The Effect of Diversification on Price Informativeness and Governance*

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Abstract

This paper shows that an asset's price informativeness and fundamental value depends on an informed investor's holdings of other, potentially unrelated, assets. If an asset is sold by a concentrated owner, the price decline is low since the sale may be motivated by a liquidity shock. A diversified owner has the choice of which assets to sell upon a shock. Thus, a sale is more revealing of poor asset quality, increasing price informativeness and strengthening governance through both exit (since the price decline upon a sale is greater) and voice (since the payoff from "cutting and running" is lower). Therefore, diversification may strengthen governance, in contrast to conventional wisdom that it necessarily weakens it by spreading an investor too thinly. Similarly, common ownership may have a positive real effect by improving governance, potentially offsetting any negative effect on consumers.

KEYWORDS: Corporate governance, banks, blockholders, monitoring, intervention, exit, trading, common ownership.

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This paper analyzes how an asset's price informativeness and fundamental value depend on an informed investor's holdings of other assets, even if they are unrelated. We show that, if a seller is diversified, a sale is more likely to be driven by information than a liquidity shock, and thus transmits more information into prices. We then endogenize asset values, demonstrating an application of our model to corporate governance. By enhancing price informativeness, diversification enhances governance through both exit (since a manager who shirks suffers a lower stock price) and voice (since an investor who sells rather than monitors receives a lower sale price). Our model thus introduces a common channel through which diversification may strengthen governance, in contrast to conventional wisdom that it necessarily weakens it by spreading an investor too thinly. Similarly, common ownership – where an investor holds stakes in multiple firms – may strengthen governance, and this strengthening arises even if the firms are in different industries. Thus, our paper identifies a channel through which common ownership has a positive real effect, in contrast to existing literature which highlights its potentially detrimental effect on consumers.

We start with a model in which asset values and private information are exogenous. The model features a seller who owns a portfolio of assets, such as a bank who owns loans, a shareholder who owns stock, or a headquarters who owns businesses. She subsequently learns private information on asset value, which can be high or low. She may also suffer a privately-observed liquidity shock that forces her to raise a given dollar amount of funds, although she may choose to sell more, or to sell even absent a shock. Examples include an alternative investment opportunity or withdrawals by her end depositors or investors. Based on her private information and liquidity need, she retains, partially sells, or fully sells her stake. The asset price is set by a competitive buyer, such as a market maker, who observes the seller's trade but not asset value.

As a benchmark, we analyze a concentrated portfolio where a seller owns n units of a single asset. If the asset turns out to be good (i.e., high-value) but the seller suffers a liquidity shock, she is forced to partially sell it. Thus, if the asset turns out to be bad (i.e., low-value), the seller sells it by the same amount, to disguise the sale as motivated by a shock. As a result, a bad asset does not command too low a price – adverse selection is mild – and a good asset does not always command a high price as it is sometimes sold and pooled with bad assets. Thus, price informativeness is relatively low.

Under a diversified portfolio, the seller owns one unit in each of n uncorrelated assets.Each asset is traded with a separate buyer, who observes trading in only that asset. The key effect of diversification is that it gives the seller both good and bad assets, and thus the choice of which assets to sell upon a shock. If the shock is small, she can satisfy it by selling only bad assets. Then, being sold is inconsistent with the asset being good and the sale being driven purely by a shock, and so fully reveals the asset as bad. For example, Warren Buffett's disposal of Exxon Mobil and ConocoPhillips in late 2014 but not Suncor Energy was viewed by the market as a negative signal on the sold companies in particular, rather than purely due to a shock (e.g., investment opportunities suddenly appearing in non-energy sectors). More broadly, Huang, Ringgenberg, and Zhang (2016) show that mutual funds sell their worst assets first upon a liquidity shock, Maksimovic and Phillips (2001) show that conglomerates tend to sell their least efficient plants, and Berndt and Gupta (2009) find that borrowers whose loans are sold in the secondary market underperform their peers. In contrast, a good asset is retained even upon a shock, and thus receives a high price. Overall, price informativeness is higher under diversification than under concentration, and decreases with the size of the liquidity shock. Intuitively, smaller shocks increase the seller's flexibility over which assets to sell upon a shock, and so being sold is a greater signal that the asset is bad.

The effect of diversification arises even though the seller is risk-neutral, and even though the buyer does not observe the seller's trades in other assets. Merely knowing that she has other assets in her portfolio, that she could have sold upon a shock, is sufficient for the buyer to give a low price to a sold asset. In addition, we demonstrate how diversifying by adding additional risky assets to the seller's portfolio is critically different from adding financial slack, i.e., liquid assets (such as Treasury bills) on which the seller has no private information or borrowing capacity.

This baseline model has a number of implications. The price decline upon a sale is stronger when an informed seller owns multiple assets. The "price" can refer either to a trading price, or market perceptions of quality. If a bank sells a loan, the borrower's perceived creditworthiness falls more if the bank had other loans it could have sold instead. 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.

We then endogenize asset values to analyze the real effects of diversification. Doing so demonstrates an application of our model to corporate governance. Now, the value of each asset depends on an effort decision by a manager – for example, the asset may be equity or debt in a firm. If the firm's manager works, the asset is good, else it is bad. The manager is concerned with both fundamental value and the short-term asset price. The threat of selling, and thus suffering a low asset price ex post, induces effort ex ante, as in the "governance through exit" models of Admati and Pfleiderer (2009) and Edmans (2009). Under a concentrated portfolio, effort incentives are low. If the manager works, the seller may suffer a shock and be forced to sell. Thus, the manager suffers a low stock price – the reward for working is low. If the manager shirks, his firm is sold, but he does not suffer too low a price, because the sale is also consistent with a shock – the punishment for shirking is also low. Under diversification, the reward for working is higher, because the manager's firm need not be sold upon a shock. In addition, the punishment for shirking is now higher since being sold is more revealing of shirking. Overall, our model demonstrates that diversification can improve governance through exit.

A second application is to "governance through voice", where the action is now taken by the seller herself. This applies to the case in which the seller is an investor who engages in monitoring. As shown by Kahn and Winton (1998) and Maug (1998), monitoring incentives are low under a concentrated portfolio for two reasons. If the investor monitors, she may suffer a shock that forces her to sell prematurely, reducing her payoff to monitoring; if she does not monitor, she may sell ("cut-and-run"), which yields a relatively high price since the sale is also consistent with a shock. Under diversification, an investor does not have to fully sell a monitored firm even if she suffers a shock, increasing the payoff to monitoring, and suffers a low price if she cuts-and-runs. On the other hand, diversification reduces the investor's stake in an individual firm, and thus the incentives to monitor. Despite diversification spreading an investor more thinly, governance may still improve overall.

Overall, our result that diversification can improve governance (through exit or voice) sheds light on the implications of common ownership – investors holding stakes in multiple firms – as has been recently documented. While some argue that common ownership leads to anti-competitive behavior, it may improve governance. Indeed, the higher prices documented by Azar, Schmalz, and Tecu (2017) may result from superior product quality or more efficient pricing rather than anti-competitiveness. Moreover, common ownership affects real outcomes even if the firms are unrelated, i.e. are not product market competitors. Relatedly, that diversification may strengthen governance has the potential to justify why ownership structures where shareholders own blocks in multiple firms can survive, even though they exacerbate the free-rider problem. Existing justifications are typically based on diversification of risk. While conventional wisdom might suggest that the diversification induced by risk concerns necessarily weakens governance, our model highlights an opposing force. Indeed, Kang, Luo, and Na (2017) find that institutional investors are more effective at governance the more blocks they have in other companies, controlling for portfolio size.

We extend our model to the case of endogenous information acquisition. Now, the seller is no longer endowed with information about asset values, but pays a cost to acquire it. One might think that the seller acquires less information under diversification, not only because prices are more informative but also because she can use information to sell only 1 rather than n units in each asset – she is spread more thinly. We show that information acquisition may actually be higher under diversification. The intuition is as follows. Under concentration, if the seller suffers a shock, she is forced to partially sell her only asset. Knowing whether the asset is good or bad has no value, since she is forced to sell it either way. Under diversification, information tells her which assets are good and bad, and so she is able to satisfy the shock by selling only bad assets. This advantage is particularly important if the shock is likely, and also small so that the seller has a choice of which assets to sell. In a second extension, we allow for information asymmetry (the difference in valuation between good and bad assets), and thus the price impact of selling or liquidity, to differ across assets, and show the results continue to hold.

Our paper is related to two literatures. The first is on the price impact of sales, starting with the adverse selection model of Akerlof (1970) and surveyed by Tirole (2011). This literature has shown how price informativeness depends on a number of characteristics of the asset in question.[1] Our results suggest that price informativeness also depends on other, unrelated assets owned by the same seller. The comparison with the classic microstructure models of Glosten and Milgrom (1985) and Kyle (1985) leads to an interesting intuition. Unlike in those papers, there are no separate noise traders in our setting, but the liquidity shock can be thought of as effectively creating a noise trader – the seller in the liquidity-shock state, with whom the investor is camouflaging. Diversification reduces this camouflage, since a shocked seller now has

[1] Examples include the presence of noise traders (Glosten and Milgrom (1985), Kyle (1985)), randomness in asset supply (Grossman and Stiglitz (1980)), the amount of information the seller (Hirshleifer (1971)) and potential purchasers (Plantin (2009)) have about the asset, limited capital among potential informed purchasers (Gromb and Vayanos (2002)), the information sensitivity of the asset (Myers and Majluf (1984), Gorton and Pennacchi (1990)), the amount that the seller retains of the asset (Leland and Pyle (1977)), future adverse selection in the same asset (Bolton, Santos, and Scheinkman (2009)), and the chain of intermediation between buyers and sellers (Glode and Opp (2016)).

flexibility over what to sell. She is an informed trader, not a noise trader, and so diversification effectively remove the noise trader from the model. As a result, an unshocked investor cannot pretend that her trades are not driven by information.

