Dr Jekyll and Mr Hyde: Feedback and welfare when hedgers can acquire information*

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Abstract

I analyze welfare in a model of financial markets where information acquisition is endogenous, information has real effects, and all agents are rational. Agents who derive a private benefit from holding the asset (hedgers) and agents who do not (speculators) have different incentives to acquire information. Information acquisition by hedgers entails an additional welfare cost because of foregone gains from trade. Speculators may produce too little or too much information compared to the social optimum. If the former, a designated market-maker contract whereby a firm pays a market-maker to lower her spread increases welfare.

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1. Introduction

Empirical evidence spanning different markets and institutions suggests that hedgers may often behave like speculators. Cheng and Xiong (2013 and 2014) show that the positions of commercial hedgers on futures markets in wheat, corn, soybeans, and cotton exhibit excess fluctuations for reasons unrelated to output fluctuations. Akey, Robertson and Simutin (2021) and Easley et al. (2021) find evidence of closet speculation by index funds and ETFs. Possible confusions between market-making and speculative activities have been at the heart of the implementation of the Volcker rule[1], and Dastarac (2021) indeed provides suggestive evidence of speculation by dealers in the US corporate bond market. Jacque (2010) reviews well-publicized examples of corporate hedgers engaging in speculative activities.

All these examples raise regulatory concerns as market participants are often regulated as much based on their official status as on their actual trading behavior[2]. Yet, the existing theoretical literature provides little guidance as to whether speculative activity by hedgers has a different welfare impact from speculative activity by other market participants, which could possibly justify a more favorable treatment by the regulator. The issue is summarized by Cheng and Xiong (2013), who write: "*In this debate, as well as in other broad contexts of analyzing risk sharing and trading in financial markets, it is common to separate two groups of traders -one group of traders with established commercial interests labeled hedgers and another group of financial traders labeled speculators. Perhaps because of this distinction, the debate heavily focuses on examining the behavior and impact of speculators, with little attention on how hedgers trade in practice. Policy prescriptions often focus on the behavior of the speculator group while exempting the hedger group. Is this categorical treatment justified?*"

This paper provides a simple model to help the regulator answer the question above from a normative standpoint. The model has three key features: all agents are rational; acquisition of information is endogenous; information has real effects as firm managers use the information produced in the financial market to make better investment decisions. Each feature is important to conduct a proper welfare analysis. Agent rationality implies that there is a well-defined welfare function. Endogenous acquisition of information implies that policies may have an impact on the production of information.

[1]See the discussion on pp. 18-25 in the recommendations of the Financial Stability Oversight Council (2011). Duffie (2012) argues that market-making is proprietary trading by nature.

[2]For instance, commercial hedgers on US commodity futures benefit from exemptions on position limits with the only constraint they need to argue the positions come as a hedge of cash trades they "anticipate" to make. Another example is market-makers in European countries such as France or Italy who are not subject to the tax on financial transactions that applies to other market participants.

Real effects of information imply the existence of a trade-off so that production of information is not necessarily bad for welfare. The market microstructure is a simplified version of Glosten and Milgrom (1985), with a competitive risk-neutral market-maker. I call "hedgers" agents who derive a private benefit from holding the asset[3]. I call "speculators" agents who do not have such a private benefit. I call "speculation" the act of acquiring costly information that can be used to make trading profits. I then ask whether hedgers who speculate and speculators who speculate have the same impact on welfare, and I characterize the conditions under which under- or over- acquisition of information obtains at the equilibrium.

A first insight from the model is that hedgers and speculators face different incentives to acquire information, and thus behave differently. A speculator acquires information if he or she can make a trading profit to compensate for the information acquisition cost. Trading profits arise when the market-maker charges a low spread. By way of contrast, because of his or her private benefit, a hedger is willing to buy the asset even if making no trading profits. Thus, he or she has little incentive to acquire information when the market-maker charges a low spread. Incentives to acquire information instead appear when the spread is high, as the hedger's expected trading loss becomes large relative to the private benefit. This generates equilibrium multiplicity: when the market maker anticipates that hedgers will (*resp. will not*) acquire information, he or she reacts by charging a high (*resp. low*) spread, which leads hedgers to indeed (*resp. not*) acquire information. Last, if hedgers acquire information, speculators cannot make trading profits. Thus, in any given equilibrium, at most one type of agent chooses to acquire information.

I then ask whether welfare is higher in the equilibrium where information is acquired by hedgers or in the equilibrium where it is by speculators. The main insight here is that acquisition of information by hedgers comes at an additional welfare cost relative to that by speculators. A social planner always wants the trader with the private benefit to hold the asset at the equilibrium. However, if a hedger acquires information and learns bad news about the quality of the asset, then the hedger will not buy the asset, and gains from trade are foregone[4]. It follows that if there are similar proportions of

[3]Note that the notion of private benefits encompasses more than hedging motives. An alternative interpretation is "warm glow feelings" of some agents when they hold stocks of companies with a strong ESG record. In either case, the existence of private benefits for some agents ensures that there are potential gains from trade.

[4]This effect arises even if the information acquired by the hedger is uncorrelated with his or her hedging needs. Thus, it differs from a classical Hirshleifer (1971) effect as analyzed by Marin and Rahi (2000) and Dow and Rahi (2003).

hedgers and of speculators, then welfare will be necessarily higher in the equilibrium where information is acquired by speculators than in the equilibrium where it is acquired by hedgers. The only case where the welfare ranking is reversed is when information has a high social value but the proportion of speculators is small relative to that of hedgers.

I finally ask whether speculators may ever acquire too little information compared to what would be socially desirable. This is possible in the model because the firm manager learns from financial markets. I show that under-provision of information occurs when the ex-ante level of uncertainty, and therefore the social value of information, is high, the cost of acquiring information is small, and the proportion of speculators relative to hedgers is large. The reason why the proportion of speculators matters is that private incentives of speculators to acquire information decrease continuously as the probability of an informed trade, and thus the equilibrium spread, increase. By way of contrast, the productive efficiency benefits from information can be shown to be increasing and convex in the probability of an informed trade. When the proportion of speculators is large relative to hedgers, their trading profits fall below the information acquisition cost before the socially optimal amount of information has been reached.

Summarizing, the welfare analysis suggests that hedgers who speculate should be regulated less than pure speculators only in specific circumstances. In particular, a necessary condition for information acquisition by hedgers to yield higher welfare than information acquisition by speculators is that the mass of potential speculators is small enough. In practice, this condition is unlikely to be satisfied in many markets. In the stock market for instance, Subrahmamyam and Titman (1999) argue that the existence of a large group of investors willing to acquire costly information may be the reason why listed companies decided to go public in the first place. In this case, the regulator, far from enforcing a more lenient regulation for hedgers who speculate, may wish instead to separate hedging and speculative activities in the spirit of the Volcker rule. An additional issue the regulor needs to be concerned with is the possibility of under-provision of information by speculators, especially for firms where managers face substantial uncertainty, with a potentially large impact on their investment strategy (technology stocks, young firms...). While it would not be realistic to expect the regulator to subsidize financial speculation directly, other instruments are available. One such instrument is to authorize private contracts between market makers and listed firms, whereby the firm pays the market maker to reduce the bid-ask spread on its stock, thus making informed trading by speculators more profitable. This possibility exists on some European markets but is currently not allowed in US[5].

This paper is broadly related to four branches of the literature. The first one is the theoretical literature on feedback effects in financial markets, that arise when information in asset prices impacts firms' investment and production decisions, and therefore firms' future cash-flows. This literature, initiated by the seminal paper of Dow and Gorton (1997), is reviewed comprehensively by Bond, Edmans and Goldstein (2012) and Goldstein (2023)[6]. My contribution here is twofold. One contribution is the new findings that hedgers and speculators have qualitatively different incentives to acquire information, that information acquisition by the two types of agents have different welfare implications, and that speculators may acquire too little information compared to what would be socially optimal. A more general contribution is that this is the first paper with both feedback effect and endogenous acquisition of information that does not rely on noise traders as a modeling device. On one end of the spectrum, Dow and Rahi (2003) provide the first comprehensive welfare analysis of the trade-offs between productive and allocative efficiency in a model with a feedback effect and where rational agents trade both for hedging and for informational motives. The main difference with my model is that information is exogenous in their model while it is endogenous here. The same difference exists with Bond and Garcia (2022), who incorporate multiple assets and endogenous market participation to a framework similar to that of Dow and Rahi in order to study the impact of indexing on informational efficiency and welfare. Closest to this paper is Gervais and Strobl (2022), where a financial intermediary is exogenously endowed with information about fundamentals, which it sells to rational traders. An important difference between our two models is that Gervais and Strobl's implies that hedgers are always fully informed while their level of information is endogenous in mine. At the other end of the spectrum, Dow, Goldstein and Guembel (2017) endogenize the decision of rational agents to acquire information but do so at the cost of having noise traders in the model. This paper offers an alternative that does not suffer from this shortcoming and thus allows for a comprehensive welfare analysis[7], with the added benefit of being extremely tractable.

