# Markets vs. Mechanisms*

Raphael Boleslavsky Christopher A. Hennessy David L. Kelly

1 December 2020

**Abstract**

We demonstrate limitations on usage of direct revelation mechanisms (DRMs) by corporations seeking decision relevant information in economies with securities markets. In such an environment, posting a DRM increases the informed agent's outside option: if the agent rejects the DRM, he convinces the market he is uninformed, and he can trade aggressively with low price impact, generating large (off-equilibrium) trading gains. Due to this endogenous outside option, using a DRM to screen uninformed agents may be impossible. When screening is possible, relying solely on the market for information is optimal if the increase in outside option is sufficiently large. Keywords: Market Microstructure, Mechanism Design
JEL Codes: G32, L14, D83.

*Boleslavsky: r.boleslavsky@miami.edu, Hennessy: chennessy@london.edu, Kelly: dkelly@miami.edu. We thank Laura Doval and seminar participants at the 2019 ASSA Meetings, EPFL, UNIL, Universite Paris-Dauphine, BI Norwegian Business School, and the University of California at Santa Barbara.

"The greatest trick the devil ever pulled was convincing the world he didn't exist."
—Verbal Kint, *The Usual Suspects*

"The Devil's greatest trick is to persuade you that he does not exist!"
—Charles Baudelaire, *The Generous Gambler*

## 1 Introduction

Information provision is critical for economic efficiency. Hayek (1945) extolled the virtues of markets in this regard, writing, "We must look at the price system as such a mechanism for communicating information..." More specifically, financial markets are commonly viewed as a vital source of information for firms making real investment decisions. For example, Fama and Miller (1972) write, "(an efficient market) has a very desirable feature. In particular, at any point in time market prices of securities provide accurate signals for resource allocation..."

Although capital markets undoubtedly have many virtues,[1] intuition suggests that, if the specific objective is to induce a well-informed agent to reveal private information, a superior outcome can be achieved by inducing them to report the information directly. Indeed, complementing the finance theory literature on stock market informativeness, an extensive corporate finance literature considers the direct provision of information by banks (e.g. Diamond 1984), venture capitalists (Casamatta 2003, Garmaise 2007), boards of directors (Song and Thakor 2006), and private equity investors (Kaplan and Stromberg 2009). At a formal level, Habib and Johnsen (2000) show that optimally-designed securities can serve as mechanisms for directly eliciting private information from investors, thus improving firm decisions.[2] Importantly, Habib and Johnsen conjecture that mechanisms may dominate markets in this regard, writing, "It is possible the firm can piece together such information by carefully observing how its stock price reacts through time to various incremental announcements, but this is likely to provide a murky signal." Consistent with this view, a growing feedback-effect literature (e.g. Kahn and Winton 1998, Bond, Goldstein, and Prescott 2009, Bond and Goldstein 2015, Boleslavsky, Kelly, and Taylor 2017, hereafter BKT) demonstrates limitations on information that can be derived from stock market prices, showing that anticipated interplay between order flow and firm decisions causes less aggressive informed trading and limited price informativeness.

Intuitively, there would seem to exist a Pareto-improving bargain to be struck between the market-reliant firm and the informed trader currently sitting outside its boundaries: The firm should compute what the trader is currently making in market gains and write a contract that delivers equal expected payoff, induces him to report truthfully, and screens out uninformed agents. After all, stock market prices do not generally fully reveal the trader's information. In fact, economic

[1] In particular, markets pool wealth and risk, and aggregate heterogeneous information dispersed across many traders. We evaluate markets in a setting where one may expect mechanisms to dominate: homogeneous information possessed by one or more experts.

[2] Axelson (2007) also shows how optimal security design can improve real decisions with investor private information.

theory points to another benefit to such an arrangement: insulation of liquidating shareholders from underpricing due to adverse selection.

In this paper, we demonstrate an inherent limitation to the use of direct revelation mechanisms by firms inhabiting economies with competitive securities markets. In particular, we show that for such firms the set of feasible mechanisms may actually be empty.[3] Furthermore, even when the feasible set is non-empty, the firm may nevertheless find it optimal to rely exclusively on the stock market for information. Finally, we show that even in those instances in which posting a mechanism dominates relying exclusively on the market, the firm can always achieve superior outcomes by stochastically limiting agents' ability to observe the posted mechanism.

At first glance, these results may seem to be inconsistent with the revelation principle. However, the revelation principle assumes the mechanism designer enjoys full commitment power, including the ability to prevent trading ex post.[4] In contrast, we assume the mechanism designer cannot prevent *voluntary* securities market-making ex post. In this way, our model captures an important problem confronting mechanism design: the fact that the mechanism-designer is often unable to prevent the existence/emergence of markets.

In the baseline setting, a competitive market-maker stands ready to trade shares ex post. The firm's objective is to maximize ex ante share value, which equals expected terminal cash flow less expected secondary market trading losses incurred by uninformed shareholders who face liquidity shocks. A countably infinite number of uninformed outsiders exist, and with a positive probability an expert outsider also exists, who will privately observe the cash flow that will accrue if the firm implements a risky rather than a safe investment. One option available to the firm, denoted *mechanism reliance*, is to post a DRM that screens for expertise and induces truth-telling. The alternative, denoted *market reliance*, is to rely exclusively on the stock market for information.

To motivate our findings, we note one of the key properties of price formation in competitive stock markets. If an informed agent may be trading the firm's securities, a competitive market maker will lower (raise) price in response to sell (buy) orders. When the informed agent trades, selling (buying) on negative (positive) private information, the price moves closer to fundamentals, reducing informed trading gains at the expense of uninformed shareholders. Further, such price impact screens out uninformed traders.

Consider instead the nature of price formation if the firm were to move away from market-reliance by "posting a mechanism," which we show can be implemented by marketing a block of an information-sensitive security or by creating a board seat. In order to induce acceptance by the informed outsider, should he exist, the firm must offer an expected payoff equal to his outside option value–the expected trading gain he would capture if he were to deviate by foregoing the posted mechanism. But note, since the mechanism is designed to induce acceptance by the informed agent,

[3] Here we say a mechanism is feasible if it screens out incompetents and satisfies the participation constraint of the informed agent, two conditions that a mechanism must satisfy in order to yield the firm more information than can be obtained by observing market transactions.

[4] Even if commitment preventing securities markets were feasible, it is unlikely to be optimal. Private firms must adhere to low caps on shareholders, constraining firm scale. Further, Koeplin, Sarin, and Shapiro (2000) present empirical evidence suggesting investors apply deep discounts to illiquid private companies.

the market maker believes the informed agent will accept it if he exists. Therefore, if the informed agent deviates, and leaves the mechanism sitting, the market maker will form the belief that the informed agent does not exist. Thus, the market maker will attribute the arrival of (on-path) sell orders to uninformed shareholders being hit with liquidity shocks, even when those orders are very large. The attenuation of price impact dramatically increases the outside option value of the informed agent.

The key point is that the act of marketing a mechanism (security/board position) that screens for expertise has the effect of transforming the informational environment: by rejecting a posted mechanism, the devil can convince the market he doesn't exist. Thus, posting a mechanism may be self-defeating. In particular, once the firm posts the mechanism, the informed agent's outside option value rises considerably. In some instances, the endogenous outside option value increases to the point where it is impossible to achieve the dual objectives of screening out incompetents and inducing informed participation. In other instances, the endogenous increase in the informed agent's outside option may exceed the value of information provided by the mechanism.

We completely characterize the conditions under which it is optimal for the firm to rely exclusively on the securities market for information, despite its limitations (BKT, Edmans, Goldstein, and Jiang 2015). Market-reliance dominates mechanism-reliance when the probability that an informed agent exists is high or the probability of shareholder liquidity shocks is low. In this case, firm decision-making under market-reliance is close to first-best since order flow is highly informative. Here switching to the mechanism generates only a small increase in expected cash flow. Further, in this case, switching to the mechanism leads to a large increase in the expert's informational rent. After all, here price discipline under market-reliance will be strong since the market maker will assign a high probability to orders arising from informed trading.

We show our results are robust to several extensions and alternative assumptions. First, we show that the conditions for market-reliant firm value to exceed mechanism-reliant firm value remain unchanged if multiple experts may exist. Intuitively, the possibility of multiple experts reduces the expert's option value from rejecting the mechanism, but this same possibility reduces adverse selection under the market. Second, we suppose the firm can stochastically limit the informed agent's ability to observe the mechanism offer. Here we derive a complementary result: Ex ante firm value is necessarily increased by introducing limits on the informed agent's ability to observe the mechanism offer. Intuitively, the firm loses some information by doing so, but is more than compensated by the endogenous reduction in the informed agent's reservation value.

We also relax a number of assumptions that streamline the baseline model. In particular, we allow trading by the informed agent even if hired by the firm, consider alternative timing specifications, and allow the firm to disregard exiting shareholder losses. The results are robust to all of these extensions, since none affect what drives the results: posting a mechanism endogenously increases an informed agent's reservation value.

**Related literature.** Our paper is novel in that we analyze the *interaction* between financial markets and alternative information acquisition schemes. By way of contrast, Grossman and Stiglitz

(1976) and Dow and Gorton (1997) analyze the allocative efficiency of financial markets when they do not interact with alternative information acquisition schemes. Comparisons of the information aggregation properties of markets and mechanisms have been conducted in variety of settings. In general, market-based information systems do not fare well. In particular, the Revelation Principle informs us that, with commitment power, indirect schemes, such as securities markets, cannot possibly achieve superior outcomes to a direct revelation mechanism when the latter is implemented in isolation. However, in contrast to our paper, the standard mechanism design literature assumes the principal has already decided to offer a mechanism and that the agent's reservation value is identical across all available mechanisms.

Endogenous reservation values have been explored in a variety of contexts. Tirole (2012), Philippon and Skreta (2012), and Bhattacharya and Nyborg (2013) study government programs to unfreeze markets, where the decision not to participate in the program reveals information about the firm's type to the market. There is a fundamental difference between our setting and other models with endogenous reservation values: mechanisms in other settings provide useful information which enhances the efficiency of the market. In our setting, offering a mechanism removes the informed trader from the securities market, so that the market and the mechanism are substitute sources of information. Other mechanism design literature focuses on type-dependent outside options (e.g. Lewis and Sappington 1989, Jullien 2000) or outside options created endogenously from relationship specific investments (Rasula and Sonderegger 2010).

Our paper also provides a new perspective within the extant literature on the boundaries of the firm.[5] Williamson (1985) emphasizes the firm as a device for avoiding transaction costs. Grossman and Hart (1986) and Hart and Moore (1990) argue that firm boundaries allocate residual control rights optimally given the need for relationship specific investments. Other ideas include resolving incentive problems (e.g. Holmstrom 1999) and minimizing rent seeking (e.g. Klein 2000). In contrast, we analyze a corporation's decision regarding whether to bring expertise inside the firm, via the mechanism, or to refrain from posting a mechanism and instead rely on market provision of information.

The feedback-effect literature analyzes the interplay between the information contained in securities prices and economic decisions (Kahn and Winton 1998, Bond, Goldstein, and Prescott 2009, Bond and Goldstein 2015, BKT). As in this literature, our model has the feature that anticipated feedback between order flow and firm decisions causes less aggressive informed trading and limited price informativeness. Therefore, our key finding that market-reliance may be optimal—even if the mechanism is feasible—is even more striking. In contrast to the feedback-effect literature, we treat the firm as making an endogenous choice between outside (market-based) information production versus inside information production.

Our analysis makes a number of testable predictions which align with the empirical literature. A key prediction of our model is that firms which opt for market reliance have a higher probability of informed trading, more informative stock prices, and real investment decisions which are more

[5]See Williamson (2002) and Gibbons (2005) for review articles.

correlated with these prices. Consistent with this prediction Chen, Goldstein, and Jiang (2007) find that two measures of private information in stock prices–price non-synchronicity and probability of informed trading–have a strong positive effect on the sensitivity of corporate investment to stock prices. Importantly, our model shows that this result arises when stock market informativeness is determined endogenously by the firm decision of whether or not to bring information inside its boundaries.

A converse prediction concerns the relationship between board size/quality and stock market liquidity. Our theory predicts that larger, more capable, and/or well-incentivized boards of directors are opting for mechanism reliance. That is, they are bringing expertise inside the firm, rather than leaving experts free to trade outside the firm. For this reason, the model predicts stock market liquidity is increasing in measures of board quality, a prediction consistent with Chung, Elder, and Kim (2010).

Finally, mergers and acquisitions provide a well-researched empirical application of our model. For example, Huang, Feng, Lie, and Yang (2014) find that 33% of acquiring firms have former or concurrent investment bankers on their boards, and provides evidence that such board members help select acquisition targets (mechanism reliance). Conversely, Luo (2005) and Kau, Linck, and Rubin (2008) find strong evidence that firms rely on markets for information in mergers. Interestingly, Huang, Feng, Lie, and Yang (2014) find that acquirers with investment bankers on their boards earn higher cumulative average returns after announcing the merger. This is consistent with our model in that, if the expert is hired and a merger is announced, the market knows that the expert has been hired and has recommended the risky option (acquire). In contrast, with market reliance, after a merger announcement the expert may either not exist or know the merger will result in a loss of value, and so the stock price will be lower if information is revealed through trade. Rau (2000) also finds merger consulting fees are higher if the deal is completed, a necessary feature of our optimal contract since the expert cannot prove he is informed if he recommends the safe option of canceling the merger.

Section 2 provides an overview of the economic setting. Section 3 derives conditions under which a mechanism exists that screens for expertise and characterizes the optimal mechanism. Sections 4 and 5 derive firm value given market reliance and contrast with mechanism reliance when trades are more and less informative, respectively. Section 6 shows the robustness of results to alternative assumptions, including limiting the informed agent's ability to observe the mechanism offer, multiple experts, non-exclusivity, and hiring after information is revealed. Section 7 concludes. Proofs are in the appendix.

