Governing Multiple Firms*

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Abstract

Conventional wisdom is that, when an investor owns multiple firms, governance is weaker because she is spread too thinly. We show that common ownership can strengthen governance; moreover, the channel through which it does so applies to both voice and exit, and equityholders and debtholders. Under common ownership, an informed investor has flexibility over which assets to retain and which to sell, and sells low-quality assets first. This increases adverse selection and thus price informativeness. In a voice model, the investor's incentives to monitor are stronger since "cutting-and-running" is less profitable. In an exit model, the manager's incentives to work are stronger since the price impact of investor selling is greater.

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Most theories of corporate governance consider a single firm. In reality, investors typically hold sizable stakes in several firms – shareholders own multiple blocks[1] and banks lend large amounts to multiple borrowers. This paper analyzes the effect of common ownership on governance. Doing so is potentially complex, because governance can be undertaken through different channels and by different types of investors. Starting with the former, investors can govern through "voice" – direct intervention such as monitoring managers, suggesting a strategic change, or blocking a pet project. Alternatively, they can govern through "exit" – sell their securities if the manager shirks, reducing the price; ex ante, the threat of exit induces the manager to work. Moving to the latter, governance can be undertaken by both equityholders and debtholders, such as banks, mutual funds, pension funds, and hedge funds.

While conventional wisdom is that common ownership weakens governance by spreading the investor too thinly, we show that it can strengthen governance. Moreover, the channel through which it does so is common to both voice and exit, and to both equityholders and debtholders – common ownership increases adverse selection and thus price informativeness.

To demonstrate this channel most clearly, we start with a model in which firm value is exogenous and the investor only engages in informed trading. As a benchmark, we analyze the case of separate ownership. An investor owns n units of the same class of security (debt, equity, or any security monotonic in firm value) in a single firm. She subsequently learns private information on firm value, which can be high or low. She may also suffer a privately-observed liquidity shock that forces her to raise at least a given dollar amount of funds, although she may choose to sell more (or to sell even absent a shock). Examples include withdrawals from her end investors, an alternative investment opportunity, or an increase in capital requirements. Based on her private information and liquidity needs, she retains, partially sells, or fully sells her stake. The security price is set by a market maker who observes the investor's trade but not firm value.

If the firm turns out to be good (i.e. have high fundamental value) but the investor suffers a liquidity shock, she is forced to partially sell it. Thus, if the firm turns out to be bad (i.e. low-value), the investor sells it by the same amount, to disguise the sale as motivated by a shock. As a result, a bad firm does not receive too low a price, and a good firm does not always enjoy a high price as it is sometimes sold and pooled with bad firms.

[1] See Antón and Polk (2014), Bartram, Griffin, Lim, and Ng (2015), Hau and Lai (2013), and Jotikasthira, Lundblad, and Ramadorai (2012).

Under common ownership, the investor owns one unit of a security in each of n uncorrelated firms. Each firm's securities are traded by a separate market maker, who observes trading in only one firm. The key effect of common ownership is that it gives the investor a diversified portfolio of both good and bad firms, and thus the choice of which firms to sell upon a shock. If the shock is small, she can satisfy it by selling only bad firms. Then, being sold is not consistent with the firm being good and the sale being driven purely by a shock, and so fully reveals the firm as bad. This intensifies adverse selection and leads to a lower price for a sold firm. Note that the above result arises even though the market maker does not observe the investor's trades in other firms, nor even which firms they are. Merely knowing that she has other firms in her portfolio, that she could have sold upon a shock, is sufficient for the market maker to give a low price to a fully sold firm.

In contrast, if the firm turns out to be good, it can be retained even upon a shock, and thus receives a high price. If the shock is moderate, it cannot be satisfied by selling only bad firms, and so the investor needs to partially sell good firms as well. However, since the market maker knows that the investor would have fully sold the firm upon a shock if it were bad, a good firm receives a higher price than under separate ownership. If the shock is large, it forces the investor to sell good firms to the same extent as bad firms – exactly as under separate ownership – and so common ownership does not give her additional flexibility over what to sell. Overall, price informativeness is the same under common ownership and large shocks as under separate ownership, higher under moderate shocks, and higher still under small shocks. Intuitively, the smaller the shock, the greater the investor's flexibility over which firms to sell. Thus, she is forced to sell fewer good firms, and so being sold is a greater signal that the firm is bad. Similarly, if all firms were perfectly correlated, common ownership does not increase the investor's flexibility. The key to flexibility is diversification, and the benefits of diversification arise even though the investor is risk-neutral.

Note that the above result does not arise simply because common ownership gives the investor a liquidity buffer, i.e. additional securities to sell upon a shock. Under both structures, the investor owns n units, her ex ante portfolio value is the same, and the liquidity shock is the same. Indeed, we show that adding additional firms to the investor's portfolio is critically different from adding financial slack, i.e. liquid securities (such as Treasury bills) on which the investor has no private information. Consider an investor who owns only firm i and adds Treasury bills to her portfolio. Treasury bills provide the investor with *uncontingent* liquidity:

since there is no private information, she always sells them first. Now assume the investor instead adds firm j to her portfolio. If firm i turns out to be good and firm j turns out to be bad, then firm j is indeed no different from a Treasury bill – it is sold first and provides liquidity. However, if firm i turns out to be bad and firm j turns out to be good, then the investor will not sell firm j – it provides no liquidity, and does not insure the investor against the need to fully sell firm i, leading to high price informativeness. As a result, price informativeness is higher when adding firm j than when adding Treasury bills, even though it provides only *contingent* liquidity and thus less of a liquidity buffer. For similar reasons, the effect of common ownership is different from reducing the size of the liquidity shock.

The trading model is flexible and tractable, and can be embedded in a model of either voice or exit. Starting with the former, we endogenize firm value as depending on an unobservable and costly intervention action ("monitoring") by the investor. If she monitors, the firm is good, else it is bad. Under separate ownership, monitoring incentives are low. If the investor monitors, she may suffer a shock, which forces her to sell and not receive the full payoff from monitoring. Alternatively, she may not monitor and sell ("cut and run"). Selling leads to a relatively high price under separate ownership, as discussed above. Thus, the payoff from monitoring (not monitoring) is relatively low (high), which leads to weak governance.

Under common ownership, the payoff to monitoring is higher. With a small shock, the investor never needs to sell a monitored firm. With a moderate shock, the investor is forced to sell a monitored firm but only partially, and so receives a higher price than under separate ownership. In addition, the payoff to cutting and running is now lower since adverse selection is intensified. A sale is more indicative that the investor has not monitored, since if she had monitored and suffered a liquidity shock, she would have sold other firms instead.

In sum, the investor's per-unit monitoring incentives are higher under common ownership than under separate ownership, with the difference decreasing in the size of the shock. On the other hand, under common ownership the investor only holds one unit of the security in each firm, rather than n, reducing monitoring incentives – the conventional wisdom that she is spread too thinly. Overall, we show that governance is stronger under common ownership if the number of firms in the investor's portfolio and the magnitude of the liquidity shock are sufficiently small. Similarly, if the investor could endogenously choose ownership structure and the liquidity shock is small, she would choose common ownership with a small number of firms.

We finally embed the trading framework into an exit model. Firm value now depends on

an effort decision undertaken by the manager, who is concerned with both fundamental value and the short-term security price. If the security is equity, his price concerns can stem from termination threat, reputational considerations, or owning equity that vests in the short-term; if it is debt, its price may affect his firm's reputation in debt markets and thus ability to raise future financing. The second interpretation extends the idea of governance through exit to debt, an application not been previously studied by the literature. The investor privately observes managerial actions in her portfolio firms.

Under separate ownership, effort incentives are low. If the manager works, the investor may suffer a shock and sell anyway. If he shirks, his firm is sold, but does not suffer too low a price. Under common ownership, the reward for working is higher. With a small shock, a manager's firm is never sold if he works; with a moderate shock, it is only partially sold while shirking would have led to full sale. The punishment for shirking is also higher, because a sale is more revealing of shirking and leads to a lower price. Intuitively, common ownership creates a tournament between the n managers, who know that the investor observes their efforts and will sell the worst performers. Since the market anticipates that the worst performers are sold, this amplifies the disciplinary power of exit. In sum, governance is stronger than under separate ownership, with the difference decreasing in the size of the shock.

We analyze several extensions. First, we study the case in which the investor receives a fixed reservation payoff upon exit, independent of the effect of exit on the firm's reputation. The investor is no longer concerned with price impact, and thus camouflaging a sale as motivated by a shock. This model applies to the case of discontinuing a relationship, such as a bank ceasing to lend or a venture capitalist not investing in a future financing round. Second, we analyze the case in which information asymmetry (parametrized by the difference in valuation between good and bad firms), and thus the price impact of selling, differs across firms. In both cases, the results remain robust. Third, we study index funds, which Appel, Gormley, and Keim (2016) find engage in monitoring, but are unable to disproportionately sell bad firms. Some commentators (e.g. Bhide (1993)) argue that such trading restrictions increase monitoring incentives, since the investor cannot cut and run and is thus locked in to monitor. We show that this need not be the case. Since an unconstrained firm does not have trading restrictions, it is unable to commit not to sell the worst assets in her portfolio, leading to a severe adverse selection problem upon selling and thus a powerful commitment to monitor. Fourth, and for similar reasons, we show that our mechanism generates a novel benefit of spin-offs and cost of

mergers. After a spin-off, the investor cannot commit not to disproportionately sell one former division, committing her to monitor that division.

The model has a number of implications. Starting with the trade-only model, adverse selection – and thus price decline upon a sale – is stronger when an informed seller owns multiple securities. The "price" can refer either to the literal trading price, or market perceptions of quality. For example, if a bank stops lending to a borrower, that borrower's perceived creditworthiness falls more if the bank had other borrowers it could have stopped lending to instead. Beyond security trading, a director's decision to quit a firm is a more negative signal if he serves on other boards; a conglomerate's decision to exit a business line is a more negative signal of industry prospects than if a focused firm scaled back its operations.

Applied to governance, our model shows that common ownership can strengthen governance, particularly if liquidity shocks and the number of firms are small. This result applies to governance by both equityholders and debtholders, and through both voice and exit. A bank's incentive to monitor a borrower, or a hedge fund's incentive to intervene, can rise if the investor owns multiple firms. A manager's incentive to work is stronger if his lender or main shareholder owns large positions in multiple firms. Overall, our model potentially justifies why shareholders own blocks in multiple firms and banks lend large amounts to multiple borrowers, despite the free-rider problem. Existing justifications are typically based on diversification of risk. While conventional wisdom might suggest that the common ownership induced by diversification concerns weakens governance, our model suggests that the opposite may be the case. An important exception is Diamond (1984), who shows in a costly state verification framework that diversification incentivizes a bank to repay its end investors. We focus on a different channel: diversification increases adverse selection in financial markets and thus governance through both voice and exit. In addition, in Diamond (1984), monitoring does not create value after a project is financed.

Relatedly, while existing studies typically use the size of the largest blockholder or the number of blockholders as a measure of governance, our paper theoretically motivates a new measure – the number of other large stakes owned by its main shareholder or creditor. Faccio, Marchica, and Mura (2011) empirically study a related measure, the concentration of a security in an investor's portfolio. They argue that diversification is desirable because a concentrated investor will turn down risky, positive-NPV projects, unlike our channel.

This paper builds on a long-standing literature of governance through voice (e.g. Shleifer

and Vishny (1986), Burkart, Gromb, and Panunzi (1997), Bolton and von Thadden (1998), Maug (1998), Kahn and Winton (1998), Pagano and Roell (1998), and Faure-Grimaud and Gromb (2004)) and a newer one on governance through exit (e.g. Admati and Pfleiderer (2009) and Edmans (2009)) – see Edmans (2014) and Edmans and Holderness (2016) for a survey of both literatures. While McCahery, Sautner, and Starks (2016) find that institutional investors use both governance mechanisms frequently, most theories analyze only one. Edmans and Manso (2011), Levit (2013) and Fos and Kahn (2015) feature both, but model each using quite different frameworks. We construct a unifying framework that can be adapted to either voice or exit, and show that common ownership enhances both. While some prior papers show that price informativeness can help governance, our key contribution is to study the impact of common ownership on price informativeness and generate a novel mechanism through which common ownership can enhance governance, in contrast to conventional wisdom. Indeed, all of the above models study a single firm. The only theory of multi-firm governance of which we are aware is the voice model of Admati, Pfleiderer, and Zechner (1994), which features no information asymmetry and instead focuses on the trade-off between risk-sharing and the free-rider problem.

1 Trade-Only Model

This section considers a pure trading model in which firm values are exogenous, to highlight the effect of common ownership on how an informed investor trades on private information, and in turn security prices and price informativeness. In Section 2, we endogenize firm value by allowing it to depend on intervention by the investor in a model of governance through voice, and in Section 4 it depends on effort by a manager in a model of governance through exit. These models will demonstrate how the increased adverse selection, resulting from common ownership, improves both governance mechanisms.

1.1 Setup

We consider two versions of the model. The first is a preliminary benchmark of separate ownership, with a single firm and a single investor. Specifically, the investor ("she") owns n

units of a security, out of a total of $m \geq n \geq 1$.[2] The security can be debt, equity, or any security monotonic in firm value. The investor is an institution who has private information on firm value, such as a hedge fund, mutual fund, or bank. The second version is the main model of common ownership, where the investor owns one unit in each of a continuum of firms of mass n. Note that, in both models, the investor owns the same number (n) of units and thus the same ex ante portfolio value. Let z denote the number of units held by the investor in a single firm, i.e. $z = n$ (1) under separate (common) ownership. The remaining $m - z$ units out of this class, and any other classes of securities, are owned by dispersed investors (households) who play no role.[3]

The model consists of three periods. At $t = 1$, Nature chooses the fundamental value of each firm i, $R_i \in \{\underline{R}, \overline{R}\}$, where $\overline{R} > \underline{R} > 0$ and R_i are independently and identically distributed ("i.i.d.") across firms. If $R_i = \overline{R}$ ($\underline{R}$), the value of each security is $v_i = \overline{v}$ ($\underline{v}$), where $\tau \equiv \Pr\left[R_i = \overline{R}\right] \in (0, 1)$ is common knowledge and $\underline{v} > 0$. We invoke the law of large numbers so that the actual proportion of firms for which $R_i = \overline{R}$ is τ.[4] In the separate ownership model, the investor privately observes v_i, and in the common ownership model, she privately observes $\mathbf{v} \equiv [v_i]_{i=0}^{n}$. Define $\Delta \equiv \overline{v} - \underline{v} > 0$, where $m\Delta \leq \overline{R} - \underline{R}$: the aggregate gain across the m units from $R_i = \overline{R}$ cannot exceed the overall gain in firm value.[5] We use "good" ("bad") firm to refer to a firm with $v_i = \overline{v}$ ($\underline{v}$).

