Costly Financial Information Processing, Investor Heterogeneity, and Investment Efficiency*

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Abstract

We investigate a firm's choice of financial reporting disaggregation when raising capital from heterogeneous investors and its impact on investment efficiency. The firm's report contains an aggregate accounting measure, which equals a finite series of random variables determining its income, and disaggregated disclosure about a subset of these determinants. Investors choose to install capacity to process the firm's disaggregated disclosure but differ in their ability to process it. We find that firms choose a disaggregation policy that, while maximizing the level of decision-useful information, may provide too little disaggregation, thereby rendering inefficient investment outcomes for its investor base. We consider tools to enhance investment efficiency. We find that reducing measurement uncertainty of accounting standards benefits investors to the detriment of the firm; enhancing processing technology improves efficiency but cannot deliver Pareto dominance for investors; and information intermediation restores efficiency but redistributes its gains to sophisticated investors. These findings are relevant to standard setters as they deliberate their ongoing disaggregation disclosure agenda. More broadly, these findings suggest that decision usefulness, while necessary, is not a sufficient criterion for choosing disclosure policy when investors differ in their capacity to process information.

Keywords: information processing; reporting disaggregation; investor heterogeneity

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1 Introduction

Financial reporting regulators are increasingly mandating the disaggregation of summary measures. ASC 606, *Revenue from Contracts with Customers*, requires firms to decompose revenues into categories that depict how economic factors affect revenues and cash flows; ASU 2024-03, *Disaggregation of Income Statement Expenses* (DISE), scheduled for implementation by the end of 2026, extends this mandate to expenses.[1] The premise underlying both standards is that greater disaggregation produces more decision-useful information for investors (FASB, 2014; FASB, 2023). Yet investors are heterogeneous in their ability to process disaggregated information (Blankespoor et al., 2020), and installing the capacity to do so, which necessitates acquiring expertise, building research infrastructure, and deploying analytical technology, is costly. Given such heterogeneity in a firm's investor base, this paper examines whether a disaggregation disclosure policy that maximizes the aggregate decision usefulness of the firm's report also maximizes the return to its investors.

We show that the level of disaggregation that maximizes aggregate decision usefulness, which a firm would voluntarily choose, can leave investors collectively worse off once the costs of installing processing capacity are recognized. This finding motivates considering *investment efficiency*, defined as investors' aggregate expected payoffs net of their processing capacity costs. Investment efficiency is an investor-side benchmark. It evaluates the consequences of a firm's reporting policy for its investor base, taking the firm's payoff as a separate object. This distinction is important because the preferences of investors and the firm for disaggregated disclosure can diverge. Indeed, accounting standards that reduce measurement uncertainty can make both investor types better off in a Pareto sense, while leaving the firm worse off, even though disaggregated disclosure is costless to the firm.

In our model, a firm issues a financial report to raise capital from heterogeneous investors. The firm's return depends on the sum of a finite number of random variables. The firm adopts a reporting policy under which it reports a noisy aggregate accounting measure of net income and provides disaggregated disclosure on a subset of the underlying net income determinants.

[1] ASC 606-10 mandates more extensive disclosures regarding revenue recognition policies, judgments, and changes in contract balances. ASU 2024-03 requires disclosures about specific types of expenses included in expense captions on the face of the income statement, including purchases of inventory, employee compensation, and depreciation and amortization as well as qualitative descriptions of amounts.

The cardinality of this subset reflects the *level of disaggregation* in the report. We distinguish between sophisticated and unsophisticated investors, who differ in their capacity to process the firm's disaggregated disclosure. Before the firm reports, each investor decides whether to incur a fixed cost to install the capacity needed to understand disaggregated disclosure. Investors who install capacity allocate it optimally across the reported income determinants within a rational inattention framework (Sims, 2003; Lu, 2022); investors who do not install capacity use only the aggregate measure. Given an investor's understanding of the aggregate measure and how much each income determinant contributes to the firm's return, each investor contributes capital. The firm invests the capital and transforms it into terminal cash flows that are allocated to the investors on a pro rata basis. The firm chooses the level of disaggregation in its report to maximize terminal cash flows, anticipating the limited information-processing capability of its investor base.

A key force in the model is that an investor's inference about the firm's return is hump-shaped in the level of disaggregation. Expanding disaggregation exposes more facets of the firm's performance, but each additional income determinant must be processed with a share of the investor's finite capacity. Beyond a threshold, the investor's capacity is spread too thinly. Given this information overload, the precision of an investor's inference about each determinant falls, and the overall informativeness of the report declines. Because sophisticated investors have greater capacity, their preferred level of disaggregation exceeds that of unsophisticated investors. The firm must therefore balance the conflicting information needs of its heterogeneous investor base when deciding on its disaggregation reporting policy.[2]

This trade-off gives rise to two types of equilibria. In the *homogeneous investor equilibrium*, the firm provides a high level of disaggregated disclosure tailored to the sophisticated investor's capacity. Here only the sophisticated investor installs processing capacity, whereas unsophisticated investors, recognizing that the disaggregation level exceeds their ability to process it productively, rely solely on the aggregate measure. In the *heterogeneous investor equilibrium*, the firm provides a lower level of disaggregation that compromises between both investor types' capacities, and both types install processing capacity. The firm selects

[2]Kalay (2015) develops a measure of the average sophistication of a firm's investor base and documents that less sophisticated investors concentrate on firms that provide information they find more accessible, whereas sophisticated investors favor firms that provide more detailed information.

the equilibrium that maximizes its own payoff, or equivalently, maximizes the aggregate decision usefulness of its report, which we term the *payoff-dominant equilibrium*. The homogenous equilibrium maximizes the total amount of decision-useful information that the firm provides, because the disaggregation level is unconstrained by unsophisticated investors' capacity. Nonetheless, the heterogeneous investor equilibrium is payoff-dominant when the mass of unsophisticated investors is sufficiently large. This outcome arises because the capital contributions of many unsophisticated investors, each extracting a moderate amount of information from a lower level of disaggregation, can outweigh the reduction in the sophisticated investor's contribution from utilizing the lower level of disaggregated disclosure.

The payoff-dominant equilibrium, however, need not be investment efficient. The firm's reporting decision maximizes decision usefulness but does not account for investors' processing costs. Aggregate investor capacity costs are minimized in the homogeneous investor equilibrium. When the heterogeneous investor equilibrium is payoff-dominant, the additional decision usefulness it generates, relative to the homogeneous investor equilibrium, comes at the cost of all unsophisticated investors installing processing capacity. When this additional decision usefulness is insufficient to cover the additional processing costs, the payoff-dominant equilibrium is *not* investment efficient. This *decision-usefulness wedge* is a consequence of investor heterogeneity alone: were all investors to share the same processing capacity, no compromise equilibrium with duplicative capacity installation would arise, and the firm's decision-usefulness-maximizing disaggregation would coincide with the level investors prefer net of their processing cost. Consequently, disclosure policy maximizing decision usefulness would suffice for investment efficiency.

This decision-usefulness wedge motivates us to consider intervention by policy-makers or regulators in firm reporting behavior. We evaluate four tools to restore investment efficiency when an investment-inefficient heterogeneous investor equilibrium prevails. The first and most direct tool is to *mandate a higher level of disaggregation* that serves only the sophisticated investor, thereby implementing the homogeneous investor equilibrium.[3] Although this mandate restores investment efficiency, it harms both the firm, which loses the capital contri-

[3]For example, policymakers may implement minimum standards for disaggregation, (e.g., ASC 606; ASU 2024-03), or regulators such as the SEC might ask registrants using comment letters to specify their operations (EY, 2024).

butions of unsophisticated investors, and unsophisticated investors themselves, who lose the surplus they earned from processing the firm's disaggregated report. Because both the firm and unsophisticated investors are worse off, this tool does not yield a Pareto improvement.

Second, regulators can *reduce the measurement uncertainty* of accounting standards, for instance, through tighter recognition rules, enhanced internal controls, or improved disclosure controls.[4] A more precise aggregate net income measure improves all investors' inferences. When the aggregate net income measure is sufficiently precise, it becomes informative enough on its own that unsophisticated investors no longer find it worthwhile to install any processing capacity. The information unsophisticated investors can glean from only using the aggregate net income measure exceeds that which they can gain, net of cost, from also processing the firm's disaggregated disclosure. Consequently, the homogeneous investor equilibrium prevails. This equilibrium is Pareto dominant for both investor types, because they each earn a higher net payoff than in the heterogeneous investor equilibrium. The firm, however, is strictly worse off when the unsophisticated investors no longer choose to install any processing capacity, as it loses the capital contributions that processing the disaggregated disclosure would have generated.

Third, regulators can *enhance investors' processing technology*, for example, through improvements to the EDGAR filing system, XBRL tagging, or generative artificial intelligence models.[5] Different investor types benefit differentially from such technologies (Bhattacharya et al., 2018; Blankespoor et al., 2014). Accordingly, we allow the technology enhancement to be directed more toward one investor type than the other. Technology improvements always raise investment efficiency within a given equilibrium, but they can paradoxically harm unsophisticated investors. The mechanism is an indirect equilibrium effect driven by the firm's reporting response. As the technology expands processing capacity, the firm responds

[4] The Sarbanes-Oxley Act of 2002 strengthened internal control and disclosure control requirements (Section 302 and Section 404).

[5] In 1993, the SEC introduced the Electronic Data Gathering, Analysis and Retrieval (EDGAR) system to improve information production in financial markets (Gao and Huang, 2020). In 2009, it mandated that financial statements be filed using eXtensible Business Reporting Language (XBRL) to reduce investors' data aggregation costs (Blankespoor et al., 2014). Standard setters are considering how users of financial statements consume financial reporting information: the Financial Accounting Standards Advisory Council (2026) observed that "investors' ability to extract, process, and analyze financial information using AI has accelerated significantly in recent years and has reduced the cost of accessing and analyzing information."

by increasing its disaggregated disclosure, pushing the report further beyond unsophisticated investors' overload threshold. When the technology primarily benefits sophisticated investors, the firm's disaggregation expands substantially while unsophisticated investors' own processing improves only modestly. The resulting information overload reduces unsophisticated investors' benefit from installing capacity. Unlike reduced measurement uncertainty, processing technology cannot deliver Pareto dominance for both investor types.

Fourth, we consider *information intermediation* in which a sophisticated investor sells its processed information to unsophisticated investors.[6] When the quality of the intermediary's message is sufficiently high, unsophisticated investors purchase the message rather than installing their own processing capacity. Acquiring processed information eliminates the duplicative costs that drive investment inefficiency. The sophisticated investor, however, prices its message to extract the entire surplus from intermediation. Unsophisticated investors are then left at their outside-option payoff of relying solely on the aggregate measure. This payoff is strictly lower than what they earned in the heterogeneous investor equilibrium. Intermediation restores investment efficiency but makes unsophisticated investors strictly worse off, precluding Pareto dominance for investors.

Taken together, the analysis of these four tools identifies a tension in the design of disaggregated disclosure policy. Among the tools we examine, none achieves a first-best outcome for the firm and all investor types simultaneously when heterogeneous processing capacity matters. Given the objective of the Financial Accounting Standards Board (FASB) to "meet the needs of the maximum number of users in cost-beneficial ways" (SFAC No. 8, BC1.18), reducing measurement uncertainty comes closest as it delivers Pareto dominance for both investor types, albeit to the firm's detriment. This ranking has implications for the FASB's ongoing disaggregation agenda. Standard-setters must weigh the decision usefulness of more disaggregated disclosure against the processing costs it imposes on a heterogeneous investor base. Our analysis suggests that the design of an effective disaggregation disclosure policy requires attention not only to what information is disclosed but also to whether

[6] In practice, equity analysts and research firms serve as intermediaries, processing disaggregated disclosures and communicating their analysis to less sophisticated investors through research reports and recommendations. Policy-makers improve the precision of this channel through mandatory continuing-education requirements and conflict-of-interest rules (e.g., FINRA Rule 2241).

investors can process it, and that decision usefulness is a necessary but not sufficient criterion for improving investment efficiency.[7]

Related literature: Our paper contributes to the literature on financial reporting design (for surveys, see Verrecchia, 2001; Beyer et al., 2010; Stocken, 2012; Goldstein and Yang, 2017). Diamond (1985) shows that a firm's public disclosure benefits investors because it eliminates the need for each of them to bear the cost of acquiring the information privately. In his setting, disclosed information is costless for investors to use. Fishman and Hagerty (1989) consider a setting in which traders' resources for becoming informed are limited. Hence, firms compete for informed traders, and more informative disclosure attracts traders away from other firms, making the disclosing firm's stock price more efficient. They show that more efficient security prices can lead to more efficient investment decisions, giving firms an incentive to disclose voluntarily. Firms, however, may expend more resources on disclosure than is socially optimal. Fishman and Hagerty (2003) further recognize that not all market participants can understand a firm's disclosure, and show that firms may withhold information when few can understand its disclosure. Our setting differs from these studies in that processing disclosure is costly for investors, as they must install processing capacity, and each disaggregated component consumes part of that capacity whether or not they learn from it. Because the firm's disaggregation choice does not internalize these costs, which differ with investor sophistication, the firm may provide too little disaggregation.