## 2 Economic Setting

We analyze the interaction between markets and mechanisms in the context of a canonical firm-level decision problem with an information asymmetry.

**Firm ownership.** We consider a widely-held public corporation with tradable shares.[6] Initially, a set of ex ante identical risk neutral atomistic shareholders owns all outstanding equity. For brevity, these original shareholders are referred to as "the shareholders." Each atomistic share entitles its holder to an infinitesimal share of the firm's cash flow. The measure of outstanding shares and the measure of original shareholders are both normalized to 1. Ex ante, the objective of the firm is to maximize the expected payoff the shareholders derive from their share, i.e. the ex ante value of the firm.

Ex ante firm value consists of two parts. First, a share held to maturity entitles the shareholder to the firm's terminal cash flow. Second, shareholders may be hit by liquidity shocks forcing them to sell their stock in a competitive secondary market. Potential adverse price impact may cause shares to sell for less than expected cash flow. Such underpricing is capitalized into ex ante share value as in Holmstrom and Tirole (1993) and Maug (1998).

**Firm decision.** As is standard, we consider a firm with a stock of assets in place and a growth option. We normalize the terminal cash flow from assets in place at 0. The firm must choose between a risky investment ($R$) and a safe investment ($S$), and this decision must be sequentially rational. The competing investments have equal costs of 0. The terminal cash flow from investment $R$ is a binary random variable $\omega \in \{0, 1\}$. We refer to $\omega$ as the *economic state*. All agents have the common prior $\Pr(\omega = 0) = q$, where $q \in (0, 1)$. If the firm instead implements investment $S$, it receives a sure terminal cash flow equal to $1 - c$, where $c \in (0, 1)$. It is assumed $c > q$, which implies investment $R$ would be optimal if the firm's decision were to be based solely on priors.

**Shareholders.** Each original shareholder holds their stock until the terminal date unless forced to liquidate. The probability of a liquidity shock is $l \in (0, 1)$. The arrival of the liquidity shock is observed only by the atomistic shareholders. If a liquidity shock does indeed arrive, the fraction of original shareholders forced to sell is itself a random variable uniformly distributed on $[0, 1]$.[7] Following Maug (1998) and Faure-Grimaud and Gromb (2004), it is assumed that the shareholders' liquidity sales arrive in the market as a batch (block).

**Outsider Agents.** A countably infinite number of identical agents exist, each of whom will never acquire any information. These agents are labeled *uninformed outsiders*. With probability $a \in (0, 1)$ an additional outsider agent exists, and this agent is labeled the *expert outsider*.[8] Should he exist, the expert outsider privately observes the economic state $\omega$ at the time it is determined by nature. We refer to an expert who learns that the economic state is $\omega$ as the "type-$\omega$ expert." The expert's existence is his private information: to others, the expert is indistinguishable from an uninformed outsider. The uninformed outsiders and the expert maximize expected wealth. Each has wealth $W \geq 1$ which is sufficient to cover any feasible short or long position. In addition, each

[6] With advanced securities markets, bets can even be placed on unlisted firms using private share trading platforms or by trading debt or credit default swaps (CDS).

[7] Aside from the compact support, the density has no bearing other than simplifying the algebra.

[8] Section 6.1 extends the results to the case of multiple experts.

has the ability to post a "bond" worth $B \geq 0$ as part of any contract signed with the firm. The bond represents the maximum the legal system can extract from an agent "hired" by the firm, inclusive of reputation costs. In practice, $B$ is a function of the legal system, the value attached to reputation, wealth, and the financial structure of a bonded agent.[9]

**Market.** The firm's stock is traded in an anonymous competive market. As discussed above, the firm's shareholders submit a uniformly distributed sell order if hit with a liquidity shock. In addition, each outsider agent $i$ has discretion to submit a single sell order of size $t_i \in [-1, 1]$. Since the focus of the formal analysis below is largely on the sell side, we denote positive values of $t$ as sell orders and negative values as buy orders. We label an order of 0 as *inactivity.* A competitive market maker observes the countably infinite vector of submitted orders without observing each order's source. The market maker updates her beliefs about the economic state based on the order vector and then fills all orders at expected terminal cash flow.

**Mechanism.** The firm has a one-time opportunity to offer a direct revelation mechanism to the outsider agents. Mechanism posting and acceptance/rejection are observable. Consistent with standard securities market regulations, an outsider who takes up the mechanism is viewed by the courts as an insider barred from trading the firm's stock. We show in section 6 that this "exclusivity assumption" is made without loss of generality.

This setting is in the spirit of Habib and Johnsen (2000) and Garmaise (2007) who analyze the mechanism function of financial securities as devices for eliciting private information. In particular, one may think of the firm as having the option to market to the outsider agents a block security (e.g. a convertible security) with the buyer of the security being allocated a board seat. Alternatively, one may think of the firm as having the option to create a new board seat and offering securities (e.g. equity warrants) as compensation. Under either interpretation, the function of the new board member would be to report the economic state to the firm. In reality, effort made by a firm to raise funds by placing a new security is publicly observable, as is the creation of a new board seat. Similarly, the success/failure of a firm in selling a security is publicly observable, as is success/failure in filling a vacant board seat.

**Timing.** If the firm offers a mechanism, the game unfolds in the following sequence.

1. *Information State.* The expert outsider's existence/not (information state) is realized.
2. *Mechanism Offered.* The firm publicly offers a mechanism to the outsider agents. The mechanism is assigned to the first outsider agent who indicates willingness to participate.
3. *Economic State.* The economic state $\omega$ is realized and is privately observed by the expert if he exists.

[9] The parameter $B$ can be less than one for a variety of reasons, e.g. limited liability and frictions in contract enforcement.

4. *Reporting.* If any agent agreed to participate, then this advisor privately issues a report of the economic state to the firm.

5. *Liquidity Shock.* The shareholder liquidity shock is realized.

6. *Market.* Orders are anonymously submitted and the market maker sets price competitively.

7. *Decision.* The firm chooses a sequentially rational investment, $S$ or $R$.

8. *Cash flows.* The firm's cash flows are revealed.

To ensure a level playing field, if the firm is market-reliant then the game unfolds exactly as in mechanism reliance, except step 2 is skipped (no mechanism is offered) and step 4 is skipped (the informed agent does not report the state to the firm). These timing assumptions are conservative in the sense of putting the mechanism in a better light. In particular, section 6 shows the mechanism would actually become infeasible if the expert were able to make his participation decision *after* observing the economic state $\omega$.

## 3 Optimal Mechanisms and their Feasibility

This section describes an optimal direct revelation mechanism (DRM), focusing on implementation and feasibility. The Online Appendix presents a rigorous treatment, deriving all constraints from first principles and presenting formal proofs.

### 3.1 Optimal Mechanism

Before proceeding, it is useful to establish the *first-best benchmark*, which is the ex ante firm value if the firm were to have direct access to the same information that is available to an expert outsider, should he exist. In this case, if the expert did not exist, the firm would implement the risky strategy, receiving $1-q$ in expectation. If the expert did exist, the firm would observe the economic state and correctly switch to the safe investment if $\omega = 0$. The implied first-best firm value is

$$V^* \equiv (1-a)(1-q) + a[q(1-c) + (1-q)\cdot 1] = 1 - q + aq(1-c). \tag{1}$$

Consider now the mechanism design problem, whereby the firm commits to a vector of wages that depends, in general, on the expert's recommendation and the realized cash flow.[10] We first derive a mechanism that implements first best project selection and pins the expert to his reservation value. In particular, the proposed mechanism is acceptable to the expert, unacceptable to the uninformed agents, the expert's expected wage equals his outside option, and the expert truthfully conveys his private information. We then show that when this mechanism is infeasible, no other mechanism can do better than market reliance.

[10] Because the firm's project selection must be sequentially rational, it can only commit to the expert's compensation as part of the contract. Thus, we cannot appeal to the Revelation Principle, which introduces additional complications in the analysis.

Any such mechanism can be represented as the firm posting a contract where the wage payment $w$ made to the hired agent depends only upon the realized cash flow $\varphi \in \{0, 1, 1-c\}$, not the reported state $w \in \{w_0, w_1, w_{1-c}\}$. To see this intuitively, suppose instead a wage $w = w_{r\varphi}$ which depends on the report $r$ as well as the realized cash flow $\varphi$, $w \in \{w_{10}, w_{11-c}, w_{11}, w_{00}, w_{01-c}, w_{01}\}$. Notice, since project selection must be sequentially rational, the wages $w_{11-c}$, $w_{01}$, and $w_{00}$ are irrelevant since each of these $r\varphi$ pairs entails the firm going directly against the adviser's recommendation. When the firm follows the adviser, wages $\{w_{10}, w_{11}, w_{01-c}\}$ generate cash flows $\{0, 1, 1-c\}$ and cash flow-based wages $\{w_0, w_1, w_{1-c}\}$, respectively.

Let $\underline{u} > 0$ denote the expert's outside option value. Consider the following program:

$$\min_{w_0, w_1, w_{1-c}} \quad (1-q)w_1 + qw_{1-c}. \tag{2}$$

subject to:

$$
\begin{aligned}
&\text{(SC1)} && w_{1-c} \leq 0 \\
&\text{(SC2)} && qw_0 + (1-q)w_1 \leq 0 \\
&\text{(PC)} && (1-q)w_1 + qw_{1-c} \geq \underline{u} \\
&\text{(TR1)} && w_1 \geq w_{1-c} \\
&\text{(TR0)} && w_{1-c} \geq w_0 \\
&\text{(BOND)} && w_i \geq -B \quad \forall\, i \in \{0, 1, 1-c\}.
\end{aligned}
$$

This program ensures the firm will implement the optimal project in each state, if the expert exists, with the expected wage bill minimized. Constraint (SC1) ensures no uninformed outsider has an incentive to take up the mechanism and report $\omega = 0$. Constraint (SC2) ensures no uninformed outsider has an incentive to take up the mechanism and report $\omega = 1$. Together, the two constraints ensure no uninformed outsider has an incentive to mix over the two possible reports. Constraint (PC) ensures the expert outsider will take up the mechanism if he exists. Constraints (TR1) and (TR0) ensure the expert will report truthfully if $\omega = 1$ and $\omega = 0$, respectively. The final constraints are on the bonding constraints.

We offer the following proposition.

**Proposition 3.1** *(DRM Feasibility and Optimality). If the expert reservation value satisfies $\underline{u} > qB$, there is no feasible mechanism that can improve upon market reliance. Otherwise, the following mechanism is feasible and optimal for all $\underline{u} \in (0, qB]$:*

$$(w_0, w_{1-c}, w_1) = \left(-B, 0, \frac{\underline{u}}{1-q}\right).$$

*In this optimal mechanism, project selection is first-best and ex ante firm value is:*

$$V_{DRM} = (1-a)(1-q) + a[(1-q) + q(1-c) - \underline{u}] = V^* - a\underline{u}. \tag{3}$$

It is readily verified the proposed contract is a solution to the implementation program for $\underline{u} \leq qB$. By inspection, the contract respects (SC1), (TR1), (TR0), and (BOND). Further, (SC2) is satisfied if $\underline{u} \leq qB$. Finally, by construction, (PC) just binds, and so the wage bill is minimized.

As shown formally in the Online Appendix, the constraints in (2) are also necessary for a mechanism to improve upon the market. In particular, in order to do better than the market, a mechanism must induce expert participation while screening out incompetents by satisfying (PC), (SC1), and (SC2). However, if we consider some $\underline{u} > qB$ it is apparent these constraints cannot be jointly satisfied since:

$$\begin{aligned} \text{PC and SC1} \quad &\Rightarrow \quad (1-q)w_1 \geq \underline{u} \ \ (> qB) \\ \text{SC2 and BOND} \quad &\Rightarrow \quad (1-q)w_1 \leq -qw_0 \leq qB. \end{aligned}$$

Intuitively, if $\underline{u} > qB$, the increase in $w_1$ required to induce expert participation would induce incompetents to sign onto the mechanism, a central tension.

The optimal mechanism is intuitive. First, since an uninformed outsider can hide ignorance by always reporting $\omega = 0$, thereby inducing the firm to implement the safe investment, the optimal mechanism offers a wage payment of zero if the adviser recommends this course of action. The optimal mechanism also features maximum punishment for an incorrect report, with $w_0 = -B$, since an incorrect report reveals the advisor to be uninformed. Finally, the wage $w_1$ is set so that the expert outsider's participation constraint is just binding.

To understand the firm value decomposition under an optimal DRM, note that if the informed outsider exists (probability $a$), he takes up the mechanism and the firm implements the optimal strategy for each state $\omega$ and the expert receives $\underline{u}$ in expectation. If no informed outsider exists, the mechanism is not taken up, there are no wages paid, and the firm implements the risky strategy. Notice also that there is no adverse selection cost under mechanism-reliance since any expert will have been siphoned out of the stock market.

The direct mechanism has a natural analog in terms of compensation for a member of a corporate board. First, the board member is given a call option that is in the money if cash flow is 1, but out of the money if the cash flow is $1 - c$ or 0. Second, if the corporation responds to this board member's recommendation to implement the risky investment, but the realized cash flow is 0, the board member should suffer a loss of $B$ due to their negligence.

The direct mechanism also has a natural analog in terms of a convertible security (stock or debt). In particular, the net payoffs described in the preceding proposition could be achieved if the firm marketed the convertible security at a non-negotiable price $B$, with the conversion option date preceding the firm's investment decision date. If the security holder elected not to convert into common equity, the firm would implement the safe investment, and the security would return the initial investment $B$. If converted into common equity, the firm would implement the risky investment, with the security returning the initial investment $B$ plus $\underline{u}/(1-q)$ if cash flow is 1 and 0 if cash flow is 0. Under such a payoff structure, the securityholder's decision to convert into common equity would be sufficient to convey to the firm that the risky investment is optimal.

The optimal mechanism is extremely powerful—provided the expert has sufficient bonding capability. It allows the firm to implement first-best decisions, eliminates adverse selection, and pins the expert to his outside option value.[11] Given these results, it might appear that improving upon an optimal mechanism is a tall order.