At $t = 2$, the investor is subject to a portfolio-wide liquidity shock $\theta \in \{0, L\}$, where $L > 0$ and $\Pr[\theta = L] = \beta \in (0, 1]$. The variable θ is privately observed by the investor and represents the dollar amount of funds that she must raise. If she cannot raise θ, she raises as much as possible. Formally, failing to raise θ imposes a cost $K > 0$ multiplied by the shortfall in funds, which is sufficiently large to induce her to meet the liquidity need to the extent possible. The investor may choose to raise more than θ dollars, i.e. we allow for voluntary sales. Note that the model allows for $\beta = 1$, i.e. common knowledge that the investor has suffered a shock, such as a financial crisis.

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[2] n is any real number; it need not be an integer.

[3] We assume that, when moving from separate to common ownership, the $n - 1$ units no longer held by the investor are now held by households. If, instead, they are held by other large investors, the net benefits of common ownership are generally stronger than in the current setup: see Edmans and Manso (2011).

[4] Invoking the law of large numbers leads to significant tractability. In a previous version of the paper, the investor held two firms rather than a continuum under common ownership. The analysis with a finite number of firms is more complicated but leads to similar results and does not provide additional insights.

[5] If this were true, the value of the other classes would be decreasing in R and so their owners would have incentives to reduce firm value (cf. Innes (1990)).

After observing the shock, the investor sells $x_i \in [0, z]$ units in firm i. We use "fully sold" to refer to firm i if $x_i = z$, and "partially sold" if $x_i \in (0, z)$. In the common ownership model, if $x_i^* = x_j^* \; \forall \; i \neq j$, we say that the investor engages in "balanced exit." Otherwise, she engages in "imbalanced exit." The sold units x_i are purchased by the market maker for firm i ("it"), which can more generally refer to a competitive pool of investors. Each firm has a separate market maker who is competitive and risk-neutral, and observes only x_i and not x_j, $j \neq i$, θ, nor v_i. Each market maker sets the security price $p_i(x_i)$ at $t = 2$ to equal the security's expected value. We denote $\mathbf{p} \equiv [p_i(x_i)]_{i=0}^n$ and $\mathbf{x} \equiv [x_i]_{i=0}^n$.

At $t = 3$, firm value, security values, and payoffs are realized. The investor's utility in the separate and common ownership models are respectively given by

$$u_I(x_i, v_i, p_i(x_i), \theta) = x_i p_i(x_i) + (n - x_i) v_i - K \times \max\{0, \theta - x_i p_i(x_i)\}. \quad (1)$$

$$u_I(\mathbf{x}, \mathbf{v}, \mathbf{p}, \theta) = \int_0^n [x_i p_i(x_i) + (1 - x_i) v_i] \, di - K \times \max\left\{0, \theta - \int_0^n x_i p_i(x_i) \, di\right\} \quad (2)$$

The equilibrium concept we use is Perfect Sequential Equilibrium. Here, it is defined as follows: (i) A trading strategy by the investor that maximizes her expected utility u_I given each market maker's price-setting rule and her private information on $\mathbf{v}$ (v_i) and (ii) a price-setting rule by each market maker that allows it to break even in expectation, given the investor's strategy. Moreover, (iii) each market maker uses Bayes' rule to update its beliefs from the investor's trades, (iv) all agents have rational expectations in that each player's belief about the other players' strategies is correct in equilibrium, (v) the pricing function is monotonic, i.e. $p_i(x_i)$ is weakly decreasing, holding constant x_j, $j \neq i$,[6] and (vi) off-equilibrium beliefs are credible as defined by Grossman and Perry (1986).[7] Since firms are ex-ante identical, we focus on symmetric equilibria, in which each market maker uses a symmetric pricing function. We

[6]Focusing on weakly decreasing price functions imposes some restrictions on off-equilibrium prices, and thus the amounts sold in equilibrium. However, since these restrictions do not affect on-equilibrium prices, they generally do not affect the investor's strategy in Section 2 or the manager's strategy in Section 4 (when we introduce real actions). In addition, weakly decreasing pricing functions are consistent with other microstructure theories (e.g. Kyle (1985)) and empirical evidence (e.g. Gorton and Pennacchi (1995), Ivashina (2009)).

[7]Loosely speaking, an equilibrium fails the Grossman and Perry (1986) refinement (i.e., is not a Perfect Sequential Equilibrium) if there exists a subset of sender types (the investor, in our setting) that will deviate to a strategy $\widehat{\mathbf{x}}$ ($\widehat{x}_i$) if, conditional upon observing $\widehat{\mathbf{x}}$ ($\widehat{x}_i$), the receiver (the market maker, in our setting) believes that this subset of types deviated and the complement of this subset did not deviate. The main implication is that, if there is an equilibrium in which the investor raises at least L dollars, then there cannot be an equilibrium in which the investor is unable to raise at least L dollars, and if the investor cannot raise at least L dollars in any equilibrium, then in any equilibrium the investor sells her entire portfolio upon a shock.

also assume that the investor does not sell a good firm if she does not suffer a liquidity shock. This is intuitive since the price can never exceed the value of a good firm $\overline{v}$, but simplifies the analysis as we need not consider equilibria under which a good firm is partially sold, but still fully revealed as good as bad firms are sold in greater volume. Prices and governance are exactly the same without this restriction.[8]

1.2 Trade Under Separate Ownership

Proposition 1 characterizes all equilibria under separate ownership.

Proposition 1 *(Separate ownership, trade only): An equilibrium under separate ownership always exists. In any equilibrium, the investor's trading strategy in firm i is:*

$$x_{so}^{*}\left(v_i,\theta\right)=\begin{cases}0 & \text{if } v_i=\overline{v} \text{ and } \theta=0\\ \overline{x}_{so}\left(\tau\right)=n\times\min\left\{\frac{L/n}{\overline{p}_{so}(\tau)},1\right\} & \text{otherwise}\end{cases},\tag{3}$$

and prices of firm i are:[9]

$$p_i^{*}\left(x_i\right)=\begin{cases}\overline{v} & \text{if } x_i=0\\ \overline{p}_{so}\left(\tau\right)=\underline{v}+\Delta\frac{\beta\tau}{\beta\tau+1-\tau} & \text{if } x_i\in\left(0,\overline{x}_{so}\left(\tau\right)\right],\\ \underline{v} & \text{if } x_i>\overline{x}_{so}\left(\tau\right).\end{cases}\tag{4}$$

We will refer to the investor's type as (v_i, θ), i.e. a pair that indicates her information on the value of firm i and whether she has suffered a liquidity shock. (Sometimes we will define the type as referring only to v_i, in which case it refers to both $(v_i, 0)$ and (v_i, L)).

[8]Note that, under both ownership structures, we hold constant the investor's information advantage: she always has a perfect signal on firm value. Conventional wisdom suggests that, if information acquisition is endogenous, the investor will acquire less information under common ownership as her stake falls from n to 1. In unreported results (available upon request), we analyze this extension and show that information acquisition may in fact be stronger under common ownership. Even when information acquisition is lower under common ownership, this must be traded off against the benefits of common ownership identified below. In particular, common ownership can lead to greater price informativeness even if information acquisition is less: low information of which a high proportion is incorporated in prices may dominate high information of which a low proportion is incorporated in prices.

[9]While the prices on the equilibrium path are unique, the prices off-equilibrium are not. The pricing function in equation (4) ensures monotonicity. A similar comment applies to subsequent pricing functions.

Equation (3) shows that, if the firm is bad, the investor sells the same amount $(\overline{x}_{so}(\tau))$ as if it were good and she had suffered a shock, to disguise the motive for her sale. The price of a sold security, $\overline{p}_{so}(\tau)$, is relatively high as the market maker attaches a probability $\frac{\beta\tau}{\beta\tau+1-\tau}$ that the sale was of a good firm and due to a shock. Thus, the adverse selection problem is not so severe under separate ownership. The amount $\overline{x}_{so}(\tau)$ is the minimum required to satisfy the shock: if it were greater, type-$(\overline{v}, L)$ would deviate and sell less, retaining more of a good firm and receiving no lower a price (since prices are non-increasing).

Since the market maker breaks even in expectation, the investor's trading gains when selling $\overline{x}_{so}(\tau)$ of a bad firm equal her trading losses when forced to sell $\overline{x}_{so}(\tau)$ of a good firm due to a shock. Thus, the possibility of trade has no effect on the ex ante value of the investor's portfolio, which is $n(\underline{v} + \Delta\tau)$. In Sections 2 and 4, when we endogenize v_i, we will show that the possibility of trade changes portfolio value by affecting governance.

1.3 Trade Under Common Ownership

Under common ownership, the investor decides not only how much of her portfolio to sell, but also which firms. Proposition 2 characterizes all equilibria.

Proposition 2 *(Common ownership, trade only): An equilibrium under common ownership always exists.*

(i) If $L/n \leq \underline{v}(1-\tau)$ then in any equilibrium

$$x^*_{co}(v_i, \theta) = \begin{cases} 0 & \text{if } v_i = \overline{v} \\ \widetilde{\underline{x}} \text{ s.t. } E[\widetilde{\underline{x}}] \in \left[\frac{\theta/n}{\underline{v}(1-\tau)}, 1\right] & \text{if } v_i = \underline{v}, \end{cases} \tag{5}$$

and prices of firm i are:

$$p^*_i(x_i) = \begin{cases} \underline{v} + \Delta\frac{\tau}{\tau+\gamma(1-\tau)} & \text{if } x_i = 0 \\ \underline{v} & \text{if } x_i > 0. \end{cases} \tag{6}$$

where $\gamma = \Pr[\widetilde{\underline{x}} = 0]$.

(ii) If $\underline{v}(1-\tau) < L/n < \underline{v}$ *then there exists an equilibrium in which*

$$x_{co}^{*}(v_i,\theta) = \begin{cases} 0 & \text{if } v_i = \overline{v} \text{ and } \theta = 0 \\ \overline{x}_{co}(\tau) = \frac{\underline{v} + \frac{L/n - \underline{v}}{\tau}}{\overline{p}_{co}(\tau)} < 1 & \text{if } v_i = \underline{v} \text{ and } \theta = 0, \text{ or } v_i = \overline{v} \text{ and } \theta = L \\ 1 & \text{if } v_i = \underline{v} \text{ and } \theta = L, \end{cases} \quad (7)$$

and prices of firm i are:

$$p_i^{*}(x_i) = \begin{cases} \overline{v} & \text{if } x_i = 0 \\ \overline{p}_{co}(\tau) = \underline{v} + \Delta \frac{\beta\tau}{\beta\tau + (1-\beta)(1-\tau)} & \text{if } x_i \in (0, \overline{x}_{co}(\tau)], \\ \underline{v} & \text{if } x_i > \overline{x}_{co}(\tau). \end{cases} \quad (8)$$

(iii) If $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} < L/n$ *then there exists an equilibrium as described by Proposition 1, except* $\overline{x}_{so}$ *is replaced by* $\overline{x}_{so}/n$*.*

(iv) No other equilibrium exists.

The intuition is as follows. If $L/n \leq \underline{v}(1-\tau)$, the liquidity shock is sufficiently small that it can be satisfied by selling only bad firms. She thus retains all good firms, regardless of whether she suffers a shock. Since the shock requires her to sell $\frac{L}{\underline{v}(1-\tau)}$ only in aggregate across the bad firms, she may retain some bad firms and does so with probability ("w.p.") γ. ($\gamma > 0$ affects the analysis of exit, but has no effect on the analysis of voice.) As a result, a retained firm is not fully revealed and only priced at $\underline{v} + \Delta\frac{\tau}{\tau+\gamma(1-\tau)}$ rather than $\overline{v}$. Any firm that is at least partially sold is fully revealed as being bad and priced at $\underline{v}$.

For $\underline{v}(1-\tau) < L/n < \underline{v}$, the shock is sufficiently large that the investor must sell some good firms to satisfy it. Thus, a partial sale does not fully reveal a firm as bad, and so the investor never retains bad firms. As a result, retained firms are fully revealed as good and priced at $\overline{v}$. However, the shock remains sufficiently small that the investor can sell good firms less than bad firms (engage in imbalanced exit). Upon a shock, she sells bad firms fully and $\overline{x}_{co}(\tau)$ from each good firm. As a result, if there is no shock, she also sells $\overline{x}_{co}(\tau)$ from each bad firm, to pool with a good firm and disguise her sale as being motivated by a shock. Thus,

$(\overline{v}, L)$ is pooled with $(\underline{v}, 0)$.[10]

Finally, for $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} \leq L/n$, the shock is sufficiently large that it forces the investor to sell good firms as much as bad firms (engage in balanced exit). Thus, $(\overline{v}, L)$ is pooled with not only $(\underline{v}, 0)$ (as in the moderate-shock case) but also $(\underline{v}, L)$, reducing the expected price of a good firm further, and increasing the price of $(\underline{v}, L)$ above $\underline{v}$. Since the investor's trading strategy is the same as under separate ownership ($(\overline{v}, L)$, $(\underline{v}, 0)$, and $(\underline{v}, L)$ are all pooled), prices are exactly the same. Note that, for $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} \leq L/n < \underline{v}$, both the imbalanced exit equilibrium of part (ii) and the balanced exit equilibrium of part (iii) can be sustained. While the investor has the option to satisfy a shock by selling bad firms more, she may also sell good firms to the same degree as bad firms. While doing so increases her trading losses on good firms, it reduces them on bad firms, since bad firms are now pooled with good firms upon a shock. For simplicity, we will refer to an equilibrium with the properties of parts (i), (ii), and (iii) of Proposition 2 as type-(i), (ii), and (iii) equilibria.[11]

We denote the investor's equilibrium payoff from owning security i (including the possibility of trade), given τ, by $V_{co}(v_i, \tau)$ under common ownership and $V_{so}(v_i, \tau)$ under separate ownership. Similarly, we denote the expected equilibrium price of firm i's, given value v_i under common and separate ownership by $P_{co}(v_i, \tau)$ and $P_{so}(v_i, \tau)$, respectively.