Our paper is related to the accounting information system design literature (e.g., Stocken and Verrecchia, 2004; Göx and Wagenhofer, 2009; Heinle and Verrecchia, 2016; Michaeli, 2017; and Gregor and Michaeli 2024). Within this literature, only a few papers jointly examine information aggregation, disclosure complexity, and costly information processing (e.g., Indjejikian, 1991; Ebert et al., 2017; Lu, 2022; Aghamolla and Smith, 2023). Our paper builds on Lu (2022), who examines the ex ante reporting design for reporting two income determinants to a homogeneous group of rationally inattentive investors endowed with processing capacity, where the investment technology features complementarities (in

[7]The FASB already solicits the views of a wide range of investor types to inform its standard-setting decisions, including its evaluation of standards' effectiveness through the post-implementation review process; FASB staff reported more than 375 investor interactions over the year ended June 30, 2026 (FASB, 2026).

the spirit of Angeletos and Pavan (2004) and Myatt and Wallace (2012)). In his setting, investors prefer a summary report over detailed information when their processing capacity is small, even if it results in some (exogenous) information loss, and that providing details may result in coordination failures. We depart from his framework in three key respects. First, we introduce investor heterogeneity, which creates the core trade-off in the firm's disaggregation disclosure decision. Second, we generalize the number of income determinants, allowing us to study disaggregation as a choice variable. Third, we assume that learning the realization of an aggregate net income measure does not consume processing capacity, but understanding its details does (see Liberti and Petersen, 2019). This structure enables us to study disaggregated disclosure as a function of its measurement quality and the composition of the firm's investor base. Furthermore, we consider investment efficiency, an investor-side benchmark, which may diverge from aggregate decision-usefulness, which maximizes the firm's payoff. As coordination failures arise from investors installing processing capacities to process disaggregated disclosure, our analysis highlights the importance of regulatory policies that recognize investor processing capacity costs.

Although much of this literature considers a firm that *ex ante* commits to a disclosure policy or precision of the information system that influences an investor's action, Michaeli (2017) shows that a manager achieves a Pareto-dominant outcome by selectively disclosing precise information to only a fraction of investors, thereby regulating the sensitivity of the aggregate investor action. In contrast, our firm reports uniformly to all investors, but costly information processing can lead a fraction of investors to endogenously choose to ignore the disaggregated disclosure.

Within an ex post setting, Aghamolla and Smith (2023) examine how managers choose disclosure complexity based on the firm's realized performance and investor sophistication. In their model, firms use complex disclosures for positive news to convey detailed information about its realized performance, allowing sophisticated investors to more fully understand the firm's results, as well as for negative news to manage market perceptions, recognizing that unsophisticated investors are less capable of processing complex disclosure. In our setting, complexity increases with the level of disaggregated information. Our analysis complements theirs by providing a foundation for their key assumption that more complex disclosures can

benefit sophisticated investors while harming unsophisticated investors.

The paper proceeds as follows: Section 2 describes the model, Section 3 characterizes the equilibria, Section 4 examines investment efficiency, Section 5 considers tools to improve it, and Section 6 concludes. All proofs are relegated to the Appendix.

2 Model

Consider a financial reporting setting containing a firm and a continuum of investors. The firm's net income, which is the aggregation of its revenues and expenses, has $N \geq 1$ income determinants. The firm's return per unit of capital $\tilde{\theta} = \sum_{n=1}^{N} b_n \tilde{\theta}_n$ is ex ante unknown to the firm and its investors. Each income determinant contributes a return $\tilde{\theta}_n$ that is independently standard normally distributed. The return variance is given by $\mathbb{V} \equiv Var\left(\tilde{\theta}\right) = \sum_{n=1}^{N} b_n^2$ with $b_n \neq 0$ for some n.[8]

There are two types of investors. One sophisticated investor, denoted S, and a continuum of unsophisticated investors with mass γ, where the individual is denoted U. An investor $i \in \{S, U\}$ contributes capital of k_i. The firm raises aggregate capital of $K = k_S + \int_0^{\gamma} k_U \, dU$.[9]

The game has five dates.

Date 1: The firm's financial reporting policy is established. Specifically, in addition to mandatorily reporting net income, denoted A, the firm privately chooses its level of *disaggregated disclosure*, denoted J, which reflects the number of income determinants that it will disclose in its financial report, where $J \leq N$. Institutionally, J describes the expansiveness of the firm's disclosure about its line items or segments, including details about the accounting policies and procedures that the firm uses to determine these line items or segments.[10]

[8] The analysis is unchanged if each income determinant has an idiosyncratic mean. Because all equilibrium conditions depend only on second moments, the means merely add constants to capital contributions and payoffs. These constants cancel from every optimization and equilibrium comparison.

[9] For expositional ease, we assume the presence of a single sophisticated investor. Alternatively, assuming a continuum of identical sophisticated investors of measure one will not affect the interpretation of our results.

[10] Under general purpose financial reporting, a firm's financial report does not vary across its investors. Accordingly, our model restricts the firm to a single financial report. In 1995, the SEC proposed a two-tiered financial reporting system aimed at addressing concerns about investor "information overload" by introducing a simplified summary report alongside GAAP compliant disclosures. The initiative failed to gain traction, however, due to concerns about reduced transparency, potential investor confusion, and resistance from preparers and regulators wary of deviating from standardized reporting norms; see Bushman et al. (1996).

Date 2: Each investor decides whether to install the processing capacity necessary to analyze the firm's disaggregated disclosure. Without processing capacity, an investor lacks the wherewithal to evaluate the firm's disaggregated disclosures, although the investor can still understand the firm's aggregate net income measure, A. When deciding to install its processing capacity, the investor conjectures the firm's level of disaggregated disclosure. Investor i's decision to install processing capacity is denoted as $F_i = 1$. To install this capacity, the investor incurs a fixed processing capacity cost $c > 0$. These include the costs of acquiring accounting and industry expertise, building research infrastructure (e.g., hiring analysts), and installing information technology for gathering, interpreting, and verifying issuer information. Alternatively, investor i's decision not to install processing capacity and forgo analyzing the firm's disaggregated disclosure is denoted as $F_i = 0$.

Date 3: The firm privately observes the output from its accounting information system and then implements its reporting policy. The accounting information system generates a noisy signal about each of the firm's N income determinants, $\mathbf{s} = \{s_n = b_n\theta_n + \varepsilon_n\}_{n=1}^{N}$, where the measurement error ε_n is independently normally distributed with mean 0 and finite variance σ_ε, which we label as *measurement uncertainty*.[11] The firm then issues a financial report containing the aggregate net income measure $A = \sum_{n=1}^{N} s_n$ as well as the disaggregated information about the J income determinants $\{s_n\}_{n=1}^{J}$.

Date 4: Investors observe the firm's financial report. When an investor has installed processing capacity, the firm's disaggregated disclosure allows the investor to learn about the error term in the each of the disclosed income determinants, thereby more accurately predicting the firm's return per unit of capital θ. When investor i analyzes the firm's disaggregated disclosure, it obtains a signal vector $\mathbf{m}^i = \{m_n^i = \varepsilon_n + \omega_n^i\}_{n=1}^{J}$ about the measurement error contained in each of the J income determinants; we label $\mathbf{m}^i$ as the *investor's learning vector*. Each element m_n^i of the investor's learning vector has an independently normally distributed noise term ω_n^i with a mean of zero and a finite variance of $\sigma_{\omega_n}^i$.[12]

[11] Throughout the paper, a variable in bold font denotes a vector; further, the notation $\{x_n\}_{n=1}^{N}$ denotes a vector with N elements.

[12] Hinson, Pündrich and Zakota (2024) empirically document that disaggregated information, when accompanied by additional qualitative disclosures, significantly increases analyst forecast accuracy and investor response coefficients. We model this complementarity in a fashion similar to an aspect of the model adopted in Kim and Verrecchia (1994). They model investors as having event-period information that they can use

We capture the extent of investor learning from the disaggregated disclosure using the concept of mutual information. *Mutual information* is a measure of uncertainty reduction attributable to a signal; this measure is used in information theory to assess the content of a signal about an uncertain state of nature (Claude Shannon, 1948; Sims, 2003; Maćkowiak, et al., 2023). Formally, investor i's mutual information, which captures the dependence between the firm's measurement error vector $\boldsymbol{\varepsilon} = \{\varepsilon_n\}_{n=1}^{J}$ and the investor's learning vector $\mathbf{m}^i$, is

$$\mathbb{M}(\boldsymbol{\varepsilon}, \mathbf{m}^i) = \frac{1}{2} \log_2 \frac{\prod_{n=1}^{J} Var\left[\varepsilon_n\right]}{\prod_{n=1}^{J} Var\left[\varepsilon_n | \mathbf{m}^i\right]}. \tag{1}$$

Mutual information is strictly increasing in the prior variance of the income determinant measurement error and strictly increasing in the information that an investor gleans about the measurement error by analyzing the firm's disclosure. The measure is useful in this analysis because it converts an investor's processing capacity into a budget that is expended across the J reported determinants.[13]

Investors have limited capacity for processing information. To differentiate between investor types S and U, the information processing capacity κ^i is lower for unsophisticated investors than for sophisticated ones, i.e., $\kappa^U < \kappa^S$. Furthermore, investors suffer information overload. Disaggregated disclosure about each income determinant in the firm's report imposes a cognitive cost that consumes processing capacity, as the investor must allocate attention to parsing and evaluating it. Thus, while more disaggregation gives the investor more items from which to learn, disclosure about each additional item leaves less capacity available for that learning. Accordingly, we assume that the bound on an investor's learning decreases in the number of income determinants disclosed in the firm's report J. Formally, $B\left(i, J\right) \equiv \kappa^i - J \geq 0$.[14]

in conjunction with a firm's announcement to value the firm more precisely. It is also reminiscent of Versano and Trueman (2017) who consider a setting in which an analyst has noisy signals about the components of a firm's earnings.

[13] Mutual information is constructed as follows. For a multivariate random variable $\tilde{\varepsilon}$ with joint probability density function $f_\varepsilon(\cdot)$, Shannon entropy measures inherent uncertainty as $H(\tilde{\varepsilon}) = -E[log_2(f_\varepsilon(\tilde{\varepsilon}))]$. Mutual information $\mathbb{M}(\varepsilon, m) = H(\varepsilon) - H(\varepsilon|m)$ is the reduction in entropy from observing the signal m. Mutual information is measured in bits, because of the $\log_2(\cdot)$ in the definition of entropy; one bit corresponds to the uncertainty reduction from learning the outcome of a fair Bernoulli trail. See Cover (1999) for further detail.

[14] This linear specification is a tractable member of a broader class of learning bounds that decrease in J; i.e., $B\left(i, J\right) = \kappa^i - \alpha\left(J\right)$, where α is an increasing function in J. To justify this assumption, we

To learn about the measurement error in the firm's income determinants, each investor $i \in \{S, U\}$ chooses the variance $\sigma^i_{\omega_n}$ of its signals m^i_n, $\boldsymbol{\sigma}^i_\omega = \left\{\sigma^i_{\omega_n}\right\}^J_{n=1}$. The investor's choice to learn about the measurement error of each determinant must comply with the investor's learning constraint, $\mathbb{M}(\boldsymbol{\varepsilon}, \mathbf{m}^i) \leq B(i, J)$.

Investors, after observing the firm's financial report, contribute capital to the firm. If investor i analyzes the firm ($F_i = 1$), the investment decision is based on information set $\Omega_i = \{A, \mathbf{m}^i\}$; alternatively, if the investor does not analyze the firm's disaggregated disclosure but merely relies on net income as a summary measure of performance ($F_i = 0$), the investment decision is only based on $\Omega_i = A$.

Date 5: The firm's and the investors' payoffs are realized after investment occurs. The firm's payoff is

$$U^M = \theta K. \tag{2}$$

The investor i's net payoff realized from contributing capital k_i, but ignoring the investor's processing installation cost c, is given by

$$U_i = \theta k_i - \frac{1}{2}(k_i)^2, \tag{3}$$

where $(k_i)^2/2$ reflects investor's cost of capital.

All aspects of the game are common knowledge, except the firm's reporting choice J and its privately observed information $\mathbf{s}$ prior to reporting, each investor i's choice whether to install processing capacity $F_i \in \{0, 1\}$, and each investor i's choice of the variance for each of its signals $\boldsymbol{\sigma}^i_\omega$ about the firm's measurement error in its reported income determinants.