### 3.2 Mechanism Feasibility

The expert's reservation value for participating in the mechanism is equal to the expected trading gain he would capture if he were to reject the posted mechanism. This expectation depends upon the nature of price formation after a mechanism has been posted and left sitting.

With this in mind, let $T$ denote the countably infinite vector consisting of the orders submitted by the shareholders and each outsider agent. Let $T = \vec{t}$ denote an order vector consisting of zeros (inactivity) along with a single sell order of size $t > 0$. Let $\chi(T)$ denote the probability assessment of the market maker and firm that the economic state is bad ($\omega = 0$) given the observed order vector $T$. Let $\alpha(T)$ denote the probability that the firm switches to the safe investment $S$ after observing order vector $T$.

Now consider trading patterns and price formation on the equilibrium path after a mechanism has been posted and left sitting. To begin, we note that an optimal mechanism has the property that the expert will take up the mechanism in equilibrium if he exists. Thus, on-path, the expert will not trade in the securities market. We further conjecture, and then verify, that in equilibrium no uninformed outsider has an incentive to trade after a posted mechanism has been left sitting. Thus, on the equilibrium path, after a mechanism has been posted and left sitting, the only possible market participants are the firm's uninformed shareholders.

It follows, after a posted mechanism has been left sitting, the only on-path order vectors are $\vec{0}$ and $\overrightarrow{t}$. In either case, the order vector is uninformative about the economic state so the firm will implement the risky investment, which is optimal under the prior, and the market maker will set the stock price at the expected cash flow, so the price will be set to $p = 1 - q$. Notice, under mechanism-reliance the market maker will set the same stock price in response to the arrival of a single sell order–*regardless of its size.*

When the mechanism has been posted and left sitting, the arrival of two sell orders is an off-path event, as is the arrival of a buy order. The beliefs formed in response to such off-path events are relevant since they determine the expert's reservation value ($\underline{u}$) as well as the incentives and reservation value of uninformed outsiders. Throughout the analysis, as we consider either the mechanism-reliant or market-reliant firm, we adopt the following simple convention for assigning beliefs to all off-path order vectors.

[11]This result is reminiscent of Riordan and Sappington (1988), who consider a contracting problem with a verifiable public signal of the agent's private information, deriving conditions under which the principal can implement the efficient production plan while just paying the agent's reservation value. Gromb and Martimort (2007) and Cremer and McLean (1988) derive similar results in models of collusion and auctions with correlated values, respectively.

**Remark 3.1** *(Off-Path Orders). If the number of buy orders is greater than or equal to the number of sell orders, then $T$ reveals state 1 and the firm selects the risky investment. Otherwise, $T$ reveals state 0 and the firm selects the safe investment.*

The preceding specification of off-path beliefs is adopted in order to minimize $\underline{u}$, giving the mechanism the best possible chance to beat the market. To see that these beliefs ensure $\underline{u}$ is minimized, consider a unilateral deviation by the expert, rejection of a posted mechanism and subsequent trading on private information. If he attempts to buy based upon positive information, two possible order vector possibilities arise, both off-path: one buy order in isolation or one buy order and one sell order. Under the specified off-path beliefs, the expert makes zero profit from such activity since in either case the market maker infers that the state is $\omega = 1$. If the expert attempts to sell based upon negative information he creates two possible order vector possibilities, one sell order or two sell orders, with the former being on-path and the latter being off-path. In order to minimize $\underline{u}$, we assume the market maker treats the latter off-path order vector as revealing $\omega = 0$.

Consider now the optimal strategy of an expert who deviates by rejecting the mechanism, and the implied reservation value $\underline{u}$.[12] If $\omega = 0$, the expert earns maximal expected profits by selling the maximal feasible amount, $t = 1$. After all, if a liquidity shock arrives, then the market maker and firm will infer that $\omega = 0$, the firm will switch to the safe investment, price will be set at fundamental value $(1 - c)$, leaving the expert with zero profit. However, if no liquidity shock arrives, then the secondary market price will be set at $p = 1 - q$ for any feasible sell order $t \leq 1$. It follows that if the expert were to deviate by rejecting a posted optimal mechanism, his maximal expected trading profit in state $\omega = 0$ is equal to $(1-q)(1-l)$. We thus have the following lemma.

**Lemma 3.2** *(Expert Reservation Value). If a mechanism satisfying the screening constraints is posted, the expert's reservation value is*

$$\underline{u} = q(1-q)(1-l). \tag{4}$$

With Proposition 3.1 and equation (4) in-hand, we are in a position to state our first important result which shows that mechanism reliance is not feasible unless bonding capability is sufficiently high.

**Proposition 3.3** *(Markets vs. Mechanisms I). A mechanism that achieves screening is feasible only if the expert has bonding capability:*

$$B \geq (1-q)(1-l). \tag{5}$$

*Otherwise, the firm offers no mechanism and relies exclusively on the market for information.*

Intuitively, mechanism posting weakens/eliminates price impact, and this raises the expert's reservation value. The firm increases $w_1$ in accordance with Proposition 3.1 in order to attract

[12] The Online Appendix shows uninformed outsiders have reservation value 0.

the expert, but this then creates a strong temptation for incompetents to claim expertise and recommend the risky investment, gambling that the state is good. Eventually, the threat of seizing the bond value $B$ is insufficient to deter such incompetent masquerading. The dual objectives of attracting the expert and screening out incompetents become mutually exclusive.

With the preceding result in mind, the remainder of the analysis assumes that condition (5) is satisfied, so that the (optimal) mechanism is feasible. From Propostion 3.1 and Lemma 3.2 it follows that under the optimal mechanism the firm value attained is

$$\begin{aligned} V_{DRM} &= 1 - q + aq(1-c) - a\underline{u} \\ &= V^* - aq(1-q)(1-l). \end{aligned} \tag{6}$$

When bonding capability is sufficiently high to ensure mechanism feasibility, it will be necessary to compare the preceding expression for firm value achieved under the optimal mechanism with firm value attained under the market.

# 4 High Market Informativeness

This section and the next perform a head-to-head comparison of firm value under market reliance versus mechanism reliance. In general, market reliance suffers from two weaknesses relative to mechanism reliance. First, noise in stock prices implies that the firm may not implement the optimal investment even if the expert exists. Second, when uninformed shareholder are hit with a liquidity shock, they may end up selling at a price below fundamental value.

The relative size of these costs depends on the information content of sell orders under market reliance, as determined by the parameters $l$ and $a$. This section considers the case where $l$ is low and $a$ is high, so that a sell order sends a strong signal to the market maker that the economic state is bad.[13] Before proceeding, we present preliminary results related to market reliance.

## 4.1 Trading and Decisions

Recall, the type-$\omega$ expert knows the economic state is $\omega$. With this in mind, let $\phi_\omega(\cdot)$, denote the probability density function from which the type-$\omega$ expert draws his order and let $u^*_\omega$ denote his expected trading profit.

Consider the firm's choice between the safe and risky investment. If the firm chooses safe, its terminal cash flow is $1 - c$ for sure. If the firm chooses risky, the expected cash flow is $1 - \chi(T)$. Therefore, any sequentially rational strategy for the firm must entail:

$$\alpha(T) = \begin{cases} 0 & \text{if} \quad \chi(T) < c \\ \in [0,1] & \text{if} \quad \chi(T) = c \\ 1 & \text{if} \quad \chi(T) > c \end{cases} \tag{7}$$

[13] BKT (2017) show in a related model that payoffs and information flow are equivalent if the firm observes securities prices, but not order flow.

Given order vector $T$, the competitive secondary market stock price must be equal to the expected terminal cash flow,

$$p(T) = [1 - \alpha(T)][1 - \chi(T)] + \alpha(T)(1 - c). \tag{8}$$

With probability $\alpha(T)$, the firm implements the safe investment, with terminal cash flow equal to $1 - c$. If the firm instead implements the risky investment, expected cash flow is $1 - \chi(T)$. Notice, price reflects information about the economic state contained in the order flow, as well as the firm's optimal investment given order flow.

Consider now the type-0 expert's expected trading gain in economic state $\omega = 0$, assuming he indeed exists. Here the expert knows that if the firm implements the risky investment a share will be worth 0. Thus, if the type-0 expert outsider submits sell order $t$, and the realized order vector is $T$, his realized trading gain is

$$u_0(t, T) = t[p(T) - \alpha(T)(1 - c)] = t[1 - \chi(T)][1 - \alpha(T)]. \tag{9}$$

Consider next the type-1 expert's expected trading gain in economic state $\omega = 1$, assuming he indeed exists. If $\omega = 1$, the type-1 expert knows that if the firm implements the risky investment a share will be worth 1. Thus, if he submits order $t$, and the realized order vector is $T$, his realized trading gain will be

$$u_1(t, T) = t[p(T) - (1 - \alpha(T)) - \alpha(T))(1 - c)] = -t\chi(T)[1 - \alpha(T)]. \tag{10}$$

From equations (9) and (10) we see that, all else equal, the expert's trading gain increases with his trade size. Conversely, his trading gain decreases when order flow reveals more information to the market maker about the true economic state. Finally, we see the expert's trading profit decreases with the probability of the firm implementing the safe investment. By implementing the safe investment, the firm severs the link between the economic state and the firm's terminal cash flow, rendering the expert's private knowledge of the economic state worthless.

From equations (9) and (10) it follows:

$$t_B < 0 < t_S \Rightarrow u_0(t_B, T) \leq 0 \leq u_0(t_S, T) \quad \text{and} \quad u_1(t_S, T) \leq 0 \leq u_1(t_B, T). \tag{11}$$

In other words, for the type-0 expert, selling a positive amount is always weakly better than inactivity or buying, and for the type-1 expert, buying a positive amount is always weakly better than inactivity or selling.

**Equilibrium Trading Patterns.** We characterize equilibria in which trading patterns satisfy three intuitive conditions.[14] First, we conjecture equilibria in which each uninformed outsider finds it optimal to be inactive, and verify in Lemma 4.1 that inactivity is indeed optimal for such agents.

[14] An earlier working paper version shows that introducing trembles creates a refinement which selects a unique equilibrium in which the type-0 expert always sells and the uniformed do not trade.

Intuitively, since uninformed outsiders have no private information, they should have no incentive to trade, especially given that prices tend to move against any trader.

Second, since equation (11) establishes that for the type-0 expert, selling a positive amount is always weakly better than inactivity or buying, we characterize equilibria in which the type-0 expert, should he exist, always sells. Third, since this same equation establishes that for the type-1 expert, buying a positive amount is always weakly better than inactivity or selling, we characterize equilibria in which the type-1 expert always buys. In this case, any equilibrium buy order must originate with the type-1 expert, so he cannot possibly earn a strictly positive expected trading gain. For ease of exposition, we posit that the type-1 expert plays a continuous mixed strategy, placing buy orders supported on the entire interval $t \in [-1, 0]$.

**Beliefs.** To begin our analysis of beliefs, the following straightforward remark describes beliefs for those on-path order vectors that are fully revealing, and beliefs given inactivity.

**Remark 4.1** *(Market: On-Path Revealing Orders and Inactivity). (i) Any order vector $T$ containing two sell orders, at least one of which is inside the support of the type-0 expert's strategy, reveals the state is zero and induces a switch to the safe investment; (ii) Market inactivity does not affect beliefs and induces the firm to select the risky investment; (iii) Any order vector $T$ containing a single buy order, or a buy order and a single sell order reveals that the state is one and induces the firm to select the risky investment.*

Consider next beliefs following the arrival of an order vector $(\vec{t})$ containing all zeros and a single sell order of size $t$. When such an order vector arrives, the firm and market maker consider two possibilities: either (1) the expert outsider does not exist and the sell order is due to a liquidity shock or (2) the expert outsider exists, the economic state is 0, and no liquidity shock arrived. Bayes' rule implies updated beliefs are:

$$\chi(\vec{t}) = \frac{aq(1-l)\phi_0(t) + q(1-a)l}{aq(1-l)\phi_0(t) + (1-a)l}. \tag{12}$$

It is readily verified that $\chi(\vec{t})$ is increasing in $\phi_0(t)$. It follows that if the type-0 expert places the sell order $t$ with higher likelihood, beliefs will be more negative in response to the observation of order vector $\vec{t}$.

As shown in the Online Appendix, each uninformed outsider prefers inactivity. Intuitively, the possibility that an order originates with the informed expert results in adverse price impact. Because an uninformed agent faces this adverse price impact without knowledge of the economic state, he cannot profit from participating in the market—price impact screens out incompetents. We have the following lemma

**Lemma 4.1** *(Market Screening) Given equilibrium beliefs, an uninformed agent's expected profit from submitting any order to the market is weakly negative.*

The equilibrium beliefs allow us to derive the type-0 expert's expected profit from selling $t$ shares. If the liquidity shock arrives along with his order, then the economic state is revealed to be $\omega = 0$. The firm will implement the safe investment, with the market maker setting the stock price at $p = 1 - c$, resulting in zero profit for the expert. With probability $1 - l$ the order vector consists of zeros along with the expert's sell order of size $t$. Consequently, when the type-0 expert submits a sell order $t$, his expected trading profit is

$$E[u_0(t, T)] = t[1 - \chi(\vec{t})][1 - \alpha(\vec{t})](1 - l). \tag{13}$$

Notice, the type-0 expert properly views his own sell order order size as being the sole determinant of beliefs and the firm's decision provided that no liquidity shock arrives. Again, his trading gain is increasing in the size of his order, holding all else equal. However, he must account for the impact of his order size on beliefs and firm decisions.