Closest to our paper are models where price informativeness depends on the probability that the seller trades for non-informational reasons such as an alternative investment opportunity (Myers and Majluf (1984)), diversification (Eisfeldt (2004)) or liquidity shocks (Diamond and Verrecchia (1991)). However, these papers only consider a single asset. Admati (1985), Caballé and Krishnan (1994), Pasquariello (2006), and He (2009) study multi-asset trading models. In those papers, the buyer can learn about asset i's payoff by observing the seller's trade in asset j which is correlated.[2] Here, asset j is relevant even though it is uncorrelated, and even if the buyer cannot observe the trade in asset j. DeMarzo (2005) studies an informed seller's incentives to pool assets before selling securities backed by them. Doing so is analogous to a concentrated portfolio in our model, since pooling does not allow the seller to divest one asset disproportionately. All of these models feature no liquidity shock and thus do not study how multi-asset ownership affects how the investor trades upon a shock, and thus the extent to which she can camouflage her trades upon no shock.

Our paper also 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)). While McCahery, Sautner, and Starks (2016) find that institutional investors use both governance mechanisms frequently, most theories analyze only one.[3] These literatures have been developed relatively independently, with quite different frameworks, and the determinants of each mechanism are different. We identify a common channel through which diversification can strengthen both mechanisms – increased price informativeness – and model both using a unified framework. In doing so, we also extend governance models to multiple firms. In reality, investors hold sizable stakes in several firms – shareholders own multiple blocks and banks lend large amounts to multiple borrowers – but most governance models

[2] Technically, in Admati (1985) there is no dedicated buyer; however, all agents can condition their order flow on the prices of all traded assets.

[3] Edmans and Manso (2011), Fos and Kahn (2015), and Levit (2017) feature both mechanisms, but model each using quite different frameworks.

consider a single firm.[4]

1 The Model

This section considers a trading model in which asset values are exogenous, to highlight the effect of portfolio diversification on price informativeness. Section 2 endogenizes asset values.

1.1 Setup

We consider two versions of the model. The first is a preliminary benchmark of a concentrated portfolio. A single seller ("she") owns a continuum of units of a single asset, of mass n. The second version is the main model of a diversified portfolio, where the seller owns one unit in each of a continuum of assets, each indexed i, of mass n. (Appendix D.1 considers the case of two assets). Note that, in both models, the seller owns the same number (n) of units and thus the same ex ante portfolio value. Let z denote the seller's number of units in a given asset, i.e., $z = n$ ($z = 1$) under concentrated (diversified) ownership. The results are identical if the benchmark is instead 1 unit in a continuum of n firms with perfectly correlated values.

The model consists of three periods. At $t = 1$, Nature chooses the fundamental value of each asset i, $v_i \in \{\underline{v}, \overline{v}\}$, where $\overline{v} > \underline{v} > 0$ and $\Delta \equiv \overline{v} - \underline{v} > 0$. v_i are independently and identically distributed ("i.i.d.") across assets, and $\tau \equiv \Pr[v_i = \overline{v}] \in (0, 1)$ is common knowledge. Due to the law of large numbers, the actual proportion of assets for which $v_i = \overline{v}$ is τ. The seller privately observes v_i under concentration and $\mathbf{v} \equiv [v_i]_{i=0}^{n}$ under diversification (in Section 3.1, the seller must pay a cost to acquire this information). We use "good" ("bad") asset to refer to an asset with $v_i = \overline{v}$ ($\underline{v}$).

At $t = 2$, the seller 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 seller 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, which is sufficiently large to induce her to meet the liquidity need to the extent possible. The seller

[4] One exception is the voice-only 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. Another is Diamond (1984), who shows that diversification reduces the deadweight loss required to incentivize the bank to repay its end investors.

may raise more than θ dollars, i.e., we allow for voluntary sales.

After observing the shock, the seller sells $x_i \in [0, z]$ units in asset i. We use "fully sold" to refer to asset i if $x_i = z$ and "partially sold" if $x_i \in (0, z)$. We assume that short selling is either costly or constrained, otherwise the seller's initial position would not matter; for simplicity, we model these costs or constraints by not allowing for short sales. When the asset is a security, some investors (e.g., mutual funds) are constrained from short selling. For assets other than securities, e.g., bank loans or divisions, short sales are not possible. The sold units x_i are purchased by the buyer for asset i ("he"). The buyer is competitive and risk-neutral, and thus can be interpreted as a pool of competitive buyers or a market maker. There is a separate buyer for each asset who observes only x_i and not x_j for $j \neq i$, θ, nor v_i; Appendix D.2 considers the case of a single buyer for all assets, who observes x_j, $j \neq i$. Each buyer sets the price $p_i(x_i)$ at $t = 2$ to equal the asset's expected value, conditional on the observed trade x_i. We denote $\mathbf{p} \equiv [p_i(x_i)]_{i=0}^n$ and $\mathbf{x} \equiv [x_i]_{i=0}^n$.[5]

At $t = 3$, asset values are realized. The seller's utilities under concentration and diversification are respectively given by:

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

The equilibrium concept we use is Perfect Bayesian Equilibrium. Here, it involves: (i) A trading strategy by the seller that maximizes her expected utility u_I given each buyer's pricing rule and her private information on $\mathbf{v}$ (v_i) and (ii) a pricing rule by each buyer that allows him to break even in expectation, given the seller's strategy. Moreover, (iii) each buyer uses Bayes' rule to update his beliefs from the seller's trades, (iv) all agents have rational expectations in that each player's belief about the other players' strategies is correct in equilibrium, and (v)

[5] Note that the seller 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 seller had the possibility of receiving positive liquidity shocks, as long as she has the option to hold the inflow as cash (or purchase new assets) rather than being forced to buy more of her existing holdings. This treatment is consistent with the seller's option to raise more than L and hold the excess as cash. If there were no option to hold the inflow of cash or purchase new assets, then the seller could partially disguise an information-based purchase as being motivated by a positive liquidity shock, and so will buy rather than hold good assets. Then, diversification would have an additional benefit to price informativeness that is analogous to that in the current model – buying additional shares has greater price impact, since it is less likely to emanate from a liquidity shock.

the pricing function is monotonic, i.e., $p_i(x_i)$ is weakly decreasing, holding constant x_j, $j \neq i$.[6] Since assets are ex-ante identical, we focus on symmetric pure strategy equilibria[7], in which each buyer uses a symmetric pricing function. We also assume that the seller does not sell a good asset if unshocked. This is intuitive since the price can never exceed the value of a good asset $\overline{v}$, but simplifies the analysis as we need not consider equilibria under which a good asset is partially sold, but still fully revealed as good since bad assets are sold in greater volume. Price informativeness is exactly the same without this restriction.

1.2 Trade Under Concentration

Lemma 1 characterizes all equilibria under a concentrated portfolio.[8]

Lemma 1 *(Concentration): An equilibrium under concentration always exists. In any equilibrium, the seller's trading strategy is:*

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

and prices are:

$$p^*_i(x) = \begin{cases} \overline{v} & \text{if } x = 0 \\ \overline{p}_{con}(\tau) = \underline{v} + \Delta\frac{\beta\tau}{\beta\tau + 1 - \tau} & \text{if } x \in (0, \overline{x}_{con}(\tau)], \\ \underline{v} & \text{if } x > \overline{x}_{con}(\tau). \end{cases} \quad (4)$$

[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 real actions when introduced in Section 2. 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] The results continue to hold if we allow for mixed strategies, although the proofs are much lengthier.

[8] 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. In addition, equilibria can differ in their on-the-path trading volumes when $L/n > \underline{v}$. Specifically, if $L/n > \underline{v}$ then any $\overline{x}_{con}(\tau) \in [\min\{\frac{n\underline{v}}{\overline{p}_{con}(\tau)}, n\}, \min\{\frac{L}{\overline{p}_{con}(\tau)}, n\}]$ can be an equilibrium. In those cases, we select $\overline{x}_{con}(\tau) = \min\{\frac{L}{\overline{p}_{con}(\tau)}, n\}$. Intuitively, this selection implies that if there is an equilibrium in which the seller can meet her liquidity needs, then selected equilibria must have this property, and if such an equilibrium does not exist, then the selected equilibrium is the one that maximizes the seller's revenue. This selection can be justified using the Grossman and Perry (1986) criterion; moreover, it has no effect on price informativeness or any of our other main results, which apply when $L/n \leq \underline{v}$.

Equation (3) shows that, if the asset is good and the seller suffered a shock, she sells $\overline{x}_{con}(\tau)$. This quantity 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 asset and receiving no lower a price (since prices are non-increasing).[9] Thus, if the asset is bad, the seller sells the same amount $(\overline{x}_{con}(\tau))$, to disguise the motive for her sale. The price of a sold asset, $\overline{p}_{con}(\tau)$, is relatively high as the buyer attaches a probability $\frac{\beta\tau}{\beta\tau+1-\tau}$ that the sale was of a good asset and due to a shock. Thus, adverse selection is not so severe under concentration.

1.3 Trade Under Diversification

Lemma 2 characterizes all equilibria under a diversified portfolio.

Lemma 2 *(Diversification): An equilibrium under diversification always exists.*

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

$$x^*_{div}(v_i, \theta) = \begin{cases} 0 & \text{if } v_i = \overline{v} \\ \underline{x}(\theta) \in [\frac{\theta/n}{\underline{v}(1-\tau)}, 1] & \text{if } v_i = \underline{v}, \end{cases} \tag{5}$$

and prices are:

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

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

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

[9] We refer to the seller's type as (v_i, θ), i.e., a pair that indicates her information on the value of asset 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)).

and prices are:

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

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

(*iv*) *No other equilibrium exists.*

The intuition is as follows. Under diversification, the seller decides not only how much of her portfolio to sell, but also which assets. If $L/n \leq \underline{v}(1-\tau)$, the liquidity shock is sufficiently small that it can be satisfied by selling only bad assets. She thus retains all good assets, regardless of whether she suffers a shock. If there is no shock (w.p. $(1-\beta)$), the seller no longer has strict incentives to sell bad assets because doing so is fully revealing. Thus, while there is an equilibrium in which the seller at least partially sells all bad assets ($\underline{x}(0) > 0$), there is also an equilibrium in which she full retains them ($\underline{x}(0) = 0$). Overall, bad assets are retained with probability ("w.p.") $(1-\beta)\cdot\mathbf{1}_{\underline{x}(0)=0}$; as a result, a retained asset is not fully revealed as good and only priced at $\underline{v} + \Delta\frac{\tau}{\tau+(1-\tau)(1-\beta)\cdot\mathbf{1}_{\underline{x}(0)=0}}$ rather than $\overline{v}$. Any asset that is at least partially sold is fully revealed as bad and priced at $\underline{v}$.