We study Rational Expectations Equilibria in pure strategies, which require the following conditions: First, the firm chooses the number of income determinates J to disclose in its

consider an information processing problem as having two stages. First, there is a screening stage in which an investor scans the firm's report to become aware of the set of signals to be processed. Investors spend more of their processing capacity in this screening stage if there are a larger number of disaggregated signals in the report. Second, once investors are aware of the set of signals, they then decide on allocating their remaining processing capacity among them. Thus, relative to rational-inattention models where the processing constraint is independent of the number of available signals (e.g., Sims 2003; Myatt and Wallace 2012), we suppose that adding sources of information impose an incremental processing cost, reflecting the cognitive cost of screening them. Our specification is consistent with the fundamental regularity in human information processing known as the Hick–Hyman law (Hick 1952; Hyman 1953), which recognizes that the cognitive resources required to discriminate among alternatives increase with the number of alternatives. Relatedly, the accounting literature documents that information processing costs are higher for reports of multi-segment firms (Cohen and Lou 2012; Frankel et al. 2006), for longer reports (Miller 2010), or reports containing more XBRL tagged items (Hoitash and Hoitash 2018).

report to maximize its expected payoff $\mathbb{E}\left[U^M\right] = \mathbb{E}\left[\tilde{\theta}\hat{K}\right]$ given the firm's conjecture of the investors' aggregate capital contribution $\hat{K}$. We assume that the firm chooses the smallest number of J when it is indifferent about the level of disaggregation. Second, each investor i chooses whether to install its processing capacity given its conjecture about the number of income determinants that the firm will disclose $\hat{J}$, its choice of the vector of signal variances $\boldsymbol{\sigma}_\omega^i$, and its choice of the capital to inject k_i. Third, if the processing capacity is installed, the investor chooses the vector of signal variances $\boldsymbol{\sigma}_\omega^i$ knowing J. Fourth, each investor i, given its information set Ω_i, chooses its capital contribution to maximize its expected net payoff $\mathbb{E}\left[\tilde{\theta}k_i - \frac{1}{2}\left(k_i\right)^2 - F_i \cdot c|\Omega_i\right]$. Lastly, the firm's conjecture of the sophisticated and unsophisticated investors' strategies to install their information processing capacity, decide the depth of their analysis, and their capital investment must be self-fulfilling; and likewise, the investors' conjectures of firm's reporting policy must be self-fulfilling.

3 Equilibrium

To characterize the equilibrium, we proceed using backward induction. We first determine an investor's decision to (i) choose the capital to invest in the firm, (ii) analyze the firm's disaggregated disclosure, and (iii) install information processing capacity. We then consider the firm's disaggregated disclosure to provide in its financial statements. Coupling the investor and firm choices, we establish the equilibria.

Investor Behavior:

First, we begin by establishing an investor's capital contribution. Every investor observes the aggregate net income measure, A. Additionally, the capital contribution depends on the investor's decision to install processing capacity to analyze the firm's disaggregated disclosure. After analyzing the disaggregated disclosure, investor i observes a learning vector $\mathbf{m}^i$ containing information about the measurement error of J income determinants that the firm discloses in its financial statements. Thus, investor i expects a return per unit of capital of $\mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right]$, and it contributes capital $k_i = \mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right]$. Alternatively, if investor i does not install processing capacity, then its capital contribution is $k_i = \mathbb{E}\left[\tilde{\theta}|A\right]$. The next lemma characterizes an investor's capital contribution.

Lemma 1 *When an investor i analyzes the disaggregated report ($F_i = 1$), the investor contributes capital of*

$$k_i = \mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right] = \beta_A^i(J) \cdot A + \sum_{n=1}^{J} \beta_n^i(J) \cdot m_n^i, \tag{4}$$

where

$$\beta_A^i(J) = \frac{\mathbb{V}}{\mathbb{V} + \sum_{n=1}^{J} Var\left[\varepsilon_n | m_n^i\right] + (N-J)\cdot\sigma_\varepsilon} \tag{5}$$

and

$$\beta_n^i(J) = -\frac{\mathbb{V}\cdot\left(\sigma_\varepsilon - Var\left[\varepsilon_n|m_n^i\right]\right)}{\sigma_\varepsilon \cdot \left(\mathbb{V} + \sum_{n=1}^{J} Var\left[\varepsilon_n|m_n^i\right] + (N-J)\cdot\sigma_\varepsilon\right)}. \tag{6}$$

Alternatively, when an investor i does not analyze the disaggregated report ($F_i = 0$), the investor contributes capital of $k_i = \mathbb{E}\left[\tilde{\theta}|A\right] = \beta_A^0 \cdot A$, where $\beta_A^0 = \mathbb{V}/(\mathbb{V} + N\sigma_\varepsilon)$.

The investor's contributed capital depends on its *posterior* beliefs about the expected return of each of the N income determinants. When an investor does not analyze the disaggregated report ($F_i = 0$), then $Var\left[\varepsilon_n|m_n^i\right] = \sigma_\varepsilon$, and the coefficient on the aggregate measure is identical for all such investors, $\beta_A^0 = \mathbb{V}/(\mathbb{V} + N\sigma_\varepsilon)$. Conversely, when an investor analyzes the disaggregated report ($F_i = 1$), the investor refines its understanding about the J income determinants the firm reports. Accordingly, the investor's posterior variance of the measurement error of each determinant is $Var\left[\varepsilon_n|m_n^i\right] = \sigma_\varepsilon \cdot \sigma_{\omega_n}^i/(\sigma_\varepsilon + \sigma_{\omega_n}^i) < \sigma_\varepsilon$. An investor i's reaction coefficient $\beta_A^i(J)$ determines the impact of the aggregate net income, A, on the investor's capital contribution, and $\beta_n^i(J)$ reflects the investor's adjustment to the response to the firm's aggregate net income from additionally analyzing each of the J income determinants in the firm's financial report.

Second, stepping backwards, we consider how an investor analyzes the firm's disaggregated disclosure. Given an investor installs the capacity to analyze the disaggregated report ($F_i = 1$), the investor chooses how much to learn about the measurement error of each reported income determinant. Specifically, the investor chooses the variance of each element in its learning vector, $\boldsymbol{\sigma}_\omega^i$, which drives its posterior beliefs about each of the J income determinants that the firm reports, $Var\left[\varepsilon_n|m_n^i\right]$. After substituting the investor's optimal capital contribution $k_i = \mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right]$ into $U^i(J) \equiv \mathbb{E}\left[U_i\right]$, the investor's expected payoff equals

$$U^i(J) = \frac{1}{2}\mathbb{E}\left[\mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right]^2\right] = \frac{1}{2}Var(\tilde{\theta}) - \frac{1}{2}Var\left[\tilde{\theta}|A, \mathbf{m}^i\right] = \frac{\mathbb{V}}{2}\beta_A^i(J), \tag{7}$$

where the second equality follows from the law of total variance, $\mathbb{E}[\tilde{\theta}] = 0$, and $Var\left[\tilde{\theta}|A, \mathbf{m}^i\right]$ is non-stochastic, and the third equality uses straightforward algebra. The investor's expected payoff $U^i(J)$ is the expectation of the quadratic function of the investor's capital contribution k_i. Hence, the posterior uncertainty of the investor's estimate of the firm's rate of return matters for the investor's expected payoffs. The aggregate net income measure *directly* informs investors about the expected rate of return. In contrast, the disaggregated disclosure is uncorrelated with the firm's rate of return. Thus, the firm's disaggregated disclosure only *indirectly* informs the investors through their learning about the measurement errors contained in the firm's aggregate measure. Consequently, the adjustment coefficient $\beta_n^i(J)$ does not feature in the investor's expected payoff, and instead, the response coefficient $\beta_A^i(J)$ captures investor learning and drives investor payoffs.

The responsiveness of the investor's capital contribution to the aggregate report $\beta_A^i(J)$, given in (5), decreases in the posterior measurement error variance of an income determinant, $Var\left[\varepsilon_n|m_n^i\right]$. Consequently, when an investor decides to learn more about the measurement error in each income determinant, it chooses a reduction in the posterior measurement error variance $Var\left[\varepsilon_n|m_n^i\right]$. This reduction in variance, however, exhausts the investor's capacity to learn about each of the other income determinants, and accordingly, the investor's learning constraint becomes binding. An investor i's problem, therefore, is to choose each element $\left\{\sigma_{\omega_n}^i\right\}_{n=1}^J$ to optimize the objective function

$$\min_{\left\{\sigma_{\omega_n}^i\right\}_{n=1}^J} \sum_{n=1}^{J} Var\left[\varepsilon_n|m_n^i\right] \quad \text{subject to} \quad \mathbb{M}\left(\boldsymbol{\varepsilon}, \mathbf{m}^i\right) \leq B(i,J).$$

The next lemma characterizes how much an investor chooses to learn about each income determinant by studying the firm's disaggregated disclosure. It establishes that an investor chooses to *uniformly* reduce the uncertainty about the measurement error in each income determinant the firm reports.

Lemma 2 *When learning about the measurement error in each reported income determinant, $\{\varepsilon_n\}_{n=1}^J$, an investor $i \in \{U, S\}$ chooses the identical noise variance $\sigma_{\omega_n}^i = \sigma_\omega^i$ for each of the J reported determinants, and therefore, each investor's posterior variance is $Var\left[\varepsilon_n|m_n^i\right] = \sigma_\varepsilon \cdot 4^{\left(1-\kappa^i/J\right)}$ for each income determinant.*

Third, an investor chooses whether to install the capacity needed to process the firm's disaggregated disclosure. As an investor makes this choice before the report is observed, it makes this choice while conjecturing the level of disaggregated disclosure the firm will report, $\hat{J}$. The ex ante expected utility of investor i, given the optimized information processing capacity allocation among the disaggregated income determinants, is $U^i(\hat{J}) = \frac{\mathbb{V}}{2}\beta_A^i(\hat{J})$.

As an investor incurs a cost c to install processing capacity, investor i will choose to analyze the firm's disaggregated disclosure if and only if the benefit of installing processing capacity exceeds the benefit of ignoring the firm's disaggregated disclosure, i.e.,

$$U^i(\hat{J}) - c \geq \frac{\mathbb{V}}{2}\beta_A^0 = U_0^i, \tag{8}$$

where U_0^i denotes investor i's expected utility when it chooses not to analyze the firm's disaggregated disclosure. Intuitively, an investor analyzes the disaggregated disclosure only when the additional information gleaned from an in-depth analysis provides sufficiently greater insights to offset the incremental cost of installing its processing capacity; that is, $U^i(\hat{J}) - U_0^i \geq c$. The sophisticated investor, who has greater processing capacity, enjoys a greater marginal return to learning about each disaggregated item than an unsophisticated investor. Thus, either only the sophisticated investor or both types of investors will install the processing capacity needed to analyze the firm's disaggregated disclosure; importantly, it is never the case that only unsophisticated investors will do so.

Firm Reporting Choice:

The firm, when choosing its level of disaggregated disclosure J, anticipates how its choice will impact an investor's behavior. From an ex ante perspective, the investor's learn about the measurement error of each disaggregated income determinant. Therefore, the investor i's response coefficient to the aggregate report can be written as

$$\beta_A^i(J) = \frac{\mathbb{V}}{\mathbb{V} + \sigma_\varepsilon \cdot J \cdot 4^{(1-\kappa^i/J)} + \sigma_\varepsilon \cdot (N - J)}. \tag{9}$$

This coefficient captures the key trade-off determining the firm's level of disaggregated disclosure, J. On one hand, as J increases, an investor can learn about the measurement errors in more of the firm's income determinants, $\sigma_\varepsilon \cdot 4^{\left(1-\kappa^i/J\right)}$, and fewer income determinants are evaluated using the prior beliefs, σ_ε. On the other hand, as J increases, investor

learning about the measurement error of each of the J income determinants decreases, i.e., $Var\left[\varepsilon_n|m_n^i\right] = \sigma_\varepsilon \cdot 4^{\left(1-\kappa^i/J\right)}$ increases for each of the J income determinants. On balance, there is a unique level of disaggregated disclosure, J^i, depending on the investor's processing capacity, that the firm chooses to maximize the investor's aggregate net income response coefficient and, in turn, the firm's payoffs.[15] This discussion is formalized in the next lemma.

Lemma 3 *The responsiveness $\beta_A^i(J)$ of investor $i \in \{U, S\}$ to the aggregate net income measure A is hump-shaped in J and is maximized when the firm reports disaggregated information about J^i income determinants given by*

$$J^i = \textit{Disaggregation-to-Capacity ratio} \cdot \kappa^i = 0.515 \cdot \kappa^i. \tag{10}$$

We find each investor type prefers an optimal level of disaggregation given its learning constraint. Lemma 3 shows that, in this setting, an investor extracts the most information from the firm's report when the level of disaggregation J^i is roughly half the investor's processing capacity κ^i, reflecting the optimal trade-off between the breadth of the firm's disaggregation of its income determinants and the depth to which the investor can analyze them. An investor with more processing capacity (larger κ^i) will process more information about the measurement error in the disaggregated disclosure. Hence, the optimal J^i increases in κ^i, implying there is a unique level of disaggregated disclosure for each investor i that maximizes their ex ante expected utility.

Within this light, the firm chooses the level of disaggregated disclosure anticipating an investor's information processing decision and its capital contribution. The firm's conjecture of the investor i's information processing decision is denoted as $\hat{F}_i$ and the aggregate capital contribution as $\hat{K}$. The aggregate capital that the firm anticipates raising is given by

$$\hat{K} = \gamma\left(\hat{F}_U\mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right] + (1-\hat{F}_U)\mathbb{E}\left[\tilde{\theta}|A\right]\right) + \left(\hat{F}_S\mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right] + (1-\hat{F}_S)\mathbb{E}\left[\tilde{\theta}|A\right]\right),$$

where the firm conjectures that unsophisticated investors behave symmetrically. When the firm decides on its disaggregated disclosure policy J, its expected payoff $U^M(J) = \mathbb{E}\left[\tilde{\theta}\hat{K}\right] =$

[15] The firm's first-order condition for maximizing investor i's response coefficient $\beta_A^i(J)$ with respect to J is $4^{1-\kappa^i/J}\left(1 + \left(\kappa^i \ln 4\right)/J\right) = 1$. Solving for J yields $J = \textit{Disaggregation-to-Capacity ratio} \cdot \kappa^i$, where the *Disaggregation-to-Capacity ratio* equals 0.515.