We introduce two transformations of model parameters to simplify exposition.

$$K \equiv \left(\frac{aq}{1-a}\right)\left(\frac{1-l}{l}\right), \quad J \equiv \frac{1-q}{1-c}.$$

Parameter $K \in (0, \infty)$ is labeled *market informativeness*, since it captures the information content of an order vector containing a single sell order combined with zeros. The variable $K$ will be high if $a$ is high and $l$ is low. If $K$ is indeed high, then the arrival of a single sell order provides a strong signal to the market maker and to the firm that the true economic state is $\omega = 0$. We rewrite the beliefs in equation (12) as a function of $K$ as follows:

$$\chi(\vec{t}) = \frac{K\phi_0(t) + q}{K\phi_0(t) + 1}. \tag{14}$$

Parameter $J \in (1, \infty)$ is labeled *switching difficulty.* Intuitively, as the cost $c$ of implementing the safe investment tends upward to 1, $J$ tends to infinity. In this case, the firm would only find it optimal to switch to the safe investment if it were certain that $\omega = 0$. Conversely, as the cost $c$ of implementing the safe investment tends downward to $q$, $J$ tends to 1, and the firm would find it optimal to switch to the safe investment in response to even a small negative revision of its beliefs.

## 4.2 Equilibria with No Information Rent

Intuition suggests that if market informativeness ($K$) is sufficiently high, it will be impossible for the expert to earn a rent even in the bad economic state, since the arrival of any sell order will carry sufficient negative signal content to induce the firm to switch to the safe investment, with the switch severing the link between the expert's private information and cash flow. Indeed, we now conjecture and verify that if $K \geq \overline{K} \equiv J - 1$ there exists just such an equilibrium in which the type-0 expert expects zero rent ($u_0^* = 0$).

**Proposition 4.2** *(High Informativeness). If market informativeness is sufficiently high,* $K \geq \overline{K} \equiv$

*$J-1$, then there exist a multiplicity of equilibria in which the firm switches to the safe investment following the arrival of a single sell order, and the expert makes zero rent. If $K < \overline{K}$, no such equilibrium exists. In any such equilibrium, $\phi_0(t) \geq (J-1)/K$ for all $t \in (0,1]$.*

The preceding result leaves us well-positioned to better understand the inherent limitations on mechanism feasibility, as described in Propositions 3.1 and 3.3. In particular, suppose momentarily that bonding capability $B$ is positive but arbitrarily small. Then the mechanism would be infeasible since the following inequalities would necessarily hold:

$$\underbrace{q(1-q)(1-l)}_{\underline{u}} > qB > 0. \tag{15}$$

However, if one were to neglect the transformative effect of the mechanism on price formation, the mechanism would appear to be feasible if $K \geq \overline{K}$. After all, in the absence of mechanism posting here, the expert makes zero trading gain regardless of the economic state. This example illustrates clearly how endogenous increases in the expert's reservation value, resulting from mechanism posting, can cause the mechanism to become infeasible.

### 4.3 Markets Versus Mechanisms: High Informativeness

Assuming that bonding capacity $B$ is sufficiently high so that the mechanism is feasible, the firm chooses market reliance if and only if market reliance generates greater firm value.

Consider ex ante firm value in a no-rent, market reliant equilibrium as described in Proposition 4.2, using as the first-best firm value $V^*$ as a benchmark. Note, since the expert's payoff is zero in both economic states, there is zero adverse selection discount. Next, note that if the expert outsider exists, the firm selects the risky investment if $\omega = 1$ and the safe investment if $\omega = 0$, just as under the first-best. However, the firm's decisions are not always first-best. After all, if the expert does not exist, the only information available is the prior, and under the prior the risky investment is optimal. However, in a no-rent equilibrium, if the expert outsider does not exist but a liquidity shock arrives, the firm will switch to the safe investment, a departure from the first-best. This scenario occurs with probability $l(1-a)$, reducing the firm's expected cash flow by $(1-q)-(1-c) = c-q$. It follows that firm value in a no-rent equilibrium is

$$\begin{aligned} V_{NR} &= V^* - l(1-a)(c-q) \\ &= 1 - q + l(1-c)(1-a)\left(\frac{K}{1-l} - \overline{K}\right). \end{aligned} \tag{16}$$

As another benchmark, we note that a firm that had no information other than the prior would always implement the risky investment, with expected cash flow equal to $1-q$. Since $K \geq \overline{K}$ here, it follows from the second line above that here the market increases firm value.

Comparing respective firm values under the mechanism (3) versus the preceding value obtained under the market, we find that

$$V_{MKT} = V_{NR} \geq V_{DRM} \iff l(1-a)(c-q) \leq aq(1-q)(1-l)$$

$$\iff K \geq \frac{J-1}{J}. \tag{17}$$

The preceding inequality illustrates the fundamental tradeoff between the market and mechanism when the market informativeness measure is high. Specifically, the left side of the first inequality captures the cost of relatively less efficient investment of a market-reliant firm, which mistakenly switches to the safe investment in response to an uninformative sell order generated by a liquidity shock. The right side of the first line of (17) captures the large endogenous increase in the expert's reservation value from 0 to $\underline{u}$ resulting from mechanism-posting.

Since $J > 1$ and here $K \geq J - 1$, the second line of (17) is necessarily satisfied. Thus, we have our second striking result, showing that under high market informativeness the firm necessarily achieves higher value under market-reliance.

**Proposition 4.3** *(Markets vs. Mechanisms II: High Informativeness). If $K \geq \overline{K} \equiv J - 1$, then the ex ante value of a market-reliant firm, $V_{NR}$, is strictly larger than the ex ante value of a mechanism-reliant firm, $V_{DRM}$.*

It is worth discussing why the market looks especially attractive when $K$ is high. First, here the expert's trading profit under market-reliance is equal to zero implying zero adverse selection cost. Second, the firm only makes an inefficient investment decision if a liquidity shock arrives but the expert does not exist. This only occurs with probability $l(1-a)$, which is low when $K$ is high. Notice also that the endogenous increase in the reservation value resulting from mechanism posting is maximal here. After all, recall that with a mechanism posted, the expert reservation value always jumps up to $\underline{u} = q(1-q)(1-l)$. However, under high market informativeness, the expert anticipates zero rent if the firm opts for market-reliance.

# 5 Low and Intermediate Market Informativeness

The preceding section showed that if market informativeness is sufficiently high, $K \geq \overline{K}$, equilibria exist in which the expert makes zero information rent under market-reliance, and mechanism-reliance is dominated. With this in mind, we now conjecture that if and only if $K < \overline{K}$, there exist equilibria in which the type-0 expert outsider can expect to earn a strictly positive information rent, with $u_0^* > 0$. Below, we characterize such equilibria and compare firm value under market-reliance with that under mechanism-reliance.

## 5.1 Market Equilibria with Expert Rents

A number of observations are immediate. First note that if the type-0 expert is to make an information rent, he must use a proper mixed strategy. After all, if he were to submit one particular order with probability 1, then observing this order would reveal the true economic state to be $\omega = 0$. This would induce the firm to implement the safe investment, resulting in zero profit. And given that the liquidity sales have no mass points, the same reasoning implies that the cumulative distribution function cannot contain any mass points.

Second, note that in an equilibrium with an expert information rent, the *minimum sell order size*, on the support, denoted $m$, must be greater than 0. After all, if $m$ were 0, then the type-0 expert's trading gain would also be 0. Third, it must be the case that the mixing density vanishes at $m$. Equation (12) implies $\chi(\vec{t}) = q$ for any $t$ outside the trading support. If $\phi_0(m)$ were to exceed 0, then order $m$ would entail an adverse price impact ($\chi(\vec{m}) > q$ ), and the expert would earn a higher expected trading gain by deviating to an order infinitesimally smaller than $m$. Finally, a similar argument rules out gaps in the trading support, since there would be a gain to deviating to a gap point, given that a gap point $t$ would also have the property that $\chi(\vec{t}) = q$. Thus, in any equilibrium with information rents, the type-0 expert outsider must play a continuous mixed strategy with no mass points or gaps.

From equation (13) we have the following indifference condition supporting the mixed strategy:

$$t \in [m, 1] \Rightarrow t[1 - \chi(\vec{t})][1 - \alpha(\vec{t})](1 - l) = u_0^*. \tag{18}$$

Notice, since $\phi_0(m) = 0$, equation (14) confirms there will be zero price impact at the minimum sell size $m$, with $\chi(m) = q$ implying sequential rationality of the firm setting $\alpha(m) = 0$. Since the expert must be indifferent among all trades inside the support of his mixed strategy, we have the following lemma.

**Lemma 5.1** *(Expert's Profit). If the type-0 expert expects an information rent in equilibrium, this rent must be* $u_0^* = m(1 - q)(1 - l)$.

Intuition suggests that if market informativeness is sufficiently low, there will be an equilibrium in which the firm will never switch to the safe investment in response to a single sell order regardless of its size. Indeed, the following proposition describes necessary and sufficient conditions for such an equilibrium.

**Proposition 5.2** *(Low Informativeness). If and only if market informativeness is sufficiently low,* $K \in \left(0, \underline{K} \equiv (J-1)^2/2J\right]$*, there exists an equilibrium in which the firm selects the risky investment in response to any single sell order. The type-0 expert submits a sell order drawn from density*

$$\phi_0^L(t) \equiv \frac{t - m_L}{K m_L},$$

*supported on interval* $[m_L, 1]$*, where*

$$m_L \equiv K + 1 - \sqrt{(K+1)^2 - 1},$$

*and expects an information rent* $m_L(1 - q)(1 - l)$.

Consider finally the remaining case of intermediate market informativeness, with $K \in (\underline{K}, \overline{K})$. From Proposition 5.2 we know that an equilibrium where $\alpha(\vec{t}) = 0$ for all $t$ cannot be supported. And from Proposition 4.2 we know that an equilibrium where the expert makes zero rent cannot be supported either, which rules out $\alpha(\vec{t}) = 1$ for any $t$. Thus, for $K \in (\underline{K}, \overline{K})$ we conjecture and verify an equilibrium and a $t'$ such that $\alpha(\vec{t}) = 0$ for all $t \in [m, t']$ and $\alpha(\vec{t}) \in (0, 1)$ for all $t \in (t', 1]$. That is, rather than never switching or always switching in response to a single sell order, here the firm mixes between the safe and risky investments provided the observed sell order is sufficiently large.

**Proposition 5.3** *(Intermediate Informativeness). If and only if there is an intermediate level of market informativeness, $K \in (\underline{K}, \overline{K})$, there exists an equilibrium in which the firm mixes its investment strategy, with $\alpha(\vec{t}) = 0$ if $t < Jm_I$ and $\alpha(\vec{t}) = 1 - Jm_I/t$ if $t \in [Jm_I, 1]$ where*

$$m_I \equiv \frac{2(J - 1 - K)}{J^2 - 1}.$$

*The type-0 expert submits a sell order drawn from density*

$$\phi_0^I(t) \equiv \begin{cases} \frac{t - m_I}{K m_I} & \text{if } t \in [m_I, Jm_I] \\ \frac{J-1}{K} & \text{if } t \in [Jm_I, 1] \end{cases}$$

*and expects an information rent $m_I(1 - q)(1 - l)$.*

The preceding two propositions again leave us well-positioned to better understand the inherent limitations on mechanism feasibility, as described in Propositions 3.1 and 3.3. Suppose for the moment that the following condition holds for $m \in \{m_L, m_I\}$:

$$\underbrace{q(1 - q)(1 - l)}_{\underline{u}} > qB > mq(1 - q)(1 - l) \ (= qu_0^*). \tag{19}$$

If the first inequality held, the mechanism would be infeasible. However, if one were to neglect the transformative effect of mechanism posting on market price formation, the feasible set for the mechanism design problem would seem to be non-empty. Again, endogenous changes in the expert's reservation value, resulting from mechanism posting, can cause the mechanism to become infeasible.

## 5.2 Markets versus Mechanisms: Low/Intermediate Informativeness

Assuming the bonding capability $B$ is sufficiently high so that the mechanism is feasible, the firm chooses market reliance if and only if market reliance generates higher firm value than mechanism reliance.

Based on the preceding characterization, we can derive a simple expression for the ex ante value of the market-reliant firm in an equilibrium with information rent, call it $V_R$. The value of a share ex ante is equal to expected cash flow less the expected trading losses of the shareholders. In turn, since the market maker breaks even in expectation, expected shareholder trading losses are just equal to the ex ante expectation of expert trading gains. Regarding expert trading gains, they only accrue if the expert indeed exists and if the economic state is bad. Thus, the ex ante expectation of shareholder trading losses is $aqu_0^*$.

Consider next expected cash flow, focusing first on the low market informativeness case where $K \leq \underline{K}$. As a benchmark, consider a firm that had zero access to outside information. Such a firm would always play the risky strategy, generating expected cash flow $1 - q$. In contrast, in the low informativeness case, the firm increases its expected cash flow by correctly switching to the safe investment in one (but only one) state of nature: the expert exists (probability $a$); the state is bad (probability $q$); and a fully revealing liquidity shock occurs (probability $l$). In this same state of nature, the always-risky strategy would generate a cash flow of 0. In contrast, by following the market and switching to the safe investment in this one state of nature, the firm gains an incremental cash flow equal to $1 - c$. It follows that expected cash flow in the low informativeness case is:

$$1 - q + aql(1 - c). \tag{20}$$

Consider next the intermediate market informativeness case where $K \in (\underline{K}, \overline{K})$, in which the firm mixes between safe and risky following some realizations of the order flow vector. Here, the fact that the firm is indifferent between safe and risky for such order vectors implies that the conditional expectation of the cash flow is the same as if it had simply played the risky investment for those order vectors. Thus, expected cash flow is still given by the preceding equation in the intermediate market informativeness case, in which the firm mixes (see the Online Appendix for a formal derivation).

