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

Jacques Olivier *

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Abstract

I ask whether hedgers who speculate should be regulated differently from other speculators in a model where information acquisition is endogenous and information has real effects. Hedging benefits and feedback effect generate strategic complementarities between market-maker, firm manager, and trader, which causes multiple equilibria. Gains from trade are lower when hedgers acquire information while speculators may produce less information than socially desirable. A "Volcker rule" separating hedging and speculative activities may help select the higher welfare equilibrium. When too little information is produced, contracts whereby a firm subsidizes losses of designated market-makers to make prices more informative increase welfare.

*olivier@hec.fr, HEC Paris Finance Department, 1 rue de la Libération, 78351 Jouy en Josas Cédex, France. I would like to thank for invaluable comments Hendrik Bessembinder (the editor), an anonymous referee, Bruno Biais, Jean-Edouard Colliard, James Dow, Thierry Foucault, Naveen Gondhi (discussant), Denis Gromb, Johan Hombert, Stefano Lovo, Simon Mayer, Sophie Moinas, Daniel Schmidt, Bart Yueshen Zhou (discussant), and participants to the 2023 Summer meeting of the FTG (Stockholm), the 2023 meeting of the EFA (Amsterdam), the 2023 Vienna Festival of Finance Theory, and the HEC Paris brownbag seminar. Any remaining error is my own.

I. Introduction

Empirical evidence spanning different markets and institutions suggests that hedgers often behave like speculators. Cheng and Xiong (2014a) and Cheng and Xiong (2014b) 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, Michayluk, O'Hara, and Putnins (2021) find evidence of closet speculation by index funds and ETFs. Dastarac (2021) provides suggestive evidence of speculation by dealers in the US corporate bond market, in line with the motivation of the Volcker rule.[1] 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 different treatment by the regulator. Cheng and Xiong (2014b) summarize the issue the following way: "*In this debate* [on regulation of financial innovation and derivatives trading]*, as well as in other broad contexts of analyzing risk sharing and trading in financial markets, it is*

[1]See the discussion on pp. 18-25 of the study and recommendations on the application of the Volcker rule by the Financial Stability Oversight Council (2011), available at: https://home.treasury.gov/policy-issues/financial-markets-financial-institutions-and-fiscal-service/fsoc/studies-and-reports.

[2]For instance, commercial hedgers on US commodity futures benefit from exemptions on position limits with the only constraint being that 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.

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. 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. 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. [3] I then ask whether hedgers who speculate and speculators who speculate have the same impact on welfare, I characterize the conditions under which under- or over- acquisition of information obtains at the equilibrium, and derive policy implications.

The central insight of the model is that the presence of a feedback effect implies strategic complementarities between the activity of a large trader and the pricing strategy of the market maker, provided the trader gets hedging benefits from holding the asset. The reason why hedging benefits matter is that hedgers and speculators face different incentives to acquire information. A

[3] The presence of a competitive risk-neutral market maker implies that an agent cannot make trading profits, and thus has no incentive to speculate, unless he or she has private information.

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. When the spread gets higher however, an uninformed hedger's expected trading loss becomes large relative to the private benefit, which creates incentives to acquire information and buy the asset only if of high quality. This generates a strategic complementarity: when the market maker anticipates that hedgers acquire information, he or she reacts by charging a high spread, which increases the incentives of hedgers to indeed acquire information. This effect is amplified by the feedback effect: when the firm manager anticipates that hedgers acquire information, he or she makes the investment policy of the firm contingent on the order flow, which destroys firm value if in fact no information was acquired. As it is not profitable for speculators to acquire information when hedgers are informed, we get multiple equilibria where information is acquired either by speculators or by hedgers (or not at all).

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 prefers 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 he or she will not buy the asset, and gains from trade are foregone. It follows that, unless hedgers can produce significantly more information than speculators, which may happen if there are too few speculators in the market, welfare is higher when information is acquired by speculators than when it is by hedgers.[4]

This finding implies that there is a role for regulation to help select the right equilibrium. Regulating hedgers less than speculators with this objective in mind may be optimal in specific circumstances. A necessary condition for information acquisition by hedgers to yield higher welfare than information acquisition by speculators is that the probability that a trade is initiated by a speculator rather than a hedger is small. A plausible example of such a market is commodity markets prior to 2004, thus providing support for policies such as the position limit exemption for commercial hedgers on US commodity futures markets. In sharp contrast however, the model suggests that the regulator should instead separate hedging and speculative activities in the spirit of the Volcker rule when probability that trades are initiated by speculators becomes larger as is now the case in most developed markets.

The model raises another regulatory issue, which is the possibility of under-provision of information when real efficiency gains more than compensate the cost of acquiring information and foregone gains from trade. This occurs in the model when the ex-ante level of uncertainty is high and the probability that a trade is initiated by a hedger is small, in other words for firms where managers face substantial uncertainty, with a potentially large impact on their investment

[4] Note that this effect, while related, is distinct from the Hirshleifer (1971) effect. The Hirshleifer effect arises when revelation of information reduces or eliminates hedging possibilities for agents, as in Marin and Rahi (2000), Dow and Rahi (2003), or, more recently, Deng, Pan, Yan, and Yang (2024), where mandating an insider to disclose her trading plan in advance can make all investors worse off when the hedging need of the insider is large enough. By way of contrast, I neutralize the Hirshleifer effect in my baseline model by assuming fixed hedging benefits and show that the social value of a given piece of information nevertheless varies depending on whether it is acquired by hedgers or by speculators.

strategy (technology stocks, young firms...), and whose stock is traded on illiquid markets. When the case, I show that a subsidy to acquisition of information by speculators plus a transfer to hedgers to compensate for trading losses financed by a tax on the firm leads to a Pareto superior allocation. While such a policy may not be politically acceptable in practice, I also show that it can be in great part replicated by 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 and equilibrium prices more informative. This possibility exists on some European markets but is currently not allowed in US.[5]

This paper is broadly related to six branches of the literature. The first one is the 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] Closest to this paper is Dow and Rahi (2003) who provide the first comprehensive welfare analysis of the trade-offs between productive and allocative efficiency, Dow, Goldstein, and Guembel (2017) who endogenize acquisition of information in a model of feedback, and Gervais and Strobl (2022), where a financial intermediary is exogenously endowed with information about fundamentals, which it sells to rational traders. My contribution here is twofold. First, I show that feedback can create strategic complementarities between the actions of strategic traders, market makers, and firm managers, which generate multiple equilibria when traders have a strong enough hedging motive. Second,

[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 evidence supporting the existence of a feedback effect.

my model allows a rigorous discussion of the welfare implications of policies such as the Volcker rule or designated market-makers that may have a first order impact on the informativeness of asset prices.

The paper also belongs to a literature on acquisition of information by agents with private values initiated by the seminal work of Vives (2011) and Vives (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.[7] 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 and the firm manager 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.

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

[7]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).

they are both present, which may reduce price informativeness and create complementarities in the decisions of speculators to acquire information. Xiong and Yang (2021) show that the existence of a financial market may incentivize firms that compete on the product market to disclose information in order to benefit from more informative asset prices. Goldstein and Yang (2022) build on Goldstein et al. (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. 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 and welfare that cannot be substituted away by informed hedgers.

Fourth, my equilibrium multiplicity result speaks to the literature on financial fragility and crashes. Financial fragility, defined in a recent survey by Goldstein, Huang, and Yang (2025) as an amplified reaction of market prices to underlying shocks, is a topic of increasing importance for academics and regulators alike following the multiplication of flash events on stock and bond markets that threaten market efficiency and trust in financial markets.[8] Many mechanisms have been proposed to rationalize such events. Early papers relied on irrationality of market participants (e.g., Gennotte and Leland (1990)) . The next wave of models emphasized the role of

[8]E.g., see Cespa and Vives (2025)

constraints such as funding constraints (e.g., Gromb and Vayanos (2002) or Brunnermeier and Pedersen (2009)), borrowing constraints (e.g., Yuan (2005)) or short-sales constraints (e.g., Marin and Olivier (2008)). More recent work have emphasized mechanisms based on information: Goldstein, Ozdenoren, and Yuan (2013) show that feedback effects may lead speculators to overweight correlated noisy signals, such as rumors, in their trading decisions. Cespa and Foucault (2014) argue that cross-asset learning may lead to feedback loops whereby a small supply shock on the liquidity of one asset may propagate to the entire market. Cespa and Vives (2015) show that persistent liquidity trading can generate strategic complementarities in the use of information by short-term informed traders while Cespa and Vives (2025) demonstrate that lack of information on past order flow can create a self-sustaining loop affecting liquidity demanders. My paper introduces a new channel through which strategic complementarities may appear, which calls for a different type of action from the regulator to avoid the instability inherent to multiple equilibria or getting stuck in the low welfare equilibrium.

Finally, the policy implications of the paper complement the insights of two branches of the existing literature, one on consequences of the Volcker rule and one on designated market makers (DMM). The literature on the Volcker rule is mainly empirical in nature and has strived to test whether concerns expressed by Duffie (2012) and Thakor (2012) that the Volcker rule may result in lower liquidity, notably in times of stress, have materialized. Two representative papers of this line of research are Bao, O'Hara, and Zhou (2018) and Trebbi and Xiao (2019). My main contribution here is to point out that, while liquidity in times of stress is an important driver of welfare, a proper assessment of the Volcker rule should also consider its impact on informativeness of prices and productive efficiency.

The literature on DMM is both theoretical and empirical. Bessembinder, Hao, and Zheng

(2015) provide a model where an IPO may fail when investors anticipate that the secondary market will be illiquid because of asymmetric information.[9] 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. Venkataraman and Waisburd (2007), Anand, Tanggard, and Weaver (2009), and Menkveld and Wang (2013) all find evidence consistent with Bessembinder et al. (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.[10] 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 et al. (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 II. Section III is devoted to the equilibrium and welfare analysis of a benchmark economy where only speculators can acquire information, which can be interpreted as an economy where a

[9] Skjeltorp and Odegaard (2015) provide evidence that the channel proposed by Bessembinder et al. (2015) for IPOs also applies to other financing events.

[10] Similar effects should obtain when the DMM's obligation to quote a reduced spread stems from its contract with the exchange rather than with the firm. See Schmickler and Tremacoldi-Rossi (2023) for supporting evidence based on a natural experiment arising from two market-maker programs in Brazil.

"Volcker rule" has been implemented. I look at the implications of hedgers acquiring information in Section IV: I first show that incentives of hedgers and speculators to acquire information differ and that multiple equilibria can arise. I then look at the welfare implications. Policy implications are discussed in Section V. Section VI concludes.