The paper also belongs to a literature on acquisition of information by agents with private values

[5]See https://www.finra.org/rules-guidance/rulebooks/finra-rules/5250

[6]See Chen, Goldstein and Jiang (2007), Bakke and Whited (2010), Foucault and Frésard (2014), and Edmans, Jayaraman and Schneemeier (2017) for empirical evidence supporting the existence of a feedback effect.

[7]Dow, Goldstein and Guembel (2017) argue that a noise trader can be seen as a rational agent who has a private benefit for the asset which is so large that he or she will find it optimal to buy the asset regardless of its price or of the information available about its payoffs. This however leaves open the welfare analysis in markets where agents have less extreme private benefits than the one required for this interpretation.

initiated by the seminal work of Vives (2011 and 2014). Rahi and Zigrand (2018) and Rahi (2021) show that strategic complementarities in the decisions to acquire information may arise when each agent tries to learn about his or her own private valuation, thus making the price less informative about the other agents' valuation for the asset and increasing their incentives to acquire information[8]. This channel is absent from my model as agents may only learn about the common value component of the asset. Multiple equilibria instead arise through self-fulfilling beliefs of the market-maker about the decision of hedgers to acquire information. Biais, Foucault and Moinas (2015) use a model with rational traders and private valuation to assess the welfare impact of fast trading, which is modeled as a technology that simultaneously allows to learn about the common component of valuation of the asset and about active venues for trading. As their model assumes that the decision to acquire information is made before agents know their type, it cannot be used to study the incentives faced by different types of agents to acquire information that are the focus of this paper.

Third, my work relates to a strand of literature that looks at interactions between informed hedgers and informed speculators in the context of commodity markets. Goldstein, Li and Yang (2014) show in a model of segmented markets with correlated fundamentals that hedgers and speculators exposed to the same information may trade in opposite directions in the market where they are both present, which may then reduce price informativeness and create complementarities in the decisions of speculators to acquire information. Goldstein and Yang (2022) build on Goldstein, Li and Yang (2014) and propose an integrated model of commodity spot and futures markets, with three types of agents: commodity producers, financial hedgers and financial speculators. Their model can be calibrated to reproduce the patterns of price informativeness, futures prices bias, and cross-asset correlations that were observed during the growing financialization of commodity markets post 2004. The reduced form I adopt to model hedging needs does not allow me to analyze the rich interactions that are the object of Goldstein and Yang's paper[9]. Conversely, their set-up does not allow them to analyze endogenous acquisition of information by hedgers and welfare, which are the focus of this paper. We however share a common underlying message that financial speculators may have a positive impact on informational efficiency

[8]Strategic complementarities in the acquisition of information when information is multi-dimensional is not specific to this class of model: see for instance Ganguli and Yang (2009) and Goldstein and Yang (2015).

[9]Another limitation of the reduced form private benefit is that it implicitly assumes that the information acquired by the financial hedger does not impact the size of the hedging benefits he or she derives from the asset. See Banerjee, Breon-Drish and Smith (2022) for a model where the investment decision of the firm manager has an impact on the quality of the asset as a hedging instrument.

and welfare that cannot be substituted away by informed hedgers.

Finally, the policy implications of the paper complement the insights of the existing literature on designated market makers (DMM). Bessembinder, Hao and Zheng (2015) provide a model where an IPO[10] may fail when investors anticipate that the secondary market will be illiquid because of asymmetric information. They show that a contract whereby the DMM commits to a low bid-ask spread and the firm compensates the DMM for its trading losses can bring a Pareto improvement: the DMM and the investor break even, while the firm receives a sufficiently higher price for the IPO to more than compensate the payment to the DMM. Venkataram and Waisburd (2007), Anand, Tanggaard and Weaver (2009), and Menkveld and Wang (2013) all find evidence consistent with Bessembinder, Hao and Zheng (2015): younger, smaller firms tend to sign DMM agreements, DMM tend to increase liquidity and price discovery, and the announcement of a DMM contract generates a positive abnormal return. My model provides an alternative, and complementary, motivation why a firm may wish to enter a private agreement with a DMM: to stimulate information acquisition by speculators and generate productive efficiency gains through the feedback effect. This alternative motivation shares the same testable implications as the model of Bessembinder, Hao and Zheng (2015), plus a new one: firms that sign a contract with a DMM should display a stronger feedback effect than comparable firms without a DMM contract.

The remainder of the paper is organized as follows. I lay out the model in Section 2. I work out the respective incentives of hedgers and speculators to acquire information in Section 3. Section 4 is devoted to the equilibrium and welfare analysis and to policy implications. Section 5 concludes.

2. The Model

In this section, I first lay out the baseline model, then define the equilibrium, and outline the solution method. I finally define the welfare function.

2.1. The agents

The model is a 1-period model with three ingredients. First, there is a firm, where a firm manager needs to decide on an investment project based on his or her private information as well as the

[10]Skjeltorp and Odegaard (2015) provide evidence that the channel proposed by Bessembinder, Hao and Zheng (2015) for IPOs also applies to other financing events.

information revealed by trading on a financial market. Second, there is a trader who may decide to acquire information about the profitability of the firm's investment project. Finally, there is a market-maker who is endowed with shares of the firm and who quotes an ask price to the trader taking into account the fact that the trader may have superior information.

2.1.1. The firm

The firm is comprised of existing assets and of a new investment project. It issued equity that pays the cash-flows generated by the firm's assets at the end of the period. There is no limited liability so that the dividend paid may be either positive or negative. The firm is managed by a manager who maximizes the expected value of the firm.

I assume the following about the firm's assets and the information set of the firm manager:

- The cash-flows of existing assets and the start-up cost of the investment project are both normalized to zero.
- If the manager decides to invest, the project generates a cash-flow per share $\widetilde{CF} = \widetilde{\theta} - \widetilde{x}$ at the end of the period, where:

  $\widetilde{\theta}$ can take two values, 0 or a, each with probability 1/2, and with $0 < a < 1$.

  $\widetilde{x}$ is uniformly distributed on [0,1].
- The realization of $\widetilde{\theta}$, which can be interpreted as the potential income from the investment project, is unknown to the firm manager but may be learned (at a cost) by the trader.
- The realization of $\widetilde{x}$, which can be interpreted as the cost of the investment project, is known to the firm manager but not to the trader.
- The firm manager observes the ask price of the market-maker and whether a trade takes place before deciding whether to invest in the new project.

These assumptions imply that the firm's value, V, is solely determined by the decision D $\in$ {0, 1} of the manager, where 0 stands for "not invest" and 1 stands for "invest", and by the cash-flow of the investment project at the end of the period:

$$V(D, \theta, x) = D\,(\theta - x) \tag{2.1}$$

2.1.2. The trader

The second ingredient of the model is a trader who can be of one of two types and who may decide to acquire information about the realization of $\widetilde{\theta}$. I assume the following about the trader:

- The trader is risk-neutral, strategic, and is endowed with an initial amount of cash, W_0.
- At the start of the period, the trader learns whether he or she is a Hedger (H), with probability $0 < q < 1$, or whether he or she is a Speculator (S), with probability 1-q.

  If the trader is a hedger, then he or she obtains a private benefit $B > 0$ if (and only if) he or she owns a share of the firm's equity at the end of the period[11]. If the trader is a speculator, then he or she does not have a private benefit. Private benefit is the only difference between hedger and speculator in the model. It enters the utility of the trader additively.
- Once the trader knows his or her type, he or she may decide to learn θ at a cost $c > 0$.
- The trader can place market orders, but is both short-sale and capacity constrained. This implies that the only two choices available are "buy" (1 share) and "no trade"[12].
- The trader cannot commit ex-ante (not) to acquire information. Neither the trader's type nor his or her decision to acquire information are observable.

For the sake of brevity, I use in the appendix acronyms to describe both the trader's type, H or S, and his or her information set: NI for Not Informed ; I+ for Informed and learned that $\theta = a$; I- for Informed and learned that $\theta = 0$. This yields 6 possible acronyms: HNI; HI+; HI-; SNI; SI+; SI-.

2.1.3. The market-maker

The last ingredient of the model is a market-maker *à la* Glosten-Milgrom (1985), with the following characteristics:

- The market-maker is risk-neutral and is endowed with a share of the firm's equity.

[11] Private benefits should be thought as a reduced form for the (unmodelled) benefits of reducing risk exposure of the trader to some other income source.