Proposition 3 *(Price informativeness and payoff precision): Suppose $\tau \in (0, 1)$, then:*

(i) If $\underline{v}(1-\tau) < L/n$ or $\gamma \leq \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)}$, then

$$P_{co}(\overline{v}, \tau) \geq P_{so}(\overline{v}, \tau) \text{ and } P_{co}(\underline{v}, \tau) \leq P_{so}(\underline{v}, \tau), \tag{9}$$

with strict inequalities if $L/n \leq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$. If $L/n \leq \underline{v}(1-\tau)$ and $\gamma > \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)}$, then

$$P_{co}(\overline{v}, \tau) < P_{so}(\overline{v}, \tau) \text{ and } P_{co}(\underline{v}, \tau) > P_{so}(\underline{v}, \tau). \tag{10}$$

[10] We continue to use "type" to refer to (v_i, θ); this is a slight abuse of terminology since, under common ownership, the investor's type consists of the entire vector of firm values.

[11] The investor has no incentive to buy additional securities, because such purchases would be fully revealed as stemming from information. This would be true even if the investor had the possibility of receiving positive liquidity shocks, as long as she has the option to hold the inflow as cash rather than being forced to buy more of her existing holdings. This treatment is consistent with the investor's option to raise more than L and hold the excess as cash.

(ii)

$$V_{co}(\overline{v},\tau) \geq V_{so}(\overline{v},\tau) \text{ and } V_{co}(\underline{v},\tau) \leq V_{so}(\underline{v},\tau), \tag{11}$$

with strict inequalities if $L/n \leq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$. *Both* $V_{so}(\overline{v},\tau) - V_{so}(\underline{v},\tau)$ *and* $V_{co}(\overline{v},\tau) - V_{co}(\underline{v},\tau)$ *decrease in* L/n.[12]

Expression (9) gives conditions under which the expected price of a good (bad) firm is higher (lower) under common ownership than separate ownership, i.e. closer to fundamental value so that price informativeness is higher. Under common ownership, the investor has a diversified portfolio of good and bad firms. This allows her to choose which firms to sell upon a shock – in particular, she sells bad firms first. In the moderate-shock equilibrium of part (ii) of Proposition 2, a shock causes her to fully sell bad firms and partially retain good firms. Thus, a fully sold firm is priced at $\underline{v}$, and so bad firms receive a lower expected price under common ownership. Scholes (1972), Mikkelson and Partch (1985), Holthausen, Leftwich, and Mayers (1990), and Sias, Starks, and Titman (2006) show that sales by large shareholders reduce the stock price due to conveying negative information; Dahiya, Puri, and Saunders (2003) find similar results for loan sales. Our model predicts that the price declines upon a sale are greater under common ownership.[13]

A similar intuition applies to the small-shock equilibrium of part (i), whether the investor fully retains good firms. As a result, the sale of firm i cannot be attributed to a shock because, if firm i were good and the investor had needed liquidity, she would have sold other firms instead. Thus, a sold firm is fully revealed as being bad and priced at $\underline{v}$. The one complication is that, since sold firms are fully revealed as bad, the investor no longer has strict incentives to sell bad firms. Thus, she retains bad firms w.p. γ, and so being retained is no longer fully revealing. If $\gamma > \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)}$, then price informativeness is lower under common ownership ($P_{co}(\underline{v},\tau) > P_{so}(\underline{v},\tau)$ in expression (10)).

In addition to reducing the expected price of bad firms, common ownership also increases the expected price of good firms. Under separate ownership, a good firm is automatically sold

[12] If $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} < L/n < \underline{v}$, more than one equilibrium exists. The comparative statics with respect to L/n implicitly assume that, in this range, once the type of the equilibrium is chosen (i.e., type-(ii) or (iii)), it does not change as we increase L/n, as long as it exists.

[13] In He (2009), the price impact of a sale is stronger if the asset is *more* correlated with other assets in the investor's portfolio. Retaining an asset is even more costly when it is positively correlated with the rest of the portfolio, and particularly so when the asset is low-quality. Thus, retention is a stronger signal of asset quality, leading to a steeper pricing function. His model features risk aversion rather than liquidity shocks.

under a shock; under common ownership and a small shock, it is retained. This result does not simply arise because common ownership gives the investor more units to sell to satisfy a shock: she owns n in both models. Again, the intuition is that common ownership gives her a diversified portfolio of both good and bad firms. Where the shock is small, she can always satisfy it by selling only bad firms. On the other hand, being retained no longer reveals a firm as being good. If γ is sufficiently small, the latter effect is weaker, and so $P_{co}(\overline{v}, \tau) > P_{so}(\overline{v}, \tau)$ overall. With a moderate shock, a good firm is sold, but only partially. The market maker knows that, if the firm were bad and the investor had suffered a shock, it would have been sold fully. Thus, it is priced at $\underline{v} + \Delta \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)}$ (i.e. pooled with only $(\underline{v}, 0)$) rather than $\underline{v} + \Delta \frac{\beta\tau}{\beta\tau+1-\tau}$ (i.e. pooled with $(\underline{v}, 0)$ and $(\underline{v}, L)$) under separate ownership. With a large shock, the investor's trading behavior is exactly the same as under separate ownership, and so price informativeness is no higher.

While part (i) concerns the closeness of prices to fundamental value (price informativeness), part (ii) concerns the closeness of the investor's payoff to fundamental value, which we call "payoff precision." The investor's payoff from firm i is given by $(1 - x_i) v_i + x_i p_i$. Since her payoff depends on the price, just as common ownership generally improves price informativeness, it always improves payoff precision. Note that common ownership always improves payoff precision, even if it does not improve price informativeness (i.e. (10) holds). Common ownership reduces price informativeness in a type-(i) equilibrium if $\gamma > \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)}$, i.e. the investor sometimes retains bad firms. Then, the price of a retained firm is less than $\overline{v}$. However, the price of a retained firm does not affect the investor's payoff – since the investor retains the firm, her payoff is given by its fundamental value rather than its price, and so it does not matter if the price is uninformative. The investor always retains good firms and receives a payoff of $\overline{v}$ from them, regardless of their price; for a bad firm, she receives their fundamental value of $\underline{v}$ if retained and the sale price of $\underline{v}$ if sold.

Note that the effect of common ownership on price informativeness stems from diversification, rather than simply owning multiple firms. If the firms were perfectly correlated, prices would be as in the separate ownership benchmark as the investor would not be able to sell bad firms more and good firms less upon a shock – either all firms are good, or all firms are bad. This result implies that price informativeness (and, as we will show, governance) is increasing in the diversification of an investor's portfolio.

In addition, the results show that diversifying by adding additional firms to the investor's portfolio is different from adding financial slack, i.e. liquid securities (such as Treasury bills) on which the investor has no private information. We start with the separate ownership model and study the effect of adding A dollars of liquid securities to the investor's portfolio. If $A \geq L$, then the addition effectively insulates the investor from a liquidity shock, leading to maximum price informativeness. Indeed, the net liquidity shock, $L-A$, is now negative. If instead $A < L$, the addition effectively reduces the liquidity shock to $L - A$; since price informativeness in the separate ownership model is independent of the liquidity shock (as long as it is positive), it is unaffected by the new securities. Intuitively, since liquid securities are always fairly priced, selling them to satisfy a shock involves no loss. Upon a shock, if the firm turns out to be good, the investor will sell liquid securities first and only raise $L - A$ from the firm. If the firm is bad, the investor will again sell liquid securities first and raise only $L - A$ from the firm, since raising more would fully reveal the firm as bad.

Now instead consider the effect of adding $A < L$ dollars of securities in a new firm j. To ease the exposition, we will consider the case in which firms i and j are negatively correlated, but all we need is less than perfect correlation as discussed above. Upon a shock, if the initial firm i is good (and new firm j is bad), the investor will sell firm j first and thus only partially sell firm i – the same as if the investor instead had liquid securities. The critical difference is if firm i is bad (and new firm j is good). Now, the investor will not sell firm j first. Unlike liquid securities, securities in firm j suffer an adverse selection discount and so she suffers a loss by selling them if they are good. She instead fully sells firm i. Even though doing so fully reveals firm i as bad, it is better than fully selling the higher-quality j.

Put differently, by adding Treasury bills, the investor knows that she will only ever have to partially sell firm i – she will never have to fully sell it since she always sells Treasury bills first. Since she will sell an unmonitored firm to the same degree as a monitored firm upon a shock, she will always receive a price strictly greater than $\underline{v}$. However, by adding firm j, the investor still risks having to fully sell firm i and receive $\underline{v}$, thus providing greater incentives to monitor. The critical difference is that Treasury bills provide *uncontingent* liquidity – they are always sold first. Adding firm j provides *contingent* liquidity – it is not sold first if firm i is bad and firm j is good. This contingency increases the investor's incentives to monitor firm i, since she only benefits from the added liquidity if firm i is good and firm j is bad. Simple intuition might suggest that price informativeness rises with liquidity, as it allows the investor

to retain good firms upon a shock, but price informativeness is actually higher when adding firm j rather than Treasury bills even though it provides less liquidity.

In sum, adding liquid securities reduces the net liquidity shock but keeps us within the separate ownership model where, upon a shock, the sale volume is independent of firm quality. Adding a firm moves us to the moderate-shock common ownership model where, upon a shock, the investor partially (fully) sells a good (bad) firm.

2 Governance Through Voice

We now endogenize firm value as depending on an action by the investor. Specifically, at $t = 1$, the investor takes a hidden action $a_i \in \{0, 1\}$, where $a_i = 1$ leads to $R_i = \overline{R}$ and thus $v_i = \overline{v}$, and $a_i = 0$ leads to $R_i = \underline{R}$ and thus $v_i = \underline{v}$.[14] Action $a_i = 1$ imposes a cost $\widetilde{c}_i \in [0, \infty)$ on the investor, which she privately observes prior to deciding her action[15]; Section 3.2 shows that the results remain robust to a publicly-known monitoring cost. The action a_i is broadly defined to encompass any action that improves firm value but is costly to the investor. Examples include advising the firm on strategy, using her business connections to benefit the firm, preventing the firm's manager from extracting perks or empire-building, or choosing not to take private benefits for herself.

The probability density function of $\widetilde{c}_i$ is given by f and its cumulative distribution function is given by F. Both are continuous and have full support. We assume $\widetilde{c}_i$ are i.i.d. across firms, and that $E[\widetilde{c}_i] \leq \overline{R} - \underline{R}$, so that $a_i = 1$ is ex-ante efficient. We refer to $a_i = 1$ as "monitoring" and $a_i = 0$ as "not monitoring". A good (bad) firm is now a firm that has been monitored (not monitored). We assume that, if the investor is indifferent between monitoring and not, she monitors; this indifference only arises for a measure zero of $\widetilde{c}_i$. Through her private knowledge

[14] Carleton, Nelson, and Weisbach (1998), Becht, Franks, Mayer, and Rossi (2009), and McCahery, Sautner, and Starks (2016) provide evidence that a significant amount of shareholder intervention occurs behind the scenes and is unobservable to outsiders; the literature on governance through voice typically assumes monitoring to be unobservable (e.g. Maug (1998), Kahn and Winton (1998), Faure-Grimaud and Gromb (2004)). Interventions by banks (outside of bankruptcy) are even more likely to be unobserved.

[15] We implicitly assume $\int_0^n c_i di < \infty$, which holds if, for example, $\widetilde{c}_i$ is bounded from above. All the results continue hold with a bounded monitoring costs. The cost of monitoring will depend on firm-specific factors that are, in part, privately known to the investor (as in Landier, Sraer, and Thesmar (2009)). For example, she may have private information on the business ties that she may lose if she engages in perk prevention, on how easily she can use her business connections to benefit the firm, or on the extent to which she can extract private benefits.

of $\mathbf{a} \equiv [a_i]_{i=0}^n$, the investor continues to have private information on $\mathbf{v}$.

The investor's utility conditional on $\mathbf{x}$ and the realization $\mathbf{c} \equiv [c_i]_{i=0}^n$ of $\widetilde{\mathbf{c}}$ is now given by:

$$u_{I,Voice} = u_I(\mathbf{x}, \mathbf{a}, \mathbf{p}, \theta) - \int_0^n c_i a_i di. \tag{12}$$

under common ownership, and analogously under separate ownership. The equilibrium definition is similar to Section 1, with the following additions: (vii) the investor's monitoring rule in each firm i maximizes her expected utility given $\widetilde{\mathbf{c}}$, her expected trading strategy, and each market maker's price-setting rule, and (viii) each market maker forms expectations about τ that are consistent with (vii), instead of taking it as given.