II. The Model

In this section, I lay out the baseline model, define the equilibrium and welfare concepts, and outline the solution method.

A. 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 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. All agents are risk-neutral.

1. The firm

The firm is comprised of existing assets and of a new investment project, each with independent cash-flows. The firm issued equity that pays the cash-flows generated by its 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 expected cash-flow 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:

(1) $$V(D, \theta, x) = D\,(\theta - x)$$

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 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 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. 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.[11]

- 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.

[11] As in Rahi and Zigrand (2018), private valuation for assets may arise for many reasons such as liquidity needs, regulatory constraints, or inventory costs. See Online Appendix for an extension of the model where the private benefit stems from an explicit hedging problem of a risk-averse trader, but which yields the same reduced form preferences as in the baseline model.

[12] See Online Appendix for an extension of the model where the trader can trade any real quantity.

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 endowed with a share of the firm's equity.
- 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 to break even at the equilibrium.

I adopt the following notations: 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. $P\left(\overline{p}\right)$ denotes the expected value of the firm conditional on observing a buy order.

The zero-profit condition implies that the price asked by the market-maker is equal to $P\left(\overline{p}\right)$. Provided there is at least some informed agent in the market, the ask price $P\left(\overline{p}\right)$ is strictly 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.

B. 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 the cash-flow as dividend.

Note that 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 hedger and speculator 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.

C. 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 conditional on observing a buy order 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.

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. 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 who each need to play best responses to the other's strategy.

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.

D. 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* 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 stock, 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 the firm. 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.

III. Benchmark economy

In this section, I solve for the equilibrium of a benchmark economy where only the speculator can acquire information and characterize the cases where too little or too much information is acquired at the equilibrium. Besides its value as an expositional tool, the benchmark economy plays an important role for the policy discussion in Section 5 as it can be interpreted as an economy where a “Volcker rule”, mandating the separation of hedging and speculative activities, has been implemented.

A. The firm's optimization problem

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

It immediately follows that the optimal investment decision is:

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

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

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

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

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.

B. 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 on the expected value of the firm. With this in mind, I define $E\left(V \mid p; \overline{p}\right)$ as the expected value of the firm from the standpoint of an agent who believes that the probability that $\theta = a$ 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 (2):

$$E\left(V \mid p; \overline{p}\right) = \int_0^{a\overline{p}} \left(ap - x\right) dx = a^2 \overline{p} \left(p - \frac{\overline{p}}{2}\right) \tag{4}$$

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 (4):

$$P\left(\overline{p}\right) = E\left(V \mid \overline{p}; \overline{p}\right) = \frac{a^2}{2} \overline{p}^2 \tag{5}$$

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

$$P\left(\underline{p}\right) = E\left(V \mid \underline{p}; \underline{p}\right) = \frac{a^2}{2} \underline{p}^2 \tag{6}$$

2. Expected trading profits and losses

Given the expressions for the expected value of the firm (4) and the ask price by the market-maker (5), 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 $\pi_{NI}(\overline{p})$:

$$\pi_{I^+}(\overline{p}) = E(V \mid 1; \overline{p}) - P(\overline{p}) = a^2\overline{p}(1-\overline{p}) \geq 0 \tag{7}$$

$$\pi_{NI}(\overline{p}) = E\left(V \mid \frac{1}{2}; \overline{p}\right) - P(\overline{p}) = a^2\overline{p}\left(\frac{1}{2} - \overline{p}\right) \leq 0 \tag{8}$$

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.[13]

3. Incentives of speculator to acquire information

As an uninformed speculator never trades, his or her payoff is 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 (7) yields:

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

$$c \leq \frac{a^2}{2}\overline{p}(1-\overline{p}) \tag{9}$$

Since $\overline{p} \geq \frac{1}{2}$, the RHS of (9) 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.

[13] Note that if we allowed for short-sales in the model, there would be an additional effect going in the opposite direction: as first pointed out by Edmans, Goldstein, and Jiang (2015), informed sales may help the manager make better investment decisions, thereby increasing firm value and lowering the profitability of short-selling and the incentives to acquire information.

C. Equilibrium and welfare

Provided B is not too large, a trivial no-trade equilibrium exists as in Glosten and Milgrom (1985), where the market-maker asks a price $P(1) = \frac{a^2}{2}$ and where neither hedger nor speculator buys the asset. Since information can only be acquired by the speculator in the benchmark economy, three types of equilibria where trading occurs may exist: two pure strategy equilibria and one mixed strategy equilibrium. Using condition (9) and the solution method discussed in Section 2.3, I show the following result in the Appendix:

Proposition 1. *1. An equilibrium of the benchmark economy where no information is acquired and where the hedger buys the asset exists if and only if:*

$$c \geq \frac{a^2}{8} \tag{10}$$

The equilibrium welfare is equal to:

$$W_0 + \frac{a^2}{8} + qB \tag{11}$$

2. An equilibrium of the benchmark economy where the speculator acquires information with probability $\kappa \in (0, 1)$ exists if and only if:

$$\frac{a^2}{2} \frac{q}{(1+q)^2} < c < \frac{a^2}{8} \tag{12}$$

and:

$$B \geq \frac{kc}{q} \tag{13}$$

where $k := \kappa(1-q)$ is the probability that the trader is informed at the equilibrium

The equilibrium welfare is equal to:

$$W_0 + \left(\frac{2q(1-q) + k(1-2q)}{(k+2q)(2(1-q)-k)}\right)\frac{a^2}{4} + qB - kc \tag{14}$$

3. *An equilibrium of the benchmark economy where the speculator acquires information with probability 1 exists if and only if:*

$$c \leq \frac{a^2}{2}\frac{q}{(1+q)^2} \tag{15}$$

and:

$$B \geq \frac{a^2}{2}\frac{1-q}{(1+q)^2} \tag{16}$$

The equilibrium welfare is equal to:

$$W_0 + \frac{1}{1+q}\frac{a^2}{4} + qB - (1-q)c \tag{17}$$

Proof: See Appendix

A first observation is that two conditions need to hold jointly for the speculator to acquire information at the equilibrium: the cost c of acquiring information needs to be low enough for acquisition of information to be profitable for the speculator and the private benefit B needs to be high enough for the hedger to be willing to buy the asset despite paying the premium generated by adverse selection.

A second observation is that the domains of the three equilibria with trading do not overlap: for a given set of parameters, the benchmark economy has at most one non-trivial equilibrium. We shall see next section that the same property does not hold when hedgers can acquire information.

Expression *(14)* in Proposition 1 provides welfare of the benchmark economy as a function of the probability of informed trading, k. For $k = 0$, equation (14) collapses into equation (11). When k takes its maximum value of $1 - q$, equation (14) becomes equation (17). The main trade-off is between the cost of acquiring information, which varies linearly with k from 0 to $(1 - q)c$ 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.

I show in the appendix that the welfare function is convex, which implies that welfare is maximized either when $k = 0$ or when $k = 1 - q$. Comparing equations (11) and (17) then yields:

Proposition 2. *Welfare in the benchmark economy is maximized:*

- *When no information is acquired if:* $c \geq \frac{a^2}{8}\frac{1}{1+q}$
- *When the speculator acquires information with probability 1 if:* $c \leq \frac{a^2}{8}\frac{1}{1+q}$

Proof: see Appendix

The conditions in Proposition 2 become easier to interpret if we multiply both sides by $(1-q)$. Indeed, $c(1-q)$ is the expected acquisition cost of information 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, Proposition 2 simply says that acquiring information is optimal if and only the social cost of information is less than the social value of information, and that if the condition is satisfied, then we should acquire as much information as possible.

Note that 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,[14] and therefore the higher are the expected productive efficiency gains from a given level of information.

The convexity of the expected value of the firm, and therefore of welfare, as a function of k implies that private and social incentives to acquire information are mis-aligned. Private incentives of the speculator are maximized when $k = 0$ and thus $\overline{p} = \frac{1}{2}$. On the other hand, I show in the Appendix that $\frac{\partial E(V)}{\partial k}\mid_{k=0} = 0$, which implies that the net social value of spending resources to increase the probability of acquiring information from 0 to ϵ is 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 increases and becomes positive as more information gets produced while private incentives of the speculator move in the opposite direction: the larger is k,

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

and therefore $\overline{p}$, the lower are the profits of an informed trader, π_{I+}. As a result, the equilibrium may be characterized by under- or over-production of information.

Comparing the conditions for existence of the three types of equilibria in Proposition 1 with the condition for optimality in Proposition 2 allows to tell which is the case depending on the value of the cost parameter c:

Proposition 3. *In the benchmark economy:*

- *The amount of information produced at the equilibrium is efficient if:*

  either: $c > \frac{a^2}{8}$

  or: $c < Min\left(\frac{a^2}{8}\frac{1}{1+q}, \frac{a^2}{2}\frac{q}{(1+q)^2}\right)$

- *Too much information is produced at the equilibrium if:*

  $\frac{a^2}{8}\frac{1}{1+q} < c < \frac{a^2}{8}$

- *Too little information is produced at the equilibrium if:*

  $\frac{a^2}{8}\frac{1}{1+q} > \frac{a^2}{2}\frac{q}{(1+q)^2} \Leftrightarrow q < \frac{1}{3}$

  and: $\frac{a^2}{2}\frac{q}{(1+q)^2} < c < \frac{a^2}{8}\frac{1}{1+q}$

The first bullet point in Proposition 3 states that when the cost of acquiring information is either very small or very large the information produced at the equilibrium is efficient: acquired with probability 0 when the cost is very large, or acquired with probability 1 if the cost is very small. Under- or over-production of information thus occur only for intermediate values of the cost, when speculators acquire information with probability κ comprised in $(0, 1)$. The probability that the market-maker is trading with a hedger, q, plays an important role in determining whether

κ is too large or too small, which is intuitive: the lower is q, the more revealing is the equilibrium price, which is bad for the private incentives of speculators to acquire information but is good for welfare as it strengthens the feedback effect and makes investment decisions of the firm manager more efficient. Thus, under-production of information may only occur in markets where there are "too few hedgers" relative to speculators.

IV. Economy where hedgers can acquire information

In this section, I analyze the full model where both hedger and speculator are able to acquire information. I first derive the incentives of the hedger to acquire information and show they are qualitatively different from the incentives of the speculator. I then show that multiple equilibria arise when the hedger can acquire information. I finally compare welfare across equilibria and ask whether it can ever be socially optimal for the hedger to acquire information.