[12] This is for simplicity. Sales can be incorporated in the model in a symmetric fashion without changing its insights.

- The market-maker observes neither θ nor x, but has rational expectations about the equilibrium strategies of the trader and of the firm manager. He or she updates his or her beliefs that $\theta = a$ using Bayes rule depending on whether the trader places a buy order.

- The market-maker behaves competitively and sets his or her ask price P to break even at the equilibrium.

I adopt the following notation: I call $\overline{p}$ the probability that $\theta = a$ conditional on observing a buy order and $\underline{p}$ the probability that $\theta = a$ conditional on observing no trade. $\overline{p}$ and $\underline{p}$ are determined at the equilibrium. This yields:

$$P = P\left(\overline{p}\right) = E\left(V \mid \overline{p}\right) \tag{2.2}$$

where the conditional expectation in (2.2) is a short-hand notation for the expected value of the firm conditional on observing a buy order, given that the equilibrium probability of $\theta = a$ conditional on observing a buy order is equal to $\overline{p}$.

Notice that P($\overline{p}$) is larger than the valuation of the firm by the market-maker conditional on observing no trade, which I note P($\underline{p}$). The difference P($\overline{p}$) - P($\underline{p}$) can be interpreted as a half bid-ask spread.

2.2. Timeline

The model unfolds as follows:

1. The firm manager learns x

   The trader learns his or her type, Hedger (H) or Speculator (S).

2. The market-maker posts an ask price based on his or her equilibrium beliefs.

   The trader decides whether to acquire information, in which case he or she learns θ.

3. The trader decides whether to place a market buy order or abstain from trading.

   The firm manager observes whether a trade took place.

4. The firm manager decides whether to invest.

   If investment took place, uncertainty is resolved and the firm pays θ - x as dividend.

5. The world ends.

Two features of this timeline are important to stress. First, the decision to acquire information is made after the trader learns his or her type, with no possibility to pre-commit. This assumption is necessary to be able to discuss the respective incentives of hedgers and speculators to acquire information. It also creates a game between the two types. I discuss this further in the next section, after having defined the equilibrium. Second, there is only a single round of trading in the model. This is a significant simplification relative to the seminal paper of Glosten and Milgrom (1985), that helps make the model tractable despite the addition of a feedback effect. It also precludes the possibility of price manipulation by the trader[13].

2.3. Definition of equilibrium and solution method

Definition 1. *The equilibrium concept is Perfect Bayesian Equilibrium. An equilibrium is defined by:*

1. *A probability of acquiring information and a trading rule that maximize the expected utility of the hedger given the price asked by the market maker and the investment decision rule of the firm manager.*

2. *A probability of acquiring information and a trading rule that maximize the expected utility of the speculator given the price asked by the market maker and the investment decision rule of the firm manager.*

3. *An investment decision rule that maximizes the expected value of the firm given x, $\overline{p}$, and $\underline{p}$.*

4. *An ask price by the market-maker, which is equal to the expected value of the firm given the investment decision rule by the firm manager and $\overline{p}$.*

$\overline{p}$ and $\underline{p}$ are derived from the equilibrium strategies of hedger and speculator using Bayes rule.

[13] See Goldstein and Guembel (2008) for a model where the combination of strategic behavior by a large trader, feedback effect, and multiple rounds of trading creates opportunities for price manipulation.

Note that Definition 1 treats hedger and speculator as separate agents. This is because the decision to acquire information is made after the types are determined, and the market-maker cannot tell which of the two types he or she is trading with. Even if only one type acquires information at the equilibrium, the market maker charges to both types a same price that reflects the relative probabilities that the trader is informed or uninformed. This implies that, even though there is a single trader and a single trade, everything in the model works as if the two types were separate agents, of respective mass q and 1-q, competing with one another, and who each need to play best responses to the other's strategy. This is also the sense why it is legitimate to talk about "hedger**s**" and "speculator**s"** (plural) to provide intuition for some results in the paper.

Definition 1 underlines the fixed-point problem that is common to all models with a feedback effect: the investment decision by the firm's manager depends on his or her beliefs about the random variable $\widetilde{\theta}$. These beliefs are updated depending on the actions of the trader, which are based on his or her valuation of the firm's assets, which is itself affected by the investment decision of the manager. The set-up of this model however simplifies the fixed point problem considerably in that it concerns only one variable: $\overline{p}$, that is the probability that $\theta = a$ conditional on observing a buy order.

This allows the following approach to solve the model:

1. Conjecture a possible equilibrium characterized by the optimal strategies (acquisition of information and trading rules) of hedger and speculator

2. Using Bayes rule, derive the $\overline{p}$ implied by these strategies

3. Given $\overline{p}$, derive the investment decision rule by the firm manager and the ask-price by the market-maker

4. Given the investment decision rule by the firm manager and the ask-price by the market-maker, check whether the conjectured strategies of hedger and speculator are optimal

5. Iterate until all possible equilibria have been covered.

While it may seem cumbersome to cover all possible cases, the task is simplified by two observations. First, it can never be optimal to purchase information but not use it. This implies that the optimal trading rule for a trader who learned that $\theta = a$ must be "buy", and that the optimal trading rule for a trader who learned that $\theta = 0$ must be "no trade". Second, an uniformed speculator can never be (strictly) better off buying the asset since he or she has neither a private benefit nor an informational advantage. Thus, "no trade" must always be an optimal trading rule for the uninformed speculator. In sum, the decision to acquire, or not acquire, information implies the optimal trading rule in all cases except one: the uninformed hedger, who may find it optimal to either buy the asset or not trade.

2.4. Welfare

I finally define the welfare function:

Definition 2. *The welfare criterion is utilitarian welfare.*

The equilibrium welfare is equal to the sum of the initial cash endowment of the trader plus the (unconditional) expected value of the firm plus the expected private benefits of the trader minus the expected cost of acquiring information

The equilibrium welfare in Definition 2 is obtained by adding the *ex-ante*[14] expected utility of the trader and of the market-maker. Since they are both risk-neutral, trading gains or losses cancel out. What is left are the value of the initial endowments, the private benefits that accrue when the trader is a hedger and buys the equity, and any cost that has been incurred to acquire information. The initial endowments are of two types: the cash endowment of the trader, which is fixed, and the equity endowment of the market-maker whose value depends on the investment decision of the firm manager. More information leads to a better decision by the firm manager and therefore a higher expected value of equity. This productive efficiency gain needs to be compared to the direct cost of acquiring information and the indirect impact on expected private benefits to obtain the total impact of acquisition of information on welfare.

3. Incentives to acquire information

In this section, I first derive the solution to the firm manager's optimization problem, then the price asked by the market-maker, the expected trading losses of an uninformed trader, and the expected profit of an informed trader as a function of $\overline{p}$. The incentives of hedgers and speculators to acquire information immediately follow.

[14] Before types are known.

3.1. The firm's optimization problem

The firm manager chooses D $\in$ {0;1} to maximize the expected value of $V(D, \theta, x) = D(\theta - x)$. The firm manager knows x and has equilibrium beliefs about $\widetilde{\theta}$: if the trader places a buy order, the manager infers that $\widetilde{\theta} =$ a with probability $\overline{p}$ and that $\widetilde{\theta} = 0$ with probability 1- $\overline{p}$. If no trade takes place, then the manager infers that $\widetilde{\theta} =$ a with probability $\underline{p}$ and that $\widetilde{\theta} = 0$ with probability 1- $\underline{p}$.

It immediately follows that the optimal investment decision is:

- If buy order: invest (D=1) if and only if:

$$E\left(\widetilde{\theta}\right) - x > 0 \Leftrightarrow x < a\overline{p} \tag{3.1}$$

- If no trade: invest (D=1) if and only if:

$$E\left(\widetilde{\theta}\right) - x > 0 \Leftrightarrow x < a\underline{p} \tag{3.2}$$

Note that $a\overline{p}$ and $a\underline{p}$ can be interpreted as conditional probabilities of investment from the perspective of an agent who does not know x. The fact that they vary continuously with the parameter a and are strictly[15] comprised between 0 and 1 regardless of the ex-ante NPV of the project matters. Indeed, if the firm manager did not have private information, and if traders could therefore perfectly forecast the investment decision of the firm manager in the absence of feedback, a discontinuity would exist at the parameter value corresponding to a 0-NPV project, with the probability of investment jumping from 1 to 0. Dow, Goldstein and Guembel (2017) analyze a model with this feature and show that the incentives of rational traders to acquire information are then qualitatively different for ex-ante profitable vs. ex-ante not profitable investment projects. This is not the case here because the introduction of the cost variable $\widetilde{x}$ convexifies the problem of the firm manager as a function of the parameter a .