$Cov(\tilde{\theta}, \hat{K})$ can be written as

$$U^M(J) = \gamma \mathbb{V}\left(\hat{F}_U \beta_A^U(J) + (1 - \hat{F}_U)\beta_A^0\right) + \mathbb{V}\left(\hat{F}_S \beta_A^S(J) + (1 - \hat{F}_S)\beta_A^0\right). \tag{11}$$

To maximize the expected net income $U^M(J)$, the firm chooses J such that

$$\gamma \hat{F}_U \frac{d\beta_A^U(J)}{dJ} + \hat{F}_S \frac{d\beta_A^S(J)}{dJ} = 0. \tag{12}$$

Suppose the firm conjectures that there are only sophisticated investors, i.e., $\hat{F}_U = 0$ and $\hat{F}_S = 1$. It follows from Lemma 3, the optimal level of disaggregated disclosure equals $J^S = 0.515 \cdot \kappa^S$. Alternatively, suppose the firm conjectures both types of investors install capacity, i.e., $\hat{F}_U = 1$ and $\hat{F}_S = 1$. Hence, the level of disaggregated disclosure that solves (12) is denoted as J^B. When both investor types analyze the report, the number of income determinants on which the firm reports detailed disclosure is lower, i.e., $J^U < J^B < J^S$. This observation follows from Lemma 3, which shows that each investor type's reaction coefficient is maximized at a disaggregation level that increases in processing capacity κ^i. Since condition (12) is a linear combination of both investor types' marginal reaction coefficients, the firm's optimal disaggregation J^B lies between the two types of investors' preferred levels of disaggregation. In particular, at J^B, additional disaggregation increases the sophisticated investor's responsiveness, whereas it reduces the unsophisticated investor's responsiveness because the report already exceeds the unsophisticated investors' preferred level.[16]

The next corollary provides comparative statics on the level of disaggregation.

Corollary 1 *The level of disaggregation J^B decreases in the mass of unsophisticated investors γ, increases in an investor's processing capacity κ^i, increases in information system measurement uncertainty σ_ε, and decreases in return variance $\mathbb{V}$. The level of disaggregation J^S increases in the sophisticated investor's processing capacity κ^S.*

The level of disaggregation J^B is driven by the firm's investor base and its measurement practices. Specifically, when the mass of unsophisticated investors increases, their information

[16] Unsophisticated investors place relatively greater weight on prior beliefs when confronted with excessively disaggregated disclosure, which attenuates their reactions to news. This mechanism is reminiscent of the empirical evidence on muted or contrarian responses to complex disclosures, showing investors rely less on the informational content of news when processing costs are high. This observation provides a rational-belief-revision foundation for the contrarian trading behavior documented empirically (e.g., Kaniel et al., 2012; Luo et al., 2023).

needs are better reflected in the firm's disaggregation policy. Hence, J^B decreases in γ. Any increase in processing capacity κ^i increases the level of disaggregation, as investors become more capable of processing information. Lastly, when the firm measures each net income determinant less precisely or return variance decreases, both of which raise the noise in the report relative to the uncertainty in the firm's return, $\sigma_\varepsilon/\mathbb{V}$,the firm relies on investors engaging in more costly disaggregated information processing to foster investment. Hence, J^B increases in the information system measurement uncertainty σ_ε and decreases in return variance $\mathbb{V}$. Interestingly, although each individual investor's preferred disaggregation level J^i is invariant to σ_ε as well as to $\mathbb{V}$ (Lemma 3), the compromise level J^B is not. An increase in σ_ε or a decrease in $\mathbb{V}$ alters the relative curvature of the two components of the firm's first-order condition $\gamma d\beta_A^U(J)/dJ + d\beta_A^S(J)/dJ = 0$, tilting the optimal compromise level J^B toward the sophisticated investor's preferred level.

Equilibrium:

The next proposition characterizes the equilibria.

Proposition 1 *The equilibria are summarized by the triplet* $J^* \equiv (F_U, F_S, J)$ *where:*

1. *If* $U^S(J^S) - U_0 < c$, *then the unique equilibrium is* $J_0^* \equiv (0, 0, 0)$.
2. *If* $U^U(J^B) - U_0 < c \leq U^S(J^S) - U_0$, *then the unique equilibrium is* $J_S^* \equiv \left(0, 1, J^S\right)$.
3. *If* $U^U(J^S) - U_0 < c \leq U^U(J^B) - U_0$, *then the equilibria are* J_S^* *and* $J_B^* \equiv \left(1, 1, J^B\right)$.
4. *If* $c \leq U^U(J^S) - U_0$, *then the unique equilibrium is* J_B^*.

At most, four cases arise from investors' information processing decisions, which vary with the level of disaggregation. For a given level of disaggregation, a sophisticated investor is more inclined to analyze the firm's disaggregated disclosure than an unsophisticated investor because $U^S(J) > U^U(J)$. Whether investors install processing capacity, however, depends on the trade-off between the processing capacity cost parameter c and an investor's incremental benefit of analyzing the disaggregated disclosure, which equals $U^i(J) - U_0^i$.

Proposition 1, Cases 1, 2, and 4 each contain a unique equilibrium. In Case 1, the processing costs exceed the incremental benefit by so much that even sophisticated investors

ignore the disaggregated reporting. As the firm is indifferent between any J, it chooses $J = 0$. In Case 2, the firm knows that, even if it recognizes the unsophisticated investors and hence chooses J^B, they will ignore the disaggregated reporting as it is too costly for them to install the capacity necessary to analyze it. The firm, therefore, will focus solely on the sophisticated investor, and the level of disaggregated disclosure is J^S. We label this a *homogeneous investor equilibrium*. In Case 4, there is also a unique equilibrium. In this equilibrium, the firm knows that all types of investors will analyze the disaggregated report, i.e., $J^B < J^S < \kappa^U$, because the incremental benefit exceeds the cost to any investor type of installing its processing capacity. Consequently, the firm reports J^B. We label this a *heterogeneous investor equilibrium*. The equilibria in Cases 1 and 2 always exist. The equilibrium in Case 4 only exists when $\kappa^U > J^S$.

In Case 3, the homogeneous and heterogeneous investor equilibria coexist. At J^S, where the disaggregation level is tailored to the sophisticated investor, information overload deters unsophisticated investors from installing processing capacity; they rely solely on the aggregate measure, sustaining the homogeneous investor equilibrium J_S^*. At the lower level of disaggregation J^B, both investor types find it worthwhile to install capacity, sustaining the heterogeneous investor equilibrium J_B^*.

For the equilibria in Case 3 to exist, the mass of unsophisticated investors needs to be sufficiently large, i.e., $\gamma > \overline{\gamma}$, where the threshold $\overline{\gamma}$ is defined in the proof of Proposition 1. By contrast, when the mass of unsophisticated investors is small, i.e., $\gamma < \overline{\gamma}$, the firm does not weigh their interests highly when choosing the level of disaggregation J^B. In fact, it chooses a level that causes the unsophisticated investors to experience information overload from processing the disaggregated report, i.e., $J^B > \kappa^U$.

Figure 1, Panel (a) illustrates the investor responsiveness to the aggregate net income measure as a function of the firm's disaggregation level J. As established in Lemma 3, each investor type's responsiveness is hump-shaped in the disaggregation level J and maximized at $J^i = 0.515\,\kappa^i$. Moreover, the firm's compromise level of disaggregated disclosure that serves both investor types satisfies $J^U < J^B < J^S$. Panel (b) illustrates the coexistence of equilibria J_S^* and J_B^* characterized in Proposition 1, Case 3. The processing capacity cost c (dash-dotted line) satisfies the cost condition $U^U(J^S) - U_0 < c \leq U^U(J^B) - U_0$. At the

firm's compromise level of disaggregation J^B, an unsophisticated investor's benefit exceeds c (filled marker), so this investor installs processing capacity, and the heterogeneous-investor equilibrium J_B^* is sustained. Conversely, at J^S, its benefit falls below c (open marker), so it declines to install processing capacity, and the homogeneous-investor equilibrium J_S^* is also sustained. The sophisticated investor's benefit exceeds the cost c for $J = J^S$, so it installs capacity when the firm reports J^S. The two equilibria therefore coexist.

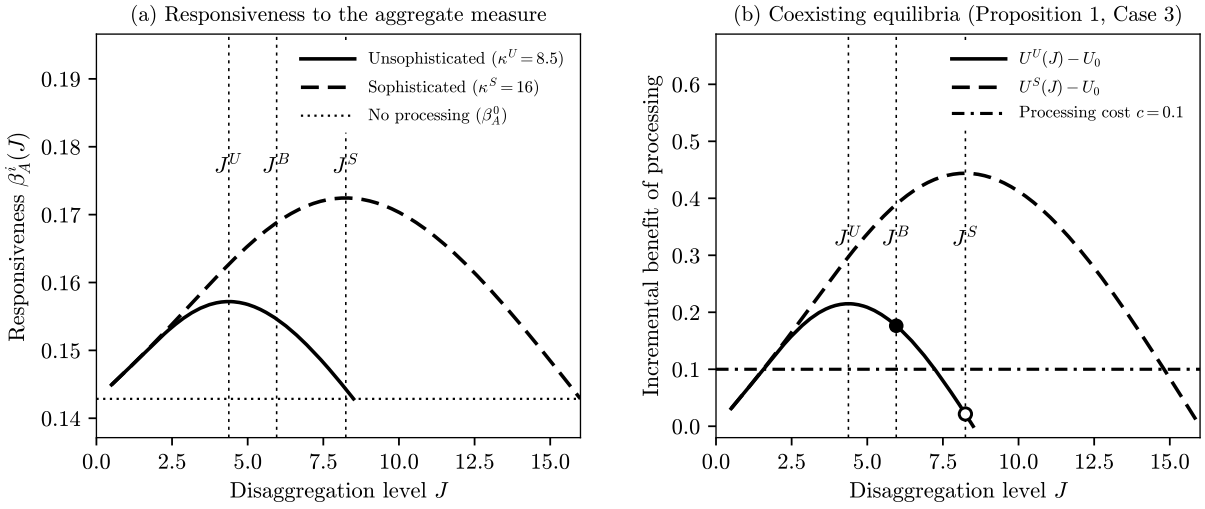


Figure 1: This figure illustrates the investor's response coefficient to the aggregate report for a disaggregation level J in Panel (a) and the presence of equilibria J_S^* and J_B^* characterized in Proposition 1, Case 3 in Panel (b). Panel (a) plots each investor type's responsiveness (solid: unsophisticated investors; dashed: sophisticated investor), which is hump-shaped in the disaggregation level J and maximized at $J^i = 0.515\,\kappa^i$. Panel (b) plots each investor type's incremental benefit of processing disaggregated disclosure, $U^i(J) - U_0$, where $U^i(J) = \mathbb{V}\beta_A^i(J)/2$ and $U_0 = \mathbb{V}\beta_A^0/2$, against the processing cost $c = 0.1$ (dash-dotted). The heterogeneous-investor equilibrium $J_B^* = (1, 1, J^B)$ is indicated by the filled marker and the homogeneous-investor equilibrium $J_S^* = (0, 1, J^S)$ by the unfilled marker. Both panels use the response coefficient $\beta_A^i(J)$ with $\kappa^U = 8.5$, $\kappa^S = 16$, $\sigma_\varepsilon = 6$, and $N = 30$. Additionally, $\gamma = 1$ and $b_n = 1$ for all n.

To refine the equilibria in Case 3 of Proposition 1 when $\gamma > \overline{\gamma}$, we use the notion of *equilibrium dominance* (Fudenberg and Tirole, 1991). Specifically, as the firm anticipates the actions of the two investor types and chooses its reporting disaggregation, it prefers the level of disaggregation that yields the highest expected firm payoffs, $U^M(J^*) = Cov(\tilde{\theta}, K(J^*))$, as noted above. The unique equilibrium in Proposition 1, Case 3 is characterized in the next proposition, where Δ captures the difference in firm payoff between equilibrium J_B^* and J_S^*.

Proposition 2 *If $U^U(J^S) - U_0 < c \leq U^U(J^B) - U_0$, then the firm's payoff $U^M(J_B^*)$ in equi-*

librium J_B^* *dominates its payoff* $U^M(J_S^*)$ *in equilibrium* J_S^* *if and only if the payoff difference* $\Delta > 0$*, where*

$$\Delta \equiv \mathbb{V}\left[\gamma\left(\beta_A^U(J^B) - \beta_A^0\right) + \left(\beta_A^S(J^B) - \beta_A^S(J^S)\right)\right]. \tag{13}$$

The firm prefers reporting to both investor types rather than focusing solely on the sophisticated investor when $\Delta > 0$. The expression for Δ in (13) reveals two competing effects of choosing the lower disaggregation level J_B^* over J_S^*.

On one hand, lowering the level of disaggregated reporting from J_S^* to J_B^* induces unsophisticated investors to analyze the firm's disaggregated disclosure. Each unsophisticated investor moves from relying solely on the aggregate net income measure, with reaction coefficient β_A^0, to also processing the disaggregated disclosure, with the higher reaction coefficient $\beta_A^U(J^B)$. The resulting gain in each unsophisticated investor's responsiveness, $\left(\beta_A^U(J^B) - \beta_A^0\right) > 0$, aggregated across the mass γ of these investors, captures the benefit of broadening the firm's informed investor base.