A. Incentives of the hedger to acquire information

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 $B + \pi_{NI}\left(\overline{p}\right)$. The expected payoff for acquiring information is equal to $-c + \frac{1}{2}\pi_{I^+}\left(\overline{p}\right) + \frac{B}{2}$. Comparing the three terms and substituting (7) and (8) provides:

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

$$c \leq Min\left(\frac{a^2\overline{p}^2}{2} - \frac{B}{2}; \frac{a^2\overline{p}\left(1-\overline{p}\right)}{2} + \frac{B}{2}\right) \tag{18}$$

Provided the private benefit, B, is large enough, condition (18) simplifies into:

$$c + \frac{B}{2} \leq \frac{a^2\overline{p}^2}{2} \tag{19}$$

Condition (19) differs from the corresponding condition for the speculator, (9), in two respects. First, the private benefit enters the LHS of (19) 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. Second, and perhaps more surprisingly, the RHS of (19) is *increasing* in $\overline{p}$ rather than decreasing as the RHS of (9). 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 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.

While the presence of a feedback effect is not crucial for the existence of a strategic complementarity between the hedger's activity and the market-maker's pricing strategy, it amplifies its effect, enlarging the set of multiple equilibria in the economy.[15] The reason is that, with feedback, it is more costly for the hedger to deviate from the equilibrium where he or she is expected to acquire information as doing so induces sub-optimal investment decisions by the firm manager, which exacerbate trading losses.

B. Equilibrium and welfare

Compared to the benchmark economy, the fact that the hedger can now acquire information has two impacts on equilibrium. The first impact is to restrict the set of parameters for which an equilibrium where the speculator acquires information exists. Indeed, when the cost of information, c, is very low, or when the private benefit, B, is not too high, the hedger's best response to the speculator acquiring information is no longer to buy the asset, but to acquire information. As the hedger acquires information, it no longer becomes profitable for the speculator to do so, and the equilibrium unravels. The second impact is that a new type of equilibrium, where the hedger acquires information, exists and may, depending on parameters, either supersede or co-exist with equilibria where information is acquired by the speculator.

[15] As pointed out by an anonymous referee, binary trading choices may generate multiple equilibria for reasons unrelated to the economic mechanism underlined here. See Online Appendix for an extension of the model where traders can trade any real quantity and where multiple equilibria nevertheless arise.

I start with the first impact and derive the conditions under which equilibria of the benchmark economy continue to exist when the hedger can acquire information:

Proposition 4. *1. An equilibrium where no information is acquired and where the hedger buys the asset exists if and only if:*

$$c \geq \frac{a^2}{8} \tag{20}$$

2. An equilibrium of the benchmark economy where the speculator acquires information with probability $\kappa \in (0,1)$ and where the hedger buys the asset exists if and only if:

$$\frac{a^2}{2}\frac{q}{(1+q)^2} < c < \frac{a^2}{8} \tag{21}$$

and:

$$\frac{B}{2} \geq \frac{kc}{q} \tag{22}$$

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

3. An equilibrium where the speculator acquires information with probability 1 and where the hedger buys the asset exists if and only if:

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

and:

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

4. *Welfare is the same as in the benchmark economy.*

Proof: identical to the proof of Proposition 1, except that we now need to check that "always buy" dominates "acquisition of information" for the hedger. Details: see Online Appendix.

We observe that conditions (22) and (24) in Proposition 4 are indeed strictly more stringent than the corresponding conditions in Proposition 1: the private benefit needs to be larger for an equilibrium where the speculator acquires information with positive probability to exist. Conditional on existence however, this equilibrium is identical in all respects to the equilibrium in the benchmark economy.

I now solve for the new equilibria, where the hedger acquires information. Both pure and mixed strategy equilibria exist. For ease of exposition, I discuss only the pure strategy equilibrium in the main text and confine the description of the mixed strategy equilibria to the online appendix.[16] Details of the proof of the following proposition are similarly confined to the online appendix as the line of argument is identical to that of Proposition 1:

[16]The property that incentives of the hedger to acquire information are increasing in $\overline{p}$ implies that equilibria

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

$$c \leq Min\left(\frac{B}{2}; \frac{a^2}{2} - \frac{B}{2}\right) \tag{25}$$

The equilibrium welfare is equal to:

$$W_0 + \frac{a^2}{4}\frac{1}{2-q} + q\left(\frac{B}{2} - c\right) \tag{26}$$

Proof: see Online Appendix

Comparing equation (25) in Proposition 5 with the corresponding conditions in Proposition 4 immediately implies that the equilibrium with an informed hedger may overlap with any of the other three equilibria. 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 equation (25) as:

$$c \leq \frac{B}{2} \leq \frac{a^2}{2} - c \tag{27}$$

---

where hedgers play mixed strategies are unstable. These equilibria otherwise share the same key features as equilibria discussed in the main text: information acquisition by hedgers implies foregone gains from trade, welfare is convex in $\overline{p}$, and we may get under-acquisition of information at the equilibrium.

Condition (27) 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 note that $\overline{p} = 1$ in this equilibrium. This is because the only type who places a buy order is a hedger who learned that $\theta = a$. But $\overline{p} = 1$ 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 buy the asset without acquiring information. Only when private benefits are in between do we get the equilibrium with informed hedger.

As we get multiple equilibria, it is natural to ask which equilibrium generates a higher welfare. Welfare is the same as in the benchmark economy when hedgers do not acquire information. We thus need to compare (26) with the welfare expressions in Proposition 1, which yields:

Proposition 6. *1. 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.*

2. 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:

$$(1-2q)\left(\frac{a^2}{4}\frac{1}{(2-q)(1+q)}-c\right)+\frac{qB}{2}\geq 0 \tag{28}$$

The first part of Proposition 6 is unsurprising since the equilibrium with no acquisition of information is efficient: 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 (20) 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.

The key insight behind the second part of Proposition 6 is that if the same amount of information is generated in both equilibria, then the social planner unambiguously prefers the equilibrium where the speculator acquires information since the information is produced for a lower social cost (no foregone gains from trade). As can easily be observed by substituting $q=1/2$ into (28), this implies that the welfare in the equilibrium with informed speculator is always strictly larger than the welfare in the equilibrium with informed hedgers if there are not more hedgers than speculators. Only for a q large enough can the ordering of the two equilibria be reversed. The intuition for the result is that when the proportion of hedgers is sufficiently larger than 1/2, more information is produced in the equilibrium where the hedger acquires information than in the equilibrium where the speculator does. If information is socially valuable, that is if c is small relative to a, and if the private benefit, B, is not too large, then the efficiency gain of more revealing prices could more than compensate the loss of private benefits.

Could we ever get into a situation where the economy would coordinate on the bad equilibrium? While equilibrium selection can be a slippery topic, an element of answer is that beliefs of the market-maker play a key role in selecting the equilibrium. Take for instance the case where both the equilibrium without acquisition of information and the equilibrium with informed hedger co-exist. 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. This in turn implies that the regulator may need to step in, which we discuss in next section.

V. Policy implications

The paper started with the policy question of whether traders who speculate should be regulated differently depending on their status as hedger or non-hedger. The answer provided by the model to this question is nuanced, as optimal regulation depends on parameter values.

A first key parameter is the social value of information, which results of the comparison between the expected increase in firm value generated by learning in financial markets, which in the model is driven by the parameter a, and the cost of acquiring information, c. When the social value of information is negative, then the optimal regulation is to tax or prohibit speculative activities, whether they are conducted by hedger or speculator. The more uncertain is the technology, and the lower is the cost of acquiring information, the less likely to be in this case.

Assuming that the cost of acquiring information is below this threshold, a first role for regulation in the model is equilibrium selection. Two main parameters determine which way the regulator should go: the probability that a trade is initiated by a hedger and the size of the hedging benefits. Proposition 6 states that if the probability that a trade is initiated by a hedger is large enough and the size of the private benefits is small enough, then welfare is higher when the hedger acquires information. When the two conditions are met, policies that provide an edge to hedgers, and thus help unravel the equilibrium with informed speculator, may increase welfare. One can argue that the position limit exemption on US commodity futures markets fits in this category, at least prior to 2004 and the rise in the number of financial speculators on commodities markets.[17] In sharp contrast, when the probability that a trade is initiated by a speculator increases, Proposition 6 implies that the optimal regulation, far from providing an edge to hedgers, should instead implement a rule akin to the Volcker rule, whereby hedgers are prohibited to engage in speculative activities.

Once equilibrium selection is taken care of, a second role for regulation arises when the probability that a trade is initiated by a hedger is small and when the cost of acquiring information is neither too small or too large. In this case indeed, Proposition 3 shows that too little information is acquired at the competitive equilibrium. Within the model, the most natural policy to remedy this inefficiency is to tax firms, use the tax proceeds to subsidize information acquisition by the

[17] See Goldstein and Yang (2022) for an in-depth analysis of the impact of the financialization of commodity futures markets.

speculator, and compensate the hedger for his or her increased trading losses. As stated in the following proposition and proved in the appendix, this results in a Pareto-superior allocation:

Proposition 7. *Assume that:*

- $q < 1/3$ *and a Volcker rule has been implemented*
- $\frac{a^2}{2}\frac{q}{(1+q)^2} < c < \frac{a^2}{8}\frac{1}{1+q}$
- $B \geq kc$

  where: k is the probability that the trader is informed in the initial equilibrium.

Then the following policy leads to Pareto-superior equilibrium allocation:

- *Give a subsidy to the speculator equal to* $c - \frac{a^2}{2}\frac{q}{(1+q)^2}$ *if he or she acquires information*
- *Give a subsidy to the hedger equal to* $\frac{a^2}{2}\frac{1-q}{(1+q)^2} - \frac{a^2}{2}\frac{k(q+k)}{(2q+k)^2}$ *if he or she buys the asset*
- *Finance the subsidies by a tax on the firm*

Proof: See Appendix

Even though the policy leads to a Pareto improvement in the model, there are some reasons why it may not be adopted in practice. One reason is that the regulator may find it hard to estimate to what extent information in asset prices is unknown of managers of a given firm or in a given industry and relevant for their corporate decisions. Another reason is that subsidizing information acquisition by speculators is unlikely to be politically acceptable.

A market-based solution that achieves almost the same outcome as the transfer policy without being subject to the same objections 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 exist in Europe but are currently not allowed on US markets.[18] The base mechanism why these contracts may increase welfare is the same as in Proposition 7: they implement a transfer from the firm to the speculator to incentivize the production of information. The main difference with Proposition 7 is the fact that transfers are intermediated by a market-maker and take the form of a lower spread, which implies that it is not possible to specify the transfer to the speculator independently of the transfer to the hedger and makes it harder to get a Pareto-superior allocation. More formally, I show that:

Proposition 8. *Assume that:*

- $q < 1/3$ *and a Volcker rule has been implemented*
- $\frac{a^2}{2}\frac{q}{(1+q)^2} < c < \frac{a^2}{8}\frac{1}{1+q}$
- $B \geq \frac{a^2}{2}\frac{1-q}{(1+q)^2}$

Then the following policy strictly increases total welfare:

- *The firm pays to the market maker a subsidy S equal to:*

  $$S = \frac{1+q}{2}\left(E\left(V \mid \frac{1}{1+q}; \frac{1}{1+q}\right) - E\left(V \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right)\right)$$

- *The market maker commits to quote an ask price P equal to:*

  $$P = E\left(\widehat{V} \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right)$$

  where: k is the probability that the trader is informed in the initial equilibrium and $\widehat{V} = V - S$.