For $\underline{v}(1-\tau) < L/n < \underline{v}$, the shock is sufficiently large that the seller cannot satisfy it by only fully selling bad assets, but sufficiently small that she can still sell good assets less. She sells $\overline{x}_{div}(\tau)$ from each good asset. Thus, upon no shock, she no longer retains bad assets but sells $\overline{x}_{div}(\tau)$ to disguise her sale as that of good assets driven by a shock. As a result, $(\overline{v}, L)$ is pooled with $(\underline{v}, 0)$. Retained assets are fully revealed as good and priced at $\overline{v}$.

Finally, for $L/n \geq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$, the shock is sufficiently large that it forces the seller to sell good assets as much as bad assets. Thus, $(\overline{v}, L)$ is pooled with not only $(\underline{v}, 0)$ (as in the moderate-shock case) but also $(\underline{v}, L)$, further reducing its price below $\overline{v}$ and increasing the price of $(\underline{v}, L)$ above $\underline{v}$. Since the seller's trading strategy is the same as under concentration ($(\overline{v}, L)$, $(\underline{v}, 0)$, and $(\underline{v}, L)$ are all pooled), prices are exactly the same.[10]

[10]Note that, for $\underline{v}\frac{1-\tau}{\beta\tau+1-\tau} \leq L/n < \underline{v}$, both the equilibria in parts (ii) and (iii) can be sustained. While the seller has the option to satisfy a shock by selling bad assets more, she may also sell good assets to the same

We denote the expected equilibrium price of asset i, given value v_i, under diversification and concentration by $P_{div}(v_i, \tau)$ and $P_{con}(v_i, \tau)$, respectively. Price informativeness measures the closeness of the expected equilibrium price to fundamental value, which is $\overline{v}$ for a good asset and $\underline{v}$ for a bad asset. Thus, price informativeness is higher under diversification if $P_{div}(\overline{v}, \tau)$ is higher than $P_{con}(\overline{v}, \tau)$ and thus closer to $\overline{v}$, and also $P_{div}(\underline{v}, \tau)$ is lower than $P_{con}(\underline{v}, \tau)$ and thus closer to $\underline{v}$. Proposition 1 gives conditions under which this is the case.

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

(i) If $L/n > \underline{v}(1-\tau)$ or $\beta \geq \frac{\sqrt{1-\tau}}{\sqrt{\tau}+\sqrt{1-\tau}}$, then in any equilibrium

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

i.e., price informativeness is weakly higher under diversification, with strict inequalities if $L/n \leq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$.

(ii) If $L/n \leq \underline{v}(1-\tau)$ and $\beta < \frac{\sqrt{1-\tau}}{\sqrt{\tau}+\sqrt{1-\tau}}$, then there is an equilibrium with $\underline{x}(0) = 0$ and

$$P_{div}(\overline{v}, \tau) < P_{con}(\overline{v}, \tau) \text{ and } P_{div}(\underline{v}, \tau) > P_{con}(\underline{v}, \tau), \tag{10}$$

i.e., price informativeness is strictly lower under diversification. In all other equilibria (i.e., if $\underline{x}(0) > 0$), we have (9).

Under diversification, the seller has a diversified portfolio of good and bad assets. This allows her to choose which assets to sell upon a shock – in particular, she sells bad assets first. In the moderate-shock equilibrium of part (ii) of Lemma 2, a shock causes her to fully sell bad assets and partially retain good assets. Thus, bad assets are fully revealed upon a shock and priced at $\underline{v}$, when they are always pooled (with $(\overline{v}, L)$ and $(\underline{v}, 0)$) under concentration. As a result, bad assets receive a lower expected price under diversification. One application of the model is to debt or equity securities. 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

degree as bad assets. Doing so increases her trading losses on good assets but reduces them on bad assets, since bad assets are now pooled with good assets upon a shock.

Saunders (2003) find similar results for loan sales. Our model predicts that the price declines upon a sale are greater under diversification.[11] Turning to good assets, they are retained and thus fully revealed upon no shock. Upon a shock, a good asset is sold, but only partially. The buyer knows that, if the asset were bad and the seller 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 concentration.

A similar intuition applies to the small-shock equilibrium of part (i), whether the seller fully retains good assets. As a result, the sale of asset i cannot be attributed to a shock because, if asset i were good and the seller had needed liquidity, she would have sold other assets instead. Thus, a sold asset is fully revealed as being bad and priced at $\underline{v}$. On the other hand, since sold assets are fully revealed as bad, the seller no longer has strict incentives to sell bad assets upon no shock. If she fully retains bad assets ($\underline{x}(0) = 0$) upon no shock (which occurs w.p. $1-\beta$), then being retained is no longer fully revealing. If β is sufficiently high ($\beta \geq \frac{\sqrt{1-\tau}}{\sqrt{\tau}+\sqrt{1-\tau}}$), this case is infrequent and so price informativeness is higher under diversification in any equilibrium. If β is low, there exists an equilibrium in which price informativeness is lower under diversification. However, price informativeness remains higher in the most informative equilibrium under diversification than under concentration, and this is the equilibrium that will be selected under the efficiency criterion (Section 2 shows that, when firm value is endogenous, the most informative equilibrium is the most efficient.) In the large-shock equilibrium of part (iii), the seller's trading behavior is exactly the same as under concentration, and so price informativeness is no higher.

Recall that the benchmark is identical if the seller holds 1 unit in a continuum of perfectly correlated assets of mass n. Then, moving from the benchmark to the diversified portfolio holds constant the number of assets and only reduces their correlation. This comparison shows that price informativeness is increasing in the diversification of a seller's portfolio. It also highlights that the effect on price informativeness stems from diversification, rather than simply giving the seller additional assets. Similarly, diversification alone is insufficient; the seller must have flexibility over which assets to sell. An index fund is diversified, but constrained to selling all assets equally.

[11] In He (2009), the price impact of a sale is stronger if the asset is *more* correlated with other assets in the seller'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.

In addition, the results show that diversifying by adding additional assets to the seller's portfolio is different from adding financial slack, i.e., liquid assets (such as Treasury bills) on which the seller has no private information, or risk-free borrowing capacity. Consider the effect of adding $A < L$ dollars of liquid assets to a concentrated portfolio.[12] This addition effectively reduces the shock to $L - A$; since price informativeness under concentration is independent of the size of the shock, it is unaffected by the liquid assets. Intuitively, since liquid assets are always fairly priced, they are always sold first. Liquid assets reduce the amount that the owner of a good asset must sell upon a shock; the owner of a bad asset simply reduces the amount that she sells by exactly the same margin, and so $(\overline{v}, L)$, $(\underline{v}, 0)$, and $(\underline{v}, L)$ remain pooled.

Now consider $A < L$ dollars instead being added in a new asset j. We consider the case in which assets i and j are negatively correlated, but the result only requires less than perfect correlation so that there is a non-zero probability that assets i and j may have different values. Upon a shock, if the initial asset i is good (and new asset j is bad), the seller will sell j first and only partially sell i – the same as if the seller had instead added liquid assets. However, if asset i is bad (and new asset j is good), the seller will not sell j first because doing so would entail a loss, unlike selling liquid assets which are always fairly priced. She instead fully sells asset i. Put differently, by adding liquid assets, the seller never has to fully sell asset i, regardless of its value, since she always sells liquid assets first. However, by adding asset j, the seller may still have to fully sell asset i. Liquid assets provide *uncontingent* liquidity (they are always sold first) but asset j provides only *contingent* liquidity (it is not sold first if it is good). Contingent liquidity depends on an asset's value, and so the sale of an asset is more likely to be driven by its value. In sum, adding liquid assets reduces the net liquidity shock but keeps us within the concentration model and so price informativeness is unchanged. Adding an illiquid asset moves us to the diversification model with a moderate shock and so price informativeness rises.

2 Governance

The core model has shown that portfolio diversification can improve price informativeness. We now demonstrate the real effects of this result by endogenizing asset value as depending on a real action. In doing so, we apply our model to corporate governance. We consider governance

[12] If $A \geq L$, then the addition effectively insulates the seller from a liquidity shock – the net liquidity shock, $L - A$, is now negative.

through exit in Section 2.1, and governance through voice in Section 2.2. Section 2.3 discusses implications common to both governance models.

2.1 Governance Through Exit

Let the asset now be a security in a firm: debt, equity, or any security monotonic in firm value. The seller can thus be interpreted as an institutional investor such as a hedge fund, mutual fund, or bank. Thus, in Section 2, we will refer to the seller as the "investor". There are a total of $m \geq n$ securities in the firm, of which z are owned by the investor (as before) and the remaining $m - z$ by dispersed investors (households) who play no role. Each firm is run by a separate manager, who takes action $a_i \in \{0, 1\}$ at $t = 1$. When $a_i = 1$ (0), the value of each asset is $v_i = \overline{v}$ ($\underline{v}$). Examples of $a_i = 0$ include shirking, cash flow diversion, perk consumption, and empire building. We 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 he privately observes prior to deciding his action. The probability density function of $\widetilde{c}_i$ is given by f and its cumulative distribution function by F. Both are continuous and have full support. We assume $\widetilde{c}_i$ are i.i.d. across firms, and that $E[\widetilde{c}_i] \leq \Delta$, so that $a_i = 1$ is ex-ante efficient.

Manager i's objective function is given by:

$$u_{M,i}(a_i, p_i, \tilde{c}_i, \omega) = (1 - \omega)\, v\,(a_i) + \omega p_i - \widetilde{c}_i a_i. \tag{11}$$

The manager cares about both the security's fundamental value and its $t = 2$ price; these price concerns are captured by $\omega \in (0, 1)$. If the security is equity, ω refers to stock price concerns, which are standard in exit models and can stem from a number of sources introduced in prior work – takeover threat (Stein (1988)), reputational concerns (Narayanan (1985)), or the manager expecting to sell his own shares 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 price, or the firm's reputation in debt markets, as it will affect the ease at which he can raise additional debt (Diamond (1989)).

This application is thus a model of "governance through exit" (Admati and Pfleiderer (2009), Edmans (2009)). The investor exerts governance by selling the asset if the manager shirks. Doing so reduces the security price and punishes the manager ex post; the threat of exit increases his incentives to work ex ante. However, the punishment for shirking depends not on the decision to sell per se but the price impact of the sale – and hence whether the investor is concentrated or diversified. We thus extend exit models to the case of multiple firms and show how the strength of exit depends on the investor's holdings of potentially unrelated firms.