2.1 Preliminaries

We first derive results that hold under both separate and common ownership. When deciding her action, the investor trades off the cost of monitoring with the increase in security value. Lemma 1 states that this trade-off gives rise to a threshold strategy: she monitors firm i if and only if her cost is sufficiently low.[16]

Lemma 1 *In any equilibrium and under any ownership structure there is a c^* such that ("s.t.") the investor chooses $a_i = 1$ if and only if $\widetilde{c}_i \leq c^*$.*

Ex-ante total surplus (firm value minus the cost of monitoring) in equilibrium is $\underline{R} + F(c^*)\left(\overline{R} - \underline{R} - E[c|c < c^*]\right)$, which is increasing in c^* if and only if $c^* \leq \overline{R} - \underline{R}$. The investor's threshold satisfies $c^* \leq z\Delta$. Since $z\Delta \leq m\Delta \leq \overline{R} - \underline{R}$, a higher c^* always increases total surplus. We thus define efficiency as the maximization of c^*. From part (viii) of the equilibrium definition, $\tau^* = F(c^*)$. Given the market maker's expectations of τ^* and the investor's implementation of τ^* through her actions, prices and trading strategies are determined as in Section 1. Therefore, our equilibrium characterizations below only specify the thresholds τ^*.

2.2 Voice Under Separate Ownership

Proposition 4 characterizes all the thresholds that emerge in any equilibrium under separate ownership.

[16] Note that different equilibria under different ownership structures can have different thresholds; the threshold c^* in Lemma 1 refers to a generic threshold.

Proposition 4 *(Separate ownership, voice): In any equilibrium under separate ownership with voice, the monitoring threshold,* $c^*_{so,voice}$, *is given by the solution of* $c^*/n = \phi_{voice}(F(c^*))$, *where*

$$\phi_{voice}(\tau) \equiv \Delta \left[1 - \beta \min\left\{\frac{L/n}{\underline{v} + (\Delta\beta - \underline{v}(1-\beta))\tau}, \frac{1}{\beta\tau + 1 - \tau}\right\}\right]. \tag{13}$$

Prices and trading strategies are characterized by Proposition 1, where τ *is given by* $\tau^*_{so,voice} \equiv F\left(c^*_{so,voice}\right)$.

Intuitively, $c^*_{so,voice}$ solves

$$V_{so}(\overline{v}, F(c^*)) - c^*/n = V_{so}(\underline{v}, F(c^*)). \tag{14}$$

The right-hand side ("RHS") of (14) is the investor's payoff from holding a bad firm, given that the market maker expects the probability of monitoring to be $F(c^*)$. The left-hand side ("LHS") is her payoff from holding a good firm, net of monitoring costs.

Even ignoring the free-rider problem (i.e. that the investor owns $n < m$ units), governance is imperfect ($c^*_{so,voice} < n\Delta$) for two reasons. First, the payoff to monitoring is relatively low. While monitoring increases security value to $\overline{v}$, w.p. β the investor suffers a liquidity shock and has to sell $\overline{x}^*_{so,voice} \equiv \overline{x}_{so}\left(\tau^*_{so,voice}\right)$ units for less than their fair value of $\overline{v}$. Second, the payoff from not monitoring and selling is relatively high. Regardless of whether she suffers a shock, a non-monitoring investor sells $\overline{x}^*_{so,voice}$ and pools with $(\overline{v}, L)$, receiving a price $\overline{p}^*_{so,voice} \equiv \overline{p}_{so}\left(\tau^*_{so,voice}\right)$ that exceeds the fair value of $\underline{v}$.[17]

Turning to comparative statics, the investor's threshold is decreasing in the shock L. A larger shock means that she must sell more units $\overline{x}^*_{so,voice}$ to satisfy it. This reduces her payoff from monitoring, and also allows her to sell more, and thus profit more, if she cuts and runs (since she pools with $(\overline{v}, L)$). The threshold is increasing in Δ for two reasons. First, it (trivially) increases the value created by monitoring. Second, it increases the price $\overline{p}^*_{so,voice}$ received from sold firms, since $\overline{p}^*_{so,voice}$ incorporates the possibility that the firm is $(\overline{v}, L)$. Due to

[17] Note that multiple thresholds are possible, since if the market maker believes that the investor monitors intensively ($c^*_{so,voice}$ is high), prices upon sale are high and so the investor can satisfy her liquidity needs by selling only a small amount $\overline{x}^*_{so,voice}$. This in turn increases the payoff to monitoring and sustains the equilibrium. Similarly, if the market maker believes that the investor monitors little, prices upon sale are low and so the investor must sell a large amount to satisfy her liquidity leads, reducing the payoff to monitoring and sustaining the equilibrium. As a result, governance is self-fulfilling. The comparative statics described in the text deal with stable equilibria, i.e. those in which $\phi_{voice}(F(c))$ intersects the line $h(c) \equiv c/n$ from above.

this higher price, she has to sell fewer units if she monitors and suffers a shock, thus increasing the payoff to monitoring. The threshold is increasing in $\underline{v}$ due to the second channel: it raises $\overline{p}^*_{so,voice}$ and thus reduces $\overline{x}^*_{so,voice}$. It is increasing in n because the monitoring gains are applied to more units, and also because the per-unit shock L/n falls with n. The threshold is decreasing in β. The more likely the shock, the higher the price $\overline{p}^*_{so,voice}$ received for selling $\overline{x}^*_{so,voice}$, because the sale may be of a good firm in response to a shock. This higher price increases the payoff to not monitoring and selling. In addition, higher β means that a monitoring investor has to sell more frequently. The effect of $F(\cdot)$ is ambiguous.

2.3 Voice Under Common Ownership

Proposition 5 below gives the most efficient equilibrium under common ownership. A single asterisk * refers to an equilibrium, and a double asterisk ** refers to the most efficient equilibrium.

Proposition 5 *(Common ownership, voice): There are $\underline{v}(1-F(\Delta)) < \underline{y} \leq \overline{y} \leq \underline{v}$ such that the monitoring threshold under the most efficient equilibrium is given by*

$$c^{**}_{co,voice} = \begin{cases} \Delta & \text{if } L/n \leq \underline{v}(1-F(\Delta)) \\ c^{**}_{ii} \equiv \text{the largest solution of } c^* = \zeta_{voice}(F(c^*)) & \text{if } \underline{v}(1-F(\Delta)) < L/n < \underline{y} \\ \max\{c^{**}_{ii}, c^{**}_{iii}\} & \text{if } \underline{y} \leq L/n < \overline{y} \\ c^{**}_{iii} \equiv \text{the largest solution of } c^* = \phi_{voice}(F(c^*)) & \text{if } \overline{y} \leq L/n, \end{cases} \tag{15}$$

where

$$\zeta_{voice}(\tau) \equiv \Delta\left[1 - \frac{L/n - \underline{v}(1-\tau)}{\underline{v}(\frac{1-\beta}{\beta}(1-\tau)+\tau)+\Delta\tau}\frac{1-\beta+\beta\tau}{\tau}\right]. \tag{16}$$

Prices and trading strategies are characterized by Proposition 2.

There are two effects of common ownership on governance. First, the investor now owns 1 rather than n units in each firm, which reduces her monitoring incentives. This is the standard cost of diversification: it spreads an investor more thinly. The second is that it increases the investor's incentives to monitor for a given number of units held. We use the term "per-unit monitoring incentives" to refer to the second effect.

These incentives are stronger under common ownership for two reasons: it increases the payoff to monitoring and reduces the payoff to cutting and running. Under a small shock ($L/n \leq \underline{v}\,(1 - F\,(\Delta))$), we have a type-(i) equilibrium. In any type-(i) equilibrium, monitored firms are always retained and yield the investor $\overline{v}$; regardless of whether unmonitored firms are sold or retained, they yield her $\underline{v}$. As a result, the per-unit incentives to monitor are at the highest possible level of Δ, and so $\tau = F\,(\Delta)$. In particular, even if price informativeness is lower than under separate ownership (i.e. $\gamma > \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)}$), payoff precision is always higher – it is always at the maximum possible level – and it is payoffs that determine the investor's incentives. Under a moderate shock ($\underline{v}\,(1 - F\,(\Delta)) < L/n < \underline{v}$), we have a type-(ii) equilibrium where $(\overline{v}, L)$ is now pooled with $(\underline{v}, 0)$, which reduces (increases) the payoff to monitoring (not monitoring). Payoff precision (and thus governance) is lower than under small shocks, but remains higher than under separate ownership, since $(\overline{v}, L)$ is not pooled with $(\underline{v}, L)$. The most efficient type-(ii) equilibrium involves $\tau = F\,(c^{**}_{ii})$. Brav et al. (2006) find that stock prices fall by 4% if an activist hedge fund subsequently exits; our model predicts that this decline, and thus monitoring incentives, will be stronger under common ownership. Separately, when $F\,(\cdot)$ is low (i.e. monitoring costs are high), we are more likely to be in the small-shock case where governance is strongest under common ownership. Intuitively, the implicit commitment to monitor provided by common ownership is particularly important when the investor's appetite for monitoring is low in the first place.

Under a large shock ($\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} < L/n$), we have a type-(iii) equilibrium where $(\overline{v}, L)$ is pooled with both $(\underline{v}, 0)$ and $(\underline{v}, L)$. Upon a shock, the investor sells all firms to the same degree, and so receives the same price regardless of whether she has monitored. Payoff precision and price informativeness are the same as under separate ownership, and so per-unit monitoring incentives are also the same: equation $c^* = \phi_{voice}\,(F(c^*))$, which defines c^*_{iii}, is the same as (13), which defines $c^*_{so,voice}$, except without the coefficient n. The most efficient type-(iii) equilibrium involves $\tau = F\,(c^{**}_{iii})$.

For $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} < L/n < \underline{v}$, both type-(ii) and (iii) equilibria are sustainable and so either equilibrium may be the most efficient. Proposition 5 states that there exists $\underline{y}$ such that, if $L/n < \underline{y}$, the type-(ii) equilibrium is most efficient. There also exists $\overline{y} \geq \underline{y}$ such that, if $L/n \geq \overline{y}$, the type-(iii) equilibrium is most efficient; for $\underline{y} \leq L/n < \overline{y}$, either may be most

efficient.[18] The proof in Proposition 5 shows that, if $\beta \geq \frac{\underline{v}}{\underline{v}+\Delta}$, then $\underline{y} = \overline{y} = \underline{v}$, and so where the type-(ii) equilibrium exists, it is always the most efficient equilibrium.

Corollary 1 *(Common ownership, voice, threshold comparison): The monitoring threshold in the most efficient equilibrium, $c^{**}_{co,voice}$, is decreasing in L/n. The investor's per-unit monitoring incentives are strictly higher under common ownership than under separate ownership if $L/n < \underline{y}$, weakly higher if $\underline{y} \leq L/n < \overline{y}$, and the same if $L/n \geq \overline{y}$.*

The intuition for the effect of L/n is that the strength of governance depends on price informativeness. Common ownership improves price informativeness because it gives the investor a choice of which firms to sell upon a shock; thus, her trade is more driven by fundamental value and less driven by the shock. This choice is greatest when the shock is small, as she then only needs to sell bad firms. The larger the shock, the greater the extent to which she has to sell good firms, which leads to less informative prices.

The above discussion has concerned per-unit monitoring incentives, the benefit of common ownership. However, the investor's threshold, and thus governance, is also affected by the cost of common ownership described previously. Proposition 6 shows that, despite this cost, common ownership is still superior if the number of firms is sufficiently low, so that the decline in the number of units from n to 1 and thus the effect of being spread too thinly is small.

Proposition 6 *(Comparison of equilibria, voice): There exist $1 < \overline{n}$ and $L^* \geq \underline{v}(1 - F(\Delta))$ such that:*

(i) If $n > \overline{n}$ and $L > 0$ then any equilibrium under separate ownership is strictly more efficient than any equilibrium under common ownership.

(ii) For any $0 < L \leq L^*$ there is $1 < \underline{n}(L)$ such that if $1 < n < \underline{n}(L)$ then any equilibrium under common ownership is strictly more efficient than any equilibrium under separate ownership.

[18] The efficiency trade-off between type-(ii) and type-(iii) equilibria is as follows. The price at which an investor can sell a good firm is lower in a type-(iii) equilibrium ($\overline{p}_{so}(\tau) < \overline{p}_{co}(\tau)$), which increases the investor's incentives to monitor. However, lower prices also imply that the investor must sell more of a good firm upon a shock, which also allows her to sell more of a bad firm without being revealed; both forces decrease her incentives to monitor. The proof of Proposition 5 shows that, when β is small and L/n is large, the difference in prices is more important than the difference in quantities, and so the type-(iii) equilibrium is more efficient.

While Proposition 5 characterizes the most efficient equilibrium, alternative equilibria also exist. For example, if $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} \leq L/n < \underline{v}$, we could have a balanced exit equilibrium which leads to weaker governance than imbalanced exit. Even so, part (ii) of Proposition 6 shows that our main result continues to hold even when considering all equilibria. The reason is that less efficient equilibria can only differ for $L/n > \underline{v}(1 - F(\Delta))$: for $L/n \leq \underline{v}(1 - F(\Delta))$, payoff precision is maximized under *any* equilibrium. Even though equilibria may differ according to γ, the frequency with which a bad firm is retained, this only affects price informativeness and not payoff precision. Even if the investor retains a bad firm with a strictly positive probability $\gamma > 0$, her payoff from such a bad firm is $\underline{v}$; since good firms are retained under any equilibrium, her payoff from such firms is $\overline{v}$. Thus, the threshold is Δ in *any* equilibrium for which $L \leq \underline{v}(1 - F(\Delta))$.

Proposition 6 solves for the ownership structure that maximizes firm value. However, if the investor could endogenously choose ownership structure, she would select the one that maximizes her expected portfolio value minus monitoring costs (expected trading profits are zero under both structures): she only internalizes the effect of her monitoring on her z units rather than the entire firm. This result is given in Proposition 7:

Proposition 7 *(Investor's choice of equilibrium, voice): For any $0 < L \leq L^*$, there exists $1 < \underline{\underline{n}}(L) \leq \underline{n}(L)$ such that, if $1 < n < \underline{\underline{n}}(L)$, the investor's expected payoff net of monitoring costs under any equilibrium of common ownership is strictly higher than under any equilibrium under separate ownership.*

3 Extensions

3.1 Index Funds

To highlight the role of price informativeness in improving governance, we now consider the case of passive index funds, which Appel, Gormley, and Keim (2016) find engage in monitoring. The benefit of common ownership does not apply to such funds, because they always engage in balanced exit, and only if there are outflows (i.e. a liquidity shock): an index fund must raise exactly θ in revenue. As a result, she is unable to strategically sell bad firms more than good firms, and so her trades (and thus prices) are uninformative. Indeed, Corollary 2 shows that the per-unit monitoring incentives of an index fund are independent of ownership structure.