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

Proof: See Appendix

The result in Proposition 8 is closely related to the literature on Designated Market Makers (DMM). Bessembinder et al. (2015) provide the first theoretical rationale why contracts between firms and DMMs 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 more than compensates 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. The introduction of DMM contracts in my model generates testable implications that are common with those of the model by Bessembinder et al. (2015) and that have been validated by the empirical literature: 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.[19] The model however also implies a specific new testable implication: firms that sign a contract with a DMM should display a stronger feedback effect than comparable firms without a DMM contract.

VI. Conclusion

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

[19]See Venkataraman and Waisburd (2007), Anand et al. (2009), and Menkveld and Wang (2013)

can acquire costly information may 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*".

The model also suggests that allowing hedgers to speculate may be the cause of financial fragility in the form of multiple equilibria while, in sharp contrast, financial speculators may not acquire enough information. I show that possible remedies include separating hedging and speculative activities in the spirit of the Volcker rule to select the higher welfare equilibrium and allowing private contracts 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.

VII. Appendix

For the sake of brevity, I use acronyms in all appendices 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-.

A. Proof of Proposition 1

1. Proof of Part 1

We need to check when the following candidate equilibrium strategies are optimal:

- neither H nor S acquires information
- HNI 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:

$$\overline{p} = \underline{p} = \frac{1}{2} \tag{29}$$

From (5) and (6), we get:

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

From (7) and (8), we get:

(31) $$\pi_{I+}\left(\overline{p}\right) = \frac{a^2}{4}$$

(32) $$\pi_{NI}\left(\overline{p}\right) = 0$$

We first check that "no trade" dominates "acquisition of information" for the speculator. From (9) and (29), this is the case when:

(33) $$c \geq \frac{a^2}{8}$$

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

(34) $$B + \pi_{NI}\left(\overline{p}\right) \geq 0$$

(34) is always satisfied because of (32) and the fact that $B > 0$.

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (10) 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:

$$E(V) = qP(\overline{p}) + (1-q)\,P\left(\underline{p}\right) = \frac{a^2}{8} \tag{35}$$

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 (11). QED.

2. Proof of Part 2

We need to check when the following candidate equilibrium strategies are optimal:

- S acquires information with probability κ
- H does not 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:

$$\overline{p} = \frac{\frac{q}{2}+\frac{k}{2}}{q+\frac{k}{2}} = \frac{q+k}{2q+k} \tag{36}$$

$$\underline{p} = \frac{\frac{1-q-k}{2}}{\frac{k}{2}+1-q-k} = \frac{1-q-k}{2(1-q)-k} \tag{37}$$

From (5) and (6), we get:

$$P(\overline{p}) = \frac{a^2}{2}\frac{(q+k)^2}{(2q+k)^2} \tag{38}$$

$$P(\underline{p}) = \frac{a^2}{2}\frac{(1-q-k)^2}{(2(1-q)-k)^2} \tag{39}$$

From (7) and (8), we get:

$$\pi_{I+}\left(\overline{p}\right) = a^2 \frac{q\left(q+k\right)}{\left(2q+k\right)^2} \tag{40}$$

$$\pi_{NI}\left(\overline{p}\right) = -\frac{a^2}{2}\frac{k\left(q+k\right)}{\left(2q+k\right)^2} \tag{41}$$

We first compute the value of k that makes the speculator indifferent between "acquisition of information" and no trade. From (9) and (36), this is the case when:

$$c = \frac{a^2}{2}\frac{q\left(q+k\right)}{\left(2q+k\right)^2} \tag{42}$$

We note that the RHS of (42) is strictly decreasing in k and takes value $\frac{a^2}{8}$ when $k=0$ and value $\frac{a^2}{2}\frac{q}{(1+q)^2}$ when $k=1-q$.

We next check that "always buy" dominates "no trade" for the hedger. This is the case when $B+\pi_{NI}\left(\overline{p}\right) \geq 0$, which after substituting (41) then (42) yields:

$$B \geq \frac{a^2}{2}\frac{k\left(q+k\right)}{\left(2q+k\right)^2} = \frac{k}{q}c \tag{43}$$

Putting it together, we find that the candidate equilibrium strategies are indeed optimal if (12) and (13) 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 (38) and (39) and simplifying:

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

$$\Leftrightarrow E(V) = \frac{a^2}{4}\frac{2q(1-q) + k(1-2q)}{(k+2q)(2(1-q)-k)} \tag{44}$$

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 (14). QED.

3. Proof of Part 3

We need to check when 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:

$$\overline{p} = \frac{\frac{q}{2} + \frac{1-q}{2}}{q + \frac{1-q}{2}} = \frac{1}{(1+q)} \tag{45}$$

$$\underline{p} = 0 \tag{46}$$

From (5) and (6), we get:

$$P\left(\overline{p}\right) = \frac{a^2}{2} \frac{1}{(1+q)^2} \tag{47}$$

$$P\left(\underline{p}\right) = 0 \tag{48}$$

From (7) and (8), we get:

(49) $$\pi_{I+}(\overline{p}) = a^2 \frac{q}{(1+q)^2}$$

(50) $$\pi_{NI}(\overline{p}) = \frac{a^2}{2} \frac{q-1}{(1+q)^2}$$

We first check that "acquisition of information" dominates no trade for the speculator. From (9) and (45), this is the case when:

(51) $$c \leq \frac{a^2}{2} \frac{q}{(1+q)^2}$$

We next check that "always buy" dominates "no trade" for the hedger. This is the case when $B + \pi_{NI}(\overline{p}) \geq 0$, which after substituting (50) yields:

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

Putting it together, we conclude that the candidate equilibrium strategies are indeed optimal if (15) and (16) 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 $q + \frac{1-q}{2}$ and that the probability of no trade is equal to $\frac{1-q}{2}$. Then, we get after substituting (47) and (48):

$$E(V)=\left(q+\frac{1-q}{2}\right)\left(\frac{a^2}{2}\frac{1}{(1+q)^2}\right)+\frac{1-q}{2}*0=\frac{a^2}{4}\frac{1}{1+q} \tag{53}$$

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 (17). QED.

B. Proof of Proposition 2

To prove Proposition 2, 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 (14) with respect to k yields:

$$\frac{\partial E(V)}{\partial k}=\frac{a^2}{4}\frac{k\left(4q\left(1-q\right)+k(1-2q)\right)}{\left(k+2q\right)^2\left(2\left(1-q\right)-k\right)^2} \tag{54}$$

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

Differentiating (54) provides:

$$\frac{\partial^2 E(V)}{\partial k^2}=\frac{a^2}{2}\frac{8q^2\left(1-q\right)^2+6k^2q\left(1-q\right)+k^3\left(1-2q\right)}{\left(k+2q\right)^3\left(2\left(1-q\right)-k\right)^3} \tag{55}$$

The only possibly negative term in the numerator of (55) is the term in $k^3\left(1-2q\right)$.

However, the fact that q<1 and k≤1-q implies that $k^3(1-2q)+k^2q(1-q)>0$. It follows that the numerator of () is strictly positive. This implies that both E(V) and the welfare in (14) 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 welfare for $k=1-q$ given by (17) is larger than welfare for $k=0$ given by (11), which is equivalent to the condition in Proposition 2. QED

C. Proof of Proposition 7

Since a Volcker rule has been implemented, the initial equilibrium allocations and welfare are given by Proposition 1. Assumptions of Proposition 7 furthermore imply that the initial equilibrium is the mixed strategy equilibrium described in Part 2 of the proposition.

We now solve for the equilibrium after subsidy. Note first that both expected value of the firm and ask price of the market-maker go down by the amount paid by the firm to finance the subsidy, which leaves expressions (7) and (8) for, respectively, expected profits of informed trader and expected losses of uninformed trader unchanged.

Notice next that the post-subsidy cost of acquiring information for the speculator is given by $\frac{a^2}{2}\frac{q}{(1+q)^2}$ and that the subsidy for the hedger is exactly equal to the difference between expected losses in the initial equilibrium, $\pi_{NI}\left(\frac{q+k}{2q+k}\right)$, and expected losses in an equilibrium where the speculator acquires information with probability 1, $\pi_{NI}\left(\frac{1}{1+q}\right)$. It then follows from the proof of Part 3 of Proposition 1 that speculator acquiring information with probability 1 and hedger always buying the asset is an equilibrium.

As the subsidy the hedger receives is exactly equal to the increase in expected losses, his or her welfare is left unchanged.

As the speculator was indifferent between acquiring information and not trading in the initial equilibrium, he or she cannot be worse off after the subsidy.

Finally, to derive the net impact of the tax / subsidy scheme on expected firm value, and thus on the value of the endowment of the market maker, we first compute the expected cost, EC, of the two subsidies that the firm has to pay:

(56)

$$EC = (1-q)\left(c - \frac{a^2}{2}\frac{q}{(1+q)^2}\right) + q\left(\frac{a^2}{2}\frac{1-q}{(1+q)^2} - \frac{a^2}{2}\frac{k\,(q+k)}{(2q+k)^2}\right) = c\,(1-q) - \frac{a^2}{2}\frac{kq\,(q+k)}{(2q+k)^2}$$

From (42), we know that $c = \frac{a^2}{2}\frac{q(q+k)}{(2q+k)^2}$, which implies that (56) can be rewritten as:

(57)
$$EC = (1-q-k)\,c$$

Assumptions of Proposition 7 imply that welfare in the pure strategy equilibrium where information is acquired with probability 1 is larger than welfare in the mixed strategy equilibrium, which from equations (14) and (17) implies that $(1-q-k)\,c$ is strictly lower than the increase in firm value, thus making the market-maker strictly better off. QED.

D. Proof of Proposition 8

Since a Volcker rule has been implemented, the initial equilibrium allocations and welfare are given by Proposition 1. Assumptions of Proposition 8 furthermore imply that the initial equilibrium is the mixed strategy equilibrium described in Part 2 of the proposition. Proposition 2 finally implies that if the equilibrium of the economy with the proposed contract is characterized by speculator purchasing information with probability 1 and hedger always buying the asset, then total welfare is strictly higher than in the initial economy.