On the other hand, reducing disaggregation to J_B^* inhibits the sophisticated investor from fully exploiting its processing capacity. By Lemma 3, the sophisticated investor's reaction coefficient is maximized at J_S^*. Thus, reducing the level of disaggregation from J_S^* to J_B^* strictly reduces this investor's responsiveness, i.e., $\beta_A^S(J^B) - \beta_A^S(J^S) < 0$. This cost reflects the information the sophisticated investor could extract from greater disaggregation but that the firm forgoes to accommodate unsophisticated investors.

On balance, the payoff difference Δ is determined by whether the gain from engaging unsophisticated investors outweighs the cost borne by the sophisticated investor. Because Δ is strictly increasing in γ, the equilibrium J_B^* will *payoff-dominate* the equilibrium J_S^* when the mass of unsophisticated investors is sufficiently large, i.e., $\overline{\gamma} < \overline{\gamma}_L < \gamma$. The threshold value $\overline{\gamma}_L$ solves the *payoff dominance condition* given by $\overline{\gamma}_L\left(\beta_A^U(J^B) - \beta_A^0\right) = \beta_A^S(J^S) - \beta_A^S(J^B)$ in (13).[17]

[17] The formal definition of the threshold $\bar{\gamma}_L$ is provided in the proof of Proposition 2.

4 Investment efficiency

Standard setters often recognize that detailed disaggregated disclosure imposes processing costs on investors. Recent standards, such as ASU 2024-03—Disaggregation of Income Statement Expenses, attempt to reduce these burdens through practical expedients like qualitative descriptions when an expense caption is substantially attributable to a single category. These accommodations address the complexity of individual disclosures rather than the aggregate cost investors incur building the capacity to process disaggregated information in the first place. We introduce investment efficiency, which nets investors' aggregate expected payoffs against their processing capacity costs, as a benchmark that captures this distinction. This measure reveals that a firm's payoff-dominant disaggregation policy, while maximizing the decision-useful information conveyed to its investor base, can nonetheless leave investors worse off. This finding motivates the regulatory tools we examine in the next section.

Formally, *Investment efficiency* equals the sum of each investor i's expected payoff from investing in the firm, $U^i(J) = \mathbb{V}\beta_A^i(J)/2$, less the processing capacity cost, c, when choosing to analyze the firm's disaggregated disclosure.[18] After aggregating all investors' expected payoffs and subtracting their processing capacity costs, we obtain investment efficiency of

$$W(J^*) \equiv \frac{\mathbb{E}\left[\tilde{\theta}K\left(J^*\right)\right]}{2} - c\left(\gamma F_U + F_S\right), \tag{14}$$

where the first term reflects the aggregate of the investors' payoffs, which depends on the information the firm's report conveys to its investor base. The investors' payoffs equal half the firm's payoff $U^M(J^*) = \mathbb{E}\left[\tilde{\theta}K(J^*)\right]$ because, while the firm captures the payoff $\mathbb{E}\left[\tilde{\theta}K(J^*)\right]$, the investors collectively keep only half of that due to their cost of capital. The second term captures the aggregate investor cost of processing the firm's disaggregated disclosure.

When there are multiple equilibria J_S^* and J_B^*, the firm chooses the level of payoff dominant disaggregated reporting that maximizes the information it conveys to investors. Its choice, however, may not maximize investment efficiency because the firm does not internalize the investors' capacity costs. The next proposition characterizes when the firm's payoff dominant reporting decision coincides with the investment efficiency decision.

[18] Our notion of investment efficiency parallels Indjejikian (1991), where investors' information interpretation costs are considered in his investor welfare measure.

Proposition 3 *Suppose there are multiple equilibria J_S^* and J_B^*.*

- *If the firm payoff-dominant equilibrium is J_S^*, then it always renders greater investment efficiency than J_B^*.*
- *If the firm payoff-dominant equilibrium is J_B^*, then there exists an* efficiency threshold *value $\overline{c} = \Delta/(2\gamma) \in \left(U^U(J^S) - U_0, U^U(J^B) - U_0\right)$ for which the payoff-dominant equilibrium J_B^* is investment efficient when investor's capacity cost $c < \overline{c}$ and J_B^* is not investment efficient when $c > \overline{c}$.*

To understand the incongruence between the firm payoff-dominant and investment efficient equilibria, first consider the payoff dominant equilibrium when the firm focuses on sophisticated investors only, J_S^*. From Proposition 2, J_S^* is the payoff dominant equilibrium when $\Delta < 0$. This occurs when the mass of unsophisticated investors is small, $\gamma < \overline{\gamma}_L$, and therefore the capital the unsophisticated investors contribute is low, i.e., $\mathbb{E}\left[\theta K(J_B^*)\right] \leq \mathbb{E}\left[\theta K(J_S^*)\right]$. In this case, J_S^* dominates J_B^* on both dimensions of investment efficiency: specifically, on the payoff side, the sophisticated investor's capital contribution is weakly larger under J_S^*. On the cost side, the disaggregated report J^S discourages the unsophisticated investors from analyzing the firm, thereby reducing the aggregate processing capacity costs the investors incur from $(1+\gamma)c$ to c. Together, investment efficiency $W\left(J_S^*\right) = \mathbb{E}\left[\theta K(J^S)\right]/2 - c$ is always greater than $W\left(J_B^*\right) = \mathbb{E}\left[\theta K(J^B)\right]/2 - (1+\gamma)c$. In sum, when the firm focuses only on the sophisticated investor, the firm's payoff-dominant equilibrium coincides with the investment efficient equilibrium.

Second, consider the payoff dominant equilibrium when the firm compromises between both types of investors, J_B^*. When $\Delta > 0$, the mass of unsophisticated investors is large, $\gamma > \overline{\gamma}_L$. Because their capital contribution has a material impact on the firm's payoff, the firm chooses to recognize both investor types. This firm payoff dominant equilibrium, however, does not minimize the investors' aggregate costs of installing processing capacity. To see why, note that the difference in investment efficiency can be decomposed as $W(J_B^*) - W(J_S^*) = \Delta/2 - c\gamma$, where $\Delta/2 > 0$ is half the firm's incremental payoff from attracting both investor types and $c\gamma$ is the aggregate processing capacity costs the unsophisticated investors incur

but the firm does not internalize. The payoff-dominant equilibrium J_B^* is therefore investment efficient if and only if $\Delta/2 > c\gamma$.

The sign of this comparison varies with the level of processing capacity costs. When c approaches the upper bound of the cost region, i.e., $c \to U^U(J^B) - U_0$, the unsophisticated investors are nearly indifferent between analyzing the disaggregated report and relying solely on aggregate net income. At this limit, each unsophisticated investor's net benefit from analyzing the report, $U^U(J^B) - U_0 - c$, vanishes, so their aggregate net contribution to investment efficiency is zero. The only remaining effect is the cost borne by the sophisticated investor, whose reaction coefficient is strictly lower under J^B than under J^S, i.e., $\beta_A^S(J^B) < \beta_A^S(J^S)$. Because this cost is strictly negative, we observe that $\Delta/2 < c\gamma$ at this boundary, and hence, J_B^* is not investment efficient. When, instead, c approaches the lower bound of the cost region, i.e., $c \to U^U(J^S) - U_0$, each unsophisticated investor obtains a large net payoff from analyzing the report. Collectively, the gross payoff advantage of J^B, which uniquely maximizes the aggregate capital contribution from both investor types, exceeds the incremental capacity cost $c\gamma$, so that $\Delta/2 > c\gamma$, and consequently, J_B^* is investment efficient.

Between these extremes, there is an efficiency threshold $\overline{c} \in \left(U^U(J^S) - U_0, U^U(J^B) - U_0\right)$ at which $\Delta/2 = \overline{c}\gamma$ where both equilibria yield identical investment efficiency. When capacity costs exceed this threshold, $c > \overline{c}$, the payoff-dominant equilibrium J_B^* is not investment efficient; whereas when $c < \overline{c}$, J_B^* is investment efficient.

5 Tools for improving investment efficiency

Policy-makers and regulators have several tools to close the decision-usefulness wedge that arises in the heterogeneous investor equilibrium J_B^*. An obvious tool is to mandate a greater level of reporting disaggregation that focuses exclusively on serving the informational needs of sophisticated investors to yield the homogenous investor equilibrium J_S^*. As this reporting mandate discourages unsophisticated investors from installing costly processing capacity, it heightens the investment efficiency of the firm's reporting policy, resulting in $W\left(J_s^*\right) > W\left(J_B^*\right)$. This mandate, however, does not yield a Pareto improvement, because the firm loses the capital contribution of the unsophisticated investors and the unsophisticated investors

lose the surplus $U^U(J^B) - U_0 - c > 0$ earned in J_B^*.

Accordingly, we consider other tools that the analysis in the previous sections suggests may induce efficient investment. These tools include lowering the measurement uncertainty of accounting standards, enhancing information processing technology available to investors, or heightening the quality of intermediated information. We show, in this section, how each of the tools can improve investment efficiency when a firm is stuck in the investment inefficiency equilibrium J_B^*. Recall that the heterogeneous equilibrium J_B^* is inefficient when capacity installation costs are high; formally, when $c > \overline{c}$.[19]

5.1 Measurement uncertainty

A firm's accounting information system generates a noisy signal about each income determinant that is aggregated to generate net income. Accounting standards mandate the policies and procedures governing financial reporting. These standards affect the measurement uncertainty σ_ε of each income determinant, which affects not only the informativeness of the disaggregated disclosure but also the precision of the aggregated net income measure.[20]

This section asks three questions. First, how does measurement uncertainty affect investment efficiency within a given equilibrium? Second, how does it alter the relative payoffs across equilibria, and thereby the firm's equilibrium selection? Third, can a reduction in measurement uncertainty restore investment efficiency or generate Pareto improvements?

The next proposition characterizes the marginal impact of increased measurement uncertainty, σ_ε, on investment efficiency as well as on the differences in the equilibrium payoffs between J_B^* and J_S^*. The thresholds $\overline{\sigma}_\varepsilon$, $\overline{\gamma}_L$, and $\overline{\gamma}_H$ are defined in the Appendix.

Proposition 4 *Consider a marginal change in measurement uncertainty σ_ε.*

- *Investment efficiency decreases in measurement uncertainty; i.e., $dW(J^*)/d\sigma_\varepsilon < 0$ for $J^* \in \{J_B^*, J_S^*\}$.*

[19] Alternatively, the cost of installing capacity might be altered. When c falls below $\bar{c}$, J_B^* becomes investment efficient. Accordingly, the aggregate processing cost are sufficiently low that the payoff from the capital contribution of both investor types exceeds it. This change does not impact the firm's payoffs. Alternatively, c might be increased when $c > \bar{c}$ and unsophisticated investors will not install processing capacity. This decreases the payoff of both unsophisticated investors and the firm but raises that of the sophisticated investor.

[20] Technological advances are reducing the production costs of disaggregated information (Munter, 2022).

- *The difference in equilibrium payoffs, Δ, is hump-shaped in measurement uncertainty σ_ε and attains its maximum when $\sigma_\varepsilon = \sigma_\varepsilon^\Delta$; at this maximum, $\gamma = \overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right)$. Furthermore, (i) when $\sigma_\varepsilon < \overline{\sigma}_\varepsilon$ and $\gamma > \overline{\gamma}_H(\sigma_\varepsilon)$, Δ increases in σ_ε, i.e., $d\Delta/d\sigma_\varepsilon > 0$; (ii) when $\sigma_\varepsilon < \overline{\sigma}_\varepsilon$ and $\overline{\gamma}_L < \gamma < \overline{\gamma}_H(\sigma_\varepsilon)$ or when $\sigma_\varepsilon > \overline{\sigma}_\varepsilon$, Δ decreases in σ_ε; i.e., $d\Delta/d\sigma_\varepsilon < 0$.*

Investment efficiency decreases in measurement uncertainty in both equilibria. The mechanism operates through two channels. First, the *aggregate* measure A captures the firm's net income less precisely, making it less useful to investors. Second, investor learning from *disaggregated* disclosure $\mathbf{m}^i$ is also reduced. Increased measurement uncertainty increases the uncertainty in disaggregated information. Given the bound on an investor's learning $B(i, J)$, an investor's ability to learn is constrained, resulting in an increase in the investor's posterior variance for each income determinant. Both channels lower an investor's reaction coefficient $\beta_A^i(J)$, reducing expected payoffs $U^i(J)$, and consequently investment efficiency.

Although measurement uncertainty lowers payoffs in both equilibria, it does not do so symmetrically. Thus, the payoff difference between the heterogenous investor equilibrium J_B^* and the homogeneous investor equilibrium J_S^* is hump-shaped in the measurement uncertainty σ_ε of the firm's information system. The intuition rests on whether an increase in measurement uncertainty σ_ε impacts the aggregate net income channel or the disaggregated disclosure channel more severely and the extent to which investors rely on each of the channels in the homogenous and heterogenous investor equilibria.

