \beta_s\left(v_g - \omega_s\right)\left(\frac{a^{*2}}{2}\left(1-\beta_h\right) - \frac{a^*}{2}\right)} \tag{11}$$

To find the effect of investors' attention allocation on the seller's propensity to disclose σ we can differentiate the threshold μ^* with respect to a^*. We find that $\frac{\partial\mu^*}{\partial a^*} < 0$ as long as the following restriction on the parameter is satisfied

$$\left(v_g - v_b\right) > \frac{\theta}{\left(1-\beta_h\right)^2} + \beta_s\left(v_g - \omega_s\right)$$

The other comparative statics results follow from the combined effect of an increase of the parameters directly on the cutoff μ^* and their effect on a_h^*. We have that the direct effect of β_s on μ^* is negative, moreover from Proposition 1 we have that $\frac{\partial a^*}{\partial\beta_s} < 0$ then we cannot sign the effect $\frac{\partial\mu^*}{\partial\beta_s}$. An increase in $\left(v_g - v_b\right)$ increases the denominator of (11) and increases a_h^*, then $\frac{\partial\mu^*}{\partial\left(v_g - v_b\right)} < 0$. Finally, the effect of v^e follows directly from the equation (11).
∎

Proof of Proposition 3. We can follow the same argument as in the previous section to get the new threshold μ^{**}. Notice that the profits in the case of no disclosure do not depend on γ. Then to understand how γ affects the seller's incentives to disclose we can just focus on $\mathbb{E}\left[\pi^D\right]$. Define $\pi_i^D(\gamma)$ the seller's profit as a function of the market's transparency. We have that

$$\begin{aligned}\mathbb{E}\left[\pi_s^D(\gamma)\right] &= \frac{1}{2}\left[\beta_s\left(v_g-\omega\right)+\left(1-\beta_s\right)\beta_h\left(1-\gamma\right)a\left(\hat{v}-\omega_h\right)\right] \\ &+\frac{\left(1-a_h^*\right)}{2}\left(1-\gamma\right)p_h\left(\sigma_g\right)>\frac{\beta_s}{2}\left(v_g-\omega_s\right)=\mathbb{E}\left[\pi_s^D\right]\end{aligned}$$

as long as $\gamma<1$. And also

$$\begin{aligned}\mathbb{E}\left[\pi_h^D(\gamma)\right] &= \frac{a^*}{2}p_h\left(\sigma_h\right)+\frac{\left(1-a^*\right)}{2}p_{sh}'\left(\gamma\right) \\ &> \frac{a^*}{2}p_h\left(\sigma_h\right)+\frac{\left(1-a^*\right)}{2}\beta_s a\left(v_g-\omega_h\right)=\mathbb{E}\left[\pi_h^D\right]\end{aligned}$$

because $p_{sh}'(\gamma)>\beta_s a\left(v_g-\omega_h\right)$ if $\gamma<1$. Then, we can conclude that the seller has a higher incentive to disclose the signal σ when the market is more opaque (low γ). ■

Proof of Proposition 4. We have that the threshold is

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

To show that it is increasing in a_h^* we can just differentiate (7) with respect to a_h^*

$$\frac{\partial\mathbb{E}\left[S_h^D\right]}{\partial a_h^*}=\frac{v_g-\omega_h}{2}-\theta a_h^*>0$$

then we have that $\frac{\partial\mu^{OPT}}{\partial a_h^*}>0$ and the effect of θ follows from the fact that both the denominator of μ^{OPT} is increasing in θ and also the optimal attention level a_h^*. ■

To prove that the seller might find it optimal to disclose information even when it is not efficient to do so, we just need to find a sufficient condition. Define $\Delta=\mathbb{E}\left[S\right]-\mathbb{E}\left[\pi\right]$ then we want to prove that $\Delta<0$ for a non-empty set of the parameter space. We have that

$$\Delta = \Delta_h^D + \Delta_s^D - \Delta^{ND}$$

where $\Delta^{ND} = (1-\beta_h)(v^e - \omega_h)$, $\Delta_s^D = \frac{(1-\beta_s)(v_g - \omega_s)}{2}$ while

$$\begin{aligned} \Delta_h^D \;=\; & \frac{(v_g - \omega_h)}{2} - \frac{\theta a^2}{2} - \frac{(1-a)(\omega_s - v_b)}{2} - \frac{(1-a)\beta_s(v_g - \omega_s)}{2} \\ & -\frac{a}{2}\left[(a v_g + (1-a) v_b - \omega_h) + (1-\beta_h)\beta_s a (v_g - \omega_h)\right] \end{aligned}$$

Consider the case in which the seller is able to capture all the surplus, i.e. $\beta_h = \beta_s \to 1$. Then in this case we have that $\Delta^{ND} = \Delta_s^D = 0$ while

$$\Delta_h^D = -\frac{(v_g + \omega_s)}{2} + v_b < 0$$

Then we can conclude that when the seller's bargaining power is really high he will disclose the new piece of information σ even if the planner would not i.e. $\mu^{OPT} > \mu^*$.

We can rewrite condition (10) as

$$L(\theta, \omega_s) = -\frac{a}{2}(\omega_s - v_b) - \frac{(v_b - \omega_h)}{2} + \frac{\theta a^2}{2}$$

and the regulator restrict market participation to speculators if and only if $L(\theta, \omega_s) \geq 0$. We can differentiate with respect to the two parameters of interests:

$$
\begin{aligned}
\frac{dL\left(\theta,\omega_s\right)}{d\theta} &= -\frac{\partial a}{\partial\theta}\left[\frac{\omega_s - v_b}{2} - \theta a\right] + \frac{a^2}{2} \\
&= \frac{\left[\left(v_g - v_b\right) - \beta_s\left(v_g - \omega_s\right)\right]\left(1-\beta_h\right)}{4\theta^2} \\
&\quad \times \left[\frac{\omega_s - v_b}{2} - \frac{\left[\left(v_g - v_b\right) - \beta_s\left(v_g - \omega_s\right)\right]\left(1-\beta_h\right)}{2}\right] \\
&\quad - \frac{\left[\left(v_g - v_b\right) - \beta_s\left(v_g - \omega_s\right)\right]^2\left(1-\beta_h\right)^2}{4\theta^2} \\
&= \frac{\left[\left(v_g - v_b\right) - \beta_s\left(v_g - \omega_s\right)\right]\left(1-\beta_h\right)}{4\theta^2}\frac{\omega_s - v_b}{2} > 0
\end{aligned}
$$

where the second line follows from the substitution of the optimal attention allocation choice as characterized by Proposition 1 and of the effect of θ on a^*. Similarly we can compute the effect of ω_s as follows

$$
\frac{dL\left(\theta,\omega_s\right)}{d\omega_s} = -\frac{\partial a}{\partial\theta}\left[\frac{\omega_s - v_b}{2} - \theta a\right] - \frac{a}{2}
$$

which is equivalent to

$$
\begin{aligned}
&-\frac{\beta_s\left(1-\beta_h\right)}{2\theta}\left[\frac{\omega_s - v_b}{2} - \frac{\left[\left(v_g - v_b\right) - \beta_s\left(v_g - \omega_s\right)\right]\left(1-\beta_h\right)}{2}\right] \\
&\qquad - \frac{\left[\left(v_g - v_b\right) - \beta_s\left(v_g - \omega_s\right)\right]\left(1-\beta_h\right)}{2} < 0
\end{aligned}
$$

where the negative sign follows from the fact that $\beta_s\left(1-\beta_h\right) < 1$.

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