We recall from the proof of Proposition 1 that $\overline{p} = \frac{1}{1+q}$ when the speculator acquires information with probability 1, while $\overline{p} = \frac{q+k}{2q+k}$ in the mixed strategy equilibrium.

We adopt the following notations:

$$\Delta E\left(V\right) = E\left(V \mid \frac{1}{1+q}; \frac{1}{1+q}\right) - E\left(V \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right) \tag{58}$$

$$\widehat{V} = V - S \tag{59}$$

We first show that acquiring information dominates no trade for the speculator. We have:

$$\pi_{I+} = E\left(\widehat{V} \mid 1; \frac{1}{1+q}\right) - P = E\left(\widehat{V} \mid 1; \frac{1}{1+q}\right) - E\left(\widehat{V} \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right) \tag{60}$$

$$= E\left(V \mid 1; \frac{1}{1+q}\right) - E\left(V \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right) \tag{61}$$

From (4), we get that $E\left(V \mid 1; \frac{1}{1+q}\right) > E\left(V \mid 1; \frac{q+k}{2q+k}\right)$ and thus:

$$\pi_{I+} > E\left(V \mid 1; \frac{q+k}{2q+k}\right) - E\left(V \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right) = a^2 \frac{q\,(q+k)}{(2q+k)^2} \tag{62}$$

From (42), we have: $c = \frac{a^2}{2}\frac{q(q+k)}{(2q+k)^2}$. We conclude that: $-c + \frac{\pi_{I+}}{2} > 0$, that is acquiring information dominates no trade for the speculator.

We next show that it is optimal for the hedger to buy the asset. We have:

$$\pi_{NI} = E\left(\widehat{V} \mid 0; \frac{1}{1+q}\right) - P = E\left(\widehat{V} \mid 0; \frac{1}{1+q}\right) - E\left(\widehat{V} \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right) \tag{63}$$

$$= E\left(V \mid 0; \frac{1}{1+q}\right) - E\left(V \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right) \tag{64}$$

From (4), we get that: $E\left(V \mid \frac{q+k}{2q+k}; \frac{q+k}{2q+k}\right) < E\left(V \mid \frac{1}{1+q}; \frac{1}{1+q}\right)$ and thus:

$$\pi_{NI} > E\left(V \mid 0; \frac{1}{1+q}\right) - E\left(V \mid \frac{1}{1+q}; \frac{1}{1+q}\right) = \frac{a^2}{2}\frac{q-1}{(1+q)^2} \tag{65}$$

Proposition 8 assumes that: $B \geq \frac{a^2}{2}\frac{1-q}{(1+q)^2}$. We conclude that: $B + \pi_{NI} > 0$, that is buying the asset dominates no trade for the hedger.

We now turn to the market maker. We first check that the zero-profit condition is satisfied with the proposed contract. The market-maker makes a loss *per trade* equal to the difference between its valuation of the firm and the ask price he or she agreed to quote, that is:

$$E\left(\widehat{V} \mid \tfrac{1}{1+q}; \tfrac{1}{1+q}\right) - E\left(\widehat{V} \mid \tfrac{q+k}{2q+k}; \tfrac{q+k}{2q+k}\right) = E\left(V \mid \tfrac{1}{1+q}; \tfrac{1}{1+q}\right) - E\left(V \mid \tfrac{q+k}{2q+k}; \tfrac{q+k}{2q+k}\right).$$

A trade occurs either when the trader is a hedger, with probability q, or when the trader is a speculator and learned that $\theta = a$, with probability $\frac{1-q}{2}$. Thus the probability of a trade is equal to $\frac{1+q}{2}$ and the expected loss is exactly equal to the subsidy received from the firm.

Finally, it is immediate to check that it is optimal for the firm manager to offer the contract to the market-maker as the value of the assets goes up by $\Delta E\left(V\right)$ while the subsidy paid to the market-maker is equal to $\frac{1+q}{2}\Delta E\left(V\right) < \Delta E\left(V\right)$.

Thus, speculator purchasing information with probability 1 and hedger always buying the asset is an equilibrium of the economy with the proposed contract and welfare is strictly higher than in the initial economy by Proposition 2. QED

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I. Internet Appendix

A. Robustness of the equilibrium multiplicity result

1. Model

I consider an extension which is identical to the baseline model as far as the market-maker and the firm manager are concerned but differs in several respects regarding traders:

1. Traders can trade any real quantity instead of the trading space being restricted to $\{0, 1\}$.
2. Noise is introduced through the presence of liquidity traders rather than uncertainty about the type of the strategic trader.
3. The private benefit from holding the asset is no longer fixed but arises from an explicit hedging problem, namely:
   - The cash-flow of the firm's existing assets is no longer normalized to zero but is equal to $\tilde{e}$, with $\sigma_e > 0$.
   - The strategic trader has mean-variance preferences.
   - The strategic trader has a non-tradable initial endowment equal to $-\tilde{e}$, which can only be hedged by trading the stock.
   - The risk of the new investment project is fully diversifiable.[20]

More precisely, the economy is comprised of:

[20]This assumption is there solely for tractability. A possible example to motivate it is that of pharmaceutical firms whose future cash-flows may stem from both existing drugs ($\tilde{e}$) and R&D projects ($\tilde{\theta} - \tilde{x}$). The risk from existing drugs has a systematic component but the probability of success of R&D projects is i.i.d. across firms.

- 1 asset which pays off: $\widetilde{CF} := \tilde{e} + D\left(\tilde{\theta} - \tilde{x}\right)$, where:

  - $E(\tilde{e}) = 0$ and $\sigma_e > 0$
  - $\widetilde{\theta}$ 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].
  - $\tilde{e}$, $\tilde{\theta}$, and $\tilde{x}$ are independent.
  - The realization of $\tilde{\theta}$ is unknown to the firm manager and the market-maker but may be learned at a cost $c > 0$ by the strategic trader.
  - The realization of $\tilde{x}$ is known to the firm manager but not to the other players.
  - The firm manager observes the order flow before setting D $\in \{0, 1\}$ that maximizes the expected value of the firm, that is sets $D = 1$ iff $x < E(\theta \mid orderflow)$.

- 1 strategic trader (she) who maximizes:

$$Max_{n\in R}\left\{E\left(\tilde{W} \mid I\right) - \frac{A}{2}Var\left((n-1)\tilde{e}\right)\right\} \tag{66}$$

Where I is the information set of the strategic trader, A is her risk-aversion and:

$\tilde{W} := -c - \tilde{e} + n(\widetilde{CF} - \tilde{P})$ if the trader acquires information

$\tilde{W} := -\tilde{e} + n(\widetilde{CF} - \tilde{P})$ otherwise

Defining $B := \frac{A\sigma_e^2}{2}$, we can rewrite (66) as:

$$Max_{n\in R}\left\{-c + nE\left((\widetilde{CF} - \tilde{P}) \mid \theta\right) - B(n-1)^2\right\} \tag{67}$$

for an informed trader and:

$$(68) \qquad Max_{n\in R}\left\{nE(\widetilde{CF}-\tilde{P})-B(n-1)^2\right\}$$

for an uninformed trader.

Note that the optimization problem above can be reinterpreted as the problem of a risk-neutral trader facing quadratic inventory costs. Note also that we get back the optimization problem of the hedger in the baseline model if n∈$\{0, 1\}$ instead of $n \in R$.

- Liquidity traders who place market orders $\tilde{z}$, where $\tilde{z}$ is uniformly distributed on $[-\epsilon, \epsilon]$, with $\epsilon \geq \frac{1}{2}$.

  I note by N the total demand for the asset: $N := n + z$.

- 1 competitive risk-neutral market-maker (he) who quotes a price:

  $P(N) = E\left(\widetilde{CF} \mid n(\theta) + z = N\right)$

The timing unfolds as follows:

1. Market-maker posts a price schedule given his beliefs.

   Rational trader decides whether to acquire information. If she does, she observes θ.

2. Rational trader places market orders.

   Liquidity traders place market orders.

3. Firm manager observes x and the order flow, and sets D.

4. Uncertainty resolves.

The objective of what follows is to demonstrate that multiple equilibria arise in this economy through the same channels as in the baseline model.

2. Candidate equilibrium 1: no acquisition of information

In this equilibrium, the market-maker and the firm manager anticipate that the trader remains uninformed unless they observe an order flow, N, which is inconsistent with their assumption. Thus, their posterior distribution for θ is:

- The same as the prior distribution if $N \in [n_U^* - \epsilon, n_U^* + \epsilon]$.
- $\theta = a$ with probability 1 if $N > n_U^* + \epsilon$
- $\theta = 0$ with probability 1 if $N < n_U^* - \epsilon$

where n_U^* is the equilibrium demand of an uninformed trader.

We then get that:

- If $N \in [n_U^* - \epsilon, n_U^* + \epsilon]$, D=1 iff $x \leq \frac{a}{2}$, which implies that:

(69)
$$P = \int_0^{\frac{a}{2}} \left(\frac{a}{2} - x\right) dx = \frac{a^2}{8}$$

- If $N > n_U^* + \epsilon$, $D = 1$ iff $x \leq a$, which implies that:

(70)
$$P = \int_0^{a} (a - x)\, dx = \frac{a^2}{2}$$

- If $N < n_U^* - \epsilon$, D = P = 0

I work by backward induction: I first solve for the optimal portfolio choice of the trader depending on her choice of acquiring or not acquiring information. I then derive the condition under which not acquiring information is optimal.

I first solve the optimization problem of an uninformed trader. As the uninformed trader has the same information as the market-maker, she makes neither trading losses nor trading profits and thus maximizes:

$$Max_{n_U} \left\{ -B(n_U - 1)^2 \right\} \tag{71}$$

Which yields:

$$n_U^* = 1 \tag{72}$$

And:

$$U_U = 0 \tag{73}$$

where U_U denotes the utility of an uninformed trader

I next solve the optimization problem of an informed trader:

1. If $\theta = 0$

The trader breaks even if the order flow reveals her information. Otherwise, she makes a loss (*resp. a profit*) if she buys (*resp. short-sells*) the asset since the market-maker charges too high a price. The expected loss per share of the trader when the order flow is uninformative is equal to $\int_0^{\frac{a}{2}}(0-x)dx - \frac{a^2}{8} = -\frac{a^2}{4}$. It is equal to $\int_0^{a}(0-x)dx - \frac{a^2}{2} = -a^2$ if the market maker and the firm manager incorrectly deduce from the order flow that $\theta = a$.