When measurement uncertainty is low ($\sigma_\varepsilon < \overline{\sigma}_\varepsilon$), the aggregate measure A is sufficiently precise, so both types of investors rely relatively little on the disaggregated disclosure to resolve uncertainty about the firm's return. An increase in measurement uncertainty σ_ε erodes the aggregate measure's precision but raises the benefit of processing the disaggregated disclosure. As both types of investors initially have enough processing capacity to filter out the added noise, the increase in measurement uncertainty more severely impacts the payoff in the equilibria that rely relatively more heavily on the aggregated net income measure. Unsophisticated investors process only the aggregate measure and not the disaggregated disclosure in equilibrium J_S^*. Accordingly, when the mass of unsophisticated investors is large ($\gamma > \overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right)$), the payoffs in J_S^* falls more quickly than the payoffs in J_B^*. Consequently,

the payoff difference Δ *increase* when σ_ε increases. Conversely, when the mass of unsophisticated investors is more moderate ($\overline{\gamma}_L < \gamma < \overline{\gamma}_H\left(\sigma_\varepsilon^{\Delta}\right)$), fewer unsophisticated investors are affected by the differential reliance on the aggregate measure across the two equilibria, so the asymmetric impact on payoffs is weaker and Δ decreases.

Alternatively, when measurement uncertainty is high ($\sigma_\varepsilon > \overline{\sigma}_\varepsilon$), the aggregate measure A is imprecise. Hence, investors resolve most of the uncertainty about the firm's performance by processing the disaggregated information $\mathbf{m}^i$. As measurement uncertainty increases, investors find the processing of the disaggregated information even more challenging and the bound on investor learning $B(i,J)$ becomes increasingly restrictive. Investors therefore are even more strained when filtering out incremental noise in each income determinant, and hence, their posterior variance for each income determinant increases. Sophisticated investors, who have larger processing capacity, are less severely impacted by the increase in measurement uncertainty. Thus, the payoffs in equilibrium J_S^* are less negatively impacted than the payoffs in equilibrium J_B^*, which relies on unsophisticated investors processing disaggregated disclosure. Therefore, Δ *decrease* when σ_ε increases regardless of γ.

We now turn to the third question and consider whether reducing accounting system measurement uncertainty can encourage or discourage investors from installing processing capacity. We focus on the unsophisticated investors' decision to install processing capacity as their processing of disaggregated disclosure can reduce investment efficiency compared to when their investment decision is based exclusively on the aggregate net income measure.

A necessary condition to support the heterogeneous investor equilibrium J_B^* is that the incremental benefit of processing disaggregated information, $U^i(J_B^*) - U_0$, exceeds the cost c of installing the capacity to do so. This condition is more restrictive for unsophisticated investors because they are less capable of processing disaggregated disclosure than the sophisticated investor. Thus, for any change in measurement uncertainty, an unsophisticated investor will stop installing processing capacity before a sophisticated one. The next corollary shows the relation between measurement uncertainty and the incremental benefit of processing capacity.

Corollary 2 *An unsophisticated investor's incremental benefit of installing processing capacity, $\beta_A^U(J) - \beta_A^0$, is hump-shaped in the information system measurement uncertainty,*

σ_ε.

The incremental benefit to unsophisticated investors of processing disaggregated information is proportional to $\beta_A^U(J) - \beta_A^0$, which Corollary 2 shows is hump-shaped in measurement uncertainty. There are two forces driving this non-monotonicity. There is a direct effect on the investors that is attributable to the interplay between the aggregate measure and disaggregated disclosure discussed above. There also is an indirect effect that operates through the firm's reporting policy response. As measurement uncertainty increases, the firm increases its disaggregated disclosure level J^B, as established in Corollary 1. However, by Lemma 3, each investor's preferred disaggregation level J^i depends only on its processing capacity, not on measurement uncertainty. Thus, as measurement uncertainty σ_ε increases, the gap between J^B and J^U widens, pushing the report further beyond the unsophisticated investors' preferred level and exacerbating their information overload.

These results have implications for regulators who can influence measurement uncertainty through recognition rules, internal control requirements, or disclosure guidance. Beyond the marginal efficiency gains established above, a sufficiently large reduction in measurement uncertainty can induce a switch from the heterogeneous investor equilibrium J_B^*, which is not investment efficient, to the homogeneous investor equilibrium J_S^*, which is investment efficient. The switch occurs because, as measurement uncertainty falls sufficiently, the aggregate measure becomes so informative that unsophisticated investors no longer find it worthwhile to install processing capacity. The resulting homogeneous investor equilibrium J_S^* is Pareto dominant for both investor types. The firm, however, is worse off following this switch because it loses the capital contributions that unsophisticated investors' processing of disaggregated information would have generated in equilibrium J_B^*. Thus, while accounting standards that reduce measurement uncertainty are an effective tool for restoring investment efficiency and benefiting investors, they can leave the firm worse off, even though compliance is costless for the firm.

5.2 Processing technology

Investors' ability to extract information from a firm's disclosure about the determinants of income depends on their processing capacity, which is influenced by the accessibility and usability of the firm's reports through, for instance, the EDGAR filing system, the use of XBRL data tagging, and generative artificial intelligence models. This section explores how changing investor processing capacities affects investment efficiency and, if so, whether this new technology benefits all investors. We find that, while improving technology helps investors process information, ironically, it may discourage unsophisticated investors from even installing processing capacity needed to analyze the firm's reporting in the first place.

To formalize the impact of processing technology, we decompose each investor type's processing capacity into an innate endowment and a technology component. Specifically, let $\kappa^U = p^U + at$ and $\kappa^S = p^S + (1-a)t$ be the processing capacity of unsophisticated and sophisticated investors, respectively, where $p^U < p^S$ are the investor-specific capacity endowments, t is a technology enhancement common to all investors, and $a \in [0,1]$ governs the extent to which the technology enhancement helps unsophisticated investors. This parameterization is motivated by the empirical evidence that different investors are differentially impacted by the introduction of the XBRL data tagging technology (Bhattacharya et al., 2018; Blankespoor et al., 2014).

We consider three questions. First, how does a technology enhancement affect investment efficiency within a given equilibrium? Second, how does it alter the relative payoffs across equilibria? Third, what are the implications for regulatory policy?

The next proposition studies the marginal impact of a technology shock on investment efficiency and then examines how differences in the payoffs between the equilibrium J_B^* and the equilibrium J_S^* vary with changes in the technology shock. The threshold $\overline{a}_L$ is defined in the Appendix.

Proposition 5 *Consider a change in technology t.*

- *Investment efficiency increases in technology enhancement; i.e., $dW(J^*)/dt > 0$ for $J^* \in \{J_B^*, J_S^*\}$.*

- *If* $0 < a < \overline{a}_L$*, then equilibrium payoff difference* Δ *decreases in* t*; whereas if* $\overline{a}_L < a < 1$*, then equilibrium payoff difference* Δ *increases in* t*.*

Investment efficiency increases in technology enhancements for any specification a in both equilibria. A technology improvement allows investors to learn more precisely about the measurement error in each reported income determinant. The resultant investor learning reduces their posterior variance and raises their reaction coefficient $\beta_A^i(J)$. This holds regardless of whether the technology primarily favors sophisticated or unsophisticated investors; i.e., for any $a \in [0, 1]$.

Although new technology raises the payoffs in both equilibria, the impact of the new technology on the difference in equilibrium payoffs, Δ, depends on the extent to which the new technology benefits unsophisticated investors, a. When unsophisticated investors do not benefit much from the new technology ($0 < a < \overline{a}_L$), the new technology widens the processing gap between the investor types. Sophisticated investors glean even greater insight from the disaggregated disclosure under J_S^*, where the disaggregation level is already tailored to their capacity. In contrast, the payoff gain in J_B^* is more muted because the disaggregation level reflects a compromise between the two investor types. The unsophisticated investor, who received little benefit from the new technology, constrain how much the firm can disaggregated. Consequently, the payoffs in equilibrium J_S^* rise faster than in equilibrium J_B^*, and thus, the difference in equilibrium payoff Δ *decreases*. Alternatively, when a new technology is sufficiently targeted towards the unsophisticated investors ($\overline{a}_L < a < 1$), the unsophisticated investors' improved processing raises the payoffs in J_B^*, and thus, Δ *increases*.

The new technology strictly improves every investor type's processing capacity and their ability to learn from a firm's disaggregated disclosure. Yet Corollary 3 below shows that a new technology can reduce unsophisticated investors' incremental benefit of installing processing capacity, potentially discouraging them from doing so altogether. The threshold $\overline{a}_H$ is defined in the Appendix.

Corollary 3 *An unsophisticated investor's incremental benefit of installing processing capacity,* $\beta_A^U(J) - \beta_A^0$*, decreases in* t *when* $0 < a < \overline{a}_H$*, and increases in* t *when* $\overline{a}_H < a < 1$*.*

This seemingly paradoxical result that technology improvements might harm unsophisticated investors stems from the interplay of two opposing forces. The unsophisticated investor's incremental benefit of installing processing capacity is shaped by a *direct* effect of the new technology on information processing and an *indirect* effect through changes in the firm's reporting strategy. The direct effect of technology, intuitively, allows unsophisticated investors to learn more from the disaggregated disclosure, raising their reaction coefficient $\beta_A^U(J)$ and increasing their incremental benefit of installing capacity. The indirect effect operates through the firm's reporting response, and it may overturn the positive direct effect for unsophisticated investors. Specifically, as t increases, both investor types can process more disaggregated disclosure, and the firm responds by expanding its level of disaggregation J^B (Corollary 1). But, because unsophisticated investors are already overwhelmed with too much disaggregated information (i.e., $J^U < J^B$), the indirect effect of the new technology further overloads the unsophisticated investors. This reduces their reaction coefficient, causing their payoffs to fall. When the new technology mainly benefits sophisticated investors ($0 < a < \overline{a}_H$), the enlarged sophisticated investor's capacity induces the firm to expand its disaggregated disclosure substantially. Accordingly, the negative indirect effect on the unsophisticated investors dominates, and their incremental benefit of installing capacity falls. In the limit, the unsophisticated investors respond by not installing any capacity whatsoever. Accordingly, the equilibrium switches from J_B^* to J_S^*.

These results reveal both the benefits and limitations of processing technology as a regulatory tool. On the positive side, technology enhancements always improve investment efficiency within a given equilibrium. Moreover, when the technology is sufficiently targeted toward unsophisticated investors ($a > \overline{a}_L$), it raises Δ, which lifts the efficiency threshold $\overline{c}$ and can thereby make the heterogeneous investor equilibrium J_B^* investment efficient (see Proposition 3).

Additionally, we find that enhancing processing technology can induce a switch in equilibrium that is not only investment efficient but also Pareto optimal for the firm and its investors. A new technology causes the firm to alter its reporting behavior in a fashion that always favors sophisticated investors. Accordingly, the new technology must be sufficiently focused on helping unsophisticated investors process information if the technology is to im-

prove the payoffs of all investors, as Corollary 3 formalizes. When the new technology favors unsophisticated investors sufficiently, it raises the payoff difference between the heterogenous and homogeneous investor equilibria J_B^* and J_S^*, ultimately rendering them equally investment efficient.

Technology can yield Pareto improvements within J_B^* and increase investment efficiency. However, this gain in efficiency does not yield a Pareto-dominant equilibrium for investors, unlike the impact of accounting policies and procedures that reduce measurement uncertainty discussed above. Achieving investment efficiency requires switching from J_B^* to J_S^*, which occurs when unsophisticated investors stop installing processing capacity altogether. But this switch, by construction, lowers unsophisticated investors' payoffs as they lose the informational gains from processing disaggregated disclosure and resort to relying solely on the aggregate measure. Thus, any equilibrium switch that new technology induces harms the unsophisticated investors and reduces the capital the firm raises, thereby precluding Pareto dominance. In contrast, reduced measurement uncertainty can trigger the same switch while simultaneously making the aggregate measure sufficiently precise that unsophisticated investors are better off without processing capacity than they were with it. This asymmetry suggests that regulators seeking Pareto improvements should prioritize enhancing the precision of accounting measurement standards over expanding the processing technology available to investors through, for instance, enhancements in XBRL data tagging technology.

5.3 Quality of intermediated information

The tools to improve accounting measurement or investor information processing examined above were aimed at enhancing investment efficiency when in the heterogenous investor equilibrium. Investment inefficiency arises when there are heterogenous investors with duplicated information processing capacity costs. Accordingly, to eliminate duplicate processing capacity costs, we consider the role of information intermediation. Specifically, we examine how a sophisticated investor with superior information processing capacity (e.g., an equity analyst or a stock brokerage) sells its processed information to unsophisticated investors, eliminating the need for them to install their own capacity. A sophisticated investor that sells its processed information is labeled as an *intermediary*. We shall show that this self-interested

behavior by the intermediary can enhance investment efficiency.

We extend the model by allowing a sophisticated investor with superior processing capacity to sell its processed information to unsophisticated investors. Before the firm reports, each unsophisticated investor chooses between either purchasing the intermediary's message at a price P or installing its own processing capacity. The intermediary privately observes its learning vector $\mathbf{m}^S$ but cannot communicate it perfectly. Its message $\mathbf{R} = \mathbf{m}^S + \mathbf{y}$ is garbled by transmission noise $\mathbf{y} = \{y_n\}_{n=1}^J$, where each y_n is independently and identically distributed normal with mean zero and finite variance σ_y. A smaller σ_y corresponds to higher quality information. As an illustration, consider an equity analyst that observes a signal about the firm's segmental information. The analyst, after processing the firm's financial report, can only communicate a noisy signal about the information about each segment relative to the analyst's private understanding because of the imprecision of the language the analyst uses in its stock report.