3.2. Expected firm value and trading profits

Once the firm's optimal investment strategy is known, it is easy to compute the expected value of the firm. A point of attention is that not all agents have the same information set and therefore disagree

[15] Except in a degenerate case where $\underline{p}$ may be equal to zero at the equilibrium.

on the expected value of the firm. With this in mind, I define $E(V \mid p; \overline{p})$ as the expected value of the firm from the standpoint of an agent who believes that the probability that $\theta = \mathrm{a}$ is equal to p but who knows that the firm manager believes that the probability is equal to $\overline{p}$, which may or may not be equal to p. We get after substituting (3.1):

$$E(V \mid p; \overline{p}) = \int_0^{a\overline{p}} (ap - x)\, dx = a^2 \overline{p} \left(p - \frac{\overline{p}}{2} \right) \tag{3.3}$$

3.2.1. Ask price of the market-maker

The ask price by the market-maker, that is the price he or she is willing to sell at if he or she receives a buy order, follows immediately from (3.3):

$$P(\overline{p}) = E(V \mid \overline{p}; \overline{p}) = \frac{a^2}{2} \overline{p}^2 \tag{3.4}$$

The expected value of the firm conditional on no trade is derived the same way:

$$P(\underline{p}) = E(V \mid \underline{p}; \underline{p}) = \frac{a^2}{2} \underline{p}^2 \tag{3.5}$$

3.2.2. Expected trading profits and losses

Given the expressions for the expected value of the firm (3.3) and the ask price by the market-maker (3.4), it is straightforward to derive the expected profit of an informed trader who received positive information about θ , which I note $\pi_{I+}(\overline{p})$, and the expected loss of a uninformed trader, which I note $\pi_{NI}(\overline{p})$:

$$\pi_{I+}(\overline{p}) = E(V \mid 1; \overline{p}) - P(\overline{p}) = a^2 \overline{p} (1 - \overline{p}) \geq 0 \tag{3.6}$$

$$\pi_{NI}(\overline{p}) = E\left(V \mid \frac{1}{2}; \overline{p}\right) - P(\overline{p}) = a^2 \overline{p} \left(\frac{1}{2} - \overline{p} \right) \leq 0 \tag{3.7}$$

Note that the expected trading loss of an uninformed trader, $\pi_{NI}(\overline{p})$, stems from two channels. The first channel, which is standard, is that the ask price contains a premium to account for the fact the market-maker may be trading with an informed trader. The second channel, which is less standard, stems from the dual assumption of a feedback effect and of a strategic trader: any buy order, whether informed or uninformed, makes the firm manager update his or her beliefs and invest whenever $x < a\overline{p}$. When the buy order comes from an uninformed trader, this investment policy is over-optimistic since the optimal investment policy when no information is available about θ is to invest if and only if $x < \frac{a}{2}$. The uninformed trader internalizes in the computation of $\pi_{NI}(\overline{p})$ the decrease of the firm's expected value resulting from the mistake made by the firm manager. *Ceteris paribus*, this effect increases the incentives of the trader to acquire information relative to the incentives a competitive trader would have, or that would exist in the absence of a feedback effect[16].

3.2.3. Incentives to acquire information

As discussed in Section 2.3, an uninformed speculator never trades. His or her payoff is thus equal to zero. An informed speculator places a buy order if and only if the information is positive, which happens with probability 1/2, and does not trade otherwise. Thus, the expected payoff of an informed speculator is equal to $-c + \frac{1}{2}\pi_{I^+}(\overline{p})$. Comparing the two and substituting (3.6) yields:

Lemma 1. *It is optimal for the speculator to acquire information if and only if:*

$$c \leq \frac{a^2}{2}\overline{p}(1-\overline{p}) \tag{3.8}$$

Since $\overline{p} \geq \frac{1}{2}$, the RHS of (3.8) is decreasing in $\overline{p}$. The intuition is straightforward: the lower is $\overline{p}$, the lower is the price charged by the market-maker and the higher is the expected trading profit.

An uninformed hedger differs from an uninformed speculator in that it may be optimal for him or her either to buy the asset or to abstain from trading. Thus, for acquisition of information to be optimal for a hedger, it needs to dominate both "never trade" and "always buy". The payoff for "never trade" is 0. The payoff for "always buy" is $B + \pi_{NI}(\overline{p})$. The expected payoff for acquiring information is equal to $-c + \frac{1}{2}\pi_{I^+}(\overline{p}) + \frac{B}{2}$. Comparing the three terms and substituting (3.6) and (3.7) provides:

Lemma 2. *It is optimal for the hedger to acquire information if and only if:*

$$c \leq Min\left(\frac{a^2\overline{p}^2}{2} - \frac{B}{2}; \frac{a^2\overline{p}(1-\overline{p})}{2} + \frac{B}{2}\right) \tag{3.9}$$

[16] As in Edmans, Goldstein and Jiang (2015), the effect would go in the opposite direction for negative news. This is because an informed sell order helps the manager make better decisions, which lowers the profitability of a short-sale.

Provided the private benefit, B, is large enough, condition (3.9) simplifies into:

$$c + \frac{B}{2} \leq \frac{a^2 \overline{p}^2}{2} \tag{3.10}$$

Condition (3.10) differs from the corresponding condition for the speculator, (3.8), in two respects. First, the private benefit enters the LHS next to the cost c: this is because acquiring information implies forfeiting private benefits when $\theta = 0$, which happens with probability 1/2. Thus, the hedger bears an additional cost of acquiring information compared to the speculator equal to the expected loss in private benefits. Second, and perhaps more surprisingly, the RHS of (3.10) is *increasing* in $\overline{p}$ rather than decreasing as the RHS of (3.8). This is because the hedger has no incentive to acquire information when the price charged by the market-maker is low as the private benefit more than compensates for the expected trading loss. It is only when the ask price by the market-maker, and therefore the expected trading losses of an uninformed trader, become too high that the hedger finds it optimal to acquire information.

This property suggests that multiple equilibria may arise in the model: if the market-maker initially believes that the the trader is unlikely to be informed, he or she charges a low price, and the hedger indeed chooses not to acquire information. If the market-maker instead believes that the trader is likely to be informed, he or she charges a high price, and the hedger indeed chooses to acquire information. It also suggests that any equilibrium with the hedger acquiring information with probability strictly comprised between 0 and 1 is unstable, as any increase (resp. decrease) in the informativeness of a buy order at the equilibrium raises (resp. lowers) the incentives of hedgers to acquire information. This is unlike acquisition of information by the speculator, which displays the opposite property.

4. Equilibrium and welfare

In this section, I first solve for equilibria where the hedger optimally chooses not to acquire information. I interpret the conditions for existence, derive the equilibrium welfare, and characterize cases where too little or too much information is produced at the equilibrium. I next turn to the equilibrium where the hedger trader acquires information. I investigate multiplicity of equilibria and compare welfare across equilibria. I finally discuss regulatory implications.

4.1. Equilibria without informed hedger

There are three possible types of equilibrium where the hedger does not acquire information: an equilibrium where no one acquires information, an equilibrium where the speculator always acquires information, and a mixed strategy equilibrium where the speculator is indifferent between acquiring or not acquiring information. Following the approach proposed in Section 2.3, I prove in the Appendix the following results:

Theorem 1. *An equilibrium where no information is acquired exists if and only if:*

$$c \geq \frac{a^2}{8} \tag{4.1}$$

The equilibrium welfare is equal to:

$$W_0 + \frac{a^2}{8} + qB \tag{4.2}$$

Proof: See Appendix

Theorem 2. *An equilibrium where the speculator acquires information with probability 1 and where the hedger does not acquire information exists if and only if:*

$$\frac{a^2}{2}\frac{1-q}{(1+q)^2} \leq \frac{B}{2} \tag{4.3}$$

and:

$$\frac{a^2}{2}\left(\frac{1}{1+q}\right)^2 - \frac{B}{2} \leq c \leq \frac{a^2}{2}\frac{q}{(1+q)^2} \tag{4.4}$$

The equilibrium welfare is equal to:

$$W_0 + \frac{1}{1+q}\frac{a^2}{4} + qB - (1-q)\,c \tag{4.5}$$

Proof: See Appendix

Theorem 3. *An equilibrium where the speculator acquires information with probability $\kappa \in (0,1)$ and where the hedger does not acquire information exists if and only if:*

$$c = \frac{a^2}{2} \frac{q(q+k)}{(2q+k)^2} \tag{4.6}$$

and:

$$\frac{B}{2} \geq \frac{kc}{q} \tag{4.7}$$

where $k \equiv \kappa(1-q)$ *is the probability that the trader is informed at the equilibrium.*

The equilibrium welfare is equal to:

$$W_0 + \left(\frac{2q(1-q) + k(1-2q)}{(k+2q)(2(1-q)-k)} \right) \frac{a^2}{4} + qB - kc \tag{4.8}$$

Proof: See Appendix

A first observation is that the three equilibria do not overlap: for a given cost of acquisition of information, at most one equilibrium exists. This can be seen from equation (4.6): when the parameter k varies from 0 to $1-q$, the RHS of (4.6) varies monotonically from $\frac{a^2}{8}$, which is the minimum cost threshold for the no information equilibrium, to $\frac{a^2}{2}\frac{q}{(1+q)^2}$, which is the maximum cost threshold for the equilibrium where the speculator acquires information with probability 1.