As in the core model, the investor privately observes v_i under concentration and $\mathbf{v} \equiv [v_i]_{i=0}^n$ under diversification, but neither she nor the buyers observe $\widetilde{\mathbf{c}} \equiv [\widetilde{c}_i]_{i=0}^n$. We will abuse language slightly by using the phrase "the manager will be sold" to refer to the securities of the firm run by the manager being sold. We continue to focus on symmetric equilibria, in which the managers follow the same strategy and each buyer uses a symmetric pricing function. The equilibrium concept is as in Section 1 with the following additions: (vii) a decision rule by each manager i that maximizes his expected utility $u_{M,i}$ given his information on $\widetilde{c}_i$, other managers' strategies, the buyer's pricing rule, and the investor's trading strategy, and (viii) each buyer forms expectations about τ that are consistent with (vii), instead of taking it as given.

Lemma 3 derives a threshold rule for the manager's effort decision that holds under both concentration and diversification:

Lemma 3 *(Threshold, exit): In any equilibrium and under any ownership structure, there is a $c^* > 0$ such that manager i chooses $a_i = 1$ if and only if $\widetilde{c}_i \leq c^*$. A higher c^* increases total surplus.*

Since a higher c^* increases total surplus, we define efficiency as the maximization of c^*. We defer the analysis of the equilibria under a concentrated and diversified portfolio (the analogs of Lemmas 1 and 2) to Appendix B.1 (Lemmas 5 and 6) and move straight to the comparison of the most efficient equilibria, which is given in Proposition 2 below. (Appendix B.1 analyzes other equilibria and gives conditions under which any equilibrium under diversification is more efficient than any equilibrium under concentration.)

Proposition 2 *(Comparison of most efficient equilibria, exit): The working threshold under the most efficient equilibrium is strictly higher under diversification than under concentration if $L/n \leq l^*$ where $l^* \geq \underline{v}(1 - F(\Delta))$.*

Under concentration, the manager's incentives to work are low for two reasons. First, the reward for working is low. If he works, the investor may suffer a liquidity shock and be forced to sell, and so the security price is lower than its fundamental value of $\overline{v}$. Second, the punishment for shirking is low. If he shirks and is sold, the sale is consistent with a working manager being sold due to a liquidity shock, and so the security price is not too low. Proposition 2 states that, if $L/n \leq l^*$, governance is strictly superior under the most efficient equilibrium under diversification than under concentration, because diversification alleviates the above two concerns. First, diversification increases the reward for working, because a working manager is no longer automatically sold upon a shock – he is retained upon a small shock and only partially sold upon a moderate shock. Second, diversification increases the punishment for shirking. Under a small shock, exit is fully revealing of shirking and leads to the lowest possible price of $\underline{v}$. Under a moderate shock, the investor fully sells bad firms and only partially sells good firms, so being sold is fully revealing that a firm is bad. Intuitively, diversification creates a tournament between the n managers, who know that the investor observes the value of their firms and will sell the worst performers. Since the market anticipates that the worst performers are sold, this amplifies the disciplinary power of exit. Moreover, this tournament means that, even if there is no explicit relative performance evaluation in the managers' contracts, the investor will engage in relative performance evaluation.

Thus far, the analysis has considered portfolio structure as exogenous and compared the investor's trading strategy under both concentration and diversification. When asset values are exogenous, if the investor endogenously chose portfolio structure, she would be indifferent between both structures as her expected payoff is the same. When asset values are endogenous, she will choose the structure that maximizes governance (i.e., a diversified portfolio, under the most efficient equilibrium) as long as the purchase of her initial position is not fully observed (as in, e.g., Kyle and Vila (1991)). This is because she can acquire assets at less than their fundamental value, and thus shares in the value created by improved governance. If her trade is fully observed, she has to acquire her initial position at their full value, including any governance benefits, and so would be indifferent. The investor may choose to be diversified for reasons outside the model, e.g., risk reduction concerns, "prudent man" rules, or downward-sloping demand curves for a single asset. In this case, our results suggest that diversification for private risk reduction or price impact reasons can have a social benefit by improving governance.

2.2 Governance Through Voice

Rather being taken by the manager, the action a_i could instead be taken by the investor, who also bears its (privately-observed) cost.[13,14] 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. We refer to $a_i = 1$ as "monitoring" and $a_i = 0$ as "not monitoring". A good (bad) firm is now one that has been monitored (not monitored). Through her private knowledge of $\mathbf{a} \equiv [a_i]_{i=0}^n$, the investor continues to have private information on $\mathbf{v}$. In addition to demonstrating the applicability of the model to governance through voice, a quite separate contribution of this section is to show how our unifying model can be applied to both voice and exit. Thus far, these literatures have developed largely independently and been modeled with quite different frameworks.

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:

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

under diversification, and analogously under concentration.[15] 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 buyer's pricing rule, and (viii) each buyer forms expectations about τ that are consistent with (vii).

Lemma 4 derives the investor's threshold strategy.

Lemma 4 *(Threshold, voice): In any equilibrium and under any ownership structure, there is a c^* such that the investor chooses $a_i = 1$ if and only if $\widetilde{c}_i \leq c^*$. A higher c^* increases total surplus.*

We defer the analysis of the equilibria under a concentrated and diversified portfolio (the

[13] 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 her ability to use her business connections to benefit the firm, or on the extent to which she can extract private benefits. The results are robust to a publicly-known monitoring cost; this analysis is available upon request.

[14] In Faure-Grimaud and Gromb (2004), the investor only trades (as in our core model) and the action is undertaken by a separate "monitor" who is also concerned about the $t = 2$ security price. This model is identical to the model of Section 2.1, with the monitor replacing the manager.

[15] We implicitly assume $\int_0^n c_i di < \infty$.

analogs of Lemmas 1 and 2) to Appendix B.2 (Lemmas 7 and 8) and move straight to the comparison of equilibria, which is given in Proposition 3 below.

Proposition 3 *(Comparison of equilibria, voice): There exist $\overline{n} > 1$ and $L^* \geq \underline{v}(1 - F(\Delta))$ such that:*

(i) If $n > \overline{n}$ then any equilibrium under concentration is weakly more efficient than any equilibrium under diversification.

(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 diversification is strictly more efficient than any equilibrium under concentration.

The intuition is as follows, which mirrors that of Section 2.1. Under concentration, the investor's incentives to monitor are low for two reasons. First, if she monitors and increases the asset value to $\overline{v}$, she may suffer a liquidity shock and be forced to sell for a price below $\overline{v}$, reducing the payoff to monitoring. Second, if she does not monitor, she can sell some assets ("cut and run"), and pretend that the sale is of a good asset but motivated by a liquidity shock, as in Kahn and Winton (1998) and Maug (1998). This increases the payoff to not monitoring. The same two reasons mean that the flexibility stemming from diversification increases the investor's payoff from monitoring. 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 concentration. In addition, the payoff to cutting and running is now lower since prices are more informative. 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. With a large shock, diversification does not provide flexibility and so this benefit is absent.

The positive effect of flexibility must be weighed against the fact that the investor now only has 1 rather than n units in each firm, which reduces her incentive to monitor. Thus, Proposition 3 shows that governance is superior under diversification 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, and the liquidity shock is not large, so that diversification provides flexibility.

Similar to the exit model, if the investor could endogenously choose ownership structure, she would select the one that maximizes her expected portfolio value. The only difference is that in the voice model, this expected value is net of her expected monitoring costs. The full analysis is in Appendix B.2.

2.3 Implications

Both the exit and voice applications suggest that diversification can strengthen governance, if the greater price informativeness outweighs any potential loss from the investor being spread too thinly. This application has the potential to justify why shareholders own blocks in multiple firms, despite the free-rider problem. Existing justifications are typically based on diversification of risk. While conventional wisdom might suggest that the diversification induced by risk concerns necessarily weakens governance, our model highlights an opposing force. Indeed, Kang, Luo, and Na (2017) find that institutional investors are more effective at governance the more blocks they have in other companies, controlling for portfolio size. This superior governance may arise due to greater price informativeness as in our paper, or other channels such as additional blocks leading to learning-by-doing. Similarly, our model shows that common ownership may improve governance, and offers an alternative explanation for its association with higher product prices documented by Azar, Schmalz, and Tecu (2017) – these higher prices may stem from superior governance. Moreover, the results suggest that mergers between investors – which generate the benefits of diversification without the costs of being spread too thinly – should improve governance, even if the investors do not have common holdings and so the merger does not increase their stake in a given firm. It also provides a potential channel through which governance may be superior in conglomerates than single segment firms.

Relatedly, while existing studies typically use the size of the largest blockholder or the number of blockholders as a measure of governance, both the exit and voice applications theoretically motivate a new measure – the number of other large stakes owned by its main shareholder or creditor, as studied by Kang, Luo, and Na (2017). Faccio, Marchica, and Mura (2011) empirically study a related measure, the concentration of an asset in an investor's portfolio. They argue that diversification can be desirable because a concentrated seller will turn down risky, positive-NPV projects, unlike our channel.

The investor in governance models is typically a large shareholder in a public firm, but our model is general and applies to any investor who has a large amount of an asset – not necessarily traded equity. This includes a bank who trades loans, debtholder who trades bonds, or a headquarters who sells businesses. Thus, the model can be applied to a corporate headquarters' or private equity general partner's decision to diversify into multiple uncorrelated business lines rather than focus on a single business or have multiple correlated businesses. Our results suggest that diversified firms face a more severe adverse selection problem when divesting than concentrated firms, since it is harder to justify a divestment as resulting from a liquidity shock.[16] Stein (1997) shows that an advantage of conglomeration is "winner-picking" – the headquarters can invest surplus funds into the business that has the best investment opportunities at the time. One may think that a related advantage is "loser-picking" – if it suffers a liquidity shock, it can choose to sell the most poorly-performing business. However, potential buyers know this and so the headquarters face a greater, not smaller, adverse selection problem when selling. On the other hand, this greater adverse selection may strengthen incentives. Under the exit application, it is the divisional manager whose actions affect firm value, and his reputation may be affected by the market's perceived value of his division. If a multi-segment firm sells a division, this signals that the division is poorly performing. If a single-segment firm sells some plants, this may be because the headquarters has suffered a liquidity shock. Under the voice application, it is the headquarters whose actions affect firm value, and its incentives to monitor are greater under diversification.