Corollary 2 *The per-unit monitoring incentives of the index fund are the same under any ownership structure. The monitoring threshold under common ownership,* $c^{**}_{co,voice,index}$*, is given by the solution of* $c^* = \xi\left(F(c^*)\right)$*, where*

$$\xi(\tau) \equiv \Delta\left[1 - \beta \min\left\{1, \frac{L/n}{\underline{v} + \tau\Delta}\right\}\right]. \tag{17}$$

Some commentators (e.g. Bhide (1993)) argue that the ability to cut and run reduces monitoring incentives. One may think that index funds may therefore have greater monitoring incentives than the active funds considered in the core model – since index funds cannot disproportionately sell bad firms, they are locked in to monitor. Our model shows that this need not be the case: if $L/n < \underline{v}(1-\tau)$ then $c^{**}_{co,voice} = \Delta > c^{**}_{co,voice,index}$, and so active funds monitor *more* than index funds. The intuition is twofold. First, the flipside of index funds' inability to cut-and-run – to disproportionately sell bad firms – is that they are also unable to disproportionately retain good firms if they suffer a shock. A shock forces them to sell good firms to the same extent as bad firms, reducing their payoff to monitoring. Second, the active fund's ability to cut and run means that, when L/n is small, she is unable to commit not to sell the worst assets in her portfolio, leading to a severe adverse selection problem upon selling and thus a powerful commitment to monitor.

3.2 Common Monitoring Cost

In our voice model, the investor trades on her private information on firm value. This stems from her private information on whether she has monitored, which in turn arises from her private information on her firm-specific monitoring cost. Appendix C.1 considers the case in which the monitoring cost is common knowledge, and monitoring instead increases firm value with a given probability, rather than with certainty. The investor's private information now stems from her knowledge of whether monitoring is successful and her monitoring intensity. The results continue to hold, and the models are very similar. Intuitively, common ownership improves governance by giving the investor greater flexibility over how she can trade on her private information. It does not matter whether this information is on the monitoring cost or the success and intensity of monitoring.

3.3 Fixed Payoff Upon Sale

Appendix C.2 considers the case in which the investor receives a fixed reservation payoff upon sale, independent of the effect that sale has on the firm's reputation. This model applies to the case of discontinuing a relationship, such as a bank terminating a lending relationship with a borrower, or a venture capital investor choosing not to invest in a future financing round.[19] Here, the investor receives her outside option regardless of how much she sells, and is thus unconcerned with her price impact. Nevertheless, the core results generally hold. It is no longer the case that the incentives to cut-and-run are lower under common ownership – doing so yields the fixed reservation payoff, regardless of ownership structure. However, the second channel through which common ownership improves monitoring incentives continues to hold: if the investor suffers a shock, and the shock is sufficiently small, she has a choice of which firms to sell under common ownership. She can thus retain monitored firms, and enjoy the full payoff to monitoring.

3.4 Heterogeneous Valuation Distributions

Appendix C.3 considers the case in which firms have different valuation distributions, and so information asymmetry Δ and thus the price impact of selling differs across firms. It remains the case that governance is stronger under common ownership with small shocks. Regardless of Δ and thus price impact, the investor always receive (weakly) more than $\underline{v}$ by selling a bad firm and less than $\overline{v}$ by selling a good firm, and thus is always better off by selling securities that she knows to be bad and retaining securities she knows to be good. Thus, regardless of whether Δ is constant or differs across firms, it remains the case that, if the shock is sufficiently small, common ownership allows the investor to fully retain good firms upon a small shock, and so a sale fully reveals that a firm is bad.

3.5 Spin-Offs and Mergers

Appendix C.4 applies our model to study the governance effects of spin-offs and mergers. After a spin-off, the investor holds stakes in two firms which she can trade independently; prior to the

[19] The latter application assumes that non-participation does not affect the value of the venture capital investor's original investment, for example because there is a large supply of available capital in the future financing round.

spin-off, she is effectively forced to trade both to the same degree.[20] The spin-off allows her to sell bad firms more and good firms less, strengthening governance; stock-financed mergers have the opposite effect. The theories of Aron (1991) and Habib, Johnsen, and Naik (1997) also point to separate security prices for each division as a channel via which spin-offs create value, but the benefits of separate security prices are not due to stronger governance. In addition, here it is separate trading, rather than only separate security prices, that is key – if the investor is an index fund, or if the divisions are perfectly correlated, the benefits do not arise.

4 Governance Through Exit

This section now endogenizes firm value as depending on an action taken by a manager rather than the investor. Each firm is now run by a separate manager ("he"), who takes action $a_i \in \{0,1\}$ at $t=1$. Examples of $a_i = 0$ include shirking, cash flow diversion, perk consumption, and empire building. We now refer to $a_i = 0$ as "shirking" and $a_i = 1$ as "working." A good (bad) firm is one in which the manager has worked (shirked). Action $a_i = 1$ imposes a cost $\widetilde{c}_i \in [0, \infty)$ on manager i, which is i.i.d. and privately observed by the manager prior to deciding his action. The effort cost $\widetilde{c}_i$ can also be interpreted as a private benefit from shirking.

Manager i's objective function is given by:

$$u_{M,i} = R\left(a_i\right) + \omega p_i - \widetilde{c}_i \cdot a_i. \tag{18}$$

The manager cares about firm value and also the $t=2$ security price; these price concerns are captured by ω.[21] If the security is equity, ω refers to stock price concerns, which are standard in theories of governance through exit and can stem from a number of sources introduced in prior work. Examples include takeover threat (Stein (1988)), concern for managerial reputation (Narayanan (1985), Scharfstein and Stein (1990)), or the manager expecting to sell his own securities at $t=2$ (Stein (1989)). To our knowledge, exit theories have not previously considered the potential application to debt securities. The manager may care about the short-term debt

[20] This is similar to Corollary 2, which analyzed index funds, but here the investor can choose to raise more than θ in revenue.

[21] An alternative objective function would be $u_{M,i} = \rho R\left(a_i\right) + \omega p_i - \widetilde{c}_i \cdot a_i$, where $\rho < 1$ captures the fact that the manager does not own the entire firm. This is equivalent to the objective function $u_{M,i} = R\left(a_i\right) + \frac{\omega}{\rho} p_i - \frac{\widetilde{c}_i}{\rho} \cdot a_i$. Thus, (18) is equivalent to a utility function in which the manager's weight on firm value is ρ, with his weight on the security price and cost of effort being normalized by ρ to economize on notation.

price, or the firm's reputation in debt markets, as it will affect the ease at which he can raise additional debt (e.g. Diamond (1989)).

The investor only trades, but unlike the trade-only model of Section 1, her trades improve governance by changing the manager's effort incentives. As in the trade-only model, she privately observes v_i under separate ownership and $\mathbf{v} \equiv [v_i]_{i=0}^n$ under common ownership, but neither she nor the market makers observe $\widetilde{\mathbf{c}} \equiv [\widetilde{c}_i]_{i=0}^n$. As before, the investor's utility is given by (1) under separate ownership and (2) under common ownership.

Since the intuition through which common ownership affects governance through exit turns out to be similar to the voice model, we defer the analysis of the threshold strategy, equilibrium under separate ownership, and equilibrium under common ownership (the analogs of Lemma 1 and Propositions 4 and 5 of the voice model) to Appendix D (Lemma 4 and Propositions 12 and 13), and move straight to the efficiency comparison. This is given in Proposition 8 below.

Proposition 8 *(Comparison of most efficient equilibrium, exit): The working threshold under the most efficient equilibrium, $c^{**}_{co,exit}$, is decreasing in L/n, strictly higher than under separate ownership if $L/n < \underline{v}$, and the same if $L/n \geq \underline{v}$.*

Proposition 8 states that, for a large shock ($L/n > \underline{v}$), governance is the same under both ownership structures; this is because prices and trading strategies are the same. For a small or moderate shock ($L/n < \underline{v}$), governance is strictly superior under the most efficient equilibrium under common ownership than under separate ownership. This is for two reasons. First, common ownership increases the punishment for shirking. Under separate ownership, exit is consistent with the investor suffering a liquidity shock and so a sold firm receives a relatively high price. Thus, the punishment for shirking is low. Here, under a small shock, exit is fully revealing of shirking and leads to the lowest possible price of $\underline{v}$. The greater punishment for shirking (lower price for the manager) is analogous to the lower price received by the investor from cutting and running under voice. Under a moderate shock, a bad firm is fully sold upon a shock and thus fully revealed. Second, common ownership increases the reward for working. Under separate ownership, a good firm is automatically sold under a shock, and so the reward for working is low. Under common ownership, it is retained upon a small shock and only partially sold upon a moderate shock. The greater reward for working is analogous to the higher payoff to monitoring under voice. Appendix D also analyzes other equilibria and the case in which the investor must pay to acquire information.

5 Conclusion

This paper has shown that common ownership can improve governance through both voice and exit, and by both equityholders and debtholders. The common channel is that common ownership gives the investor a diversified portfolio of good and bad firms. As a result, she has greater flexibility over which firms to sell, and will sell bad firms first. This intensifies the adverse selection problem – the sale of a firm is a stronger signal that it is bad, since if it were good and the investor had suffered a liquidity shock, she would have sold bad firms first. In addition to reducing the expected price for a bad firm, common ownership also increases the expected price for a good firm, since the investor may not have to sell it, or may only have to sell it partially, if she suffers a shock. Moreover, common ownership has a different effect from reducing the size of the liquidity shock or adding financial slack to the investor's portfolio.

In a voice model, this greater price informativeness enhances the investor's incentives to monitor. If she cuts and runs, she receives a low payoff due to severe adverse selection. If instead monitors, she is more likely to be able to retain the firm and thus enjoy the full value created by monitoring. In an exit model, greater price informativeness enhances the manager's incentives to work. If he shirks, the investor sells, which has a particularly negative price impact. If he works, he is more likely to be retained as the investor can sell other firms upon a shock. In both models, a smaller shock increases the investor's flexibility over which firms to sell, thus increasing price informativeness and the strength of governance under common ownership. The results suggest that centralizing ownership among a small number of investors may improve governance. On the other hand, consistent with conventional wisdom, common ownership is costly as it spreads the investor more thinly. In a voice model, this directly reduces her incentives to intervene; however, common ownership remains superior if the shock and number of firms are sufficiently small.

While we show that, if ownership structure were an endogenous choice of the investor, she would choose common ownership if the liquidity shock is sufficiently small, our results do not require the investor to choose ownership structure to deliberately maximize price informativeness (and thus governance) or even be cognizant of this effect of her ownership structure choice. Even if she chooses common ownership to reduce risk, our result suggest that diversification for private risk reduction reasons has a social benefit by improving governance. This result parallels the governance through exit literature, where the investor trades purely to maxi-

mize profits, but such trading has the side benefit of improving price informativeness and thus governance.

The core result of our trade-only model, that having private information over multiple assets worsens adverse selection, can be applied outside a trading context. Examples include a director's decision to quit a board, a firm's decision to exit or scale back a line of business, or an employer's decision to fire a worker. In all of these cases, the negative inference resulting from termination is attenuated is stronger if the decision-maker had many other relationships that she could have terminated instead.

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A Proofs of Main Results

This section contains proofs of our main results. Proofs of auxiliary results are in Appendix B.

A.1 Proofs of Section 1

Proof of Proposition 1. Let $x^*(v,\theta)$ be an equilibrium strategy for type-(v,θ). If the equilibrium involves mixed strategies, then $x^*(v,\theta)$ is a set. We start by proving that there is a unique $\overline{x}>0$ such that $x_i^*(\underline{v},L)=x_i^*(\underline{v},0)=x_i^*(\overline{v},L)=\overline{x}$. We argue six points:

1. If $x_i'\in x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$ then $x_i'>0$. By choosing $x_i=0$, type-$\underline{v}$ receives a payoff of $\underline{v}$. However, note that there is $x_i''>0$ s.t. $x_i''\in x_i^*(\overline{v},L)$. Therefore, $p_i\left(x_i''\right)>\underline{v}$ with positive probability. By choosing x_i'', type-$\underline{v}$ increases her revenue and obtains an expected payoff strictly greater than $\underline{v}$. Therefore, $0\notin x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$.

2. If $x_i'\in x_i^*(\overline{v},0)$ then $x_i'\notin x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$. Suppose not. Since $x_i'\in x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$, with positive probability $p_i\left(x_i\right)<\overline{v}$. Based on point 1, it must be $x_i'>0$. Since $x_i'>0$, type-$(\overline{v},0)$ will deviate to $x_i=0$, which generates a strictly higher payoff of $\overline{v}$.

3. If $x_i'\in x_i^*(\overline{v},0)$ then $x_i'\notin x_i^*(\overline{v},L)$. Suppose not. Based on point 2, $x_i'\in x_i^*(\overline{v},0)$ implies $x_i'\notin x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$. Therefore, $p_i\left(x_i'\right)=\overline{v}$ w.p. 1, and type-$(\overline{v},L)$ can satisfy her liquidity need by choosing x_i'. She chooses $x_i''\neq x_i'$ only if $p_i\left(x_i''\right)=\overline{v}$ w.p. 1. Thus, there is no $x_i''\in x_i^*(\overline{v},L)$ s.t. $x_i''\in x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$. Therefore, $p_i\left(x_i'''\right)=\underline{v}$ $\forall$ $x_i'''\in x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$ w.p. 1, and so type-$(\underline{v},\theta)$ receives a payoff of $\underline{v}$. However, type-$(\underline{v},0)$ can always choose x_i' and secure a payoff strictly larger than $\underline{v}$, since $p_i\left(x_i'\right)=\overline{v}$ w.p. 1. We conclude, if $x_i'\in x_i^*(\overline{v},0)$, then $x_i'\notin x_i^*(\overline{v},L)\cup x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$.