This implies that $n_I = 1$ strictly dominates $n_I > 1$ (lower expected trading losses and smaller quadratic term for $n_I = 1$). Note also that $n_I = 1-2\epsilon$ strictly dominates $n_I < 1-2\epsilon$ (fully revealing order flow with probability 1 in both cases, but smaller quadratic term for $n_I = 1-2\epsilon$). Thus, $n_I \in [1-2\epsilon, 1]$ and the probability that the order flow does not reveal the information is equal to $\frac{n_I-(1-2\epsilon)}{2\epsilon}$.

The informed trader then maximizes:

(74) $$Max_{n_I\in[1-2\epsilon,1]}\left\{-c - n_I\left(\frac{n_I-1+2\epsilon}{2\epsilon}\right)\left(\frac{a^2}{4}\right) - B(n_I-1)^2\right\}$$

Which yields:

(75) $$n_I = \frac{8\epsilon B - (2\epsilon-1)\frac{a^2}{2}}{a^2+8\epsilon B} = 1 - \frac{(2\epsilon+1)\frac{a^2}{2}}{a^2+8\epsilon B}$$

Note that $\epsilon \geq \frac{1}{2}$ implies that $1 - \frac{(2\epsilon+1)\frac{a^2}{2}}{a^2+8\epsilon B} \in [1-2\epsilon, 1]$.

And thus:

(76)
$$E(U_I \mid \theta = 0) = -c - \frac{a^2}{4\left(a^2+8\epsilon B\right)^2}\left(64\epsilon^2B^2 + (4-4\epsilon-\frac{1}{\epsilon})\frac{a^4}{8} + (-1+12\epsilon-4\epsilon^2)a^2B\right)$$

where U_I denotes the utility of an informed trader.

2. If $\theta = a$

   When the trader receives good news, she makes profits if and only if the order flow is uninformative. This implies that $n_I = 1$ dominates $n_I < 1$ (order flow uninformative in both cases but smaller quadratic term for $n_I = 1$) and that $n_I = 1 + 2\epsilon$ dominates $n_I > 1 + 2\epsilon$ (order flow fully informative in both cases but smaller quadratic term for $n_I = 1 + 2\epsilon$). Thus, $n_I \in [1, 1 + 2\epsilon]$ and the probability the order flow does not reveal her information is equal to $\frac{1+2\epsilon-n_I}{2\epsilon}$.

   The expected profit of the trader when the order flow is uninformative is equal to:

   $\int_0^{\frac{a}{2}}(a - x)dx - P = \frac{a^2}{4}$.

   The informed trader thus maximizes:

$$(77) \qquad Max_{n_I \in [1,1+2\epsilon]} \left\{ -c + n_I \left(\frac{1 + 2\epsilon - n_I}{2\epsilon} \right) \left(\frac{a^2}{4} \right) - B(n_I - 1)^2 \right\}$$

   Which yields:

$$(78) \qquad n_I = \frac{(1 + 2\epsilon)\frac{a^2}{2} + 8\epsilon B}{a^2 + 8\epsilon B} = 1 + \frac{(2\epsilon - 1)\frac{a^2}{2}}{a^2 + 8\epsilon B}$$

   And:

   (79)

$$E(U_I \mid \theta = a) = -c + \frac{a^2}{4\left(a^2 + 8\epsilon B\right)^2} \left(64\epsilon^2 B^2 + (4 + 4\epsilon + \frac{1}{\epsilon})\frac{a^4}{8} + (1 + 12\epsilon + 4\epsilon^2)a^2 B \right)$$

From (76) and (79), we get the ex-ante expected utility of an informed trader:

(80)
$$E(U_I) = \frac{1}{2}E(U_I \mid \theta = 0) + \frac{1}{2}E(U_I \mid \theta = a) = -c + \frac{(4\epsilon + \frac{1}{\epsilon})a^4}{32\,(a^2 + 8\epsilon B)}$$

From (73), we finally get:

Lemma 3. *An equilibrium where the trader does not acquire information exists iff:*

(81)
$$c > \frac{(4\epsilon + \frac{1}{\epsilon})a^4}{32\,(a^2 + 8\epsilon B)}$$

3. Candidate equilibrium 2: acquisition of information

We now assume that the market-maker and the firm manager anticipate that the trader acquires information and rationally conjecture that the demand of the trader takes the form:

- $n = n_L^* < 1$ if $\theta = 0$
- $n = n_H^* > 1$ if $\theta = a$

We further conjecture that: $n_H^* - \epsilon < n_L^* + \epsilon$.

Then, the posterior distribution for θ of the market maker and the firm manager is:

- The same as the prior distribution if $N \in [n_H^* - \epsilon, n_L^* + \epsilon]$.
- $\theta = a$ with probability 1 if $N > n_L^* + \epsilon$

- $\theta = 0$ with probability 1 if $N < n_H^* - \epsilon$

By the same argument as in the previous section, this implies that:

- If $N \in [n_H^* - \epsilon, n_L^* + \epsilon]$: $D = 1$ iff $x < \frac{a^2}{2}$, and thus $P = \frac{a^2}{8}$.
- If $N > n_L^* + \epsilon$: $D = 1$ iff $x < a$, and thus $P = \frac{a^2}{2}$
- If $N < n_H^* - \epsilon$: $D = P = 0$

I first look at the optimization problem of an informed trader:

1. If $\theta = 0$

   The trader breaks even if the order flow reveals her information. Otherwise, she makes a loss (*resp. a profit*) if she buys (*resp. short-sells*) the asset since the market-maker charges too high a price. The expected loss per share of the trader when the order flow is uninformative is equal to $\int_0^{\frac{a}{2}}(0-x)dx - \frac{a^2}{8} = -\frac{a^2}{4}$. It is equal to $\int_0^a (0-x)dx - \frac{a^2}{2} = -a^2$ if the market maker and the firm manager incorrectly deduce from the order flow that $\theta = a$.

   Note that $n_I = 1$ dominates $n_I > 1$ (higher probability of avoiding trading losses while minimizing the quadratic term) and that $n_I = n_H^* - 2\epsilon$ dominates $n_I < n_H^* - 2\epsilon$ (fully informative order flow in both cases but smaller quadratic term for $n_I = n_H^* - 2\epsilon$).

   Note also that the probability that the order flow does not reveal information is equal to $\frac{n_L^*+\epsilon-(n_H^*-\epsilon)}{2\epsilon} = 1 - \frac{n_H^*-n_L^*}{2\epsilon}$ if $n_I \in [n_L^*, 1]$ and is equal to $\frac{n+\epsilon-(n_H^*-\epsilon)}{2\epsilon} = 1 - \frac{n_H^*-n}{2\epsilon}$ if $n_I \in [n_H^* - 2\epsilon, n_L^*]$ while the probability that $N > n_L^* + \epsilon$ is equal to $\frac{n-n_L^*}{2\epsilon}$ if $n_I \in [n_L^*, 1]$ and is equal to 0 if $n_I \in [n_H^* - 2\epsilon, n_L^*]$. This implies that the expected utility of the informed trader may have a kink at the point $n_I = n_L^*$.

It can easily be checked that $n_L^* < 0$ implies that $\lim_{n_I \uparrow n_L^*} \frac{\partial E(U_I(n_I))}{\partial n_I} < \lim_{n_I \downarrow n_L^*} \frac{\partial E(U_I(n_I))}{\partial n_I}$, in which case expected utility is not concave and n_L^* cannot be a maximum. This implies that there does not exist a pure strategy equilibrium with $n_L^* < 0$.

When $n_L^* \geq 0$, we get $\lim_{n_I \uparrow n_L^*} \frac{\partial E(U_I(n_I))}{\partial n_I} \geq \lim_{n_I \downarrow n_L^*} \frac{\partial E(U_I(n_I))}{\partial n_I}$. As the second derivative of the trader's expected utility is strictly negative on both $[n_H^* - 2\epsilon, n_L^*)$ and $(n_L^*, 1]$, this implies that expected utility is strictly concave on the entire interval $[n_H^* - 2\epsilon, 1]$ when $n_L^* \geq 0$. The presence of a kink when $n_L^* > 0$ however implies that there may exist an infinite number of pure strategy equilibria where the trader acquires information.

As I do not need to fully characterize all equilibria of the economy to show that there exists parameter values for which both an equilibrium where the trader does not acquire information and (at least) an equilibrium where she acquires information exist, I impose a restriction which implies that an equilibrium with $n_L^* = 0$ with a very simple analytical characterization exists and I focus on this equilibrium from there on.

Assumption 1. *$a^2 > 8B$ and $\epsilon \in \left[\underline{\epsilon}, \frac{a^2}{a^2-8B}\right]$,*
where $\underline{\epsilon} := Max\left(\frac{1}{2}, \frac{a^2}{4B}\frac{6B-\frac{a^2}{4}}{a^2-8B}\right)$

Note that $a^2 > 8B$ implies that the interval $\left[\underline{\epsilon}, \frac{a^2}{a^2-8B}\right]$ is non-empty. Note also that Assumption 1 is in no way necessary for the main multiplicity result of the section but is just there to construct an example with simple closed form expressions.

I now state, then prove, the following lemma:

Lemma 4. *An equilibrium where the trader acquires information, purchases*

$n_H^* = 2\epsilon\frac{a^2-8B}{a^2}$ *if* $\theta = a$ *and* $n_L^* = 0$ *if* $\theta = 0$*, exists iff:*

$$c < 2\epsilon B\left(-\frac{2B}{a^2+4\epsilon B} + \frac{a^2-8B}{a^2}\left(2 - \frac{\epsilon(a^2-8B)}{a^2}\right)\right) \tag{82}$$

Note first that $n_H^* - \epsilon < n_L^* + \epsilon$, as conjectured.

We next check that choosing $n = n_L^* = 0$ is optimal on the interval $[n_L^*, 1]$. The optimization problem for $n \in [n_L^*, 1]$ is given by:

$$Max_{n_I \in [n_L^*, 1]}\left\{-c - n_I\left(1 - \frac{n_H^* - n_L^*}{2\epsilon}\right)\frac{a^2}{4} - n_I\left(\frac{n_I - n_L^*}{2\epsilon}\right)a^2 - B(n_I-1)^2\right\} \tag{83}$$

We get that $n = n_L^* = 0$ is optimal iff:

$$-\left(1 - \frac{n_H^*}{2\epsilon}\right)\frac{a^2}{4} + 2B \leq 0 \tag{84}$$

which is implied by $n_H^* = 2\epsilon\frac{a^2-8B}{a^2}$.