3 Extensions

Section 1 showed that diversification increases price informativeness, which we applied to governance in Section 2. This section discusses which features of our setting are necessary for our price informativeness result and which can be relaxed.

[16] Where the asset is a business, it may also be sold for strategic reasons such as dissynergies. However, evidence suggests that liquidity needs are an important motive for asset sales (e.g., Borisova, John, and Salotti (2013), Campello, Graham, and Harvey (2010)). Our analysis studies how diversification affects the likelihood that a sale is driven by a liquidity shock rather than private information, effectively holding synergy motives constant when comparing diversification to concentration. Edmans and Mann (2017) consider both synergy and overvaluation motives for asset sales. Their model features exogenous asset values, a publicly-known liquidity shock and only consider the case of diversified and not concentrated ownership.

3.1 Endogenous Information

In the core model, the seller is endowed with private information. This applies to cases in which owning and operating the asset automatically gives the seller information. For example, a conglomerate will have information on the value of its businesses simply by running them (termed "learning by holding" by Plantin (2009)). Large shareholders have greater access to firm management, and lenders are able to request information from borrowers at little cost. We now study the case in which the seller has to acquire private information at a cost. One might think that information acquisition is lower under diversification (offsetting our earlier result of greater price informativeness) for two reasons. First, since prices are more revealing of the seller's information, her ability to profit from it is lower (if unshocked). Second, since the seller owns 1 rather than n units in each asset, she can sell fewer assets upon negative information and so information is less useful to her. Put differently, diversification leads to the investor being spread too thinly to motivate information acquisition. We show that, despite these forces, information acquisition may be strictly higher under diversification.

Just after asset values are realized at $t = 1$, for asset i the seller can now pay a cost $c(\lambda_i) \geq 0$ to learn v_i w.p. $\lambda_i \in [0,1]$; w.p. $1 - \lambda_i$ she remains uninformed. Whether the seller is informed about asset i is her private information and independent across firms. We assume $c''(\cdot) > 0$ with $c(0) = 0$, $c'(0) = 0$ and $c'(1) = \infty$. We refer to the choice of λ_i as "investigating" or "acquiring information". Having chosen λ_i, she observes asset values and chooses how much to sell.

We defer the equilibria under concentration and diversification to Lemmas 11 and 12 in Appendix , respectively, and move straight to comparing investigation under the two equilibria. Proposition 4 shows that, if β is sufficiently large and L is sufficiently small, investigation is higher in any equilibrium under diversification than in any equilibrium under concentration.

Proposition 4 *(Information Acquisition, Comparison of Ownership Structures): There is $\overline{\beta} < 1$ such that, if $\beta > \overline{\beta}$ and $L/n \leq (c')^{-1}(\overline{\beta}\tau(1-\tau)\Delta) \cdot (1-\tau)\underline{v}$, the seller acquires strictly more information in any equilibrium under diversification than in any equilibrium under concentration.*

The intuition is as follows. If the seller suffers a liquidity shock, information has no value under concentration as she has to sell the same number of units regardless of whether the asset is good or bad. In contrast, information has value under diversification since it guides her on which assets to sell to satisfy the shock. Thus, investigation incentives are higher under diversification when the probability of the shock β is sufficiently high. However, this information is only valuable under diversification if the shock is sufficiently small that the seller can satisfy it by selling only bad assets. Thus, investigation incentives are higher when L/n is small.

Note that if the seller endogenously chose her initial position and asset values were exogenous, she would prefer the ownership structure under which investigation is *lower*. This is because information is a deadweight cost to her. While information increases her trading gains if she does not suffer a shock, and thus can trade freely on her information, it also leads to a lower sale price and thus increases her trading losses if shocked. The seller cannot commit not to acquiring information, and so a rational buyer sets a pricing function that takes into account his expectation of the seller's level of information.

3.2 Robustness

Two Assets. The model uses a continuum of assets to invoke the law of large numbers, in turn leading to significant tractability – since we know that the seller will have a proportion τ of good assets, this is the only case that we need to consider. Appendix D.1 shows that the results continue to hold with two assets, albeit with more cases to consider. The intuition is as follows. Under two assets, we must also consider cases in which the assets are either both good or both bad, but these cases are uninteresting because the seller has no trading flexibility. She has trading flexibility – due to owning one good and one bad asset – $2\tau(1-\tau)$ of the time, rather than all of the time under a continuum. Flexibility still improves compared to the case of concentration, where she never has trading flexibility because all units are necessarily perfectly correlated with each other. Diversification – whether to a finite number or a continuum of assets – provides trading flexibility since individual shares need not be perfectly correlated. The increment to flexibility is increasing in the number of assets. Specifically, with N assets, the probability that assets are either all good or all bad (and thus there is zero trading flexibility) is $\tau^N + (1-\tau)^N$, which decreases with N. Our core model captures this force by studying the two polar cases, of concentration (no flexibility) and owning a continuum of assets (full flexibility), to highlight the benefits of diversification most clearly.

Single Buyer. The model assumes that there is a separate buyer for each asset i. This is for two reasons. The first is empirical realism: in reality, there are several market makers for traded securities and different market makers make markets for different securities. Away from a securities application, a conglomerate selling multiple divisions, or a private equity firm selling multiple businesses, will likely be selling them to different buyers, and so the buyer of one division does not know the details of the sale of the other division in real time. The second is to highlight the economic forces behind our result – that diversification gives the seller trading flexibility. Our result does not arise because the buyer can observe the seller's trades in other firms and compare her trade in asset i to that in asset j.

An alternative assumption is to have a single buyer who observes the trades in all assets, such as a market maker for many securities. Appendix D.2 shows that price informativeness can be even higher under diversification than with separate buyers (i.e., the results become stronger), since the single buyer is able to engage in "relative performance evaluation". For example, consider the moderate-shock equilibrium of part (ii) of Lemma 2, where $(\overline{v}, L)$ is pooled with $(\underline{v}, 0)$ under separate buyers because both are partially sold. Under a single buyer, prices depend not on the *absolute* trade in a given asset, but the trade *relative* to that in other assets. If other assets are sold more (less), the buyer infers a shock (no shock) and thus that the partially-sold asset is good (bad). Thus, $(\overline{v}, L)$ and $(\underline{v}, 0)$ can now be fully distinguished. By comparing the trade in asset i to that in asset j, the buyer can better discern whether a sale was due to a liquidity shock or low asset value, leading to perfect price informativeness.[17]

Appendix D.2 also shows that there also exists an equilibrium under diversification where prices are fully uninformative. The intuition is as follows. The buyer knows with certainty the value of the seller's portfolio, which is $\underline{v} + \Delta\tau$ by the law of large numbers. As a result, if the seller sells a tranche of her entire portfolio (engaged in "balanced exit"), the buyer pays $\underline{v} + \Delta\tau$ for a portfolio worth $\underline{v} + \Delta\tau$.[18] Intuitively, by selling all assets to the same degree, the seller loses on the good assets but gains on the bad assets since the buyer cannot distinguish

[17] Gervais, Lynch, and Musto (2005) show that mutual fund families can add value by monitoring multiple managers, since firing one manager increases sellers' perceived skill of retained managers. Inderst, Mueller, and Münnich (2007) show that when a seller finances several entrepreneurs, an individual entrepreneur may exert greater effort. To obtain refinancing, he needs to deliver not only good absolute performance, but also good performance relative to his peers. In Fulghieri and Sevilir (2009), multiple entrepreneurs compete for the limited human capital of a single venture capitalist. These effects are similar to the relative performance evaluation channel under a single buyer, but will not arise in the case of our core model where trades in other assets are unobservable, and so are fundamentally different from the effect of flexibility in this paper.

[18] This contrasts with both the case of concentration and the case of diversification with separate buyers, since the buyer for an individual asset does not know whether it is worth $\overline{v}$ or $\underline{v}$.

the two). If the seller sells bad assets more than good assets (engages in "imbalanced exit"), the buyer knows that assets sold more are bad and so pays $\underline{v}$ for assets worth $\underline{v}$. The seller thus makes zero profit under both balanced and imbalanced exit (regardless of whether she has suffered a shock) and is thus indifferent between the two trading strategies. As a result, there is also an equilibrium in which she retains all assets when $\theta = 0$ and sells all assets when $\theta = L$. Since the seller's trade is independent of asset value, prices are fully uninformative. Section 2 showed that, when asset values are endogenous, higher price informativeness leads to higher real efficiency. Thus, under the efficiency criterion, the equilibrium with greater price informativeness will be selected. Moreover, Appendix D.1.2 analyzes the single-buyer model with two firms, where the law of large numbers does not apply and so the buyer does not know the value of the seller's portfolio. It derives conditions under which price informativeness under a single buyer is higher under *any* equilibrium under diversification than *any* equilibrium under concentration. Thus, our results are robust to the assumption of a single buyer.

Heterogeneous Assets. Appendix D.3 considers the case in which assets have different Δ, which parameterizes uncertainty or information asymmetry. As a result, the price impact of selling – and thus the asset's liquidity – differs across assets. It remains the case that price informativeness is strictly higher under diversification when the shock is small. Regardless of Δ and thus price impact or liquidity, the seller always receives (weakly) more than $\underline{v}$ by selling a bad asset and less than $\overline{v}$ by selling a good asset, and so is always better off by selling assets that she knows to be bad and retaining assets she knows to be good. Thus, it remains the case that diversification allows the seller to fully retain good assets upon a small shock, and so a sale fully reveals that an asset is bad. Note that the analysis of holding cash (see the discussion at end of Section 1.3) also shows that the model is robust to heterogeneous assets, since cash has information asymmetry of $\Delta = 0$.