Putting this analysis together, we have the following proposition:

**Proposition 5.4** *(Ex Ante Firm Value–Eq. With Rent). If market informativeness is not high, with $K < \overline{K}$, there exists an equilibrium in which type-0 expects an information rent, and ex ante firm value is*

$$V_R \equiv 1 - q + aql(1 - c) - aqu_0^* = V^* - aq(1 - l)[(1 - c) + m^*(1 - q)], \tag{21}$$

*where*

$$m^* \equiv \begin{cases} m_L & K \in [0, \underline{K}] \\ m_I & K \in (\underline{K}, \overline{K}) \end{cases}$$

Equation (21) illustrates the two weaknesses associated with market-reliance. First, the firm does not make first-best decisions. In particular, the firm fails to switch to the safe investment if an informed expert exists and the economic state is bad, but no liquidity shock occurs to fully reveal this fact. Second, in this very same state of nature, the type-0 expert makes trading gains at the expense of shareholders, by short-selling $m^*$ shares at a price $p = 1 - q$ versus a fundamental value of 0.

Comparing the expressions for ex ante firm value under mechanisms (3) versus markets (21), we find that

$$V_{MKT} = V_R \geq V_{DRM} \iff aq(1-l)(1-c) \leq aq(1-l)(1-q)(1-m^*). \tag{22}$$

The preceding equation again reveals the fundamental tradeoff between markets and mechanisms, a tradeoff between relative investment efficiency and relative implementation costs. The left side of the equation reflects the fact that even if the expert investor exists, the market-reliant firm incorrectly fails to switch to the safe investment in the bad state absent a fully revealing liquidity shock, with the output loss equal to $1-c$. The right side of the equation reflects the difference in relative implementation costs. In particular, the right hand side represents the change in the reservation value, or expert trading gains, resulting from posting a mechanism.

Rearranging terms in the preceding equation we find that

$$V_{MKT} = V_R \geq V_{DRM} \iff \frac{1}{J} \leq 1 - m^*(K). \tag{23}$$

Next, we note that $m^*$ is a continuous and decreasing function of $K$, satisfying $m^*(0) = 1$ and $m^*(\overline{K}) = 0$. The next result follows immediately.

**Proposition 5.5** *(Markets vs. Mechanisms III: Low and Intermediate Informativeness). Suppose* $K < \overline{K}$. *For each* $J$, *there exists a threshold for market informativeness* $\widehat{K}(J) < \overline{K}$ *such that the ex ante value of the market-reliant firm is strictly larger than the ex ante value of a mechanism-reliant firm if and only if* $K > \widehat{K}(J)$. *Furthermore,* $\widehat{K}(J)$ *is decreasing in the switching difficulty* $J$.

The intuition for the preceding proposition is simple. First, the proposition informs us that, holding all else equal, larger values of $K$ increase the attractiveness of market-reliance since trades by the type-0 expert then reveal more information. This improves the efficiency of the firm's investment decisions, and also lowers adverse selection costs. Second, the proposition reveals that market reliance becomes more attractive as the switching cost parameter $J$ increases. After all, the advantage of the mechanism is that it always implements the first-best switching policy. As $J$ increases, this advantage has less value.

# 6 Extensions

The objective of this section is to explore further the extent to which the baseline model results can be strengthened, as well as the extent to which they must be qualified. Further, this analysis will help clarify the types of firms and settings for which market-reliance may dominate mechanism-reliance. The first subsection considers multiple informed traders. The second subsection considers a technology that effectively allows the firm to randomize over market and mechanism reliance. The final subsection discusses other extensions that can be demonstrated in passing.

## 6.1 Multiple Informed Traders

This section considers an extension allowing for expert competition. In particular, assume now that there is an additional state of nature in which $N \geq 4$ informed outsiders exist with probability $\psi > 0$. As shown below, $N \geq 4$ is sufficient to ensure that each outside experts acts competitively, as a price-taker, in the state of nature where multiple experts exist.[15] The overall distribution of informed outsiders, $n$, is:

$$n = \begin{cases} N & \text{w.p. } \psi \\ 1 & \text{w.p. } (1-\psi)\,a \\ 0 & \text{w.p. } (1-\psi)\,(1-a) \end{cases} .$$

The previous analysis with one expert now emerges as a special case of $\psi = 0$. Anticipating, the baseline model conditions for the dominance of markets over mechanisms, (17) and (22), remain robust to the possibility of multiple informed experts.

### 6.1.1 Market Reliance: Multiple Experts

To demonstrate the preceding claim, consider first market reliance. As shown in the Online Appendix, for each $K$, there readily exists an equilibrium identical in form to the one described in the baseline model in the sense that the uninformed are inactive while type-1 (type-0) informed traders sell (buy) shares using the same density as in the baseline model. Intuitively, each informed trader will find it optimal to behave just as in the baseline model since the exogenous arrival of other experts reduces profit to zero regardless of their strategy. Further, in equilibrium, the firm and market maker respond to the sole non-revealing order vector featuring a single sell ($\vec{t}$) just as in the baseline model. Intuitively, the Bayesian belief arising from vector $\vec{t}$ is left unaffected by the the existence of a multiple-expert state, since in this state there will be many sell/buy orders.

The important effect arising from the multiple expert state is that $n = N$ sell orders fully reveals the economic state. This increases firm value. Suppose first $K < \overline{K}$. Recall, in the baseline model, the firm's payoff is as if the firm would only switch to the safe investment in response to two sell orders. With multiple experts, the firm now makes the switch to the safe investment in two cases: if a single type-0 expert exists and a liquidity shock reveals them (as in the baseline model) or multiple type-0 experts exist. Starting from equation (21) and making the upward adjustment to cash flow and downward adjustment to adverse selection costs, the implied firm value is:

$$V_R = (1-q) + q[a\,(1-\psi)\,l + \psi]\,(1-c) - aqm^*(1-q)\,(1-\psi)\,. \tag{24}$$

The second term in the preceding equation accounts for the new probability of the firm correctly switching to the safe investment, while the final term scales down adverse selection costs by the factor $\psi$ since expert profits go to zero if multiple experts exist.

[15]The results also follow with $N = 3$ but then a deviating expert can influence the price complicating the exposition. For $N = 2$, the mechanism does not eliminate the adverse selection costs, severely limiting the value of mechanism reliance.

The first best value of the firm with multiple experts, call it $V^{**}$, differs from equation (1) in the baseline model, since the probability of information changes. Again, the firm implements what is optimal in each economic state if information exists, and instead always implements the risky investment if information does not exist. We thus have:

$$V^{**} = [\psi + a(1-\psi)][(1-q)1 + q(1-c)] + (1-\psi)(1-a)(1-q) \tag{25}$$
$$= 1 - q + [\psi + a(1-\psi)]q(1-c).$$

Combining the two preceding equations we find that

$$K < \overline{K} \Rightarrow V_{MKT} = V_R = V^{**} - aq(1-l)[(1-c) + m^*(1-q)](1-\psi). \tag{26}$$

Comparing the preceding equation with equation (21) from the baseline model, we see that the wedge between firm value under market-reliance and first-best scales down by the factor $\psi$.

Consider next $K \geq \overline{K}$. Recall, here the firm is on a hair trigger and will switch the safe investment in response to the arrival of any single sell order. This implies that the firm only incorrectly switches when no informed trader exists but a liquidity shock occurs. This now occurs with a lower probability $l(1-a)(1-\psi)$. Thus, here there is only a small modification to the firm value equation (16) from the baseline model:

$$K \geq \overline{K} \Rightarrow V_{MKT} = V_{NR} = V^{**} - l(1-a)(c-q)(1-\psi). \tag{27}$$

Comparing the preceding equation with equation (16) we see that, once again, the possibility of multiple experts scales down the wedge between firm value under market-reliance with first-best by the factor $\psi$.

### 6.1.2 Mechanism Reliance: Multiple Informed Traders

For mechanism reliance, we conjecture an equilibrium in which the firm will offer the mechanism described in Proposition 3.1, but with a new (lower) endogenous reservation value $\underline{u}$ derived below. The firm is posited to follow its advisor, if one is hired, with the market maker setting price based upon order flow. The mechanism is offered to each outside investor sequentially, and each outsider is posited to play a pure strategy, accepting if informed and rejecting if not.[16] If there are multiple experts, the $N-1$ experts who have not signed the mechanism are posited to buy (sell) 1 share on good (bad) news. The uninformed are posited to remain passive. This gives rise to three additional on-path order vectors, $N-1$ and $N$ sell orders, and $N-1$ buy orders with and without a liquidity sell order. Multiple buy (sell) orders reveal state 1 (0), in which case the market maker sets a price of 1 $(1-c)$. The market maker responds to all other order vector types, on and off path, as in the baseline model.

With the preceding in mind, consider trading incentives. In the state of nature with multiple

[16]Mixed strategy equilibria may also exist.

experts, the first expert offered the mechanism accepts it, which reveals to the remaining experts that they face competition from other experts. None of these $N-1 \geq 3$ experts has incentive to deviate from the posited equilibrium since the trades of the remaining $N-2 \geq 2$ experts always push price to fundamental value. Further, no uninformed outsider has incentive to trade since they break even if multiple experts exist, while, being uninformed, they stand to make an expected loss by moving price with positive probability in those states of nature where multiple experts do not exist.

Consider finally an expert who is offered the mechanism but deviates by not accepting. An expert trader who deviates and does not take up the mechanism earns profit from trading if: the state is bad, no liquidity shock occurs, *and* he is the only expert. Using Bayes' law to compute the conditional probability of being the sole expert, we see that the expected profit from deviating is lower than in the baseline model, with

$$\underline{u} = \frac{(1-\psi)\,a}{\psi + (1-\psi)\,a} \times q\,(1-l)\,(1-q)\,. \tag{28}$$

Recall, the mechanism is feasible if and only if $\underline{u} \leq qB$, which now requires

$$B \geq \frac{(1-\psi)\,a}{\psi + (1-\psi)\,a} l\,(1-q)\,. \tag{29}$$

Notice, with $\psi > 0$ the mechanism is feasible for lower bonding capabilities $B$, since potential competition from other experts reduces the expected gain to deviating.

Consider now the mechanism reliant firm value. The firm follows the advisor and makes the first-best expected cash flow $V^{**}$, while paying $\underline{u}$ in expected wages whenever an informed outsider exists. Thus:

$$\begin{aligned} V_{DRM} &= V^{**} - [\psi + (1-\psi)\,a]\underline{u}. \\ &= V^{**} - aq\,(1-q)\,(1-l)\,(1-\psi) \end{aligned} \tag{30}$$

Comparing the preceding equation with equation (6) from the baseline model, we see that the possibility of multiple experts scales down the value loss relative first-best by the factor $\psi$, just as it did for the market-reliant firm. Here, the threat of competition from other experts reduces the expected trading gain from deviating and rejecting the mechanism, resulting in lower expected expert wages.

### 6.1.3 Markets versus Mechanisms: Multiple Informed Traders

Recall, in the preceding two subsections it was shown that the possibility of multiple experts causes the wedge between first-best value and firm value under either markets or the mechanism to scale down by the factor $\psi$–the probability of multiple experts. It follows from this fact that the parametric conditions for market dominance over mechanisms (if feasible) remain unchanged from the baseline setting. The following proposition summarizes this important result.

**Proposition 6.1** *If multiple informed outsiders exist with probability $\psi$ and a single informed outsider exists with probability $a(1-\psi)$, mechanism-reliance is feasible if and only if*

$$B \geq \frac{(1-\psi)\,a}{\psi + (1-\psi)\,a} l\,(1-q)\,.$$

*If this inequality is satisfied, the parametric conditions for market-reliance to dominate mechanism-reliance remain as in the baseline model.*

The intuition for this result is as follows. In terms of expected cash flow, both the mechanism and the market benefit from the possibility of multiple experts. After all, the mechanism will naturally implement the optimal state-contingent investment policy if multiple experts exist, but so too will the market since trading by multiple experts reveals the state. Consider next the costs of information. The expected wage bill under the mechanism will fall by the factor $\psi$ since the gain to an expert deviating and rejecting a posted mechanism falls to zero in the event of multiple experts existing/trading. However, expected adverse selection costs under the market will also scale down by the factor $\psi$ since trading by multiple experts reveals the state.

### 6.2 Search Friction Extension

This subsection assumes the firm has the ability to introduce a search friction limiting the expert's ability to observe the posted mechanism. In particular, the firm can choose the probability $\pi \in [0,1]$ that the contract will be observed by the expert if he exists, with the firm's choice being common knowledge.[17] For example, by advertising the mechanism less widely or for less time, the firm can reduce the probability the expert will see it. Notice, this technology subsumes the market-reliant and mechanism-reliant firm as special cases in which, respectively, $\pi = 0$ and $\pi = 1$. Thus, we refer to $\pi = 0$ and $\pi = 1$ as "pure market-reliance" and "pure mechanism-reliance," respectively. With this in mind, this subsection demonstrates the following important result: *pure mechanism-reliance is never optimal but pure market-reliance is sometimes optimal.*

The search friction results in only small modifications of the baseline model. First, a posted mechanism can be left sitting for one of two reasons: either the expert does not exist or the expert exists but did not observe the offer. Therefore, the conditional probability of the expert's existence, given that the posted mechanism has not been accepted is

$$\widehat{a}(\pi) = \left[\frac{1-\pi}{a(1-\pi)+(1-a)}\right] a. \tag{31}$$

[17]The model in this section is formally equivalent to the setting of the preceding sections, except that the expert mixes, accepting with probability $\pi \in (0,1)$.