4. $x_i^*(\overline{v},L)=x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$. Suppose on the contrary there is $x_i'\in x_i^*(\overline{v},L)$ s.t. $x_i'\notin x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$. The contradiction follows from the same arguments as in point 3. Suppose on the contrary there is $x_i'\in x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$ s.t. $x_i'\notin x_i^*(\overline{v},L)$. Based on point 2, it must be $x_i'\notin x_i^*(\overline{v},0)$, and so $p_i\left(x_i'\right)=\underline{v}$ w.p. 1. Moreover, note that if $x_i''\in x_i^*(\overline{v},L)$ then $x_i''>0$ and $p_i\left(x_i''\right)>\underline{v}$ w.p. 1. However, type-$(\underline{v},0)$ can always choose x_i'' and secure a payoff strictly larger than $\underline{v}$, a contradiction.

5. If $x'\in x_i^*(\overline{v},0)$ then $x'<x''$ $\forall$ $x''\in x_i^*(\overline{v},L)\cup x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$. Suppose on the contrary there are $x'\in x_i^*(\overline{v},0)$ and $x''\in x_i^*(\overline{v},L)\cup x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$ s.t. $x'\geq x''$. Based on the previous points, $x'\notin x_i^*(\overline{v},L)\cup x_i^*(\underline{v},L)\cup x_i^*(\underline{v},0)$, and so $x'>x''$. Moreover, since

$x' \notin x_i^*(\underline{v}, L) \cup x_i^*(\underline{v}, 0)$, w.p. 1 $p_i(x') = \overline{v}$. However, type-$(\overline{v}, L)$ has a profitable deviation to x': she receives a payoff of $\overline{v}$ and also satisfies her liquidity need. Indeed, since $x' > x''$ and $x'' \in x_i^*(\overline{v}, L)$, then if the investor can satisfy her liquidity need by choosing x'', she can do so by choosing x'.

6. $x_i^*(\overline{v}, L)$ is a singleton (types-$(\overline{v}, L)$, $(\underline{v}, L)$, and $(\underline{v}, 0)$). Suppose on the contrary there are $x' < x''$ where $x', x'' \in x^*(\overline{v}, L)$. Since $\theta = L$ it must be $0 < x'$. Based on point 3, $x', x'' \in x_i^*(\underline{v}, L) \cup x_i^*(\underline{v}, 0)$, and so $p_i(x') \in (\underline{v}, \overline{v})$ and $p_i(x'') \in (\underline{v}, \overline{v})$. Since type-$(\overline{v}, L)$ must be indifferent between x' and x'', then

$$\begin{aligned} x'' p_i(x'') + (1 - x'')\overline{v} &= x' p_i(x') + (1 - x')\overline{v} \Leftrightarrow \\ (x'' - x')\left(p_i(x'') - \overline{v}\right) &= x'\left(p_i(x') - p_i(x'')\right). \end{aligned}$$

This implies $p_i(x') < p_i(x'')$. Since $x' < x''$, type-$\underline{v}$ strictly prefers x'' over x'. This implies that $x' \in x_i^*(\overline{v}, L) \backslash x_i^*(\underline{v}, L)$, a contradiction.

Given the claims above, Bayes' rule implies $p_i(\overline{x}) = \overline{p}_{so}(\tau)$. We prove that in any equilibrium that survives the Grossman and Perry (1986) refinement, $\overline{x} = \overline{x}_{so}(\tau)$. Suppose on the contrary that $\overline{x} > \frac{L}{\overline{p}_{so}(\tau)}$. Since the price function is non-increasing, there is $\varepsilon > 0$ such that $(\overline{x} - \varepsilon) p_i(\overline{x} - \varepsilon) \geq L/n$. This implies that type $(\overline{v}, L)$ will strictly prefer deviating to $\overline{x} - \varepsilon$, a contradiction. We conclude $\overline{x} \leq \overline{x}_{so}(\tau)$. Suppose on the contrary that $\overline{x} < \overline{x}_{so}(\tau)$. This implies that the investor does not raise L in equilibrium by selling $\overline{x}$. Consider a deviation where all types other than $(\overline{v}, 0)$ deviate from $\overline{x}$ to $\overline{x}_{so}(\tau)$. Given the deviation, the market maker will set $p(\overline{x}_{so}(\tau)) = \overline{p}_{so}(\tau)$. Therefore, all types who deviate raise strictly more revenue, and so are strictly better off. Since $\overline{p}_{so}(\tau) < \overline{v}$ type, $(\overline{v}, 0)$'s equilibrium payoff is still strictly higher than selling $\overline{x}_{so}(\tau)$ claims of the firm. Therefore, an equilibrium with $\overline{x} < \overline{x}_{so}(\tau)$ violates the Grossman and Perry (1986) refinement.

Next, note that in equilibrium it must be $x_i^*(\overline{v}, 0) > 0 \Rightarrow p_i(x_i^*(\overline{v}, 0)) = \overline{v}$. Since $x_i^*(\overline{v}, 0) = 0$, the price function given by (4) is consistent with (3) and is non-increasing. Note that (3) is incentive compatible given (4). First, the equilibrium payoff of type-$(\overline{v}, 0)$ is $\overline{v}$. Since $x_i > 0 \Rightarrow p_i^*(x_i) < \overline{v}$, type $(\overline{v}, 0)$ has no profitable deviation. Second, since $\overline{p}_{so}(\tau)\overline{x}_{so}(\tau) \leq L/n$ and $p_i^*(x_i)$ is flat on $(0, \overline{x}_{so}]$, deviating to $(0, \overline{x}_{so}]$ generates revenue strictly lower than L, and so is suboptimal if $\theta = L$. Moreover, since $x_i > \overline{x}_{so}(\tau) \Rightarrow p_i^*(x_i) = \underline{v}$, the investor has no optimal deviation to $x_i > \overline{x}_{so}(\tau)$, regardless of firm value. Last, it is easy to see that $x_i = \overline{x}_{so}(\tau)$ is

optimal for type-$(\underline{v}, 0)$. Before we conclude, we note that Lemma 2 proves that the equilibrium that is given by Proposition 1 satisfies the Grossman and Perry (1986) refinement. ■

Proof of Proposition 2. Suppose $L/n \leq \underline{v}(1-\tau)$. The investor can raise at least L by selling only bad firms, even if she receives the lowest possible price of $\underline{v}$. Since the investor is never forced to sell a good firm, she sells a positive amount $x_i' > 0$ from a good firm only if $p(x_i') = \overline{v}$, i.e. she does not sell x_i' from a bad firm. We first argue that, in any equilibrium, $x_i > 0 \Rightarrow p(x_i) < \overline{v}$. Suppose on the contrary there is $x_i' > 0$ s.t. $p(x_i') = \overline{v}$, and let x_i' be the highest quantity with this property. The investor chooses not to sell x_i' from a bad firm only if there is x_i'' that she chooses with strictly positive probability, where

$$x_i'' p_i(x_i'') + (1 - x_i'')\underline{v} \geq x_i' p_i(x_i') + (1 - x_i')\underline{v}. \tag{19}$$

The above inequality requires $p_i(x_i'') > \underline{v}$. Since she sells x_i'' from a bad firm with positive probability, we have $p_i(x_i'') < \overline{v}$. Given this price, she will never sell x_i'' from a good firm, contradicting $p_i(x_i'') > \underline{v}$. Therefore, she sells x_i' from a bad firm with strictly positive probability, which contradicts $p(x_i') = \overline{v}$. We conclude that in any equilibrium $x_i > 0 \Rightarrow p(x_i) < \overline{v}$, and so $v_i = \overline{v} \Rightarrow x_i = 0$. These conditions also imply $x_i > 0 \Rightarrow p(x_i) = \underline{v}$. Note that the condition on $\widetilde{\underline{x}}$ simply requires that in expectation (i.e. when the investor plays mixed strategies) she sells enough of the bad firms to meet her liquidity needs, given by the realization of θ. Last, $p^*(0)$ follows from Bayes' rule and the observation that $v_i = \overline{v} \Rightarrow x_i = 0$. This completes part (i).

Next, suppose $\underline{v}(1-\tau) < L/n$. We proceed by proving the following claims.

1. In any equilibrium there is a unique $\overline{x} > 0$ s.t. $x_i^*(\overline{v}, L) = x_i^*(\underline{v}, 0) = \overline{x}$. To prove this, suppose that in equilibrium, the investor is selling x_i'' and x_i' of a good firm when $\theta = L$ with strictly positive probability. Without loss of generality, suppose $x_i'' > x_i' \geq 0$. Since she must be indifferent between x_i'' and x_i',

$$x_i'' p(x_i'') - x_i' p(x_i') = \overline{v}(x_i'' - x_i') > 0. \tag{20}$$

   This condition implies that x_i'' generates strictly higher revenue than x_i'. It also achieves a higher payoff:

$$\begin{aligned} x_i'' p(x_i'') + (1 - x_i'')\underline{v} &> x_i' p(x_i') + (1 - x_i')\underline{v} \\ &\Rightarrow x_i'' p(x_i'') - x_i' p(x_i') > \underline{v}(x_i'' - x_i') > 0. \end{aligned}$$

Since x_i' is played with positive probability, but only when $v_i = \overline{v}$, then $p(x_i') = \overline{v}$. Combined with (20), this implies $p(x_i'') = \overline{v}$. Recall that $p_i(x_i^*(\overline{v}, 0)) = \overline{v}$. Therefore, the investor cannot sell $x_i^*(\overline{v}, \theta)$ of a bad firm. This in turn implies $p_i(x_i(\underline{v}, \theta)) = \underline{v}$ for $\theta \in \{0, L\}$, and so her payoff from selling a bad firm is always $\underline{v}$ in equilibrium. This creates a contradiction, since when $\theta = 0$, she can sell $x_i'' > 0$ of a bad firm and obtain $x_i''\overline{v} + (1 - x_i'')\underline{v} > \underline{v}$. We conclude that, in any equilibrium, there is a unique $\overline{x}$ such that the investor sells $\overline{x}$ of each good firm when $\theta = L$.

Since $\underline{v}(1 - \tau) < L/n$, it must be $\overline{x} > 0$. We denote $p_i(\overline{x}) = \overline{p}$. Since the investor sells $\overline{x}$ of a good firm with positive probability, $\overline{p} > \underline{v}$. We argue that, in any equilibrium, if $\theta = 0$ then she sells $\overline{x}$ of every bad firm. Suppose she sells a different quantity. Recall that $p_i(x_i^*(\overline{v}, 0)) = \overline{v}$ implies that she does not sell $x_i^*(\overline{v}, 0)$ of a bad firm in equilibrium. Since $x_i^*(\underline{v}, 0) \neq \overline{x}$ and $x_i^*(\underline{v}, 0) \neq x_i^*(\overline{v}, 0)$, we must have $p_i(x_i^*(\underline{v}, 0)) = \underline{v}$, which yields a payoff of $\underline{v}$. This creates a contradiction since she has strict incentives to deviate and sell $\overline{x}$ of a bad firm, thereby obtaining a payoff above $\underline{v}$. Note that this implies that $\overline{p} < \overline{v}$.

2. In any equilibrium, either $x_i^*(\underline{v}, L) = \overline{x}$ w.p. 1, or $x_i^*(\underline{v}, L) = 1$ w.p. 1, where $\overline{x}$ is defined as in Claim 1. To prove this, note that the investor cannot sell $x_i^*(\overline{v}, 0)$ of a bad firm in equilibrium. Therefore, if $x_i^*(\underline{v}, L) \neq \overline{x}$, then $p_i(x_i^*(\underline{v}, L)) = \underline{v}$. Suppose $x_i^*(\underline{v}, L) \neq \overline{x}$ and $x_i^*(\underline{v}, L) < 1$. Then, she can always deviate to fully selling a bad firm, and not selling some good firms, to keep revenue constant. Her payoff from selling a bad firm is no lower (since she previously received $\underline{v}$ for each bad firm), but by not selling some good firms, for which she previously received $\overline{xp} + (1 - \overline{x})\overline{v} < \overline{v}$, she increases her payoff. Therefore, $x_i^*(\underline{v}, L) \in \{\overline{x}, 1\}$. Suppose the investor chooses $x_i^*(\underline{v}, L) = 1$ with probability strictly between zero and one. Therefore, $p(1) = \underline{v} < \overline{p}$, and the investor chooses $x_i^*(\underline{v}, L) = 1$ with strictly positive probability only if $\overline{xp} < \min\{L/n, \tau\overline{xp} + (1 - \tau)\underline{v}\}$. That is, it must be that by selling $\overline{x}$ from all firms, she cannot raise revenue of at least L, and by selling $\overline{x}$ of all good firms and 1 of all bad firms, she can raise strictly more. This, however, implies the investor cannot be indifferent between 1 and $\overline{x}$, thereby proving that either $x_i^*(\underline{v}, L) = \overline{x}$ w.p. 1, or $x_i^*(\underline{v}, L) = 1$ w.p. 1, as required.