Discontinuing Relationships. In our model, the seller is concerned with the price impact of her sale, as she receives the sale price. Appendix D.4 extends the model to the case in which the seller is not concerned with price impact, as in the case of a headquarters closing a business rather than selling it. In this case, there is no sale price, and the headquarters' payoff from shut down is its alternative use of capital, which is independent of the market's perception of the shut-down business – but, in an exit model, the business manager will still care about his reputation implied by the shut-down. We show that, even with a fixed reservation payoff, price informativeness is always weakly higher under diversification, because it remains the case that diversification gives sellers a choice of what asset to sell when they suffer a shock, and so their sale decisions convey information. This model can also apply to other discontinuation decisions, such as a bank ceasing to lend or a venture capitalist not investing in a future financing round,[19] as well as to stakeholders other than sellers, such as a supplier or customer's decision to terminate its relationship with a firm. The threat of being the only business with which the stakeholder terminates the relationship improves the manager's effort incentives.

Noise Traders. In general, informed sellers can make profits on their information for two reasons. First, their trade may be unobservable, because it is pooled with that of noise traders, as modeled by Kyle (1985) in a securities application. Second, their trade may be observable, but the buyer does not know whether it is due to information or a liquidity shock, as modeled by Diamond and Verrecchia (1991) in a securities application. Our model uses the second framework, since it is the fact that liquidity shocks are at the portfolio level that leads to connection between unrelated assets. We conjecture that the results will be robust to adding noise traders to the model.[20] The buyer is now only able to partially infer the probability that a sale comes from the informed seller (rather than noise traders), rather than observing it directly. However, given a probability that the seller has sold asset i, the likelihood that this sale was due to negative information is higher under diversification due to the seller's flexibility over which assets to sell to satisfy a shock. The model only requires a strictly positive probability of a liquidity shock for diversification to be beneficial (it allows for any $\beta \in (0, 1]$, including $\beta = 1$, i.e., no private information about the liquidity shock), because it is the portfolio-wide liquidity shock that creates the link between trading in the individual assets, and can accommodate any volume of noise trader demand.

Distribution of Liquidity Shocks. While our model assumes a binary liquidity shock $\theta \in \{0, L\}$, we conjecture that our core mechanism, that diversification provides flexibility, applies regardless of the distribution of θ. Even with a more general distribution of liquidity

[19] In this model, the discontinuation decision has no direct effect on firm value, for example because there are other banks or venture capitalists who can provide financing. This highlights the channel through which the trading / discontinuation decision affects firm value – indirectly through affecting incentives.

[20] As in Kyle (1985), this extension assumes that the volume of noise traders is independent of price informativeness and thus their trading losses, since they are forced to trade due to a liquidity shock (similar to the seller's liquidity shock in our model). The results will likely go through even if noise traders adjust part of their trading volume based on their expected losses, as long as at least part of the trading volume is non-discretionary.

shocks, as long as there is a strictly positive probability that the shock is not large, a diversified seller can sometimes sell good assets less than bad ones upon a shock, whereas a concentrated seller is always forced to sell them to the same degree.

4 Conclusion

This paper has shown that the informativeness of an asset's price depends on an informed seller's holdings of other assets, even if they are unrelated and even if the buyer cannot observe her trades in those assets. A diversified seller has the choice of which assets to sell upon a liquidity shock. She cannot commit to not sell the worst assets first, and so an asset sale is more revealing of low asset value than a liquidity shock. Thus, her trades convey more information, increasing price informativeness. This result has implications 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 stronger if the decision-maker had many other relationships that she could have terminated instead. Moreover, even though diversification increases the extent to which private information is revealed in prices and reduces the seller's skin-in-the-game in any individual asset, it may raise information acquisition incentives. Since diversification gives her the option to sell bad assets and retain good ones under a liquidity shock, it increases her incentives to learn asset values.

We show that the greater price informativeness provides a common channel through which diversification can strengthen governance through both exit and voice. This is in contrast to conventional wisdom that diversification necessarily weakens governance by spreading an investor too thinly, or that common ownership necessarily has negative real effects by leading to anti-competitive behavior. If the manager works or the investor monitors, the firm is more likely to be retained since the investor has other assets that she can sell upon a shock. If the manager shirks or the investor cuts and runs, the stock price is lower than under concentration. This result suggests that concentrating ownership of many firms within a small number of investors may strengthen governance. Thus, mergers of investors and demergers of firms may improve governance; demergers of investors and mergers of firms reduce it. Similarly, diversification by a corporate headquarters, private equity general partner, venture capitalist, or bank can improve managers' incentives to work and investors' incentives to monitor. In addition, our paper identifies a novel channel through which common ownership has a positive real effect on firm value, even if the firms are in unrelated industries.

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A Proofs

Proof of Lemma 1. Let $x^*(v,\theta)$ be an equilibrium strategy for type-(v,θ). We start by proving that there is a unique $\overline{x} > 0$ such that ("s.t.") $x^*(\underline{v},L) = x^*(\underline{v},0) = x^*(\overline{v},L) = \overline{x} > x^*(\overline{v},L)$. We argue five points:

1. *In any equilibrium, $x^*(\underline{v},L) > 0$, $x^*(\underline{v},0) > 0$, and $x^*(\overline{v},L) > 0$.* Proof: Suppose on the contrary that $x^*(\overline{v},L) = 0$. Since $\beta > 0$, the seller can raise a positive amount of revenue (thereby strictly increasing her payoff) by deviating to selling n units. Note that, $p\left(x^*(\overline{v},L)\right) > \underline{v}$. Next, suppose on the contrary $x^*(\underline{v},\theta) = 0$. The seller's payoff is $\underline{v}$. However, since $x^*(\overline{v},L) > 0$ and $p\left(x^*(\overline{v},L)\right) > \underline{v}$, the seller obtains a strictly higher payoff than $\underline{v}$ by deviating to $x^*(\overline{v},L)$.

2. *In any equilibrium, $x^*(\overline{v},0) \neq x^*(\underline{v},0)$ and $x^*(\overline{v},0) \neq x^*(\underline{v},L)$.* Proof: If on the contrary $x^*(\overline{v},0) = x^*(\underline{v},\theta)$, then $p\left(x^*(\overline{v},0)\right) < \overline{v}$. Based on point 1, $x^*(\underline{v},\theta) > 0$. Therefore, the payoff of type-$(\overline{v},0)$ is strictly smaller than $\overline{v}$ and so she will deviate to fully retaining the asset.

3. *In any equilibrium, $x^*(\overline{v},0) \neq x^*(\overline{v},L)$.* Proof: Suppose not. Based on point 1, $x^*(\overline{v},0) > 0$. Based on point 2, $p\left(x^*(\overline{v},0)\right) = \overline{v}$. Suppose not. Based on point 1, $x^*(\overline{v},0) > 0$. Based on point 2, $p\left(x^*(\overline{v},\theta)\right) = \overline{v}$. Therefore, $x^*(\underline{v},0) \neq x^*(\overline{v},\theta)$, which implies $p\left(x^*(\underline{v},0)\right)) = \underline{v}$. However, type-$(\underline{v},0)$ can obtain a strictly higher payoff by deviating to $x^*(\overline{v},0) > 0$.

4. *In any equilibrium, there is $\overline{x} > 0$ such that $x^*(\underline{v},L) = x^*(\underline{v},0) = x^*(\overline{v},L) = \overline{x}$.* Proof: Let $x^*(\overline{v},L) = \overline{x}$, and note that based on point 1, $\overline{x} > 0$. Moreover, the seller can either satisfy her liquidity need by selling $\overline{x}$ from each asset, or she obtains the highest revenue possible by following strategy $\overline{x}$. Suppose on the contrary, $x^*(\underline{v},\theta) \neq \overline{x}$ for some $\theta \in \{0, L\}$. Then, based on point 2, it must be $p\left(x^*(\underline{v},\theta)\right) = \underline{v}$, and the payoff of type-$(\underline{v},\theta)$ is $\underline{v}$. However, type-$(\underline{v},\theta)$ can deviate to $\overline{x}$ and generate a payoff strictly higher than $\underline{v}$ and meet her liquidity need.

5. *In any equilibrium, $x^*(\overline{v},0) < \overline{x}$.* Proof: from points 2 and 3, $x^*(\overline{v},0) \neq \overline{x}$, and so $p\left(x^*(\overline{v},0)\right) = \overline{v}$. Suppose on the contrary $x^*(\overline{v},0) > \overline{x}$. Then, type-$(\underline{v},0)$ has a strictly profitable deviation from $\overline{x}$ to $x^*(\overline{v},0)$: she can sell strictly more units from a bad asset at a strictly higher price.

Given the claims above, Bayes' rule implies $p_i(\overline{x}) = \overline{p}_{con}(\tau)$, as given by the lemma. We prove that in any equilibrium $\overline{x} \leq \overline{x}_{con}(\tau)$. Suppose on the contrary that $\overline{x} > \overline{x}_{con}(\tau)$. Then it has to be $\overline{x}_{con}(\tau) = \frac{L}{\overline{p}_{con}(\tau)} < n$, and so $\overline{x}\overline{p}_{con}(\tau) > L$. Since the pricing function is non-increasing, there is $\varepsilon > 0$ such that $(\overline{x} - \varepsilon) p (\overline{x} - \varepsilon) \geq L/n$. This implies that type $(\overline{v}, L)$ will strictly prefer deviating to $\overline{x} - \varepsilon$, a contradiction. We conclude $\overline{x} \leq \overline{x}_{con}(\tau)$. Next, we prove that if $L/n \leq \underline{v}$ then $\overline{x} = \overline{x}_{con}(\tau)$ in any equilibrium. Suppose on the contrary that $\overline{x} < \overline{x}_{con}(\tau)$. Then the seller does not raise L in equilibrium by selling $\overline{x}$. Consider a deviation to selling all units. Since $p(n) \geq \underline{v}$, the revenue raised would be at least $n\underline{v} \geq L$, and so the deviation is optimal, a contradiction. Suppose $L/n > \underline{v}$. In this case, any $\frac{n\underline{v}}{\overline{p}_{con}(\tau)} \leq \overline{x} \leq \overline{x}_{con}(\tau)$ can be an equilibrium. Indeed, showing that $\overline{x} < \frac{n\underline{v}}{\overline{p}_{con}(\tau)}$ cannot occur in an equilibrium with $L/n > \underline{v}$ can be done by noting that there is an optimal deviation to selling n units. Among all $\frac{n\underline{v}}{\overline{p}_{con}(\tau)} \leq \overline{x} \leq \overline{x}_{con}(\tau)$, we select the equilibrium in which the seller's liquidity need is satisfied, which is $\overline{x}_{con}(\tau)$.