Similarly, the optimization problem for $n \in [n_H^* - 2\epsilon, n_L^*]$ is given by:

$$Max_{n_I \in [n_H^* - 2\epsilon, n_L^*]}\left\{-c - n_I\left(1 - \frac{n_H^* - n_I}{2\epsilon}\right)\frac{a^2}{4} - B(n_I-1)^2\right\} \tag{85}$$

We get that $n = n_L^* = 0$ is optimal iff:

(86) $$-\left(1-\frac{n_H^*}{2\epsilon}\right)\frac{a^2}{4}+2B\geq 0$$

which is implied by $n_H^* = 2\epsilon\frac{a^2-8B}{a^2}$.

Note finally that $n_L^* = 0$ implies that:

(87) $$E(U_I \mid \theta = 0) = -c - B$$

2. If $\theta = a$

Note that the trader makes a profit if the order flow does not reveal her information and breaks even otherwise. The expected profit per share of the trader when the order flow is uninformative is equal to $\int_0^{\frac{a}{2}}(a-x)dx - P = \frac{a^2}{4}$.

For similar reasons as in the $\theta = 0$ case, we get that $n_I = 1$ dominates $n_I < 1$ and that $n_I = n_L^* + 2\epsilon$ dominates $n_I > n_L^* + 2\epsilon$.

Note finally that the probability that the order flow does not reveal information is equal to $1 - \frac{n_H^* - n_L^*}{2\epsilon}$ if $n_I \in [1, n_H^*]$ and is equal to $1 - \frac{n_I - n_L^*}{2\epsilon}$ if $n_I \in [n_H^*, n_L^* + 2]$. This implies that the expected utility of the informed trader has a kink at the point $n_I = n_H^*$. However, we can easily show that expected utility is strictly concave on both $(n_H^*, n_L^* + 2\epsilon]$ and $[1, n_H^*)$ and that $n_H^* > 0$ implies that $\lim_{n_I \uparrow n_H^*} \frac{\partial E(U_I(n_I)}{\partial n_I} > \lim_{n_H \downarrow n_L^*} \frac{\partial E(U_I(n_I)}{\partial n_I}$.

The optimization problem for $n_I \in [1, n_H^*]$ is given by::

(88) $$Max_{n_I \in [1, n_H^*]} \left\{ -c + n_I \left(1 - \frac{n_H^* - n_L^*}{2\epsilon} \right) \frac{a^2}{4} - B(n_I - 1)^2 \right\}$$

Given $n_L^* = 0$, it follows that $n_I = n_H^* = 2\epsilon \frac{a^2 - 8B}{a^2}$ is optimal iff:

(89) $$2B - 2B \left(2\epsilon \frac{a^2 - 8B}{a^2} - 1 \right) \geq 0$$

Which is implied by:

(90) $$\epsilon \leq \frac{a^2}{a^2 - 8B}$$

The optimization problem for $[n_H^*, n_L^* + 2\epsilon]$ is given by:

(91) $$Max_{n_I \in [n_H^*, n_L^* + 2\epsilon]} \left\{ -c + n_I \left(1 - \frac{n_I - n_L^*}{2\epsilon} \right) \frac{a^2}{4} - B(n_I - 1)^2 \right\}$$

Given $n_L^* = 0$, it follows that $n_I = n_H^* = 2\epsilon \frac{a^2 - 8B}{a^2}$ is optimal iff:

(92) $$\frac{a^2}{4} - \frac{a^2 - 8B}{2} - 2B \left(2\epsilon \frac{a^2 - 8B}{a^2} - 1 \right) \leq 0$$

Which is implied by:

(93) $$\epsilon \geq \frac{a^2}{4B}\frac{6B-\frac{a^2}{4}}{a^2-8B}$$

Substituting n_L^* and n_H^* into the objective function finally yields:

(94) $$E(U_I \mid \theta = a) = -c - B + 4\epsilon B\frac{a^2-8B}{a^2}\left(2 - \frac{\epsilon(a^2-8B)}{a^2}\right)$$

Which implies:

(95) $$E(U_I) = \frac{1}{2}E(U_I \mid \theta = 0) + \frac{1}{2}E(U_I \mid \theta = a) = -c - B + 2\epsilon B\frac{a^2-8B}{a^2}\left(2 - \frac{\epsilon(a^2-8B)}{a^2}\right)$$

I next look at the optimization problem of an uninformed trader

An uninformed trader does not know θ and may incur trading losses stemming from two channels:

- The market-maker may charge the wrong price for the asset.
- The firm manager may make the wrong inference from the order flow and adopt a sub-optimal investment policy, thus lowering the true value of the firm.

More precisely:

- When $N \in [n_H^* - \epsilon, n_L^* + \epsilon]$: the market-maker and the firm manager correctly infer that the order flow is uninformative. Thus, no trading loss for the trader.
- When $N > n_L^* + \epsilon$: the market-maker and the firm manager incorrectly infer that $\theta = a$.

Thus the firm manager invests in the new project iff $x < a$ while the market-maker charges $P = \frac{a^2}{2}$. This implies an expected trading loss per share of: $\int_0^a (\frac{a}{2} - x)dx - \frac{a^2}{2} = -\frac{a^2}{2}$

- When $N < n_H^* - \epsilon$: the market-maker and the firm manager incorrectly infer that $\theta = 0$. Thus the firm manager never invests in the new project and the market-maker charges $P = 0$. This however does not entail any trading loss for the trader.

This implies that $n_U = n_L^*$ dominates $n_U < n_L^*$ (no trading losses in either case, but lower quadratic term for $n_U = n_L^*$) and that $n_U = 1$ dominates $n_U > 1$ (lowers both the probability of a trading loss and the quadratic term). The uninformed trader then maximizes:

(96)
$$Max_{n_U \in [n_L^*, 1]} \left\{ -n_U \left(\frac{n_U - n_L^*}{2\epsilon} \right) \frac{a^2}{2} - B(n_U - 1)^2 \right\}$$

where $\frac{n_U - n_L^*}{2}$ is the probability that $N > n_L^* + \epsilon$ and therefore that the trader make losses.

Given $n_L^* = 0$, the f.o.c. is:

(97)
$$-n_U \left(\frac{a^2}{2\epsilon} + 2B \right) + 2B = 0$$

Which yields:

(98)
$$n_U^* = \frac{2B}{\frac{a^2}{2\epsilon} + 2B} = \frac{4\epsilon B}{a^2 + 4\epsilon B}$$

It is interesting to point out that the uninformed trader deviates from a pure hedging position as $n_U^* < 1$. The difference $n_U^* - 1 = -\frac{a^2}{a^2+4\epsilon B}$ can be interpreted as a speculative demand for the asset based on the trader's private information she decided to remain uninformed, contrary to the beliefs of the market-maker and of the firm manager.

Substituting (98) into the expected utility of the uninformed trader, we get that:

$$E(U_U) = -\frac{Ba^2}{a^2 + 4\epsilon B} \tag{99}$$

I finally solve for the optimal decision to acquire information

Putting together (95) and (99) yields that it is optimal for the trader to acquires information iff:

$$c < 2\epsilon B \left(-\frac{2B}{a^2 + 4\epsilon B} + \frac{a^2 - 8B}{a^2} \left(2 - \frac{\epsilon(a^2 - 8B)}{a^2} \right) \right) \tag{100}$$

Which completes the proof of Lemma 4.

4. Equilibrium Multiplicity

Putting together Lemmas 3 and 4, we get the main proposition of this appendix, namely that the multiplicity result of Section 4.2 carries through in an economy where there is no uncertainty about the type of the strategic trader, where hedging benefits are endogenized, and where the trading space is **R** instead of $\{0, 1\}$:

Proposition 9. *Both the equilibrium where the trader acquires information and the equilibrium* *where she does not acquire information exist if:*

$$\frac{(4\epsilon+\frac{1}{\epsilon})a^4}{32(a^2+8\epsilon B)} < 2\epsilon B\left(-\frac{2B}{a^2+4\epsilon B}+\frac{a^2-8B}{a^2}\left(2-\frac{\epsilon(a^2-8B)}{a^2}\right)\right) \tag{101}$$

and:

$$\frac{(4\epsilon+\frac{1}{\epsilon})a^4}{32(a^2+8\epsilon B)} < c < 2\epsilon B\left(-\frac{2B}{a^2+4\epsilon B}+\frac{a^2-8B}{a^2}\left(2-\frac{\epsilon(a^2-8B)}{a^2}\right)\right) \tag{102}$$

It can easily be checked that the set of parameters that satisfy both Assumption 1 and the first condition of Proposition 9 is non-empty (e.g. $a = 0.95$, $B = 0.1$, $\epsilon = \frac{a^2}{a^2-8B} = 8.8$). Note however that the condition is violated in a neighborhood of $B = 0$. Thus, we have established that multiple equilibria may exist in this economy when the hedging motive of the trader is strong enough. **QED.**

B. Proof of Proposition 4

1. Proof of Part 1

The proof follows the same lines as the proof in Appendix A1 except that we now also need to 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 (31) and (32), we find:

$$c \geq \frac{a^2}{8} - \frac{B}{2} \tag{103}$$

Which is implied by (33). Thus the condition for existence of the equilibrium is the same as in the benchmark economy. Welfare computations are unchanged. QED.

2. Proof of Part 2

The proof follows the same lines as the proof in Appendix A2 except that we now also need to 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 (40) and (41), we get:

(104)
$$c \geq \frac{a^2}{2}\frac{(q+k)^2}{(2q+k)^2} - \frac{B}{2}$$

After substituting (42) into the RHS, (104) simplifies into:

(105)
$$\frac{B}{2} \geq \frac{k}{q}c$$

We note that (13) is implied by (105), and thus conclude that that the candidate equilibrium strategies are indeed optimal if (21) and (22) are satisfied. Welfare computations are unchanged. QED.

3. Proof of Part 3

The proof follows the same lines as the proof in Appendix A3 except that we now also need to check that check that "always buy" dominates "acquisition of information" for the hedger.

This is the case when $B+\pi_{NI}\left(\overline{p}\right)\geq -c+\frac{B}{2}+\frac{1}{2}\pi_{I+}\left(\overline{p}\right)$. After substituting (49) and (50), we get:

$$c\geq \frac{a^2}{2}\frac{1}{\left(1+q\right)^2}-\frac{B}{2} \tag{106}$$

We note that (15) is implied by (51) and (106) and thus conclude that that the candidate equilibrium strategies are indeed optimal if (23) and (24) satisfied. Welfare computations are unchanged. QED.