Note also that an equilibrium where the speculator acquires information may not always exist, regardless of how low the cost of information gets. This is because information acquisition is profitable only if the hedger buys the asset at the equilibrium, thus leaving the market-maker unsure of whether the buy order is informed or not. If the cost of acquiring information is too low, the hedger chooses instead to acquire information. If the private benefit is too low, he or she optimally stops trading. Condition (4.7) for the mixed strategy equilibrium, and condition (4.3) plus the lower bound on c in (4.4) for the pure strategy equilibrium, provide the required conditions on c, B and q, for the hedger's prescribed equilibrium strategy to be indeed optimal.

Turning to welfare, the comparison between (4.2), (4.5), and (4.8) reveals a trade-off between the cost of acquiring information, which varies linearly from 0 to $(1-q)c$ when k varies from 0 to $(1-q)$, and the expected value of the firm, which varies non-linearly from $\frac{a^2}{8}$ to $\frac{a^2}{4}\frac{1}{1+q}$. The other two terms, W_0 and qB , are constant across the three equilibria, W_0 because it is a cash endowment, qB because the hedger buys the firm's equity with probability 1 in each equilibrium.

A first welfare question we may ask is whether welfare in an economy where the cost of acquisition of information c is low and where speculators acquire information is lower or higher than the welfare in an otherwise identical economy where the cost of information is higher and no information gets acquired. Direct comparison of (4.5) and (4.2) yields:

Corollary 1. *Welfare in the equilibrium where the speculator acquires information is higher than welfare in the equilibrium where no information is acquired if and only if:*

$$c \leq \frac{a^2}{8}\frac{1}{1+q} \tag{4.9}$$

Condition (4.9) is easier to interpret if we multiply both sides by $(1-q)$. Indeed, $c(1-q)$ is the expected acquisition cost of information[17]while $\frac{a^2}{8}\frac{1-q}{1+q} = \frac{a^2}{4}\frac{1}{1+q} - \frac{a^2}{8}$ is the increase in expected firm value due to more efficient investment decisions in the equilibrium with informed speculator. Thus, condition (4.9) simply says that the social cost of information should be less than the social value of information. The social value of information is decreasing in q and increasing in a. Both properties are intuitive. A smaller q implies a larger probability that the trader is a speculator and thus that the order contains information, while the parameter a scales the project: the larger it is, the higher is the level of ex-ante uncertainty[18], and therefore the higher are the expected productive efficiency gains from a given level of information.

Corollary 1 compares welfare across economies with different costs of information acquisition. The lesson we can draw is that if condition (4.9) is satisfied, then taxing acquisition of information up to the point where it becomes prohibitively expensive destroys welfare. A different welfare question is whether, *for a given cost c*, the equilibrium production of information is too high or too low. This question can be asked in the context of the mixed strategy equilibrium: would the central planner wish the speculator acquires information with a lower or a higher probability?

The answer to this question happens to be the same as in Corollary 1. This is because the term corresponding to the expected value of the firm in (4.8) can be shown to be a convex function of k , which in turn implies that welfare is maximized either when the speculator acquires no information or when he or she acquires it with probability 1. The comparison of social cost and social value of

[17]As the hedger buys the asset in both equilibria, expected private benefits are left unchanged.

[18]$Var(\theta) = \frac{a^2}{4}$

information for *k=1-q* tells which it is and thus whether there is too little or too much information produced by speculators in the mixed strategy equilibrium:

Theorem 4. *There is under-acquisition of information in the mixed strategy equilibrium if and only if:*

$$c \leq \frac{a^2}{8} \frac{1}{1+q} \tag{4.10}$$

Proof: See Appendix

The convexity of the expected value of the firm as a function of k implies that private and social incentives to acquire information are necessarily mis-aligned. Private incentives of the speculator are maximized when $k = 0$, and thus $\overline{p} = 1/2$. On the other hand, I show in the appendix that $\frac{\partial E(V)}{\partial k} \mid_{k=0} = 0$, which implies that the social value of spending resources to increase marginally the probability of acquiring information is strictly negative: having just a little bit of information does not provide enough of an improvement in the investment decision to justify the cost. The social value of information progressively increases and becomes positive as more information gets produced but private incentives of the speculator move in the opposite direction: the larger is k, and therefore $\overline{p}$, the lower are the profits of an informed trader, π_{I+}. When the proportion of hedgers, q, is small, the spread charged my the market-maker adjusts faster to changes in κ, and trading profits net of the acquisition cost of information turn negative before the point where the speculator acquires information with probability 1. As a consequence, there is under-acquisition of information at the equilibrium.

4.2. Equilibrium with informed hedger

I prove in the Appendix the following:

Theorem 5. *An equilibrium where the hedger acquires information with probability 1 and where the speculator does not trade exists if and only if:*

$$c \leq Min\left(\frac{B}{2}; \frac{a^2}{2} - \frac{B}{2}\right) \tag{4.11}$$

The equilibrium welfare is equal to:

$$W_0 + \frac{a^2}{4}\frac{1}{2-q} + q\left(\frac{B}{2} - c\right) \tag{4.12}$$

Proof: see Appendix

Comparing (4.11) in Theorem 5 with the corresponding (4.1), (4.4), and (4.6) in Theorems 1 to 3 immediately implies that the equilibrium with an informed hedger may overlap with any of the three equilibria in Section 4.1. The value of the private benefit B determines how much of an overlap there is with each equilibrium. To understand the role played by B in the equilibrium with informed hedger, it is useful to rewrite (4.11) as:

$$c \leq \frac{B}{2} \leq \frac{a^2}{2} - c \tag{4.13}$$

Condition (4.13) states that for an equilibrium with informed hedger to exist, the private benefit of the hedger should be neither too small nor too high. To see why this makes sense, first notice that $\overline{p} = 1$ since only a hedger who learned that $\theta = a$ places a buy order at the equilibrium. $\overline{p} = 1$ implies that the trading profit of an informed trader is equal to 0. Thus, if the private benefit is so small that it does not compensate for the cost of acquiring information, then the best response of the hedger when the market-maker asks a price P(1) is to stop trading. Conversely, if the private benefit is so large that it more than compensates the expected trading loss of an uninformed trader at price P(1), then the best response of the hedger is to keep buying the asset. Only when private benefits are in between do we get the equilibrium with informed hedger[19].

Since the equilibrium with informed hedgers can co-exist both with the equilibrium where no one gets informed and with the equilibrium where the speculator acquires information, it is natural to ask which equilibrium generates a higher welfare.

Given (4.1), comparing (4.12) and (4.2) yields:

Corollary 2. *Whenever both the equilibrium with no acquisition of information and the equilibrium with informed hedger exist, welfare is strictly higher in the equilibrium with no acquisition of information.*

[19] A mixed strategy equilibrium may exist outside these bounds. Such an equilibrium is however necessarily unstable for reasons discussed in Section 3.2.

The reason why the welfare comparison between the no information and the informed hedger equilibria is unambiguous is that the social value of information is bounded above by $\frac{a^2}{8}$ as the expected firm value under perfect information is equal to $\frac{a^2}{4} = \frac{1}{2}\int_0^a (a-x)dx + \frac{1}{2} * 0$ while the expected firm value under no information is equal to $\frac{a^2}{8} = \int_0^{a/2} \left(\frac{a}{2} - x\right) dx$. Thus, condition (4.1) for the existence of the equilibrium with no acquisition of information also implies that the social cost of information is strictly larger than its social value for these parameter values.

Could we ever get into a situation where the economy would coordinate on the bad equilibrium? Equilibrium selection can be a slippery topic for economists. An element of answer here however is that beliefs of the market-maker play a key role in selecting the equilibrium. If the market-maker believes that $\overline{p} = \frac{1}{2}$, then the price he or she asks will not lead to any acquisition of information. Conversely, if the market-maker believes that $\overline{p} = 1$, then the price he or she asks will incentivize the hedger to acquire information, thus validating the beliefs of the market-maker. But notice that the market-maker is better off in the bad equilibrium. This is because the market-maker is endowed with equity, and that the value of this initial endowment is strictly increasing in the information produced in the financial market. The cost of acquiring information and the foregone private benefits are both borne by the trader, not by the market-maker. So, and even though this is stepping outside the model, there are reasons to think that, if market-makers were strategic rather than competitive, the economy could coordinate on an equilibrium where hedgers acquire information even though they should not.