Since $x^*(\overline{v}, 0) = 0$, the pricing 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 $\overline{v}$, the highest possible. Second, since $\overline{p}_{con}(\tau)\,\overline{x}_{con}(\tau) \leq L$ and $p^*(x)$ is flat on $(0, \overline{x}_{con}]$, deviating to $(0, \overline{x}_{con}]$ generates revenue strictly lower than L, and so is suboptimal if $\theta = L$. Moreover, since $x > \overline{x}_{con}(\tau) \Rightarrow p^*(x) = \underline{v}$, the seller has no optimal deviation to $x > \overline{x}_{con}(\tau)$, regardless of the asset's value. Last, it is easy to see that $x = \overline{x}_{con}(\tau)$ is optimal for type-$(\underline{v}, 0)$. ■

Proof of Lemma 2. Suppose $L/n \leq \underline{v}(1-\tau)$. The seller can raise at least L by selling only bad assets, even if she receives the lowest possible price of $\underline{v}$. Since the seller is never forced to sell a good asset, she sells a positive amount $x_i' > 0$ from a good asset only if $p(x_i') = \overline{v}$, i.e., she does not sell x_i' from a bad asset. 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 seller chooses not to sell x_i' from a bad asset only if there is x_i'' that she chooses with strictly positive probability, where

$$x_i'' p_i(x_i'') + (1 - x_i'')\underline{v} \geq x_i' p_i(x_i') + (1 - x_i')\underline{v}. \tag{13}$$

The above inequality requires $p_i(x_i'') > \underline{v}$. Since she sells x_i'' from a bad asset with positive probability, we have $p_i(x_i'') < \overline{v}$. Given this price, she will never sell x_i'' from a good asset, contradicting $p_i(x_i'') > \underline{v}$. Therefore, she sells x_i' from a bad asset with strictly positive probability, contradicting $p(x_i') = \overline{v}$. We conclude that in any equilibrium $x_i > 0 \Rightarrow p(x_i) < \overline{v}$, and so $v_i = \overline{v} \Rightarrow x_i = 0$. Note that the condition on $\underline{x}(\theta)$ simply requires that the seller sells enough of the bad assets to meet her liquidity need, 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 $L/n > \underline{v}(1-\tau)$. 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, let $\overline{x} = x_i^*(\overline{v}, L)$. Since $L/n > \underline{v}(1-\tau)$, $\overline{x} > 0$. We denote $p_i(\overline{x}) = \overline{p}$. Since the seller sells $\overline{x}$ of a good asset, $\overline{p} > \underline{v}$. We argue that, in any equilibrium, if $\theta = 0$ then she sells $\overline{x}$ of every bad asset. Suppose not. 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 asset 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 asset, thereby obtaining a payoff above $\underline{v}$. Note that this implies that $\overline{p} < \overline{v}$.

2. In any equilibrium, either $x_i^*(\underline{v}, L) = \overline{x}$ or $x_i^*(\underline{v}, L) = 1$, where $\overline{x}$ is defined as in Claim 1. To prove this, note that the seller cannot sell $x_i^*(\overline{v}, 0)$ of a bad asset 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 asset, and not selling some good assets, keeping revenue constant. Her payoff from selling a bad asset is no lower (since she previously received $\underline{v}$ for each bad asset), but by not selling some good assets, for which she previously received $\overline{xp} + (1-\overline{x})\overline{v} < \overline{v}$, she increases her payoff. Therefore, $x_i^*(\underline{v}, L) \in \{\overline{x}, 1\}$, as required.

3. If in equilibrium $x_i^*(\underline{v}, L) = 1$ and $\overline{x} < 1$ then $L/n < \underline{v}$ and $\overline{x} = \overline{x}_{div}(\tau)$, 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 $\overline{p}_{div}(\tau)$, as given by (8). Suppose $\theta = L$. Since $\overline{p}_{div}(\tau) > \underline{v}$, the seller chooses $x_i^*(\underline{v}, L) = 1$ only if the revenue from selling $\overline{x}$ from all assets is strictly smaller than L and also the revenue from selling $\overline{x}$ of all good assets and 1 from all bad assets, i.e.,

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

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

We now prove that

$$(1-\tau)\underline{v} + \tau\overline{x}\overline{p}_{div}(\tau) = L/n, \tag{14}$$

i.e., fully selling bad assets and selling $\overline{x}$ of good assets raises exactly L. We do so in two steps. We first argue that this strategy cannot raise more than L, i.e.,

$$(1-\tau)\underline{v} + \tau\overline{x}\overline{p}_{div}(\tau) \leq L/n. \tag{15}$$

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

$$(1-\tau)\underline{v} + \tau\overline{x}\overline{p}_{div}(\tau) \geq L/n. \tag{16}$$

Suppose not. If the strategy did not raise L, then it must be that $\underline{v} \leq (1-\tau)\underline{v}+\tau\overline{x}\overline{p}_{div}(\tau)$, i.e., the alternative strategy of fully selling her entire portfolio raises even less revenue. Therefore, $\underline{v} \leq \overline{x}\overline{p}_{div}(\tau)$, which contradicts $\overline{x}\overline{p}_{div}(\tau) < \underline{v}$. Intuitively, if fully selling an asset for $\underline{v}$ raises less revenue than selling $\overline{x}$ of an asset for $\overline{p}_{div}(\tau)$, then the seller would not fully sell bad assets. Combining (15) and (16) yields (14) as required, implying $\overline{x} = \overline{x}_{div}(\tau)$, and $\overline{x}_{div}\overline{p}_{div}(\tau) < \underline{v}$ implies $L/n < \underline{v}$ as required.

4. If in equilibrium $x_i^*(\underline{v}, L) = \overline{x}$ then $L/n \geq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$, $\overline{p} = \overline{p}_{con}(\tau)$ and $\overline{x} = \overline{x}_{con}/n$. To prove this, since prices are non-increasing, we must have $\overline{x}\overline{p} \leq L/n$. Otherwise, if $\theta = L$, the seller deviates by selling $\overline{x}-\varepsilon$ instead of $\overline{x}$ from a good asset. For small $\varepsilon > 0$, she can raise the same amount of revenue and sell less from the good assets. Note that $x_i^*(\underline{v}, L) = \overline{x} \Rightarrow \overline{p} = \overline{p}_{con}(\tau)$. Suppose on the contrary that $L/n < \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$.We argue that there is an optimal deviation to fully selling all bad assets, and selling x' from good assets, for some $x' \in (0, \overline{x}]$. Since $\frac{L/n}{\underline{v}} < \frac{1-\tau}{\beta\tau+1-\tau} < 1$, the seller can always raise at least L

by selling all assets. Therefore, $\overline{x}\overline{p}_{con}(\tau) = L/n$. Moreover, $\overline{p}_{con}(\tau) > \underline{v} \Rightarrow \overline{x} < 1$. Since $\overline{x}$ is an equilibrium, $xp(x) < L/n$ for any $x < \overline{x}$. Let

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

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

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

Using $\overline{x}\overline{p}_{con}(\tau) = L/n$, $x' = \frac{L/n-(1-\tau)\underline{v}}{\tau\overline{p}_{con}(\tau)}$, and $\overline{p}_{con}(\tau) = \underline{v} + \Delta\frac{\beta\tau}{\beta\tau+1-\tau}$, 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 seller would retain more of good assets. For the same reasons as in the benchmark, $\overline{x} = \overline{x}_{con}/n$.

Consider part (ii). We show that if $\underline{v}(1-\tau) < L/n < \underline{v}$ then the specified equilibrium indeed exists. First, note that $L/n < \underline{v} \Rightarrow \overline{x}_{div}(\tau) < 1$. 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 pricing function in (8), the seller's trading strategy in (7) is indeed optimal. Suppose $\theta = 0$. Given (8), the seller's optimal response is $v_i = \overline{v} \Rightarrow x_i = 0$ and $v_i = \underline{v} \Rightarrow x_i = \overline{x}_{div}(\tau)$, as prescribed by (7). Suppose $\theta = L$. Given (8), the seller's most profitable deviation involves selling $\overline{x}_{div}$ from each bad asset, and the least amount of a good asset, such that she raises at least L. However, recall that by the construction of $\overline{x}_{div}(\tau)$, $(1-\tau)\underline{v}+\tau\overline{x}_{div}(\tau)\overline{p}_{div}(\tau) = L/n$. Also note that $L/n < \underline{v} \Rightarrow \overline{x}_{div}(\tau)\overline{p}_{div}(\tau) < L/n$. 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 $L/n \geq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$, the specified equilibrium indeed exists. The proof is as described by Lemma 1, where $\overline{x}_{con}$ is replaced by $\overline{x}_{con}/n$. The only addition is that we note that as per the proof of Claim 4, $L/n \geq \underline{v}\frac{1-\tau}{\beta\tau+1-\tau}$ guarantees that, if $\theta = L$, the seller has no profitable deviation. The proof that the seller 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. ■

Proof of Proposition 1. From Lemma 1

$$P_{con}(v_i,\tau) = \begin{cases} \overline{p}_{con}(\tau) & \textit{if } \ v_i = \underline{v} \\ \beta\overline{p}_{con}(\tau) + (1-\beta)\,\overline{v} & \textit{if } \ v_i = \overline{v}. \end{cases} \tag{17}$$

Let $\gamma = (1-\beta)\cdot \mathbf{1}_{\underline{x}(0)=0}$, then from Lemma 2,

$$P_{div}(\underline{v},\tau) = \begin{cases} \gamma[\underline{v} + \Delta\frac{\tau}{\tau+\gamma(1-\tau)}] + (1-\gamma)\,\underline{v} & \textit{if } \ L/n \leq \underline{v}\,(1-\tau) \\ \{\beta\underline{v} + (1-\beta)\,\overline{p}_{div}(\tau)\,, P_{con}(\underline{v},\tau)\} & \textit{if } \ \underline{v}\,(1-\tau) < L/n < \underline{v} \\ P_{con}(\underline{v},\tau) & \textit{if } \ L/n \geq \underline{v} \end{cases}$$

$$P_{div}(\overline{v},\tau) = \begin{cases} p_i^*(0) & \textit{if } \ L/n \leq \underline{v}\,(1-\tau) \\ \{\beta\overline{p}_{div}(\tau) + (1-\beta)\,\overline{v}, P_{con}(\overline{v},\tau)\} & \textit{if } \ \underline{v}\,(1-\tau) < L/n < \underline{v} \\ P_{con}(\overline{v},\tau) & \textit{if } \ L/n \geq \underline{v}, \end{cases}$$

and the curly brackets encompass the two possible equilibria (types-(ii) and (iii)) that can exist when $\underline{v}\,(1-\tau) < L/n < \underline{v}$.