C. Proof of Proposition 5

We need to check when 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:

$$\overline{p} = 1 \tag{107}$$

$$\underline{p} = \frac{\frac{1}{2}(1-q)}{\frac{1}{2}q + (1-q)} = \frac{1-q}{2-q} \tag{108}$$

From (5) and (6), we get:

$$P(\overline{p}) = \frac{a^2}{2} \tag{109}$$

$$P(\underline{p}) = \frac{a^2}{2}\left(\frac{1-q}{2-q}\right)^2 \tag{110}$$

From (7) and (8), we get:

$$\pi_{I+}(\overline{p}) = 0 \tag{111}$$

$$\pi_{NI}(\overline{p}) = -\frac{a^2}{2} \tag{112}$$

We first check that "acquisition of information" dominates both "no trade" and "always buy" for the hedger. From *Lemma 2* and (107), this is the case when:

$$c \leq Min\left(\frac{B}{2}; \frac{a^2}{2} - \frac{B}{2}\right) \tag{113}$$

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 (111), we get:

$$c \geq 0 \tag{114}$$

Which is always true. Similarly (112) implies that "no trade" also dominates "always buy".

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (25) 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 (47) and (48):

$$E(V) = \left(\frac{1-q}{2}\right)\left(\frac{a^2}{2}\right) + \left(1-\frac{q}{2}\right) * \frac{a^2}{2}\left(\frac{1-q}{2-q}\right)^2 = \frac{a^2}{4}\frac{1}{2-q} \tag{115}$$

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 (26). QED.

D. Equilibria in mixed strategy for the hedger

Proposition 10. • *An equilibrium where the hedger acquires information with probability $\kappa \in (0,1)$ and always buys the asset with probability $1-\kappa$ and where speculator does not trade exists if and only if:*

$$c = \frac{a^2}{2}\frac{q^2}{(2q-k)^2} - \frac{B}{2} \tag{116}$$

where $k := \kappa q$

and:

$$\frac{B/2}{c+B/2} \leq \frac{k}{q} \leq \frac{B}{c+B/2} \tag{117}$$

- *The equilibrium welfare is equal to:*

$$W_0 + \left(q - \frac{k}{2}\right)B + \frac{a^2}{4}\frac{2q(1-q) - k(1-2q)}{(2q-k)(2(1-q)+k)} - kc \tag{118}$$

- *Welfare is a convex function of k*

We need to check when the following candidate equilibrium strategies are optimal:

- H acquires information with probability κ_{-}
- S does not acquire information
- HI+ and HNI buy ; HI- and SNI don't 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+ (of mass $\frac{k}{2}$, where $k \equiv \kappa q$) and HNI (of mass $q - k$). Out of these buy orders, half of the orders from HNI and all the orders from HI+ coincides with $\theta = a$.

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

We then get from Bayes law:

$$\overline{p} = \frac{\frac{k}{2} + \frac{q-k}{2}}{\frac{k}{2} + q - k} = \frac{q}{2q - k} \tag{119}$$

$$\underline{p} = \frac{\frac{1-q}{2}}{\frac{k}{2} + 1 - q} = \frac{1 - q}{2(1 - q) + k} \tag{120}$$

From (5) and (6), we get:

$$P(\overline{p}) = \frac{a^2}{2} \frac{q^2}{(2q - k)^2} \tag{121}$$

$$P\left(\underline{p}\right)=\frac{a^{2}}{2}\frac{\left(1-q\right)^{2}}{\left(2\left(1-q\right)+k\right)^{2}} \tag{122}$$

From (7) and (8), we get:

$$\pi_{I+}\left(\overline{p}\right)=a^{2}\frac{q\left(q-k\right)}{\left(2q-k\right)^{2}} \tag{123}$$

$$\pi_{NI}\left(\overline{p}\right)=-\frac{a^{2}}{2}\frac{kq}{\left(2q-k\right)^{2}} \tag{124}$$

We first compute the value of k that makes the hedger indifferent between "acquisition of information" and "always buy". This is the case when $B+\pi_{NI}\left(\overline{p}\right)=-c+\frac{B}{2}+\frac{1}{2}\pi_{I+}\left(\overline{p}\right)$. After substituting (123) and (124), we get:

$$c=-\frac{B}{2}+\frac{a^{2}}{2}\frac{q^{2}}{\left(2q-k\right)^{2}} \tag{125}$$

We next check that "always buy" dominates "no trade" for the hedger.

This is the case when $B+\pi_{NI}\left(\overline{p}\right)\geq 0$. After substituting (124), we get:

$$B\geq\frac{a^{2}}{2}\frac{kq}{\left(2q-k\right)^{2}} \tag{126}$$

Which after substituting (125) into the RHS simplifies into:

$$\frac{B}{c+B/2} \geq \frac{k}{q} \tag{127}$$

We finally check that “no trade” is optimal for the speculator. As $\pi_{NI}\left(\overline{p}\right) < 0$, it dominates “always buy”. We need to check that it dominates “acquisition”. This is the case when $-c + \frac{1}{2}\pi_{I+}\left(\overline{p}\right) \leq 0$, which after substituting (123) yields:

$$c \geq \frac{a^2}{2}\frac{q\left(q-k\right)}{\left(2q-k\right)^2} \tag{128}$$

Which after substituting (125) into the RHS yields:

$$c \geq \frac{q-k}{q}\left(c+\frac{B}{2}\right) \tag{129}$$

Which can finally be rewritten as:

$$\frac{k}{q} \geq \frac{B/2}{c+B/2} \tag{130}$$

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (116) and (117) are satisfied.

To compute 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 $q - k + \frac{k}{2} = q - \frac{k}{2}$ and that the probability of no trade is equal to $1 - q + \frac{k}{2}$. Then, we get after substituting (121) and (122) and simplifying:

$$(131) \quad E(V) = \left(q - \frac{k}{2}\right)\left(\frac{a^2}{2}\frac{q^2}{(2q-k)^2}\right) + \left(1 - q + \frac{k}{2}\right) * \left(\frac{a^2}{2}\frac{(1-q)^2}{(2(1-q)+k)^2}\right)$$
$$\Leftrightarrow E(V) = \frac{a^2}{4}\frac{2q(1-q) - k(1-2q)}{(2q-k)(2(1-q)+k)}$$

Since the hedger buys the asset either if uninformed (with probability $q - k$) or if informed and learned bad news (with probability $\frac{k}{2}$), the expected private benefit is equal to $\left(q - \frac{k}{2}\right) B$. Since information is acquired solely by informed hedgers (with probability k), the expected cost of acquiring information is kc. Putting it all together yields (118). Convexity of welfare follows from the proof of Proposition 2 and the observation that (131) is the same expression as (44) replacing k by $-k$. QED.

Proposition 11.
- *An equilibrium where the hedger acquires information with probability $\kappa \in (0,1)$ and always buys the asset with probability $1 - \kappa$ and where the speculator acquires information with probability 1 exists if and only if:*

$$(132) \qquad c = \frac{a^2}{2}\frac{1}{(1+q-k)^2} - \frac{B}{2}$$

where $k := \kappa q$ and:

(133) $$\frac{B/2}{c+B/2} \leq 1-q+k \leq \frac{B}{c+B/2}$$

- *The equilibrium welfare is equal to:*

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

- *Welfare is a convex function of k*

We need to check when the following candidate equilibrium strategies are optimal:

- H acquires information with probability κ
- S acquires information
- HI+, SI+ and HNI buy ; HI- and SI- don't 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+ (of mass $\frac{k}{2}$, where $k \equiv \kappa q$), SI+ (of mass $\frac{1-q}{2}$ and HNI (of mass $q-k$). Out of these buy orders, half of the orders from HNI and all the orders from HI+ coincides with $\theta = a$.

Conversely, only agents who learned that $\theta = 0$ don't trade.

We then get from Bayes law:

(135) $$\overline{p} = \frac{\frac{k}{2} + \frac{1-q}{2} + \frac{q-k}{2}}{\frac{k}{2} + \frac{1-q}{2} + q - k} = \frac{1}{1+q-k}$$

$$\underline{p} = 0 \tag{136}$$

From (5) and (6), we get:

$$P\left(\overline{p}\right) = \frac{a^2}{2} \frac{1}{\left(1+q-k\right)^2} \tag{137}$$

$$P\left(\underline{p}\right) = 0 \tag{138}$$

From (7) and (8), we get:

$$\pi_{I+}\left(\overline{p}\right) = a^2 \frac{(q-k)}{\left(1+q-k\right)^2} \tag{139}$$

$$\pi_{NI}\left(\overline{p}\right) = -\frac{a^2}{2} \frac{1-q+k}{\left(1+q-k\right)^2} \tag{140}$$

We first compute the value of k that makes the hedger indifferent between "acquisition of information" and "always buy". This is the case when $B + \pi_{NI}\left(\overline{p}\right) = -c + \frac{B}{2} + \frac{1}{2}\pi_{I+}\left(\overline{p}\right)$. After substituting (139) and (140), we get:

$$c = -\frac{B}{2} + \frac{a^2}{2} \frac{1}{(1+q-k)^2} \tag{141}$$

We next check that "always buy" dominates "no trade" for the hedger.

This is the case when $B + \pi_{NI}(\overline{p}) \geq 0$. After substituting (140), we get:

$$B \geq \frac{a^2}{2} \frac{1-q+k}{(1+q-k)^2} \tag{142}$$

Which after substituting (141) into the RHS simplifies into:

$$\frac{B}{c + B/2} \geq 1 - q + k \tag{143}$$

We finally check that "acquires information" dominates "no trade" for the speculator. This is the case when $-c + \frac{1}{2}\pi_{I+}(\overline{p}) \geq 0$, which after substituting (139) yields:

$$c \geq \frac{a^2}{2} \frac{(q-k)}{(1+q-k)^2} \tag{144}$$

Which after substituting (141) into the RHS yields:

$$c \geq (q-k)\left(c+\frac{B}{2}\right) \tag{145}$$

Which can finally be rewritten as:

$$1-q+k \geq \frac{B/2}{c+B/2} \tag{146}$$

Putting it it all together, we find that the candidate equilibrium strategies are indeed optimal if (132) and (133) are satisfied.

To compute 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 $q-k+\frac{1-q+k}{2}=\frac{1+q-k}{2}$ and that the probability of no trade is equal to $\frac{1-q+k}{2}$. Then, we get after substituting (137) and (138) and simplifying:

$$E(V)=\left(\frac{1+q-k}{2}\right)\left(\frac{a^2}{2}\frac{1}{(1+q-k)^2}\right)+\left(\frac{1-q+k}{2}\right)*0=\frac{a^2}{4\,(1+q-k)}$$

Since the hedger buys the asset either if uninformed (with probability $q-k$) or if informed and learned bad news (with probability $\frac{k}{2}$), the expected private benefit is equal to $\left(q-\frac{k}{2}\right)B$. Since information is acquired either by the speculator (with probability $1-q$) or by informed hedgers (with probability k), the expected cost of acquiring information is $(1-q+k)\,c$. Putting it all together yields (134). QED.