With this in mind, let

$$K_\pi \equiv \frac{\widehat{a}(\pi)q}{1-\widehat{a}(\pi)}\frac{1-l}{l} = K(1-\pi). \tag{32}$$

Notice, $K_\pi$ replaces $a$ with $\widehat{a}$ in the original informativeness measure $K$. It is readily verifed that for each given value of $\pi \in [0,1)$, if the posted mechanism has not been accepted, the continuation-game equilibrium is identical to the one characterized under pure market-reliance, but now with $K_\pi$ replacing the original informativeness measure $K$.[18]

To demonstrate that $\pi = 1$ cannot be optimal, consider $\pi$ sufficiently close to 1 such that $K_\pi < \underline{K}$. In this case, the securities market equilibrium would be the low informativeness case, characterized in Proposition 5.2, with $K_\pi$ replacing $K$. The type-0 expert's expected trading profit is

$$u_0^*(\pi) = m_L(K_\pi)(1-q)(1-l), \tag{33}$$

where Proposition 5.2 defines $m_L(\cdot)$. Thus, if the expert exists but fails to observe the mechanism, his expected trading profit is $qu_0^*(\pi)$. But note, exactly the same expected trading profit is available to the expert if he deviates by failing to take up the mechanism despite observing it. Thus, in the case being considered, the expert's reservation value for participating in the mechanism is

$$\underline{u}(\pi) = qu_0^*(\pi) = m_L(K_\pi)q(1-q)(1-l). \tag{34}$$

Consider next expected cash flow, recalling that implementing the risky investment with probability 1 generates $1-q$ in expectation. Given low market informativeness, the firm will deviate from the risky strategy in only two instances. First, if the expert exists and sees the posted mechanism, the firm will switch to the safe strategy if $\omega = 0$. Second, if the expert exists, but does not see the posted mechanism, the firm will switch to the safe strategy if $\omega = 0$ and a revealing liquidity shock hits. In both cases, the firm captures a cash flow increase of $1-c$ relative to a firm that implements the risky strategy with probability one.

From the preceding discussion it follows that we have the following firm valuation result:

$$K_\pi < \underline{K} \Rightarrow V(\pi) = (1-q) + qa[\pi + (1-\pi)l](1-c) - am_L(K_\pi)q(1-q)(1-l). \tag{35}$$

The preceding expression reveals a fundamental tradeoff. An increase in $\pi$ (mechanism reliance) results in an increase in the probability that the firm selects the correct investment in the bad state, reflected in the second term. However, increasing $\pi$ reduces price impact (since $K_\pi$ is decreasing in $\pi$), making informed trading more profitable. This effect simultaneously increases the expected wage bill if the mechanism offer is observed (and thus accepted) and the expected adverse selection cost borne by shareholders if it is not observed.

[18]If $\pi = 1$ this continuation-game is never reached on-path.

Differentiating we obtain

$$K_\pi < \underline{K} \Rightarrow V'(\pi) = qa(1-l)(1-c)\left[1 - JK\left(\frac{K(1-\pi)+1}{\sqrt{[K(1-\pi)+1]^2-1}} - 1\right)\right]. \tag{36}$$

It is readily verified that $V'$ tends to $-\infty$ as $\pi \uparrow 1$. Thus, $\pi = 1$ cannot be optimal. In fact, the following proposition, proved in the Online Appendix, characterizes optimal $\pi$ in detail.

**Proposition 6.2** *If $K \leq \underline{K}$, pure market reliance is optimal ($\pi^* = 0$) if switching difficulty is sufficently high such that*

$$\frac{1}{J} \leq K\left(\frac{K+1}{\sqrt{(K+1)^2-1}} - 1\right).$$

*Otherwise, an interior optimum $\pi^*$ obtains which is continuously decreasing in the switching difficulty $J$. If $K \in (\underline{K}, \overline{K})$, then pure market reliance ($\pi^* = 0$) is optimal if $K \in ((J^2-1)/2J, \overline{K})$. Otherwise $\pi^* = 1 - \underline{K}/K$. If $K \geq \overline{K}$, then pure market reliance is optimal ($\pi^* = 0$).*

### 6.3 Alternative Assumptions

**Weakening Market Maker Inference.** One may be concerned that the "markets may dominate mechanisms" result is due to the fact that the market maker believes he knows with complete certainty the expert does not exist if a mechanism is posted and not taken. With this in mind, consider again the preceding subsection but suppose feasible $\pi \in [0, 1-\varepsilon]$, with $\varepsilon$ arbitrarily small. For example, with probability $\varepsilon$ the expert might: "tremble"; have an intrinsic preference to trade; miss the posted mechanism due to limited attention; or be banned from activities other than trading. In such an economy, the market maker could never reject the possibility of expert trading. Nevertheless, the analysis of the preceding subsection informs us that maximum feasible mechanism reliance ($\pi = 1 - \varepsilon$) cannot be optimal, but maximum feasible market reliance ($\pi = 0$) can be optimal (see Proposition 6.2).

**Alternative Real Technology.** Equations (17) and (22) illustrate the central tradeoff captured by our framework. On one hand, if feasible, reliance on a mechanism will allow the firm to implement more efficient real decisions. On the other hand, the mechanism is more costly due to endogenous changes in the expert's reservation value resulting from the posting of a mechanism. As a general matter, either force can be strengthened/weakened depending on assumed parameter values. This is best illustrated by considering alternative real technologies, as captured by the switching cost parameter $c$.

Recall, it was assumed $c \in (q, 1)$. But note, in the limit as $c$ approaches 1 from below, the variable $J$ goes to infinity. Here Proposition 5.5 informs us that the market necessarily dominates the mechanism. Intuitively, with $c$ approaching 1, the efficiency channel supporting the mechanism becomes unimportant, since the incremental cash flow generated by switching in the bad state becomes negligible.

Conversely, suppose $c < q$. In this case, the mechanism would necessarily dominate because the expert would be unable to make any trading gains whether or not a mechanism is posted. To see this, suppose the firm is watching the market for information–either because it posted a mechanism that was left sitting, or because a mechanism was never posted. With $c < q$, the expert cannot make a trading gain selling based upon negative information because the firm would implement the riskless investment even if no sell order arrived. Further, the expert cannot make a trading gain buying based upon positive information because his buy orders have no cover under the posited noise-trading setup.

Notice however that if we were to flip the model's microstructure to feature noise-buying, rather than noise-selling, the posited tradeoff between operational efficiency and endogenous reservation values would re-emerge with $c < q$. Under such a flipped microstructure, the mechanism would allow the firm to switch from the status quo to the *risky* investment more efficiently. On the other hand, the expert would enjoy higher expected trading gains on his buy orders if a mechanism was posted–since the market maker would attribute the arrival of any single buy order to noise, regardless of its size. That is, once again, mechanism posting would reduce/eliminate price impact, raising mechanism implementation costs.

**Firm Objectives.** It has been assumed the firm maximizes ex ante share value, and thus, accounts for the adverse selection discount that will be priced in. An alternative assumption is that the firm does not account for the adverse selection discount. The case for market-reliance would only be strengthened if the firm disregarded adverse selection costs since the market-reliant firm value incorporates such costs while the mechanism-reliant firm value instead incorporates the expert board member wage bill.

**Exclusivity.** For realism, we adopted the assumption that an agent who agrees to participate in the mechanism is prohibited from trading in the firm's securities (exclusivity). However, it is readily apparent that the firm cannot improve upon the DRM by posting a mechanism that does not impose exclusivity. To see this, note that the firm makes first-best production decisions under the DRM, so any alternative incentive scheme cannot increase expected cash flow. Next note that, the sum of the expert's expected wages and trading gains must not fall below his reservation value $\underline{u}$ (equation 4), which is the cost of information (expected wage bill) under the DRM with exclusivity imposed. Finally, it would be impossible to shift wages into trading gains by violating exclusivity. After all, when/if the mechanism contract was signed, the market-maker would know an expert exists and anticipates the expert will trade. Thus, any sell order would be attributed to the expert, as would any buy order.

**Timing.** One might also wonder whether the mechanism could be improved upon by posting it after the economic state $\omega$ is revealed. It is readily verified that such a scheme cannot improve upon pure market-reliance. To see this, note that no mechanism could screen for the type-0 expert. After all, the type-0 expert would have a positive reservation value. But offering a contract that delivers a positive wage if the agent recommends the safe investment would induce uninformed outsiders to accept that contract. Further, any mechanism screening for the type-1 expert replicates the payoffs of the market-reliant firm. In the good state, the market reliant firm implements the risky investment and the expert receives zero rent since buy orders are fully revealing. Similarly, the mechanism-reliant firm would pay the expert zero in return for his recommending the risky strategy.

## 7 Concluding Remarks

When awarding the Nobel Prize in Economic Sciences, the Royal Swedish Academy generally makes efforts to highlight real-world applications to which a given contribution has been put, or to highlight the successes of a given framework in helping to better understand empirical regularities or existing institutional arrangements. The 2007 Prize, given for mechanism design theory, was notable in that here the Academy went to some effort to explain that the theory is not intended to be positive: "While direct mechanisms are not intended as descriptions of real-world institutions, their mathematical structure makes them relatively easy to analyze." In a similar vein, in his Nobel lecture, Eric Maskin (2008) positioned mechanism design theory primarily as a normative theory:

> The theory of mechanism design can be thought of as the "engineering" side of economic theory. Much theoretical work, of course, focuses on *existing*[his italics] economic institutions. The theorist wants to explain or forecast the economic or social outcomes that these institutions generate. But in mechanism design theory, the direction of inquiry is reversed. We begin by identifying our desired outcome or social goal. We then ask whether an appropriate institution (mechanism) could be designed to attain that goal.

In this paper we showed how the existence of securities markets may impose limits on the usage of mechanisms. After all, posting a DRM meeting an informed agent's participation constraint generates a high endogenous reservation value since rejecting said DRM (deviating) convinces markets no informed agent exists, allowing aggressive informed trading sans price impact. The DRM-reliant firm must pay expected wages equal to this high outside option value, implying high costs of information. For the market-reliant firm, information acquisition costs (paid via uninformed shareholder trading losses) are necessarily lower, since price impact naturally limits informed trading gains when agents know informed parties have been left outside firm boundaries, and left free to trade. However, this reduction in information acquisition costs must be weighed against the concomitant reduction in information quality associated with reliance on noisy securities prices.

In our framework the firm considers two alternative sources of information: the mechanism and the market. One might expect similar results to apply in other mechanism design settings where a market provides an alternative source of information. Regardless, the use of securities prices and hired advisor's for information is ubiquitous, and so a theory of markets versus mechanisms in this setting is an important step forward.

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**ONLINE APPENDIX MATERIAL**

# A Proofs: Sections 3-5

This appendix gives concise proofs of the propositions in the paper. For a more detailed, step by step derivation of all results, please see Boleslavsky, Hennessy, and Kelly (2020).

## A.1 Optimality of Uninformed Passivity: Mechanism-Reliance

Consider a unilateral deviation by an uninformed outsider, given the mechanism has been left sitting. If he places a buy order, he creates two possible order vector possibilities, both off-path: one buy order in isolation or one buy order and one sell order. The uninformed outsider placing a buy order would make an expected loss since the market maker infers $\omega = 1$ and sets $p = 1$ whereas the fundamental value is only $1 - q$. If an uninformed outsider instead places a sell order, he creates two possible order vector possibilities, one sell order or two sell orders, the former being on-path and the latter off-path (since the mechanism is left sitting and the expert does not exist). In the former case, the firm will implement the risky investment and the market maker sets price at $p = 1 - q$. In the latter case, the firm implements the safe investment and the market maker sets $p = 1 - c$. In both cases, the price equals expected cash flow, resulting in zero profits.

## A.2 Optimality of Uninformed Passivity: Market-Reliance

The uninformed investor confronts six possible combinations of: type-0 expert, type-1 expert, no expert, and liquidity shock/not. With these scenarios in mind, consider first an uninformed outsider submitting a buy order. If the expert does not exist, the firm will implement the risky investment in response to the buy order, and price will be set to 1, but expected cash flow is only $1 - q$, implying an expected loss of $q$. If the type-1 expert exists, the two buy orders will push price to the fundamental 1, resulting in zero profits. However, if the type-0 expert exists, the price will be set to 1 and the risky investment implemented absent a fully revealing liquidity shock, resulting in an uninformed loss of 1. Hence submitting a buy order results in an expected loss.

Consider next an uninformed outsider submitting a sell order. If a liquidity shock occurs or a type-0 expert exists, there will be at least two sell orders, the firm will switch to safe, and there is zero profit. If no liquidity shock arrives, and the type-1 expert exists, the combination of a buy and a sell will induce the firm to select the risky investment and the price will be set at fundamental, $p = 1$, resulting in zero profit. Finally, absent either a liquidity shock or expert existence, there will be the single uninformed sell order. If the firm switches to the safe investment, there will be zero profit. If the firm implements the risky investment, a loss results since the updated belief $\chi(\vec{t}) \geq q$ implies price $p = 1 - \chi(\vec{t})$ is less than expected cash flow $1 - q$. Hence, a sell order results in an expected loss.

### A.3 Construction of High Market Informativeness Equilibrium

The construction of the posited zero-rent equilibrium proceeds as follows. If $u_0^* = 0$, then each sell order $t$ must generate zero expected profit, otherwise the type-0 expert would have a profitable deviation. Equation (9) then implies that for all $t > 0$, $\chi(\vec{t}) = 1$ and/or $\alpha(\vec{t}) = 1$, so that price equals fundamental value. But note, from the firm sequential rationality condition (7) it follows that $\chi(\vec{t}) = 1$ implies $\alpha(\vec{t}) = 1$. Therefore, in any no-rent equilibrium, the posterior must be sufficiently negative to justify switching to the safe investment for any $t \in (0, 1]$:

$$c \leq \frac{K\phi_0(t) + q}{K\phi_0(t) + 1}. \tag{37}$$

This implies that for all $t \in (0, 1]$, the type-0 expert's trading density must satisfy:

$$\phi_0(t) \geq \frac{J-1}{K}. \tag{38}$$

Since the trading density must integrate to 1 on the unit interval, a no-rent equilibrium cannot be sustained if $K < J - 1$. Conversely, if $K \geq \overline{K} = J - 1$, many feasible mixing densities exist which satisfy the preceding equation. That is, a multiplicity of payoff equivalent equilibria exist if $K \geq \overline{K}$.