3. If in equilibrium $x_i^*(\underline{v}, L) = 1$ and $\overline{x} < 1$ then $L/n < \underline{v}$ and $\overline{x} = \overline{x}_{co}(\tau)$, as given by (7). To prove this, since $x_i^*(\underline{v}, L) = 1$ and $v_i = \overline{v} \Rightarrow x_i^* < 1$, $p_i(1) = \underline{v}$. Moreover, given claims 1 and 2, and by Bayes' rule, $\overline{p}$ is given by $\overline{p}_{co}(\tau)$, as given by (8). Suppose $\theta = L$. Since $\overline{p}_{co}(\tau) > \underline{v}$, the investor chooses $x_i^*(\underline{v}, L) = 1$ only if the revenue from selling $\overline{x}$ from all

firms is strictly smaller than L and also the revenue from selling $\overline{x}$ of all good firms and 1 from all bad firms, i.e.

$$\overline{xp}_{co}(\tau) < \min\{(1-\tau)\underline{v} + \tau\overline{xp}_{co}(\tau), L/n\} \Leftrightarrow \overline{xp}_{co}(\tau) < \min\{\underline{v}, L/n\}.$$

Intuitively, we require $\overline{xp}_{co}(\tau) < \underline{v}$, since the investor receives $\overline{xp}_{co}(\tau)$ by partially selling $\overline{x}$ of a bad firm for price $\overline{p}_{co}(\tau)$, and $\underline{v}$ by fully selling a bad firm for price $\underline{v}$. In equilibrium, she would only fully sell a bad firm if doing so raises more revenue.

We now prove that $(1-\tau)\underline{v} + \tau\overline{xp}_{co}(\tau) = L/n$, i.e. fully selling bad firms and selling $\overline{x}$ of good firms raises exactly L. We do so in two steps. We first argue that this strategy cannot raise more than L, i.e.

$$(1-\tau)\underline{v} + \tau\overline{xp}_{co}(\tau) \leq L/n. \tag{21}$$

Suppose not. Then, the investor has "slack": she can deviate by selling only $\overline{x}-\varepsilon$ instead of $\overline{x}$ from each good firm, while still meeting her liquidity need. Since prices are non-increasing, $p_i(\overline{x}-\varepsilon) \geq \overline{p}_{co}(\tau)$, and so for small $\varepsilon > 0$, she still raises at least L. Her payoff is strictly higher since she sells less from the good firms. We next argue that this strategy cannot raise less than L, i.e.

$$(1-\tau)\underline{v} + \tau\overline{xp}_{co}(\tau) \geq L/n. \tag{22}$$

Suppose not. If the strategy did not raise L, then it must be that $\underline{v} \leq (1-\tau)\underline{v} + \tau\overline{xp}_{co}(\tau)$, i.e. the alternative strategy of fully selling her entire portfolio raises even less revenue. Therefore, $\underline{v} \leq \overline{xp}_{co}(\tau)$, which contradicts $\overline{xp}_{co}(\tau) < \underline{v}$. Intuitively, if fully selling a firm for $\underline{v}$ raises less revenue than selling $\overline{x}$ of a firm for $\overline{p}_{co}(\tau)$, then the investor would not pursue the strategy of fully selling bad firms. Combining (21) and (22) yields

$$(1-\tau)\underline{v} + \tau\overline{xp}_{co}(\tau) = L/n$$

as required, implying $\overline{x} = \overline{x}_{co}(\tau)$, and $\overline{x}_{co}\overline{p}_{co}(\tau) < \underline{v}$ implies $L/n < \underline{v}$ as required.

4. If in equilibrium $x_i^*(\underline{v}, L) = \overline{x}$ then $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} \leq L/n$, $\overline{p} = \overline{p}_{so}(\tau)$ and $\overline{x} = \overline{x}_{so}/n$. To prove this, since prices are monotonic, we must have $\overline{xp} \leq L/n$. Otherwise, if $\theta = L$ the investor deviates by selling $\overline{x}-\varepsilon$ instead of $\overline{x}$ from a good firm. For small $\varepsilon > 0$,

she can raise the same amount of revenue and sell less from the good firms. Note that $x_i^*(\underline{v}, L) = \overline{x} \Rightarrow \overline{p} = \overline{p}_{so}(\tau)$. Suppose on the contrary that such an equilibrium exists and

$$L/n < \underline{v}\frac{1-\tau}{\beta\tau + 1 - \tau}.$$

We argue that there is an optimal deviation to fully selling all bad firms, and selling x' from good firms, for some $x' \in (0, \overline{x}]$. Since $\frac{L/n}{\underline{v}} < \frac{1-\tau}{\beta\tau+1-\tau} < 1$, she can always raise at least L by selling all firms. Therefore, it must be $\overline{x}\overline{p}_{so}(\tau) = L/n$. Moreover, $\overline{p}_{so}(\tau) > \underline{v} \Rightarrow \overline{x} < 1$. Since $\overline{x}$ is an equilibrium, $xp(x) < L/n$ for any $x < \overline{x}$. Let

$$x' = \frac{L/n - (1-\tau)\underline{v}}{\tau\overline{p}_{so}(\tau)}$$

Note that $L/n - (1-\tau)\underline{v} > 0$ implies $x' > 0$ and $\overline{x}\overline{p}_{so}(\tau) = L/n < \underline{v}$ implies $x' < \overline{x}$. By deviating to fully selling all bad firms and selling only $x' \leq \overline{x}$ from all good firms, the revenue raised is at least L. This deviation generates a higher payoff if and only if

$$x'\tau\overline{p}_{so}(\tau) + (1-x')\tau\overline{v} + (1-\tau)\underline{v} > \overline{x}\overline{p}_{so}(\tau) + (1-\overline{x})(\tau\overline{v} + (1-\tau)\underline{v})$$

Using $\overline{x}\overline{p}_{so}(\tau) = L/n$, $x' = \frac{L/n-(1-\tau)\underline{v}}{\tau\overline{p}_{so}(\tau)}$, and $\overline{p}_{so}(\tau) = \underline{v} + \Delta\frac{\beta\tau}{\beta\tau+1-\tau}$, we obtain $L/n < \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$, which implies that this deviation is optimal, a contradiction. We conclude that $L/n \geq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$ as required. Intuitively, if the shock were smaller, the investor would retain more of good firms. For the same reasons as in the benchmark, $\overline{x} = \overline{x}_{so}/n$.

Consider part (ii). We show that if $\underline{v}(1-\tau) < L/n < \underline{v}$ then the specified equilibrium indeed exists. First note that $L/n < \underline{v} \Rightarrow \overline{x}_{co}(\tau) < 1$. Second, note that the prices in (8) are consistent with the trading strategy given by (7). Moreover, the pricing function in (8) is non-increasing. Third, we show that given the price function in (8), the investor's trading strategy in (7) is indeed optimal. Suppose $\theta = 0$. Given (8), the investor's optimal response is $v_i = \overline{v} \Rightarrow x_i = 0$ and $v_i = \underline{v} \Rightarrow x_i = \overline{x}_{co}(\tau)$, as prescribed by (7). Suppose $\theta = L$. Given (8), the investor's most profitable deviation involves selling $\overline{x}_{co}$ from each bad firm, and the least amount of a good firm, such that she raises at least L. However, recall that by the construction of $\overline{x}_{co}(\tau)$, $(1-\tau)\underline{v} + \tau\overline{x}_{co}(\tau)\overline{p}_{co}(\tau) = L/n$. Also note that $L/n < \underline{v} \Rightarrow \overline{x}_{co}(\tau)\overline{p}_{co}(\tau) < L/n$. Therefore, the most profitable deviation generates a revenue strictly lower than L, and hence is suboptimal. This concludes part (ii).

Consider part (iii). We show that if $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} \leq L/n$ then the specified equilibrium indeed

exists. The proof is as described by Proposition 1, where $\overline{x}_{so}$ is replaced by $\overline{x}_{so}/n$. The only exception is that we note that as per the proof of Claim 4, the condition $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} \leq L/n$ guarantees that, if $\theta = L$, the investor has no profitable deviation. The proof that the investor has no profitable deviation when $\theta = 0$ is the same as in the proof of part (ii) above.

Finally, part (iv) follows from claims 1-4. ∎

A.2 Proofs of Section 2

We now move to the proofs of the statements in Section 2. Some of these proofs use auxiliary Lemma 3 in Appendix B.[22]

Proof of Lemma 1. For separate ownership, see the proofs of Proposition 4. For common ownership, recall that in equilibrium, $\tau^* \in \arg\max_{\tau\in[0,1]} \Pi(\tau^*, \tau)$, where $\Pi(\tau^*, \tau)$ is defined in Lemma 3. Since all firms are ex-ante identical, the investor will necessarily monitor the mass of $n\tau^*$ firms with the lowest monitoring costs. That is, the investor will monitor firm i if and only if $\widetilde{c}_i \leq F^{-1}(\tau^*)$, as required. ∎

Proof of Proposition 4. We solve for the investor's monitoring threshold. Note that even if the investor chooses $\tau \neq \tau^*$, she still faces prices as given by (4), where the market maker anticipates monitoring probability τ^*. Therefore, as in the proof of Proposition 1, the investor has incentives to follow the trading strategy prescribed by (3). She thus chooses $v_i = \overline{v}$ if and only if

$$\widetilde{c}_i/n \leq V_{so}(\overline{v}, \tau^*) - V_{so}(\underline{v}, \tau^*), \tag{23}$$

[22] In the proof of Lemma 3 and in the proofs below, we seemingly ignore the cost K the investor incurs when she does not satisfy her shock. This is without loss of generality. The Grossman and Perry (1986) refinement ensures that, if in equilibrium $\underline{v} + \tau^*\Delta \geq L/n$ (i.e. total portfolio value exceeds L, the region in which our main results hold), the investor sells exactly enough to satisfy her liquidity needs. Moreover, it also implies that, if in equilibrium $\underline{v} + \tau^*\Delta < L/n$, the investor sells her entire portfolio if she suffers a shock, and fully sells (retains) the bad (good) firms if she does not suffer a shock. In this case, the investor incurs the cost K whenever she suffers a shock. She is unable to avoid this by monitoring more: since her monitoring is unobserved by the market makers, it does not affect the prices she receives upon selling, and so will not allow her to meet the liquidity need.

where $V_{so}(v_i, \tau)$ is given in the proof of Proposition 3 by (28). This holds if and only if

$$\begin{aligned} \widetilde{c}_i/n &\leq \overline{v} - \beta \frac{\overline{x}_{so}(\tau^*)}{n}(\overline{v} - \overline{p}_{so}(\tau^*)) - \underline{v} - \frac{\overline{x}_{so}(\tau^*)}{n}(\overline{p}_{so}(\tau^*) - \underline{v}) \Leftrightarrow \\ \widetilde{c}_i/n &\leq \Delta\left[1 - \beta \frac{\overline{x}_{so}(\tau^*)}{n} \frac{1}{\beta\tau^* + 1 - \tau^*}\right] \Leftrightarrow \\ \widetilde{c}_i/n &\leq \phi_{voice}(\tau^*) \end{aligned}$$

Thus, the cutoff in any equilibrium must satisfy $c^*/n = \phi_{voice}(\tau^*)$. In equilibrium, $\tau^* = F(c^*)$, and hence, $c^*_{so,voice}$ must solve $c^*/n = \phi_{voice}(F(c^*))$, as required. Note that as a function of c^*, $\phi_{voice}(F(c^*))$ is strictly positive and bounded from above. Therefore, a strictly positive solution always exists. If $\Delta\beta - \underline{v}(1-\beta) \leq 0$, then $\phi_{voice}(F(c^*))$ is decreasing in c^* and so the solution is unique.[23] Note that since $V_{so}(v_i, \tau)$ is derived from Proposition 1, the equilibrium is characterized by Proposition 1, where τ is given by $\tau^*_{so,voice}$. The comparative statics are proven in Appendix B. ■

Proof of Proposition 5. We prove the result in three parts. First, suppose $\underline{v} \leq L/n$. Based on Proposition 2, the equilibrium must be type-(iii). Based on part (iii) of Lemma 3, the monitoring threshold must solve $c^* = \phi_{voice}(F(c^*))$. Note that $\phi_{voice}(F(c))$ is continuous, $\phi_{voice}(F(0)) = \Delta(1-\beta)$ and $\phi_{voice}(1) = \Delta(1 - \min\{\frac{L/n}{\underline{v}+\Delta}, 1\})$, and hence, by the intermediate value theorem, a solution always exists. Given a threshold that satisfies $c^* = \phi_{voice}(F(c^*))$, by construction there is a type-(iii) equilibrium with this threshold.

Second, suppose $L/n \leq \underline{v}(1 - F(\Delta))$. Based on Lemma 3, in any equilibrium the threshold is smaller than Δ. Therefore, $L/n \leq \underline{v}(1-\tau^*)$, and from Proposition 2, the equilibrium must be type-(i). From part (i) of Lemma 3, and since $L/n \leq \underline{v}(1 - F(\Delta)) \Rightarrow \Delta \leq 1 - F^{-1}\left(1 - \frac{L/n}{\underline{v}}\right)$, we have $c^* = \Delta$. By construction, there is a type-(i) equilibrium with such a threshold.

Third, suppose $\underline{v}(1 - F(\Delta)) < L/n < \underline{v}$. We first analyze which equilibria are sustainable in this range, and then compare the efficiency of the sustainable equilibria. Starting with the first step, we prove that if $\underline{v}(1 - F(\Delta)) < L/n < \underline{v}$, there always exists a type-(ii) equilibrium where the monitoring threshold is given by part (ii) of Lemma 3, i.e. the largest solution of $c^* = \zeta_{voice}(F(c^*))$. In particular, it is sufficient to show that $c^* = \zeta_{voice}(F(c^*))$ has a solution such that $F^{-1}\left(1 - \frac{L/n}{\underline{v}}\right) < c^*$ (which is equivalent to $\underline{v}(1-\tau^*) < L/n$). In-

[23]For the comparative statics we restrict attention to stable equilibria, i.e. ones for which $n\phi_{voice}(F(c^*))$ crosses the 45-degree line from above.

deed, when $c^* = F^{-1}\left(1 - \frac{L/n}{\underline{v}}\right)$ then $\zeta_{voice}(F(c^*)) = \Delta$. Since $\underline{v}(1 - F(\Delta)) < L/n$, then $c^* = F^{-1}\left(1 - \frac{L/n}{\underline{v}}\right) \Rightarrow \zeta_{voice}(F(c^*)) > F^{-1}\left(1 - \frac{L/n}{\underline{v}}\right)$. Furthermore, when $F(c^*) = 1$ then $\zeta_{voice}(F(c^*)) = \Delta\left[1 - \frac{L/n}{\underline{v}+\Delta\tau}\right] < \infty$, since $F(c^*) = \tau^* = 1$. Since $\zeta_{voice}(F(c^*))$ is continuous in c^*, by the intermediate value theorem, a solution strictly greater than $F^{-1}\left(1 - \frac{L/n}{\underline{v}}\right)$ always exists. By construction, there is a type-(ii) equilibrium with such a threshold.