What about the case where c is lower, and where the two possible equilibria are "speculator acquires information" and "hedger acquires information"? If the same amount of information is generated in both equilibria, then the central planner unambiguously prefers the equilibrium where the speculator acquires information since the information is produced for a lower social cost (no loss in expected private benefits). This implies that the welfare of the equilibrium with informed speculator will always be strictly larger than that of the equilibrium with informed hedger for economies in a neighborhood of $q = 1/2$. Comparing (4.5) and (4.12) yields that the welfare ranking of the two equilibria is reversed only in the case of a high social value of information combined with a low probability that the trader is a speculator. I state the formal result in Corollary 3 below and discuss it further in next section:

Corollary 3. *Whenever both the equilibrium where the hedger acquires information with probability 1 and the equilibrium where the speculator acquire information with probability 1 exist, welfare is higher in the equilibrium where the speculator acquires information if and only if:*

$$(1-2q)\left(\frac{a^2}{4}\frac{1}{(2-q)(1+q)}-c\right)+\frac{qB}{2}\geq 0 \tag{4.14}$$

4.3. Policy implications

The paper started with the question of whether the regulation of speculative activities should be differentiated depending on their official status as hedger or non-hedger. Corollary 3 states that there can be cases where the equilibrium with an informed speculator does not generate enough information, and where an equilibrium with an informed hedger will do better. This is when the private benefit, B, the cost of acquiring information, c, and the relative proportion of speculators, $1-q$, are all small. In all other cases, the foregone gains from trade in the equilibrium with informed hedger imply that the economy is better off either with a speculator acquiring information, or with no acquisition of information at all.

How likely is it that the proportion of potential speculators is small relative to the proportion of hedgers in actual markets? This is an empirical question whose answer may vary according to markets. For the stock market however, an element of answer is provided by Subrahmamyam and Titman (1999), who argue that the existence of a large group of investors willing to acquire costly information may be the reason why listed companies decided to go public in the first place. If the case indeed, then the welfare analysis of the paper not only suggests that having a more lenient regulation for hedgers who speculate than for pure speculators may not be a good idea but pushes toward a strict separation of hedging and speculative activities, in the spirit of the Volcker rule[20].

If in addition to having a large enough proportion of speculators ($1-q$ large), we also have a high level of ex-ante uncertainty about the productivity of the firm's investment project (a large), then there might be under-provision of information by the speculation at the equilibrium (Theorem 4). Within the model, the best policy to remedy this inefficiency is to tax firms and commit to use the tax proceeds to subsidize information acquisition by speculators and compensate hedgers for their increased trading losses. This policy is however unlikely to be adopted in practice, first because the regulator may not

[20]Note that the main motivation of the regulator to impose the Volcker rule is concerns for banking stability, which go beyond the model in this paper.

always be able to distinguish hedgers and speculators, and second because subsidizing information acquisition by speculators is unlikely to be politically acceptable even if welfare increasing.

Other policy tools may however at least partially substitute. One possibility is to allow private contracts between the firm and the market maker, whereby the firm pays the market maker to charge a lower spread. Such private contracts are currently not allowed on US markets[21] but exist in Europe. Bessembinder, Hao and Zheng (2015) provide the first theoretical rationale why such contracts may be welfare-enhancing in an IPO context. In their model, liquidity issues due to asymmetric information in the secondary market may cause an IPO to fail at the initial stage. A contract between the firm and the market-maker can be Pareto improving provided that the expected increase in the IPO price is more than enough to compensate the market maker for his or her trading losses resulting from the low spread agreed upon in the contract. A similar mechanism is at play here, where the incentives of the firm to pay the market maker stem from the productive efficiency gains generated by the feedback effect. For instance, a contract whereby the ask price of the market maker is capped at the competitive price of the mixed strategy equilibrium will incentivize the speculator to acquire information with probability 1 and thus increase total welfare under the assumptions of Theorem 4[22].

The introduction of DMM contracts in my model generate many testable implications that are common with those of Bessembinder, Hao and Zheng's model and that have been validated by the empirical literature[23] : younger, smaller firms, with a higher level of ex-ante uncertainty should be more likely to sign DMM agreements, DMM should increase liquidity and price discovery, the announcement of a DMM contract should generate a positive abnormal return. A new testable implication is specific to the mechanism of my model: firms that sign a contract with a DMM should display a stronger feedback effect than comparable firms without a DMM contract.

5. Conclusion

Like the celebrated Dr Jekyll in "The strange case of Dr Jekyll and Mr Hyde" (1886), the trader in my model is "*cursed by the duality of his purpose*". A hedger who can acquire costly information may

[21] See https://www.finra.org/rules-guidance/rulebooks/finra-rules/5250

[22] Note however that even though total welfare goes up, the hedger is left worse off. This is because the hedger makes losses for two reasons: the spread asked by the market maker and the loss in expected value of the asset due to the mistakes made by the firm manager when he or she interprets the buy order as positive news even though it originates from an uninformed trader. The more the firm manager believes the order flow is informative, the stronger is the latter effect.

[23] See Venkataram and Waisburd (2007), Anand, Tanggaard and Weaver (2009), and Menkveld and Wang (2013).

decide to do so but find himself or herself worse off than if he or she did not have this flexibility. He or she may instead gain to restrict him- or herself to trading for hedging purposes and have another type, a financial speculator, freely acquire information and make trading profits, the same way as Dr Jekyll initially gained having Mr Hyde "*delivered from the aspirations and remorse of his more upright twin*".

Not only does the model suggest that it is generally better to have Mr Hyde speculate instead of Dr Jekyll, but it also suggests that Mr Hyde may actually not speculate enough. I discuss possible remedies, which include the possibility of having private contracting between firms and market-makers, whereby firms pay market-makers to charge a lower spread and benefit in return from a more informative stock price that allows them to make better informed investment decisions.

Besides its regulatory implications, the model in this paper may have some value as a methodological innovation as it is the first model with both endogenous acquisition of information and feedback that does not rely on noise traders while remaining extremely tractable.

References

[1] Akey, P., A. Robertson, and M. Simutin (2021) Closet active management of passive funds, *Working paper*.

[2] Anand, A., Tanggaard, C., and D. Weaver (2009), Paying for market quality, *Journal of Financial and Quantitative Analysis* 44, 1427-1457

[3] Bakke T. E., and Whited, T. M. (2010) Which firms follow the market? An analysis of corporate investment decisions, *Review of Financial Studies* 23, 1941—1980

[4] Banerjee, S., Breon-Drish, B., and Smith, K. (2022), Feedback effects with risk aversion: an application to climate risk, *Working Paper*.

[5] Bessembinder, H., Hao J., and Zheng K. (2015), Market making contracts, firm value, and the IPO decision, *Journal of Finance 70*, 1997-2028

[6] Biais, B., T. Foucault, and S. Moinas (2015), Equilibrium fast trading, *Journal of Financial Economics* 116, 292-313.

[7] Bond, P., Edmans, A., and Goldstein, I. (2012), The real effects of financial markets, *Annual Review of Financial Economics* 4, 339—360.

[8] Chen, Q., Goldstein, I., and Jiang, W. (2007) Price informativeness and investment sensitivity to stock price, *Review of Financial Studies* 20, 619—650

[9] Cheng, I-H, and W. Xiong (2013) Why do hedgers trade so much?, *Journal of Legal Studies* 43 (52), S183-S207

[10] Dastarac, H. (2021), Market making and proprietary trading in the US corporate bond market, *Working paper*

[11] Dow, J., Goldstein, I., and Guembel, A. (2017), Incentives for information production in markets where prices affect real investment, *Journal of the European Economic Association* 15, 877—909.

[12] Dow, J., and Gorton, G. (1997), Stock market efficiency and economic efficiency: Is there a connection?, *Journal of Finance* 52, 1087—1129.

[13] Dow, J., and Rahi, R. (2003), Informed trading, investment, and welfare, *Journal of Business* 76, 439—454.

[14] Duffie, D. (2012), Market making under the proposed Volcker rule, *Working paper*

[15] Easley, D., D. Michayluk, M. O'Hara and T. Putnins (2021) The active world of passive investing, *Review of Finance*, 1433-1471

[16] Edmans, A., Goldstein, I., and Jiang, W. (2015), Feedback effect, asymetric trading, and limits to arbitrage, *American Economic Review* 105, 3766—3797.