### A.4 Construction of Low Market Informativeness Equilibrium

Consider an equilibrium in which $\alpha(\vec{t}) = 0$ for all $t \in (0, 1]$. In this case, the type-0 expert's indifference condition is that for all $t \in [m, 1]$,

$$m(1-q)(1-l) = t[1 - \chi(\vec{t})](1-l). \tag{39}$$

Substituting the market maker belief (14) into the preceding indifference condition we find that

$$m(1-q)(1-l) = t\left[1 - \frac{K\phi_0(t) + q}{K\phi_0(t) + 1}\right](1-l) \Rightarrow \phi_0(t) = \frac{t-m}{Km}. \tag{40}$$

Thus, in the posited equilibrium, the type-0 expert outsider exploits his private information by using a mixing density that increases linearly in the trade size $t$. To determine the minimum sell order $m$, note that $\phi_0(t)$ must integrate to 1. We have:

$$\int_m^1 \frac{t-m}{Km} dt = 1 \Rightarrow m = K + 1 - \sqrt{(K+1)^2 - 1}. \tag{41}$$

Finally, since the market maker belief (14) is increasing in $\phi_0$ which is itself increasing in $t$, we must verify that, as posited, the firm will find it optimal not to switch even if $t = 1$, which demands belief $\chi(1) \leq c$. The preceding inequality holds only if $m \geq 1/J$, which itself holds only if $K \leq \underline{K}$, where

$$\underline{K} \equiv \frac{(J-1)^2}{2J}. \tag{42}$$

## A.5 Construction of Intermediate Market Informativeness Equilibrium

With $\alpha(\vec{t}) = 0$ on the interval $[m, t']$, the type-0 expert's trading density can once again be derived from equation (40), with $\phi_0 = (t-m)/Km$. At $t' = Jm$, $\chi(t') = c$ and further increases in $t'$ would be inconsistent with $\alpha(t') = 0$. Therefore, on the interval $(t', 1]$, the firm must mix between the safe and risky investments. In order for this mixing to be sequentially rational, it must be that $\chi(\vec{t}) = c$ on this interval. Combining this fact with (14) and (18), we conclude that

$$\text{for } t \in (Jm, 1], \quad m(1-q)(1-l) = t(1-c)\left[1-\alpha(\vec{t})\right](1-l), \quad \text{and} \quad \frac{K\phi_0(t)+q}{K\phi_0(t)+1} = c. \tag{43}$$

From the preceding equation it follows that

$$\text{for } t \in (Jm, 1], \quad \alpha(\vec{t}) = 1 - \frac{Jm}{t}, \quad \text{and} \quad \phi_0(t) = \frac{J-1}{K}. \tag{44}$$

Notice, since beliefs and prices are constant on this interval, the probability of the firm switching to the safe investment must increase in the size of the sell order to just offset the type-0 expert's temptation to submit larger orders. Once again, the fact that the expert's trading density $\phi_0(t)$ must integrate to 1 allows us to pin down the minimum sell order size:

$$\int_m^{Jm} \frac{t-m}{Km} dt + (1-Jm)(J-1)/K = 1 \Rightarrow m = \frac{2(J-K-1)}{J^2-1}. \tag{45}$$

Finally, based on the preceding equation we can verify the conjectured equilibrium is internally consistent. First, in order for the type-0 expert to make a rent, it must be the case that $m > 0$, which holds if and only if $K < J-1 \equiv \overline{K}$. Second, in order for the firm's mixed investment interval to be nondegenerate, it must be the case that $Jm < 1$, which holds if and only if $K > \underline{K}$ as defined above.

## A.6 Expected Cash Flow: Intermediate Market Informativeness

We provide a calculation for the ex ante expected cash flow in the case of intermediate market informativeness. Conditional on order vector $T$, the firm's expected cash flow is

$$(1-\chi(T))(1-\alpha(T)) + \alpha(T)(1-c) = 1 - \chi(T) + \alpha(T)(\chi(T)-c).$$

Hence, expected cash flow is given by:

$$E[1-\chi(T)] + E[\alpha(T)(\chi(T)-c)],$$

where the expectation is taken with respect to the distribution of the equilibrium order flow vector. Because $1-\chi(T)$ is the probability of economic state one conditional on order vector $T$, the Law of Iterated Expectations implies that $E[1-\chi(T)] = 1-q$. Next note that $\alpha(T) = 0$ if a buy order arrives or the market is inactive, and hence, in these cases $\alpha(T)(\chi(T)-c) = 0$. If instead a single sell order arrives, the firm either selects risky, $\alpha(T) = 0$, or it mixes, $\alpha(T) \in (0,1)$. In the latter case, sequential rationality requires $\chi(T) = c$. Thus, whenever a single sell order arrives, $\alpha(T)(\chi(T)-c) = 0$. Finally, under the remaining order flow configuration with two sell orders, $\chi(T) = 1$ and $\alpha(T) = 1$, and hence, $\alpha(T)(\chi(T)-c) = 1-c$. Therefore,

$$E[\alpha(T)(\chi(T)-c)] = aql(1-c).$$

## B Proof Proposition 6.2 Optimal Search Friction

We prove the claims in Proposition 6.2 as a series of lemmas. We begin with the derivative of firm value given low informativeness with respect to $\pi$, equation (36), which determines the level of $\pi$ which maximizes firm value.

$$K_\pi < \underline{K} \Rightarrow V'(\pi) = qa(1-l)(1-c)\left[1 - JK\left(\frac{K(1-\pi)+1}{\sqrt{[K(1-\pi)+1]^2-1}} - 1\right)\right]. \tag{46}$$

It is readily verified that $V'' < 0$ on this interval and that $V'$ tends to $-\infty$ as $\pi \uparrow 1$ on this interval. It follows that an interior solution results if $V'(0) > 0$, otherwise $\pi = 0$ is optimal:

**Lemma B.1** *If $K \leq \underline{K}$, pure market reliance is optimal ($\pi^* = 0$) if switching difficulty is sufficently high such that*

$$\frac{1}{J} \leq K\left(\frac{K+1}{\sqrt{(K+1)^2-1}} - 1\right).$$

*Otherwise, an interior optimum $\pi^*$ obtains which is continuously decreasing in the switching difficulty $J$.*

Consider next optimal $\pi$ if $K \in (\underline{K}, \overline{K})$. To begin, note that for any $K_\pi \in (\underline{K}, \overline{K})$, the intermediate informativeness market equilibrium would obtain resulting in the same firm value expression as in equation (35), but with $m_I$ replacing $m_L$ just as in the baseline model:

$$K_\pi \in (\underline{K}, \overline{K}) \Rightarrow V(\pi) = (1-q) + qa[\pi + (1-\pi)l](1-c) - am_I(K_\pi)q(1-q)(1-l).$$

Since $m_I < m_L$ it is apparent that if $K \in (\underline{K}, \overline{K})$, the firm would never want to choose $K_\pi \leq \underline{K}$, pushing the valuation into low informativeness territory. Further, we find that:

$$K_\pi \in (\underline{K}, \overline{K}) \Rightarrow V'(\pi) = qa(1-l)(1-c)\left[1 - \frac{2JK}{J^2-1}\right].$$

From the preceding equation we have the following lemma.

**Lemma B.2** *If $K \in (\underline{K}, \overline{K})$, then pure market reliance ($\pi^* = 0$) is optimal if $K \in ((J^2-1)/2J, \overline{K})$. Otherwise $\pi^* = 1 - \underline{K}/K$.*

Consider finally $K \geq \overline{K}$. If such a firm chooses any $K_\pi \geq \overline{K}$ then the zero rent market equilibrium would obtain, implying a reservation value of zero for the expert participating in the mechanism. Moreover, so long as the expert existed, the firm would choose the optimal strategy in each economic state. But as in the zero rent equilibrium in the baseline model, the firm would act suboptimally by switching to the safe investment if the expert did not exist but a liquidity shock were to hit. The implied firm value is then exactly as in the baseline model. That is:

$$K_\pi \geq \overline{K} \Rightarrow V(\pi) = V_{NR} = V^* - l(1-a)(c-q). \tag{47}$$

It is readily verified the preceding value is higher than what the firm could obtain if it pushed $\pi$ high enough to switch to the intermediate informativeness valuation, which is higher than the low informativeness valuation. We thus have the following lemma.

**Lemma B.3** *If $K \geq \overline{K}$ then pure market reliance is optimal ($\pi^* = 0$).*

The preceding lemmas together prove Proposition 6.2.

# C Formal Derivation of the DRM

This section derives the direct revelation mechanism (DRM) from first principles, when the reservation value is exogenous. Such a derivation is needed because the firm has only limited commitment power. In particular, the requirement that the firm allocates the mechanism to the first willing agent and the firm's fiduciary responsibility to act optimally on its information (sequential rationality) both limit commitment power. In spite of the limited commitment, we show that given a sufficient bonding capability $B$, the firm can devise a mechanism in which the firm selects the first-best investment, while reducing the expert outsider's payoff to his reservation value.

The analysis in this section proceeds as follows. We first derive a set of constraints that are *necessary* for a mechanism to achieve higher ex ante firm value than can be achieved under market-reliance. We next characterize conditions under which it is feasible to satisfy these necessary conditions, and then solve for the optimal mechanism(s) among those satisfying the necessary conditions.

Let $\underline{u}$ represent the expert's continuation payoff from rejecting the posted mechanism. In this section, we treat $\underline{u}$ as exogenous and assume that $\underline{u} > qu_0^*$. Note that an uninformed outsider's continuation payoff from rejecting the firm's mechanism offer is zero, since an uninformed outsider has no private information or market power.

Recall, fiduciary duty requires that the firm's behavior is sequentially rational. Since the firm cannot commit to future actions, the Revelation Principle does not apply directly. However, we establish an analogous result in Lemmas C.1 and C.3. Some formalities are first necessary. To this end, let $\chi_r$ be the firm's belief that the state is $\omega = 0$ following report $r \in \{0, 1\}$. As a normalization, let us label the reports so that $\chi_1 \leq q \leq \chi_0$.[19] Let $\rho_r$ be the probability that the firm selects the risky investment following report $r$. Let $x \in \{0, 1\}$ denote the expert's participation decision, where $x = 1$ represents the decision to participate.[20] Let $\gamma_\omega$ be the probability that the advisor sends report $r = 1$ in economic state $\omega$. Finally, let $d$ be the probability that each uninformed outsider agrees to participate in the mechanism.

Any mechanism that outperforms market-reliance must have certain properties. First, any such mechanism must be rejected by the uninformed outsiders and accepted by the expert outsider if he exists. After all, the uninformed outsiders are countably infinite, and the mechanism is assigned to the first willing agent. Thus, a mechanism that does not screen out the uninformed will almost surely be accepted by an uninformed outsider, and hence, cannot deliver useful information about the economic state. The firm would therefore watch the market for information, and both the firm and the market maker anticipate that the expert will be active in the market if he exists. Thus, offering a mechanism that fails to screen out incompetents cannot do better than market-reliance. Following the same logic, any mechanism that fails to induce participation by the expert also cannot do better than market-reliance. We have the following lemma.

**Lemma C.1** *(Screening). If a mechanism delivers higher ex ante firm value than market-reliance, then it must screen out uninformed agents and induce participation by the expert if he exists, $d = 0$ and $x = 1$.*

Second, any mechanism that achieves higher ex ante firm value than market-reliance has the property that it grants the expert real authority in the sense that $\rho_1 = 1$ and $\rho_0 = 0$. That is, in equilibrium the firm will follow the "recommendation" of its agent, implementing the risky investment with probability 1 (0) in response to report $r = 1$ ($r = 0$). To see why this must be the case, recall first that report-contingent beliefs are such that $\chi_1 \leq q \leq \chi_0$. Sequential rationality therefore demands $\rho_1 = 1$. Consider next why any mechanism that is value-increasing relative to market-reliance must satisfy $\rho_0 = 0$. To begin, note that any mechanism that induces participation by the expert, as is necessary, features an expected wage bill no less than $a\underline{u} > aqu_0^*$. This exceeds the adverse selection cost under market-reliance. Therefore, any value-increasing mechanism must

[19] The Law of Iterated Expectations requires $\Pr(r = 0)\chi_0 + \Pr(r = 1)\chi_1 = \Pr(\omega = 0) = q$. Therefore one posterior belief must be weakly smaller than the prior and the other weakly larger.

[20] For brevity, we abstract from mixing by the expert in his participation decision in this section. Section 6.2 considers an extension that is formally equivalent to a setting in which the expert mixes in the participation decision.

lead to a strict increase in expected cash flow relative to market-reliance. With this in mind consider expected cash flow under a mechanism featuring $\rho_0 \in (0,1]$. If $\rho_0 = 1$, the firm always implements the risky investment, and expected cash flow is $1-q$, which is less than the expected cash flow under market-reliance.[21] If instead $\rho_0 \in (0,1)$, sequential rationality requires the firm to be indifferent between $S$ and $R$ following $r = 0$. But note, mixing implies expected cash flow is the same as if the firm were to always choose the risky investment. To see this formally, note that the firm is willing to mix only if $\chi_0 = c$, and hence:

$$\begin{aligned} E[\varphi] &= \Pr(r=0)[\rho_0(1-\chi_0) + (1-\rho_0)(1-c)] + \Pr(r=1)(1-\chi_1) \\ &= \Pr(r=0)[\rho_0(1-\chi_0) + (1-\rho_0)(1-\chi_0)] + \Pr(r=1)(1-\chi_1) \\ &= \Pr(r=0)(1-\chi_0) + \Pr(r=1)(1-\chi_1) = 1-q. \end{aligned}$$

The last line above follows from the Law of Iterated Expectations. We thus have the following lemma.

**Lemma C.2** *(Delegated Decision). If a mechanism delivers higher ex ante firm value than market-reliance, then it must delegate the decision to the expert, $\rho_0 = 0$ and $\rho_1 = 1$.*

Third, any mechanism that achieves higher ex ante value than under market reliance induces the expert to report truthfully with probability 1. After all, if it is sequentially rational for the firm to follow the expert's advice, with $\rho_0 = 0$ and $\rho_1 = 1$ (see preceding lemma) then it must be that $\chi_0 \geq c > q \geq \chi_1$. Therefore, it must be that the expert tells the truth with positive probability (i.e. he cannot strictly prefer to lie): $\gamma_1 > 0$ and $\gamma_0 < 1$. These conditions imply two constraints on wages. First, to ensure $\gamma_1 > 0$, it must be that $w_{11} \geq w_{01-c}$. Second, to ensure $\gamma_0 < 1$, it must be that $w_{01-c} \geq w_{10}$. Furthermore, as we show in Appendix D, in any mechanism that delivers a higher payoff than market reliance (consistent with Lemma C.1 and C.2), these two constraints on wages hold with strict inequality, and so the expert strictly prefers to report truthfully.