We now move to the efficiency comparison. We first show that, for $\underline{v}(1 - F(\Delta)) < L/n < \underline{v}$, any type-(i) equilibrium is less efficient than a type-(ii) equilibrium. Based on Lemma 3, if the equilibrium is type-(i), then $c^* = \min\left\{\Delta, F^{-1}(1 - \frac{L/n}{\underline{v}})\right\}$. However, $\underline{v}(1 - F(\Delta)) < L/n$ implies $c^* = F^{-1}(1 - \frac{L/n}{\underline{v}}) < c^*_{ii}$.

Next, consider type-(iii) equilibria. When $L/n < \underline{v}$, such equilibria exhibit $\overline{x}^*\overline{p}^* = L/n$, where $\overline{p}^* = \underline{v} + \Delta\frac{\beta\tau}{\beta\tau+1-\tau}$. Therefore, whenever these equilibria exist,

$$\phi_{voice}(\tau) \equiv \Delta\left[1 - \beta\frac{L/n}{\underline{v} + (\Delta\beta - \underline{v}(1-\beta))\tau}\right].$$

Note that $\zeta_{voice}(\tau) > \phi_{voice}(\tau)$ if and only if

$$\Delta\left[1 - \frac{L/n - \underline{v}(1-\tau)}{\underline{v}\left(\frac{1-\beta}{\beta}(1-\tau) + \tau\right) + \Delta\tau}\frac{1-\beta+\beta\tau}{\tau}\right] \;>\; \Delta\left[1 - \beta\frac{L/n}{\underline{v} + (\Delta\beta - \underline{v}(1-\beta))\tau}\right] \Leftrightarrow$$
$$\left(\frac{1-\beta}{1-\beta+\beta\tau} + \frac{\beta\tau}{1-\beta+\beta\tau}\frac{\underline{v}}{\underline{v} + (\Delta\beta - \underline{v}(1-\beta))\tau}\right)L/n \;<\; \underline{v}. \tag{24}$$

Also note that

$$1 \geq \frac{1-\beta}{1-\beta+\beta\tau} + \frac{\beta\tau}{1-\beta+\beta\tau}\frac{\underline{v}}{\underline{v} + (\Delta\beta - \underline{v}(1-\beta))\tau} \Leftrightarrow \beta \geq \frac{\underline{v}}{\underline{v}+\Delta}.$$

Therefore, if $\beta \geq \frac{\underline{v}}{\underline{v}+\Delta}$, then (24) always holds, which implies that the most efficient equilibrium is type-(ii). In this case, $\underline{y} = \overline{y} = \underline{v}$. In other words, whenever a type-(ii) equilibrium exists (i.e. $\underline{v}(1 - F(\Delta)) < L/n < \underline{v}$), it is the most efficient equilibrium.

Suppose $\beta < \frac{\underline{v}}{\underline{v}+\Delta}$. Note that (24) is equivalent to $\Lambda(\tau) < 0$, where

$$\Lambda(\tau) = \tau^2 - \tau\left[\frac{\frac{\underline{v}}{\Delta+\underline{v}}}{\frac{\underline{v}}{\Delta+\underline{v}}-\beta} - \frac{1-\beta}{\beta}\right]\frac{\underline{v}-L/n}{\underline{v}} - \frac{1-\beta}{\beta}\frac{\frac{\underline{v}}{\Delta+\underline{v}}}{\frac{\underline{v}}{\Delta+\underline{v}}-\beta}\frac{\underline{v}-L/n}{\underline{v}}$$

Note that $\min\Lambda(\tau) < 0$. Also, recall $\underline{v}(1 - \tau^{**}_{ii}) < L/n$. Therefore, it is sufficient to focus

on $\underline{v}(1-\tau) < L/n \Leftrightarrow \frac{\underline{v}-L/n}{\underline{v}} < \tau$. It can be verified that $\Lambda\left(\frac{\underline{v}-L/n}{\underline{v}}\right) < 0$. Therefore, there is $\hat{\tau} > \frac{\underline{v}-L/n}{\underline{v}}$ such that $\Lambda(\tau) \geq 0 \Leftrightarrow \tau \geq \hat{\tau}$ where $\hat{\tau}$ is the largest root of $\Lambda(\tau)$, given by

$$\hat{\tau} = \frac{1}{2}\frac{\underline{v}-L/n}{\underline{v}}\left(\frac{\frac{\underline{v}}{\Delta+\underline{v}}}{\frac{\underline{v}}{\Delta+\underline{v}}-\beta} - \frac{1-\beta}{\beta}\right) + \frac{1}{2}\frac{\underline{v}-L/n}{\underline{v}}\sqrt{\left(\frac{\frac{\underline{v}}{\Delta+\underline{v}}}{\frac{\underline{v}}{\Delta+\underline{v}}-\beta} - \frac{1-\beta}{\beta}\right)^2 + 4\frac{1-\beta}{\beta}\frac{\frac{\underline{v}}{\Delta+\underline{v}}}{\frac{\underline{v}}{\Delta+\underline{v}}-\beta}\frac{\underline{v}}{\underline{v}-L/n}}. \tag{25}$$

Note that a type-(iii) equilibrium requires

$$\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} < L/n \Leftrightarrow \frac{1}{1+\frac{L/n}{\underline{v}-L/n}\beta} < \tau$$

where $\frac{\underline{v}-L/n}{\underline{v}} < \frac{1}{1+\frac{L/n}{\underline{v}-L/n}\beta}$. Also note that $\tau^* < F(\Delta)$ in both a type-(ii) and type-(iii) equilibrium. Therefore, the relevant range is $\frac{1}{1+\frac{L/n}{\underline{v}-L/n}\beta} \leq \tau \leq F(\Delta)$. This interval is non-empty if and only if

$$\frac{\underline{v}}{1+\frac{F(\Delta)}{1-F(\Delta)}\beta} < L/n \Leftrightarrow \frac{\underline{v}-L/n}{L/n}\frac{1-F(\Delta)}{F(\Delta)} < \beta.$$

Note that $\underline{v}(1-F(\Delta)) < \frac{\underline{v}}{1+\frac{F(\Delta)}{1-F(\Delta)}\beta}$ for all β. Since $\beta < \frac{\underline{v}}{\underline{v}+\Delta}$ if $L/n < \frac{\underline{v}}{1+\frac{F(\Delta)}{1-F(\Delta)}\frac{\underline{v}}{\underline{v}+\Delta}}$, the most efficient equilibrium is type-(ii). This establishes the existence of $\underline{y}$, the threshold below which a type-(ii) equilibrium is most efficient.

Suppose

$$\frac{\underline{v}-L/n}{L/n}\frac{1-F(\Delta)}{F(\Delta)} < \beta < \frac{\underline{v}}{\underline{v}+\Delta}. \tag{26}$$

If $\beta < \frac{\underline{v}}{\underline{v}+\Delta}$, then $\phi_{voice}(\tau)$ is a decreasing function, and so τ^{**}_{iii}, given by the solution of $\tau = F(\phi_{voice}(\tau))$, is unique. Therefore, the equilibrium with τ^{**}_{iii} is most efficient if and only if

$$\max\left\{\frac{1}{1+\frac{L/n}{\underline{v}-L/n}\beta}, \hat{\tau}\right\} < \tau^{**}_{iii}.$$

In Lemma **??** in Appendix B we show that $\hat{\tau} \geq \frac{1}{1+\frac{L/n}{\underline{v}-L/n}\beta}$. Therefore, τ^{**}_{iii} is most efficient only if $\hat{\tau} < \tau^{**}_{iii}$ and $\beta < \frac{\underline{v}}{\underline{v}+\Delta}$, i.e.

$$\frac{\frac{\underline{v}}{\Delta+\underline{v}}}{\frac{\underline{v}}{\Delta+\underline{v}}-\beta} < \tau^{**}_{iii}\frac{\frac{1-\beta}{\beta}+\tau^{**}_{iii}\frac{\underline{v}}{\underline{v}-L/n}}{\frac{1-\beta}{\beta}+\tau^{**}_{iii}}.$$

Note that $\lim_{L/n \to \underline{v}} \tau^{**}_{iii} > 0 = \lim_{L/n \to \underline{v}} \hat{\tau}$. By continuity, there is $\overline{y} \in [\underline{y}, \underline{v})$ such that, if $L/n > \underline{y}$, the most efficient equilibrium is type-(iii). This completes the proof. ■

Proof of Corollary 1. Recall from Proposition 5 that

$$c^{**}_{co,voice} = \begin{cases} \Delta & \textit{if } L/n \leq \underline{v}\,(1 - F\,(\Delta)) \\ \max\{c^{**}_{ii}, c^{**}_{iii}\} & \textit{if } \underline{v}\,(1 - F\,(\Delta)) < L/n < \underline{v} \\ c^{**}_{iii} & \textit{if } \underline{v} \leq L/n. \end{cases} \tag{27}$$

It is straightforward to see that $\phi_{voice}(\cdot)$ and $\zeta_{voice}(\cdot)$ are decreasing in L/n. Our focus on stable equilibria (the RHS of equations $c = \phi_{voice}(F(c))$ and $c = \zeta_{voice}(F(c))$ cross the 45-degree line from above) implies that c^{**}_{ii} and c^{**}_{iii} are decreasing in L/n. Therefore, $\max\{c^{**}_{ii}, c^{**}_{iii}\}$ is also decreasing in L/n. Finally, note that $\Delta > \max\{c^{**}_{ii}, c^{**}_{iii}\} \geq c^{**}_{iii}$. Therefore, $c^{**}_{co,voice}$ is globally decreasing in L/n.

The second statement follows directly from Proposition 5, the observation that $c^{**}_{co,voice} = c^{**}_{so,voice}$ when $n = 1$ and $c^{**}_{co,voice} = c^{**}_{iii}$, where $c^{**}_{so,voice}$ is the largest solution of $c^*/n = \phi_{voice}(F(c^*))$. ■

Proof of Proposition 6. Let $c^*_{so}(n, L)$ be a solution of $c^* = n\phi_{voice}(F(c^*))$ that constitutes a stable equilibrium (i.e., $n\phi_{voice}(F(c^*))$ crosses the 45 degree line from above) under separate ownership. Note that $n\phi_{voice}(F(\cdot))$ is strictly increasing in n. Therefore, $c^*_{so}(n, L)$ locally increases in n as well. Since for a given c^* we have $\lim_{n\to\infty} n\phi_{voice}(F(c^*)) = \infty$, $\lim_{n\to\infty} c^*_{so}(n, L) = \infty$ as well. In addition, $c^*_{so}(1, L) < \Delta$. It follows that there is $\overline{n} > 1$ such that if $n > \overline{n}$ then the smallest solution of $c^* = n\phi_{voice}(F(c^*))$ is strictly greater than Δ. Since $c^{**}_{co,voice} \leq \Delta$, if $n > \overline{n}$ then any equilibrium under separate ownership is strictly more efficient than any equilibrium under common ownership. This completes part (i).

Consider part (ii). Since $\phi_{voice}(F(c^*)) < \Delta$, there is $\underline{n}(L) > 1$ such that the largest solution of $c^* = n\phi_{voice}(F(c^*))$, denoted by $\overline{c}^*_{so}(n, L)$, is strictly smaller than Δ if $n < \underline{n}(L)$. Note that $\underline{n}(L)$ satisfies $\overline{c}^*_{so}(\underline{n}(L), L) = \Delta$. Recall from Lemma 3 part (i) that, if $L/n \leq \underline{v}(1 - \tau^*)$, then $c^* = \Delta$ in *any* equilibrium under common ownership. Based on Proposition 5, in any equilibrium under common ownership $\tau^* \leq F(\Delta)$. Therefore, if $L/n \leq \underline{v}(1 - F(\Delta))$ then $c^* = \Delta$ in *any* equilibrium under common ownership. Since an equilibrium under common ownership always exists according to Proposition 5, we conclude that if $n < \underline{n}(L)$ and $L \leq$

$\underline{v}\left(1-F\left(\Delta\right)\right)$ then indeed any equilibrium under common ownership is strictly more efficient than any equilibrium under separate ownership. Therefore, there exists $L^{*}\geq\underline{v}\left(1-F\left(\Delta\right)\right)$ as required. ■

Proof of Proposition 7. Given threshold c and number of firms n, the investor's net payoff under separate and common ownership, respectively, are

$$\begin{aligned}\Pi_{so,voice}\left(n,c\right) &= n\left(\underline{v}+F\left(c\right)\Delta\right)-F\left(c\right)E\left[c_{i}|c_{i}<c\right]\\ \Pi_{co,voice}\left(n,c\right) &= n\left(\underline{v}+F\left(c\right)\Delta\right)-nF\left(c\right)E\left[c_{i}|c_{i}<c\right].\end{aligned}$$

Note that $\Pi_{co,voice}\left(1,c\right)=\Pi_{so,voice}\left(1,c\right)$ for any fixed c, that $\Pi_{co,voice}\left(n,c\right)$ and $\Pi_{so,voice}\left(n,c\right)$ have a unique maximum at Δ and $n\Delta$ respectively, and that in any equilibrium $c^{*}_{so,voice}\leq\Delta$ and $c^{*}_{co,voice}<n\Delta$. Moreover, under the conditions of part (ii) of Proposition 6, $c^{*}_{so,voice}<c^{*}_{co,voice}$ under any equilibrium of common and separate ownership. ■