[17] Edmans, A., Jayaraman, S., and Schneemeier, J. (2017) The source of information in prices and investment-price sensitivity, *Journal of Financial Economics* 126, 74—96.

[18] Financial Stability Oversight Council. (2011) Study and recommendations on proprietary trading & certain relationships with hedge funds & private equity funds

[19] Foucault, T., and Frésard, L. (2014) Learning from peers' stock prices and corporate investment, *Journal of Financial Economics* 111, 554—577

[20] Ganguli, J., and L. Yang (2009), Complementarities, multiplicity, and supply information, *Journal of the European Economic Association* 7, 90-115.

[21] Gervais, S. and Strobl, G. (2022), Money management and real investment, *Working paper*

[22] Glosten, L., and Milgrom, P. (1985), Bid, ask, and transaction prices in a specialist market with heterogeneously informed traders, *Journal of Financial Economics* 14, 71-100.

[23] Goldstein, I., (2023), Information in financial markets and its real effects, *Review of Finance 27*, 1-32.

[24] Goldstein, I., and Guembel, A. (2008) Manipulation and the allocational role of prices, *Review of Economic Studies* 75, 133—164.

[25] Goldstein, I., Li, Y.,and Yang, L. (2014) Speculation and hedging in segmented markets, *Review of Financial Studies* 27, 1723-1765.

[26] Goldstein, I., and Yang, L. (2015) Information diversity and complementarities in trading and information acquisition, *Journal of Finance* 70, 881-922.

[27] Goldstein, I., and Yang, L. (2022) Commodity financialization and information transmission, *Journal of Finance*, forthcoming.

[28] Grossman, S. J., and Stiglitz, J. E. (1980), On the impossibility of informationally efficient markets, *American Economic Review* 70, 393—408.

[29] Hirshleifer, J. (1971), The private and social value of information and the reward to inventive activity, *American Economic Review* 61, 561-574.

[30] Jacque, L. (2010) Global derivative debacles: from theory to malpractice, *World Scientific*.

[31] Marin, J., and Rahi, R. (2000) Information revelation and market incompleteness, *Review of Economic Studies* 67, 455-481

[32] Menkveld, A.J. and Wang T. (2013), How do designated market makers create value for small-caps?, *Journal of Financial Markets* 16, 571-603

[33] Rahi, R. (2021), Information acquisition with heterogeneous valuations, *Journal of Economic Theory* 191, 1-31

[34] Rahi, R. and Zigrand, J.P., (2018), Information acquisition, price informativeness, and welfare, *Journal of Economic Theory* 177, 558-593

[35] Skjeltorp, J.A. and Odegaard, B.A. (2015), When do listed firms pay for market making in their own stock?, *Financial Management*, 241-266

[36] Stevenson, R.L., (1886), The strange case of Dr Jekyll and Mr Hyde", *Charles Scribner's Sons*

[37] Subrahmamyam, A., and Titman, S. (1999), The going-public decision and the development of financial markets, *Journal of Finance* 54, 1045-1082

[38] Venkataram, K. and Waisburd, A. (2007), The value of the designated market maker, *Journal of Financial and Quantitative Analysis* 42, 735-758

[39] Vives, X. (2011), "Strategic supply function competition with private information", *Econometrica* 79, 1919-1966.

[40] Vives, X. (2014)"On the possibility of informationally efficient markets", *Journal of the European Economic Association* 12, 1200-1239

Appendices

A. Proof of Theorem 1

We need to find conditions under which the following candidate equilibrium strategies are optimal:

- neither H nor S acquires information
- HNI[24] buys
- SNI does not trade
- Firm manager and market-maker act optimally given the trader's strategy

Given no information is acquired in the candidate equilibrium, we have:

$$\overline{p} = \underline{p} = \frac{1}{2} \tag{A.1}$$

From (3.4) and (3.5), we get:

$$P\left(\overline{p}\right) = P\left(\underline{p}\right) = \frac{a^2}{8} \tag{A.2}$$

From (3.6) and (3.7), we get:

$$\pi_{I+}\left(\overline{p}\right) = \frac{a^2}{4} \tag{A.3}$$

$$\pi_{NI}\left(\overline{p}\right) = 0 \tag{A.4}$$

We first check that "no trade" dominates "acquisition of information" for the speculator. From (3.8) and (A.1), this is the case when:

$$c \geq \frac{a^2}{8} \tag{A.5}$$

[24] As explained in Section 2.1.2, I use acronyms to describe both the trader's type, H or S, and his or her information set: NI for Not Informed ; I+ for Informed and learned that $\theta = a$; I- for Informed and learned that $\theta = 0$. This yields 6 possible acronyms: HNI; HI+; HI-; SNI; SI+; SI-

We next check that "always buy" dominates "no trade" for the hedger. This is the case when:

$$B + \pi_{NI}(\overline{p}) \geq 0 \tag{A.6}$$

(A.6) is always satisfied because of (A.4) and the fact that $B > 0$.

We finally check that "always buy" also dominates "acquisition of information" for the hedger. This is the case when $B + \pi_{NI}(\overline{p}) \geq -c + \frac{B}{2} + \frac{1}{2}\pi_{I+}(\overline{p})$. After substituting (A.3) and (A.4), we find:

$$c \geq \frac{a^2}{8} - \frac{B}{2} \tag{A.7}$$

Which is implied by (A.5).

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (4.1) is satisfied.

To compute the equilibrium welfare, we need to compute the unconditional expected value of the firm. The equilibrium strategies imply that the probability of a buy order is equal to q and that the probability of no trade is equal to 1-q. Then, we get:

$$E(V) = qP(\overline{p}) + (1-q)P(\underline{p}) = \frac{a^2}{8} \tag{A.8}$$

Since the hedger always buys the asset, the expected private benefit is equal to qB. Since no one acquires information, the expected cost of acquiring information is 0. Putting it all together yields (4.2). QED.

B. Proof of Theorem 2

We need to find conditions under which the following candidate equilibrium strategies are optimal:

- S acquires information with probability 1
- H does noes acquire information
- SI+ buys ; SI- does not trade
- HNI buys

- Firm manager and market-maker act optimally given the trader's strategy

From the equilibrium strategies, a buy order can come from types HNI (of mass q) and SI+ (of mass $\frac{1-q}{2}$). Out of these buy orders, half of the orders from HNI and all the orders from SI+ coincides with $\theta = a$. Conversely, no trade comes only from type SI-, of which none coincides with $\theta = a$. We then get from Bayes law:

$$\overline{p} = \frac{\frac{q}{2} + \frac{1-q}{2}}{q + \frac{1-q}{2}} = \frac{1}{(1+q)} \tag{B.1}$$

$$\underline{p} = 0 \tag{B.2}$$

From (3.4) and (3.5), we get:

$$P(\overline{p}) = \frac{a^2}{2} \frac{1}{(1+q)^2} \tag{B.3}$$

$$P(\underline{p}) = 0 \tag{B.4}$$

From (3.6) and (3.7), we get:

$$\pi_{I+}(\overline{p}) = a^2 \frac{q}{(1+q)^2} \tag{B.5}$$

$$\pi_{NI}(\overline{p}) = \frac{a^2}{2} \frac{q-1}{(1+q)^2} \tag{B.6}$$

We first check that "acquisition of information" dominates no trade for the speculator. From (3.8) and (B.1), this is the case when:

$$c \leq \frac{a^2}{2} \frac{q}{(1+q)^2} \tag{B.7}$$

We next check that "always buy" dominates "acquisition of information" for the hedger.

This is the case when $B + \pi_{NI}(\overline{p}) \geq -c + \frac{B}{2} + \frac{1}{2}\pi_{I+}(\overline{p})$. After substituting (B.5) and (B.6), we get:

$$c \geq \frac{a^2}{2} \frac{1}{(1+q)^2} - \frac{B}{2} \tag{B.8}$$

We finally check that "always buy" also dominates "no trade" for the hedger. This is the case when $B + \pi_{NI}(\overline{p}) \geq 0$, which after substituting (B.6) yields:

$$B \geq \frac{a^2}{2}\frac{1-q}{(1+q)^2} \tag{B.9}$$

Which is implied by (B.7) and (B.8).

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (4.4) is satisfied.

To compute the equilibrium welfare, we need to compute the unconditional expected value of the firm. The equilibrium strategies imply that the probability of a buy order is equal to $q + \frac{1-q}{2}$ and that the probability of no trade is equal to $\frac{1-q}{2}$. Then, we get after substituting (B.3) and (B.4):

$$E(V) = \left(q + \frac{1-q}{2}\right)\left(\frac{a^2}{2}\frac{1}{(1+q)^2}\right) + \frac{1-q}{2} * 0 = \frac{a^2}{4}\frac{1}{1+q} \tag{B.10}$$

Since the hedger always buys the asset, the expected private benefit is equal to qB. Since the speculator acquires information, the expected cost of acquiring information is $(1-q)c$. Putting it all together yields (4.5). QED.