**Lemma C.3** *(Truthful Reporting). If a mechanism screens out uninformed agents and induces participation by the expert (as in Lemma C.1) and delegates the decision to the expert (as in Lemma C.2), then the expert's unique sequentially rational strategy is to report truthfully with probability 1, $\gamma_0 = 0$ and $\gamma_1 = 1$.*

Lemma C.2 allows us to focus on mechanisms in which the advisor's wage depends only on the firm's terminal cash flow, not on his report. To see this, note that if the advisor reports $r = 1$, the firm implements the risky investment with probability 1 which implies wage $w_{11-c}$ is irrelevant. Similarly, if the advisor reports $r = 0$, the firm implements the safe investment which implies wages $w_{00}$ and $w_{01}$ are irrelevant. We thus need only focus on wages $\{w_{01-c}, w_{11}, w_{10}\}$, which can be written as a function only of the realized cash flow. Therefore, in what follows we drop the first subscript (the report) from the agent's wage.

[21]See equations 16 and 21.

Therefore, Lemmas C.1-C.3, along with the agents' liability constraint, imply that any mechanism delivering higher ex ante firm value than market reliance must satisfy constraints (SC1), (SC2), (PC), and (BOND) from section 3.

Constraint (SC0) ensures that an uninformed outsider prefers to reject the mechanism, rather than accept and report $r = 0$. Similarly, (SC1) rules out an uninformed agent participating and reporting $r = 1$.[22] Constraint (PC) ensures that the expert outsider is willing to participate in the mechanism if he indeed exists, anticipating that he will report the state truthfully; from Lemma C.3 we know that the expert's only sequentially rational strategy is truthful reporting (with probability 1) in any mechanism that delivers a higher payoff than market-reliance. The constraints in (BOND) reflect the expert's limited liability. We refer to the set of constraints as $\mathcal{S}$. Because (SC0), (SC1), and (PC) are imposed by the mechanism's need to screen out uninformed outsiders and screen in the expert, we refer to $\mathcal{S}$ as the *screening constraints.* If the screening constraints are mutually consistent, we say that *screening is feasible*, and we refer to a mechanism that satisfies $\mathcal{S}$ as a *feasible* mechanism.[23]

In order to meet the expert's participation constraint, the firm needs to ensure that a particular linear combination of $w_{1-c}$ and $w_1$ is sufficiently large. However, increasing $w_{1-c}$ makes it more attractive for an uninformed agent to accept and report $\omega = 0$, while increasing $w_1$ makes it more attractive for an uninformed agent to accept and report $\omega = 1$. The temptation for an uninformed agent to report $\omega = 1$ can be offset by reducing $w_0$, thereby generating a punishment for incorrectly reporting that the state is good. However, the firm's ability to punish is restricted by the agent's limited liability, and so screening is not always feasible as shown in the following proposition.

**Proposition C.4** *(Feasible Screening). If the expert's reservation value $\underline{u} > qB$, then screening is infeasible and every mechanism does no better than market-reliance.*

We now find the optimal mechanism assuming liability is large enough that screening is feasible. The firm's objective is to maximize the ex ante value of a share (or equivalently, total firm value) subject to $\mathcal{S}$. In any feasible mechanism, ex ante firm value is

$$(1-a)(1-q) + a[(1-q) + q(1-c)] - a[qw_{1-c} + (1-q)w_1].$$

The first term reflects the fact that if no expert exists, the firm will implement the risky investment, with expected cash flow $1-q$. The second term is the firm's expected cash flow if the expert exists, with Lemmas C.2 and C.3 informing us that any feasible mechanism has the property that the firm selects the correct investment in each economic state if the expert exists. The final term is the expected wage bill.[24]

Summarizing, we have proven Proposition 3.1, which we state formally in Proposition C.5.

[22] (SC0) and (SC1) also ensure that an uninformed agent would rather reject than accept and then report randomly.

[23] Note we define feasibility as existence of a mechanism which potentially delivers ex ante value in excess of market-reliance.

[24] Note that Lemmas C.2 and C.3 imply that the firm always selects the correct action in each state whenever the expert exists.

**Proposition C.5** *(Optimality). If $\underline{u} \leq qB$, then a feasible mechanism is optimal if and only if (PC) holds with equality. In every optimal mechanism, project selection is first best and ex ante firm value is*

$$\begin{aligned} V_{DRM} &= (1-a)(1-q) + a[(1-q) + q(1-c) - \underline{u}] \\ &= 1 - q + aq(1-c) - a\underline{u} \\ &= V^* - a\underline{u}. \qquad (48) \end{aligned}$$

*The following mechanism is feasible and optimal whenever $\underline{u} \leq qB$:*

$$(w_0, w_{1-c}, w_1) = \left(-B, 0, \frac{\underline{u}}{1-q}\right).$$

# D Proofs from Appendix C

**Proof.** (Lemma C.2) (i) $\rho_1 = 1$ follows from $\chi_1 \leq q$ and the firm's sequential rationality, equation (7). (ii). Note that any mechanism that beats remaining unadvised must induce the expert to participate and screen out uninformed agents and has $\rho_1 = 1$. Hence, the expected payoff to the firm in any such mechanism is

$$\begin{aligned} (1-a)(1-q) + &a \Pr(r=0)\{(1-\chi_0)\rho_0 + (1-\rho_0)(1-c))\} + \\ &a \Pr(r=1)(1-\chi_1) - aU, \end{aligned}$$

where $U \geq \underline{u}$ is the expert's expected wage. Suppose $\rho_0 = 1$. Using the Law of Iterated Expectations, the firm's payoff simplifies,

$$\begin{aligned} (1-a)(1-q) + a \Pr(r=0)(1-\chi_0) + a \Pr(r=1)(1-\chi_1) - aU = \\ (1-a)(1-q) + a(1-q) - aU = 1 - q - aU. \end{aligned}$$

Therefore, $\rho_0 = 1$ is inferior to market reliance.

Suppose $\rho_0 \in (0,1)$. Sequential rationality by the firm (7) requires $\chi_0 = c$, and hence, the firm's payoff simplifies to

$$\begin{aligned} (1-a)(1-q) + a \Pr(r=0)\{(1-\chi_0)\rho_0 + (1-\rho_0)(1-\chi_0))\} + a \Pr(r=1)(1-\chi_1) - aU = \\ (1-a)(1-q) + a \Pr(r=0)(1-\chi_0) + a \Pr(r=1)(1-\chi_1) - aU = \\ (1-a)(1-q) + a(1-q) - aU = \\ (1-q) - aU. \end{aligned}$$

Note that the transition from the second to the third line uses the Law of Iterated Expectations. Note that $U \geq \underline{u} > qu_0^*$. Thus, the cost of offering the mechanism $aU$ exceeds the adverse selection cost under market-reliance, $aqu_0^*$. Finally, consider the firm's cash flow under market-reliance. If

$K < \overline{K}$, then equation (20 ) gives the firm's cash flow of $1-q+aql(1-c) > 1-q$. If $K > \overline{K}$, then from equation (16) it is $1-q+l\,(1-c)\,(1-a)\left(K/(1-l)-\overline{K}\right) > 1-q$. Thus, the firm's expected cash flow is larger under market reliance. Simultaneously, the adverse selection cost under market reliance is smaller than the expected wage bill under the mechanism. Therefore, $0 < \rho_0 < 1$, is inferior to market reliance. ■

**Proof.** (Lemma C.3). Claim 1: *If a mechanism delivers the firm a higher expected payoff than market-reliance, then it cannot be the case that* $\gamma_0 = \gamma_1 = 1$. If $\gamma_0 = \gamma_1 = 1$, then $\chi_1 = q$ and any value of $\chi_0$ is consistent with Bayes' rule. Because the expert always reports $r = 1$ in equilibrium, the firm always implements the risky action, and hence expected firm value is $1 - q - aU$, where $U \geq \underline{u}$ is the expert's expected wage. This is smaller than expected firm value under market-reliance, as shown in the proof of Lemma C.2.

Claim 2: *If a mechanism delivers the firm a higher expected payoff than market-reliance, then* $w_{11} \geq w_{01-c}$ *and* $w_{01-c} \geq w_{10}$. From Lemma C.2, $\rho_0 = 0$, and hence, $\chi_0 \geq c$. From Bayes' Rule,

$$\chi_0 = \frac{q(1-\gamma_0)}{q(1-\gamma_0)+(1-q)(1-\gamma_1)}.$$

From Claim 1, $\chi_0$ is well defined. Hence,

$$\chi_0 \geq c \iff q(1-c)\gamma_0 + c - q \leq c(1-q)\gamma_1. \tag{49}$$

First we show $w_{11} \geq w_{01-c}$. Note that

$$\begin{aligned} q(1-c)\gamma_0 + c - q \leq c(1-q)\gamma_1 &\Rightarrow \\ c - q \leq c(1-q)\gamma_1 &\Rightarrow \\ \gamma_1 \geq \frac{c-q}{c(1-q)} &> 0. \end{aligned}$$

Thus, $\gamma_1 > 0$, which implies the expert must report truthfully in state 1 with positive probability. Thus, the expert's expected payoff of reporting truthfully in state 1 must be at least as large as his expected payoff of lying, and hence $w_{11} \geq w_{01-c}$.

Next we show $w_{01-c} \geq w_{10}$. Suppose that $\gamma_0 = 1$. Substituting into (49),

$$q(1-c) + c - q \leq c(1-q)\gamma_1 \Rightarrow \gamma_1 \geq 1.$$

Hence, $\gamma_0 = 1$ implies $\gamma_1 = 1$, contradicting Claim 1. Hence, $\gamma_0 < 1$, which implies that the expert must report truthfully in state 0 with positive probability. Thus, the expert's expected payoff of reporting truthfully in state 0 must be at least as large as his expected payoff of lying, and hence $w_{01-c} \geq w_{10}$.

Claim 3: *If a mechanism delivers the firm a higher expected payoff than market-reliance, then* $w_{11} > w_{01-c}$ *and* $w_{01-c} > w_{10}$. From Lemma C.1, any mechanism which achieves higher value than market reliance screens out uninformed outsiders and requires participation of the expert. These constraints are:

(SC0) $\quad w_{01-c} \leq 0$

(SC1) $\quad qw_{10} + (1-q)w_{11} \leq 0$

(PC) $\quad q[\gamma_0 w_{10} + (1-\gamma_0)w_{01-c}] + (1-q)[\gamma_1 w_{11} + (1-\gamma_1)w_{01-c}] \geq \underline{u}$

Constraint (SC0) ensures that uninformed outsiders prefer to reject the mechanism over accepting and reporting $r = 0$, (SC1) ensures that uninformed outsiders prefer to reject the mechanism over accepting and reporting $r = 1$, and (PC) ensures that an expert prefers to participate (if he exists).

Next, note that Claim 2 ensures $w_{11} \geq w_{01-c}$. Therefore, either $w_{11} > w_{01-c}$ which implies $\gamma_1 = 1$, or $w_{11} = w_{01-c}$. In either case (PC) reduces to:

$$q[\gamma_0 w_{10} + (1-\gamma_0)w_{0,1-c}] + (1-q)w_{11} \geq \underline{u}$$

Analogously, either $\gamma_0 = 1$ or $w_{01-c} = w_{10}$ in which case (PC) reduces further to

(PC′) $$qw_{01-c} + (1-q)w_{11} \geq \underline{u}.$$

Hence:

$$w_{11} \geq \frac{\underline{u}}{1-q} - \frac{q}{1-q}w_{01-c} > 0,$$

where the last inequality follows because $\underline{u} > 0$ and $w_{01-c} \leq 0$. Hence, $w_{11} > 0 \geq w_{01-c}$.

Note further that subtracting (SC1) from (PC′) yields

$$qw_{01-c} + (1-q)w_{11} - (qw_{10} + (1-q)w_{11}) \geq \underline{u} \Rightarrow w_{01-c} \geq w_{10} + \frac{\underline{u}}{q} \Rightarrow w_{01-c} > w_{10},$$

where the last inequality follows from $\underline{u} > 0$.

Claim 4: *The expert's unique sequentially rational reporting strategy is* $\gamma_0 = 0$ *and* $\gamma_1 = 1$. Follows immediately from Claim 3. ■

**Proof.** (Proposition C.4). We show that (SC0), (SC1), (PC), and (BOND) imply $\underline{u} \leq qB$. Subtracting (SC0) from (PC′) yields $(1-q)w_1 \geq \underline{u}$. Substituting into (SC1) we find that $w_0 \leq -\underline{u}/q$. Hence, (BOND) implies that $\underline{u}/q \leq B$, and hence $\underline{u} \leq qB$. ■

**Proof.** (Proposition 3.1). In the text, we argued that in any feasible mechanism, expected firm value is

$$(1-a)(1-q) + a[(1-q) + q(1-c)] - a[qw_{1-c} + (1-q)w_1].$$

Thus, the firm would like to minimize expected compensation, $qw_{1-c} + (1-q)w_1$, but (PC) requires $qw_{1-c} + (1-q)w_1 \geq \underline{u}$. Hence, any feasible mechanism in which (PC) holds with equality is optimal, yielding payoff

$$(1-a)(1-q)+a[(1-q)+q(1-c)]-a\underline{u}=1-q+aq(1-c)-a\underline{u}.$$

Via direct substitution, it is readily verified that the proposed mechanism is feasible and optimal if $\underline{u}\leq qB$. ■