To prove (9), first suppose $L/n > \underline{v}\,(1-\tau)$. It is sufficient to note that

$$\beta\underline{v} + (1-\beta)\,\overline{p}_{div}(\tau) < \overline{p}_{con}(\tau)$$

and

$$\beta\overline{p}_{div}(\tau) + (1-\beta)\,\overline{v} > \beta\overline{p}_{con}(\tau) + (1-\beta)\,\overline{v}.$$

The latter holds given that $\overline{p}_{div}(\tau) > \overline{p}_{con}(\tau)$, and the former holds given that

$$\begin{gathered} \beta\underline{v} + (1-\beta)\,\overline{p}_{div}(\tau) < \overline{p}_{con}(\tau) \Leftrightarrow \\ \frac{1-\beta}{\beta\tau + (1-\beta)(1-\tau)} < \frac{1}{\beta\tau + 1 - \tau} \Leftrightarrow \\ (1-\beta)\beta\tau < \beta\tau, \end{gathered}$$

which holds.

Next, suppose $L/n \leq \underline{v}(1-\tau)$. Note that

$$\begin{aligned}
\overline{p}_{con}(\tau) &\geq \gamma\left[\underline{v}+\Delta\frac{\tau}{\tau+\gamma(1-\tau)}\right]+(1-\gamma)\underline{v} \Leftrightarrow \gamma \leq \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)} \\
\beta\overline{p}_{con}(\tau)+(1-\beta)\overline{v} &< \underline{v}+\Delta\frac{\tau}{\tau+\gamma(1-\tau)} \Leftrightarrow \gamma < \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)}.
\end{aligned}$$

Therefore, this condition holds if $\underline{x}(0) > 0$ or, $\underline{x}(0) = 0$ and $1-\beta < \frac{\beta\tau}{\beta\tau+(1-\beta)(1-\tau)} \Leftrightarrow \beta > \frac{\sqrt{1-\tau}}{\sqrt{\tau}+\sqrt{1-\tau}}$, as required. ■

Proof of Lemma 3. Suppose in equilibrium under ownership structure $\chi \in \{con, div\}$ the buyer believes that the manager works w.p. τ^*_χ. From (11), if the manager works, his expected utility is $(1-\omega)\overline{v}+\omega P_\chi\left(\overline{v},\tau^*_\chi\right)-\widetilde{c}_i$, and if he shirks it is $(1-\omega)\underline{v}+\omega P_\chi\left(\underline{v},\tau^*_\chi\right)$. Therefore, he works if and only if $\widetilde{c}_i \leq c^* \equiv (1-\omega)\Delta+\omega\left[P_\chi\left(\overline{v},\tau^*_\chi\right)-P_\chi\left(\underline{v},\tau^*_\chi\right)\right]$.

To show that a higher c^* increases total surplus, note that manager i works only if his weight on the value gain $(1-\omega)\Delta$ plus ω times the expected price rise exceeds his cost. The maximum price rise is Δ, which arises if the price is fully informative. Thus, in any equilibrium, $c^* \leq (1-\omega)\Delta+\omega\Delta = \Delta$. Ex-ante total surplus (firm value minus the cost of effort) in equilibrium is increasing in c^* if and only if $c^* \leq \Delta$. Since the manager always chooses $c^* \leq \Delta$, a higher c^* always increases total surplus ■

Proof of Proposition 2. According to Lemma 5 in Appendix B.1, under concentration, the working threshold, $c^*_{con,exit}$, is given by the unique solution of $c^* = \phi_{exit}(F(c^*))$, where $\phi_{exit}(\tau) = \Delta - \frac{\omega\Delta}{\tau+\frac{1-\tau}{\beta}}$. Therefore, $c^*_{con,exit} < \Delta$. In addition, according to Lemma 6 in Appendix B.1, under diversification, the working threshold under the most efficient equilibrium, $c^{**}_{div,exit}$, is given by Δ if $L/n \leq \underline{v}(1-F(\Delta))$. The proof trivially follows from these two results. ■

Proof of Lemma 4. Consider concentration and suppose the buyer anticipates monitoring probability τ^*. Regardless of her monitoring decision, the investor still faces prices as given by (4), evaluated at $\tau = \tau^*$. Therefore, as in the proof of Lemma 1, the investor has follows the trading strategy prescribed by (3). She thus monitors if and only if

$$n\underline{v}+\overline{x}_{con}(\tau^*)\left(\overline{p}_{con}(\tau^*)-\underline{v}\right) \leq n\overline{v}-\beta\overline{x}_{con}(\tau^*)\left(\overline{v}-\overline{p}_{con}(\tau^*)\right)-\widetilde{c}_i.$$

This inequality can be rearranged as

$$\widetilde{c}_i/n \leq \overline{v} - \beta \frac{\overline{x}_{con}(\tau^*)}{n}(\overline{v} - \overline{p}_{con}(\tau^*)) - \left(\underline{v} + \frac{\overline{x}_{con}(\tau^*)}{n}(\overline{p}_{con}(\tau^*) - \underline{v})\right).$$

which implies a threshold strategy.

Consider diversification, and suppose the investor decides to monitor a mass of $n\tau$ firms. Since all firms are ex-ante identical, the investor will monitor the mass of $n\tau$ firms with the lowest monitoring costs. That is, the investor will monitor firm i if and only if $\widetilde{c}_i \leq F^{-1}(\tau)$ – a threshold strategy.

To show that a higher c^* increases total surplus, let firm value be $\overline{R}$ if $v = \overline{v}$ and $\underline{R}$ if $v = \underline{v}$. Then, $m\Delta \leq \overline{R} - \underline{R}$: the aggregate gain across the m units from $R_i = \overline{R}$ cannot exceed the overall gain in firm value, otherwise the value of any other classes of securities would be decreasing in R and so their owners would have incentives to reduce firm value (cf. Innes (1990)). Then, 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. ■

Proof of Proposition 3. Consider part (i). First note that in any equilibrium under diversification, the monitoring threshold is weakly smaller than Δ. The maximum increase in the value of the investor's portfolio from monitoring is Δ (which occurs when prices are fully revealing), and so the investor will never monitor firm i if the cost is higher than Δ. Next, note that according to Lemma 7 in Appendix B.2, the monitoring threshold under concentration must solve $c^* = n\phi_{voice}(F(c^*))$ where

$$\phi_{voice}(\tau) \equiv \Delta\left[1 - \beta \min\left\{\frac{L/n}{\underline{v} + (\Delta\beta - \underline{v}(1-\beta))\tau}, \frac{1}{\beta\tau + 1 - \tau}\right\}\right]. \tag{18}$$

Let $c^*_{con}(n, L)$ be the smallest solution. Suppose either $\beta < 1$, or $\beta = 1$ and $\frac{L}{\underline{v}} < n$. In either case, $n\phi_{voice}(F(0)) > 0$ for all n in this range. Then, $\phi_{voice}(F(c))$ crosses the 45 degree line at $c^*_{con}(n, L)$ from above. Note that $n\phi_{voice}(F(\cdot))$ is strictly increasing in n. Therefore, $c^*_{con}(n, L)$ locally increases in n as well. Since, for a given c^* we have $\lim_{n\to\infty} n\phi_{voice}(F(c^*)) = \infty$, $\lim_{n\to\infty} c^*_{con}(n, L) = \infty$ as well. In addition, $c^*_{con}(1, L) < \Delta$. It follows that for any $\beta \in (0, 1]$

there is $\overline{n} > \max\{\frac{L}{\underline{v}}, 1\}$ such that if $n > \overline{n}$ then $c^*_{con}(n, L) > \Delta$. Therefore, if $n > \overline{n}$, then any equilibrium under concentration is strictly more efficient than any equilibrium under diversification. This completes part (i).

Consider part (ii). First note that 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 $\overline{c}^*_{con}(n, L)$, is strictly smaller than Δ if $n < \underline{n}(L)$. Note that $\underline{n}(L)$ satisfies $\overline{c}^*_{con}(\underline{n}(L), L) = \Delta$. Second, Lemma 8 in Appendix B.2 shows that if $L/n \leq \underline{v}(1 - F(\Delta))$, the monitoring threshold is Δ in any equilibrium under diversification, and an equilibrium always exists. We therefore conclude that if $n < \underline{n}(L)$ and $L \leq \underline{v}(1 - F(\Delta))$, any equilibrium under diversification is strictly more efficient than any equilibrium under concentration. Therefore, there exists $L^* \geq \underline{v}(1 - F(\Delta))$ as required. ■

Proof of Proposition 4. Lemma 11 in Appendix C shows that, in any equilibrium under concentration, $\lambda^*_{con}(\beta)$ is unique and given by the solution to

$$c'(\lambda) = \beta(1-\beta)\tau(1-\tau)n\Delta \min\left\{\begin{array}{c} \frac{L/n}{\underline{v}[\lambda(1-\beta)(1-\tau)+\beta]+\Delta\beta\tau}, \\ \frac{1}{\lambda(1-\beta)(1-\tau)+\beta} \end{array}\right\}.$$

Therefore, $\lim_{\beta\to 1}\lambda^*_{con}(\beta) = 0$. Parts (i) and (ii) of Lemma 12 in Appendix C show that, if $L/n \leq (c')^{-1}(\beta\tau(1-\tau)\Delta)\cdot(1-\tau)\underline{v}$ then an equilibrium always exists under diversification, and in any equilibrium and for any $\beta \in (0, 1]$ we have $\lambda^*_{div}(\beta) > 0$. Since $(c')^{-1}(\beta\tau(1-\tau)\Delta)\cdot(1-\tau)\underline{v}$ is increasing in β, there exists $\overline{\beta} < 1$ such that if $L/n \leq (c')^{-1}(\overline{\beta}\tau(1-\tau)\Delta)\cdot(1-\tau)\underline{v}$ and $\beta > \overline{\beta}$ then $\lambda^*_{div}(\beta) > \lambda^*_{con}(\beta)$, as required. ■