C. Proof of Theorem 3

We need to find conditions under which the following candidate equilibrium strategies are optimal:

- S acquires information with probability κ
- H does noes acquire information
- SI+ buys ; SI- and SNI don't trade
- HNI buys
- Firm manager and market-maker act optimally given the trader's strategy

From the equilibrium strategies, a buy order can come from types HNI (of mass q) and SI+ (of mass $\frac{k}{2}$, where $k \equiv \kappa(1-q)$). Out of these buy orders, half of the orders from HNI and all the orders from SI+ coincides with $\theta = a$.

Conversely, no trade comes from type SI- (of mass $\frac{k}{2}$) and SNI (of mass $1-q-k$). Out of those, half of the no trade from SNI and none from SI- coincides with $\theta = a$.

We then get from Bayes law:

$$\overline{p} = \frac{\frac{q}{2}+\frac{k}{2}}{q+\frac{k}{2}} = \frac{q+k}{2q+k} \tag{C.1}$$

$$\underline{p} = \frac{\frac{1-q-k}{2}}{\frac{k}{2}+1-q-k} = \frac{1-q-k}{2(1-q)-k} \tag{C.2}$$

From (3.4) and (3.5), we get:

$$P(\overline{p}) = \frac{a^2}{2}\frac{(q+k)^2}{(2q+k)^2} \tag{C.3}$$

$$P(\underline{p}) = \frac{a^2}{2}\frac{(1-q-k)^2}{(2(1-q)-k)^2} \tag{C.4}$$

From (3.6) and (3.7), we get:

$$\pi_{I+}(\overline{p}) = a^2\frac{q(q+k)}{(2q+k)^2} \tag{C.5}$$

$$\pi_{NI}(\overline{p}) = -\frac{a^2}{2}\frac{k(q+k)}{(2q+k)^2} \tag{C.6}$$

We first compute the value of k that makes the speculator indifferent between "acquisition of information" and no trade. From (3.8) and (C.1), this is the case when:

$$c = \frac{a^2}{2}\frac{q(q+k)}{(2q+k)^2} \tag{C.7}$$

We next check that "always buy" dominates "acquisition of information" for the hedger.

This is the case when $B + \pi_{NI}(\overline{p}) \geq -c + \frac{B}{2} + \frac{1}{2}\pi_{I+}(\overline{p})$. After substituting (C.5) and (C.6), we get:

$$c \geq \frac{a^2}{2}\frac{(q+k)^2}{(2q+k)^2} - \frac{B}{2} \tag{C.8}$$

After substituting (C.7) into the RHS, (C.8) simplifies into:

$$\frac{B}{2} \geq \frac{k}{q} c \tag{C.9}$$

We finally check that "always buy" also dominates "no trade" for the hedger. This is the case when $B + \pi_{NI}(\bar{p}) \geq 0$, which after substituting (C.6) and (C.7) yields:

$$B \geq \frac{a^2}{2} \frac{k(q+k)}{(1+q)^2} = \frac{k}{q} c \tag{C.10}$$

Which is implied by (C.9).

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (4.6) and (4.7) are satisfied.

To compute the equilibrium welfare, we need to compute the unconditional expected value of the firm. The equilibrium strategies imply that the probability of a buy order is equal to $q + \frac{k}{2}$ and that the probability of no trade is equal to $1 - q - \frac{k}{2}$. Then, we get after substituting (C.3) and (C.4) and simplifying:

$$E(V) = \left(q + \frac{k}{2}\right)\left(\frac{a^2}{2} \frac{(q+k)^2}{(2q+k)^2}\right) + \left(1 - q - \frac{k}{2}\right)\left(\frac{a^2}{2} \frac{(1-q-k)^2}{(2(1-q)-k)^2}\right)$$

$$\Leftrightarrow E(V) = \frac{a^2}{4} \frac{2q(1-q) + k(1-2q)}{(k+2q)(2(1-q)-k)} \tag{C.11}$$

Since the hedger always buys the asset, the expected private benefit is equal to qB. Since the speculator acquires information, the expected cost of acquiring information is kc. Putting it all together yields (4.8). QED.

D. Proof of Theorem 4

To prove Theorem 4, we need to show that welfare is a convex function of k on the interval [0,1-q]. The conclusion then follows from the Bauer maximum principle: any continuous convex function defined on a compact set reaches its maximum at an extreme point.

Differentiating (C.11) with respect to k yields:

$$\frac{\partial E(V)}{\partial k} = \frac{a^2}{4} \frac{k(4q(1-q) + k(1-2q))}{(k+2q)^2(2(1-q)-k)^2} \tag{D.1}$$

We remark that $\frac{\partial E(V)}{\partial k} \mid_{k=0} = 0$.

Differentiating (D.1) provides:

$$\frac{\partial^2 E(V)}{\partial k^2} = \frac{a^2}{2} \frac{8q^2(1-q)^2 + 6k^2 q(1-q) + k^3(1-2q)}{(k+2q)^3 (2(1-q)-k)^3} \tag{D.2}$$

The only possibly negative term in the numerator of (D.2) is the term in $k^3(1-2q)$. However, the fact that q<1 and k≤1-q implies that $k^3(1-2q) + k^2 q(1-q) > 0$. It follows that the numerator of () is strictly positive. This implies that both E(V) and the welfare in (4.8) are strictly convex functions of k. Thus, it is either maximized at $k = 0$ or at $k = 1 - q$.

k=1-q is optimal if and only if the welfare for $k = 1 - q$ given by (4.5) is larger than the welfare for $k = 0$ given by (4.2), which is equivalent to condition (4.10) in Theorem 4. The statement of the theorem follows from the fact that if $k = 1 - q$ is optimal and the equilibrium k is strictly below $1 - q$, then there is under-acquisition of information. QED.

E. Proof of Theorem 5

We need to find conditions under which the following candidate equilibrium strategies are optimal:

- H acquires information with probability 1
- S does noes acquire information
- HI+ buys ; HI- does not trade
- SNI does not trade
- Firm manager and market-maker act optimally given the trader's strategy

From the equilibrium strategies, a buy order can come from types HI+ and thus always coincides with $\theta = a$. Conversely, no trade comes either from type SNI, of which half coincides with $\theta = a$ or of type HI-, of which none coincides with $\theta = a$. We then get from Bayes law:

$$\overline{p} = 1 \tag{E.1}$$

$$\underline{p} = \frac{\frac{1}{2}(1-q)}{\frac{1}{2}q + (1-q)} = \frac{1-q}{2-q} \tag{E.2}$$

From (3.4) and (3.5), we get:

$$P(\overline{p}) = \frac{a^2}{2} \tag{E.3}$$

$$P(\underline{p}) = \frac{a^2}{2}\left(\frac{1-q}{2-q}\right)^2 \tag{E.4}$$

From (3.6) and (3.7), we get:

$$\pi_{I+}(\overline{p}) = 0 \tag{E.5}$$

$$\pi_{NI}(\overline{p}) = -\frac{a^2}{2} \tag{E.6}$$

We first check that "acquisition of information" dominates both "no trade" and "always buy" for the hedger. From *Lemma 2* and (E.1), this is the case when:

$$c \leq Min\left(\frac{B}{2}; \frac{a^2}{2} - \frac{B}{2}\right) \tag{E.7}$$

We next check that "no trade" dominates "acquisition of information" for the speculator. This is the case when $0 \geq -c + \frac{1}{2}\pi_{I+}(\overline{p})$. After substituting (E.5), we get:

$$c \geq 0 \tag{E.8}$$

Which is always true. Similarly (E.6) implies that "no trade" also dominates "always buy".

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (4.11) is satisfied.

To compute the equilibrium welfare, we need to compute the unconditional expected value of the firm. The equilibrium strategies imply that the probability of a buy order is equal to $\frac{q}{2}$ and that the probability of no trade is equal to $1 - \frac{q}{2}$. Then, we get after substituting (B.3) and (B.4):

$$E(V) = \left(\frac{1-q}{2}\right)\left(\frac{a^2}{2}\right) + \left(1 - \frac{q}{2}\right) * \frac{a^2}{2}\left(\frac{1-q}{2-q}\right)^2 = \frac{a^2}{4}\frac{1}{2-q} \tag{E.9}$$

Since the hedger buys with probability $\frac{1}{2}$, the expected private benefit is equal to $\frac{qB}{2}$. Since the hedger acquires information, the expected cost of acquiring information is qc. Putting it all together yields (4.12). QED.