An unsophisticated investor who purchases the intermediary's message observes both the aggregate measure A and the message $\mathbf{R}$. The unsophisticated investor's capital contribution $k_i = \mathbb{E}[\tilde{\theta} \mid A, \mathbf{R}]$, is determined in an analogous fashion to the main analysis. This investor's expected payoff is $\mathbb{E}\left[\mathbb{E}[U^i \mid A, \mathbf{R}]\right] = \mathbb{V}\beta_A^R(J)/2$, where the reaction coefficient on the aggregate net income measure is

$$\beta_A^R(J) \equiv \frac{\mathbb{V}}{\mathbb{V} + \sum_{n=1}^J Var\left[\varepsilon_n \mid m_n^S + y_n\right] + (N-J)\sigma_\varepsilon}. \tag{15}$$

Intuitively, $\beta_A^R(J)$ decreases in the variance of the transmission noise σ_y that impedes the unsophisticated investor's understanding of each income determinant's measurement error ε. In the absence of transmission noise ($\sigma_y = 0$), the intermediary's message perfectly conveys its learning vector $\mathbf{m}$ and hence the sophisticated and unsophisticated investors would share the same posterior beliefs. As the variance of the transmission noise in the intermediary's message increases, the message becomes increasingly uninformative.

The sophisticated investor has monopolistic pricing power and sets the price P to keep the unsophisticated investors indifferent between purchasing the message and their next-best alternative, which depends on the conjectured firm reporting policy.

When the investors conjecture J^B, the unsophisticated investors' next-best alternative

is to install their own processing capacity. The price that makes unsophisticated investors indifferent must satisfy $P(J^B) = c + \mathbb{V}\left[\beta_A^R(J^B) - \beta_A^U(J^B)\right]/2$, which reflects two components: the capacity cost savings c and the change in the unsophisticated investor's information from switching to the intermediary's message. The second component can be negative when the transmission noise σ_y is so large that the intermediary's message is less informative than the unsophisticated investor's own processing. Specifically, there exists a threshold $\overline{\sigma}_{y1}$ for which the price for the intermediated information drops to zero, and for any $\sigma_y > \overline{\sigma}_{y1}$, this price would be negative, implying intermediation will not arise.

When investors conjecture J^S, the unsophisticated investors' next-best alternative is to rely solely on the aggregate measure when investing in the firm, yielding $\mathbb{V}\beta_A^0/2$. Because the intermediary's message is always at least weakly more informative than when unsophisticated investors choose to not to process any disaggregated disclosure, they will purchase the intermediary message for a price $P(J^S) > 0$ for any finite σ_y. Intermediation therefore will always occur under the conjectured firm disclosure policy J^S.

The firm anticipates the investors' choice and the prevalence of information intermediation when it decides on the level of its disaggregated disclosure. Two forces shape this choice. First, when the firm conjectures that intermediation will arise, the firm optimally chooses J^S, as both investor types' capital contributions are now driven by the sophisticated investor's processed information either directly for the sophisticated investor or through the intermediary's message for unsophisticated investors. The firm no longer needs to compromise between heterogeneous investors, so it tailors disaggregation to the sophisticated investor.

Second, when intermediation does not occur, because transmission noise σ_y is too high, the firm faces the same trade-off as in the baseline model and may choose either J^B or J^S, depending on which equilibrium is payoff-dominant.

Combining these observations, the equilibrium depends on the quality of the intermediary's message. When $\sigma_y < \overline{\sigma}_{y1}$, intermediation occurs for both reporting policies J^B and J^S, as the intermediary's pricing lures unsophisticated investors to purchase its message. Thus, the unique equilibrium is J_S^*. Alternatively, when $\sigma_y > \overline{\sigma}_{y1}$, both equilibria J_S^* and J_B^* arise, but intermediation only occurs for J_S^*. The firm's payoff in the equilibrium with choice J^S

are enhanced by the additional informativeness that the intermediary's message provides. In this case, the firm chooses the payoff-dominant equilibrium. Infinitely noisy intermediated information yields the identical equilibrium payoff to that when there is no intermediation. Accordingly, the firm chooses to remain in the investment inefficient equilibrium J_B^*. However, as the quality of intermediated information increases, the payoff in equilibrium J_S^* increases. There is a threshold value $\overline{\sigma}_{y2}$ that makes the firm indifferent between the two equilibria J_S^* and J_B^*. For $\sigma_y < \overline{\sigma}_{y2}$, the firm chooses equilibrium J_S^* in which intermediation occurs. The next proposition summarizes the equilibrium characterization and relates it to investment efficiency.

Proposition 6 *An investment-efficient equilibrium J_S^* with intermediated information arises when the variance σ_y in the transmission noise is sufficiently low that $\sigma_y \leq \max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$. This equilibrium is never Pareto dominant.*

When information intermediation arises because transmission noise is sufficiently low, $\sigma_y \leq \max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$, unsophisticated investors no longer install processing capacity (as we consider the heterogenous investor equilibrium in which $c > \overline{c}$). Intermediation displaces the cost that unsophisticated investor incur from installing capacity, thereby attaining the investment-efficient equilibrium J_S^*.

This improvement in investment efficiency, however, does not generate a Pareto improvement. The reason stems directly from the intermediary's monopolistic pricing power. Under monopolistic pricing, the sophisticated investor extracts the entire surplus that its intermediation generates. It sets the price so that unsophisticated investors are exactly indifferent between purchasing the message and their outside option. As a result, the switch in equilibria that the presence of intermediation causes the unsophisticated investors' payoff to fall from $\mathbb{V}\beta_A^U(J)/2 - c$ in equilibrium J_B^* without intermediation to $\mathbb{V}\beta_A^R(J^S)/2 - P = \mathbb{V}\beta_A^0/2$ in the investment-efficient equilibrium J_S^* featuring intermediation. Moreover, any further improvement in the quality of the intermediary's message (i.e., a reduction in σ_y) accrues entirely to the sophisticated investor through a higher price, leaving unsophisticated investors' payoffs unchanged at their outside-option level.

This result contrasts with the measurement uncertainty tool discussed above, which can

achieve both investment efficiency and Pareto dominance for investors. There, reducing measurement uncertainty σ_ε of each income determinant makes the aggregate measure sufficiently precise that unsophisticated investors are better off without processing capacity than they were with it, so the equilibrium switch benefits them. In contrast, the equilibrium switch that intermediation causes, benefits the sophisticated investor to the detriment of the unsophisticated investors. In principle, if the intermediary were to price below the monopolistic level (when faced with competition among multiple sophisticated investors), a Pareto improvement for investors would become feasible. But absent such competitive pressure, intermediation alone cannot align the interests of all market participants. As better intermediation creates a loss for unsophisticated investors, no equilibrium Pareto dominates.

6 Conclusion

We show that a firm's disaggregation disclosure policy, regarding the expansiveness of the firm's disclosure about its line items or segments, depends on the information-processing capacity of its investor base. We highlight that the firm chooses its disaggregation policy to maximize the decision-usefulness of its financial report for the aggregate investor base. This may imply that sophisticated investors will demand more disaggregated information. Although such an expansion enhances their amount of decision-useful information, the aggregate investor base, including unsophisticated investors, will be informationally worse off. This setting creates a situation where no equilibrium allocation Pareto dominates the other.

We examine the importance of recognizing capacity costs needed to process decision-useful information when regulating firm financial reporting. We highlight that when a firm designs its disaggregation disclosure policy to compromise between heterogeneous investors' processing capacities, the financial reporting policy that maximizes aggregate decision-usefulness may not maximize the investor investment efficiency measure, which includes not only the aggregate investment return to investors but also their processing costs.

Several tools may resolve the investment inefficiencies that arise when a firm chooses a reporting policy that serves a heterogeneous investor base. A mandate for greater disaggregation to establish investment efficiency does not yield a Pareto improvement for investors

and the firm. Another tool to induce an investment efficient outcome is to enhance the processing capacity of unsophisticated investors by introducing technology that serves them (e.g., XBRL data tagging). Although such a policy is Pareto improving for investors, it does not implement a Pareto-dominant equilibrium. A tool that can create a Pareto dominant solution for investors is to mandate accounting standards, internal control systems, and disclosure policies that improve the precision of aggregate accounting measures, such as net earnings, so that unsophisticated investors forgo investing in the capability of processing disaggregated disclosure in the first place. This solution, however, lowers the firm's payoff. Moreover, we show that information intermediation from sophisticated to unsophisticated investors restores investment efficiency but does not yield a Pareto-dominant equilibrium for investors.

Taken together, our results reveal that the decision-usefulness wedge cannot be closed by any single regulatory tool. Reducing measurement uncertainty benefits investors to the firm's detriment; enhancing processing technology improves efficiency but cannot deliver Pareto dominance; and information intermediation restores efficiency, but redistributes its gains to sophisticated investors.

This tension is relevant to the FASB's ongoing disaggregation disclosure agenda, including the disaggregated disclosure of income statement expenses under ASU 2024-03. When deliberating these agenda items, it weighs the decision-usefulness benefits of greater disaggregation against the processing costs it imposes on a firm's heterogeneous investor base as it seeks to "meet the needs of the maximum number of users in cost-beneficial ways" (SFAC No. 8, BC1.18). Our analysis suggests that effective financial reporting policy design is likely to require not a single instrument but a combination of tools that are calibrated to the composition of a firm's investor base and the precision of its existing accounting measures. More broadly, the analysis underscores that decision usefulness, the objective of financial reporting regulation, is a necessary but not sufficient criterion for efficiency-improving disclosure policy when investors differ in their capacity to process information. Were investors to be homogenous in their processing capacity, however, decision usefulness would be a sufficient criterion for evaluating efficiency-improving disclosure policies.

Appendix

This appendix includes the proofs of the lemmas and propositions.

Proof of Lemma 1:

Each investor i, given its information set, chooses its capital contribution to maximize its expected net payoff

$$\mathbb{E}\left[\tilde{\theta}k_i - \frac{1}{2}(k_i)^2 - F_i \cdot c | A, F_i \cdot \mathbf{m}^i\right] = \mathbb{E}\left[\tilde{\theta}|A, F_i \cdot \mathbf{m}^i\right] k_i - \frac{1}{2}(k_i)^2 - F_i \cdot c.$$

Taking investor i's first-order derivative with respect to k_i and solving the first-order condition reveals that the optimal capital contribution satisfies $k_i = \mathbb{E}\left[\tilde{\theta}|A, F_i \cdot \mathbf{m}^i\right]$. Because all primitive random variables are jointly normally distributed and mutually independent, the conditional expectation coincides with the linear projection of $\tilde{\theta}$ onto the information set $\{A, \mathbf{m}^i\}$, i.e., it equals $\mathbb{E}\left[\tilde{\theta}|A, \mathbf{m}^i\right] = \beta_A^i(J) \cdot A + \sum_{n=1}^J \beta_n^i(J) \cdot m_n^i$. Recall that $A = \tilde{\theta} + \sum_{n=1}^N \varepsilon_n$ and $m_n^i = \varepsilon_n + \omega_n^i$ for $n = 1, \ldots, J$. The covariance vector between $\tilde{\theta}$ and the observable signals $(A, \mathbf{m}^i)$ is given by $Cov(\tilde{\theta}, A) = Var(\tilde{\theta}) = \mathbb{V}$ and $Cov(\tilde{\theta}, m_n^i) = 0$ for all n. The covariance matrix of $(A, \mathbf{m}^i)$ satisfies $Var(A) = \mathbb{V} + N\sigma_\varepsilon$, and for each of the J signals m_n^i we have $Cov(A, m_n^i) = \sigma_\varepsilon$, and $Var(m_n^i) = \sigma_\varepsilon + \sigma_{\omega_n}^i$. Lastly, recognize that $Var[\varepsilon_n | m_n^i] = \sigma_\varepsilon \cdot \sigma_{\omega_n}^i / (\sigma_\varepsilon + \sigma_{\omega_n}^i)$. The coefficient on A in the linear projection is

$$\beta_A^i(J) = \frac{\mathbb{V}}{\mathbb{V} + N\sigma_\varepsilon - \sum_{n=1}^J \frac{\sigma_\varepsilon^2}{\sigma_\varepsilon + \sigma_{\omega_n}^i}} = \frac{\mathbb{V}}{\mathbb{V} + (N-J)\sigma_\varepsilon + \sum_{n=1}^J Var[\varepsilon_n \mid m_n^i]},$$

and the coefficient on each learning signal m_n^i is

$$\beta_n^i(J) = -\beta_A^i(J)\frac{\sigma_\varepsilon}{\sigma_\varepsilon + \sigma_{\omega_n}^i} = -\frac{\mathbb{V} \cdot (\sigma_\varepsilon - Var[\varepsilon_n \mid m_n^i])}{\sigma_\varepsilon \cdot \left(\mathbb{V} + (N-J)\sigma_\varepsilon + \sum_{n=1}^J Var[\varepsilon_n \mid m_n^i]\right)}.$$

For $F_i = 0$, we have $\sigma_{\omega_n}^i \to \infty$, so the coefficients are $\beta_A^0 = \mathbb{V}/(\mathbb{V} + N\sigma_\varepsilon)$ and $\beta_n^0 = 0$, where $F_i = 0$ indicates a disaggregated report that is not analyzed. For $F_i = 1$, we have $\sigma_{\omega_n}^i > 0$, and the coefficients are as stated above. ■

Proof of Lemma 2:

Each investor i, given $F_i = 1$, allocates processing capacity across the J elements of the disaggregated report, knowing J. As $k_i = \mathbb{E}\left[\tilde{\theta}|A, F_i \cdot \mathbf{m}^i\right]$, investor i holds expectations of the terminal payoff that equals

$$\begin{aligned}\mathbb{E}\left[\mathbb{E}\left[U_i|A,\mathbf{m}^i\right]\right] &= \frac{1}{2}\mathbb{E}\left[\mathbb{E}\left[\tilde{\theta}|A,\mathbf{m}^i\right]^2\right] = \frac{1}{2}Var\left[\mathbb{E}\left[\tilde{\theta}|A,\mathbf{m}^i\right]\right] \\ &= \frac{\mathbb{V}}{2}\cdot\frac{\mathbb{V}}{\mathbb{V}+\sigma_\varepsilon\cdot(N-J)+\sum_{n=1}^{J}Var\left[\varepsilon_n|m_n^i\right]}.\end{aligned}$$

Maximizing the expected payoff for investor i is equivalent to minimizing the sum of posterior variances $\sum_{n=1}^{J} Var\left[\varepsilon_n|m_n^i\right]$ subject to the investor learning constraint $\mathbb{M}\left(\varepsilon,\mathbf{m}^i\right) \leq B\left(i,J\right)$. Formally, each investor $i \in I$ chooses each element $\left\{\sigma^i_{\omega_n}\right\}_{n=1}^{J}$ in the signal variance vector $\boldsymbol{\sigma}^i_\omega$ such that

$$\min_{\left\{\sigma^i_{\omega_n}\right\}_{n=1}^{J}} \sum_{n=1}^{J} Var\left[\varepsilon_n|m_n^i\right],$$

$$\text{s.t.} \quad \frac{1}{2}\log_2\frac{\prod_{n=1}^{J}Var\left[\varepsilon_n\right]}{\prod_{n=1}^{J}Var\left[\varepsilon_n|m_n^i\right]} \leq B(i,J).$$

Using the Gaussian updating formula, $Var\left[\varepsilon_n|m_n^i\right] = \sigma_\varepsilon\cdot\sigma^i_{\omega_n}/(\sigma_\varepsilon+\sigma^i_{\omega_n})$, the optimization can equivalently be written directly in terms of posterior variances. Since the objective is strictly decreasing in each $Var\left[\varepsilon_n|m_n^i\right]$, the investor learning constraint binds at the optimum. Setting up the Lagrangian for the optimization of investor i yields

$$\mathcal{L} = \sum_{n=1}^{J} Var\left[\varepsilon_n|m_n^i\right] + \lambda\left(\sum_{n=1}^{J}\log_2 Var\left[\varepsilon_n|m_n^i\right] - \sum_{n=1}^{J}\log_2\sigma_\varepsilon + B(i,J)\right).$$

The first-order condition for each $n = 1,\ldots,J$ is $\frac{\partial\mathcal{L}}{\partial Var[\varepsilon_n|m_n^i]} = 1 + \frac{\lambda}{\ln 4}\frac{1}{Var[\varepsilon_n|m_n^i]} = 0$, which implies equal posterior variance for each determinant chosen by investor i, i.e., $Var\left[\varepsilon_n|m_n^i\right] = -\lambda/\ln 4 \quad \forall n$. Imposing the binding investor learning constraint yield with equal posterior variances yields $\frac{1}{2}\log_2(\sigma_\varepsilon^J\cdot Var\left[\varepsilon_n|m_n^i\right]^{-J}) = B(i,J)$. Recognizing that $B(i,J) = \kappa^i - J$ as well as $Var\left[\varepsilon_n|m_n^i\right] = \sigma_\varepsilon\cdot\sigma^i_{\omega_n}/(\sigma_\varepsilon+\sigma^i_{\omega_n})$ and solving the constraint for the identical noise variance renders $\sigma^i_{\omega_n} = \sigma^i_\omega = \frac{\sigma_\varepsilon}{4^{(\kappa^i/J-1)}-1}$. ■

Proof of Lemma 3:

Consider the coefficient $\beta_A^i(J) = \mathbb{V}/(\mathbb{V}+(N-J)\sigma_\varepsilon+\sum_{n=1}^{J} Var\left[\varepsilon_n \mid m_n^i\right])$. Plug in $Var[\varepsilon_n \mid m_n^i] = 4^{1-\kappa^i/J}\sigma_\varepsilon$ and differentiate $\beta_A^i(J)$ with respect to J to obtain

$$\frac{\partial \beta_A^i(J)}{\partial J} = -\frac{\mathbb{V}\sigma_\varepsilon\left(4^{1-\kappa^i/J} + \kappa^i\left(\ln 4\right)\frac{4^{1-\kappa^i/J}}{J} - 1\right)}{\left(\sigma_\varepsilon J 4^{1-\kappa^i/J} + \sigma_\varepsilon(N-J) + \mathbb{V}\right)^2}.$$

As the denominator is strictly positive for any $J > 0$ and $\mathbb{V}\sigma_\varepsilon > 0$, the first-order condition implies $4^{1-\kappa^i/J} + \frac{\kappa^i \ln(4) 4^{1-\kappa^i/J}}{J} - 1 = 0$. Solving for J yields

$$J = \frac{\ln\frac{1}{4}}{1 + \text{LambertW}\left(-1, -\frac{1}{4e}\right)} \cdot \kappa^i = 0.514\,85 \cdot \kappa^i.$$

The second derivative evaluated at J^i is negative, confirming that J^i maximizes $\beta_A^i(J)$. ■

Proof of Proposition 1:

The proof is in two parts. Part 1 establishes equilibria in four distinct parameter regions. Part 2 derives existence conditions for the four parameter regions.

Part 1: Equilibria. The firm and investors play best responses summarized by the triplet $J^* \equiv (F_U, F_S, J)$. The firm chooses a level of disaggregation, J, to satisfy

$$\left(\frac{d\beta_A^U(J)}{dJ}\right)\int_0^\gamma \hat{F}_U\, dU + \hat{F}_S\frac{d\beta_A^S(J)}{dJ} = 0.$$

Concavity of $\beta_A^i(J)$ implies a unique optimal disclosure level for each conjecture, denoted J^B when both investor types analyze the report and J^S when only the sophisticated investor does.. Investors analyze the disaggregated report if $U^i(\hat{J}) - c \geq U_0^i$, which translates into $\frac{\mathbb{V}}{2}\beta_A^i(\hat{J}) - c \geq \frac{\mathbb{V}}{2}\beta_A^i(0)$. Because $\partial U^i(\hat{J})/\partial\kappa^i > 0$ it follows that $\beta_A^S(J^S) > \beta_A^S(J^B) > \beta_A^U(J^B)$. Hence, sophisticated investors analyze the report for a larger c than unsophisticated investors. Depending on the parameter c, four cases emerge.

First, let $c > U^S(J^S) - U_0^S$. Each investor's payoff from analyzing the disaggregated report is insufficient, i.e., $U^i(\hat{J}) - c < U_0^i$. Hence, it is the best response not analyze the disaggregated report, formally $F_U = F_S = 0$. As the firm is indifferent, it is a best response to choose $J = 0$. Hence, the unique equilibrium is established by $J_0^* \equiv (0, 0, 0)$.

Second, let $U^S(J^S) - U_0^S \geq c > U^U(J^B) - U_0$. Conjecturing $\hat{J} = J^S$ it is a best response for the sophisticated investor to analyze the disaggregated report as $U^S(J^S) - U_0^S \geq c$ so that $F_S = 1$ while for the unsophisticated investors not analyze the report is the best response as $c > U^U(J^B) - U_0$ so that $F_U = 0$. The firm conjecturing $\hat{F}_U = 0, \hat{F}_S = 1$ chooses J^S as it satisfies its first-order condition. Hence, the unique equilibrium is $J_S^* \equiv \left(0, 1, J^S\right)$

Third, let $U^U(J^B) - U_0 \geq c > U^U(J^S) - U_0$. Conjecturing $\hat{J} = J^S$, the equilibrium J_S^* unfolds as stated in the previous paragraph, i.e., an equilibrium is $J_S^* \equiv \left(0, 1, J^S\right)$. Conjecturing $\hat{J} = J^B$ it is a best response for the sophisticated investor and the unsophisticated investor to analyze the disaggregated report as $U^S(J^B) - U_0^S > c$ and $U^U(J^B) - U_0 \geq c$ so that $F_S = 1$ and $F_U = 1$. The firm conjecturing $\hat{F}_U = 1, \hat{F}_S = 1$ chooses J^B as it satisfies its first order condition. Hence, an equilibrium is $J_B^* \equiv \left(1, 1, J^B\right)$.

Fourth, let $U^U(J^S) - U_0 \geq c$, then conjecturing $\hat{J} = J^B$ the equilibrium J_B^* unfolds as stated in the previous paragraph.

Part 2: Existence of parameter regions. The incremental benefit of sophisticated investors is in either equilibrium always positive $U^S(J^S) - U_0^S > 0$. Hence, case 1 with $c > U^S(J^S) - U_0^S$ and case 2 with $U^S(J^S) - U_0 \geq c > U^U(J^B) - U_0$ trivially exists. For cases 3 and 4, a positive incremental benefit of unsophisticated investors is required.

The existence of case 3 requires that $U^U(J^B) - U_0 > 0$ which is invoked by $J^B \leq \kappa^U$. The smallest possible incremental benefit for unsophisticated investors is generated when $J^B \to \kappa^U$ as $U^U(J^B) - U_0 \to 0$. A reduction of $J^B < \kappa^U$ increases $U^U(J^B)$, as $J = J^U \leq J^B$ uniquely maximizes $U^U(J)$. Recall that J^B decreases in γ. We define a threshold value on the group size of unsophisticated investors $\overline{\gamma}$ that yields $J^B = \kappa^U$, which is obtained by solving $dU^M(J)/dJ|_{J=\kappa^U} = 0$. Specifically, the threshold equals

$$\overline{\gamma} = \frac{(N\sigma_\varepsilon + \mathbb{V})^2 4^{\kappa^S/\kappa^U} \left(\kappa^U \left(4^{\kappa^S/\kappa^U} - 4\right) - 4\kappa^S \log(4)\right)}{\kappa^U \log(4) \left((N\sigma_\varepsilon + \mathbb{V}) 4^{\kappa^S/\kappa^U} - \sigma_\varepsilon \kappa^U \left(4^{\kappa^S/\kappa^U} - 4\right)\right)^2}.$$

The relevant condition for the existence of case 3 is thus $\gamma > \overline{\gamma}$.[21]

The existence of case 4 requires $U^U(J^S) - U_0 > 0$. Because $U^U(J^S) - U_0$ increases in κ^U, the region for case 4 exists when $\kappa^U > J^S$ which translates to $\kappa^U > \frac{\ln \frac{1}{4}}{1 + \text{LambertW}\left(-1, -\frac{1}{4e}\right)} \kappa^S$. ■

[21] The condition $\gamma > 0 > \overline{\gamma}$ is always satisfied when $\kappa^S < -\frac{1}{\ln 4} \left(\text{LambertW}\left(-1, -\frac{1}{4e}\right) + 1\right) \kappa^U \approx 1.942 \kappa^U$. Conversely, the threshold value $\overline{\gamma} > 0$ when $\kappa^S > 1.942 \kappa^U$.

Proof of Proposition 2:

The result follows from a discrete comparison of firm payoffs $U^M(J^B) = \mathbb{V}\left[\beta_A^S(J^B) + \gamma\beta_A^U(J^B)\right]$ with $U^M(J^S) = \mathbb{V}\left[\beta_A^S(J^S) + \gamma\beta_A^0\right]$, where equilibrium J_B^* is chosen by the firm if and only if $\Delta = \mathbb{V}\left[\beta_A^S(J^B) + \gamma\beta_A^U(J^B)\right] - \mathbb{V}\left[\beta_A^S(J^S) + \gamma\beta_A^0\right] > 0$.

The firm's indifference condition is given by $\mathbb{V}\left[\beta_A^S(J^B) + \gamma\beta_A^U(J^B)\right] - \mathbb{V}\left[\beta_A^S(J^S) + \gamma\beta_A^0\right] = 0$. Partially differentiating the indifference condition (both parts are maximum value functions and thus the Envelope Theorem applies) with respect to the mass of unsophisticated investors, γ, reveals that the condition monotonically increases in it as $\beta_A^U(J^B) - \beta_A^0 > 0$. At the existence point of the region with multiple equilibria, where $\gamma = \overline{\gamma}$, the payoff dominance condition is $\mathbb{V}\left[\beta_A^S(J^B) + \overline{\gamma}\beta_A^U(J^B)\right] - \mathbb{V}\left[\beta_A^S(J^S) + \overline{\gamma}\beta_A^0\right] < 0$ because $\beta_A^0 = \beta_A^U(J^B)$ and hence equilibrium J_S^* is payoff dominant. As γ increases, there exists some $\gamma = \overline{\gamma}_L$ that solves the indifference condition. The threshold value renders

$$\overline{\gamma}_L = \frac{\beta_A^S(J^S) - \beta_A^S(J^B)}{\beta_A^U(J^B) - \beta_A^0} > 0.$$

A further increase in γ renders equilibrium J_B^* payoff dominant. ■

Proof of Proposition 3:

Investment efficiency in equilibrium J_S^* is $W(J_S^*) = \mathbb{E}\left[\theta K\left(J_S^*\right)\right]/2 - c$ and in equilibrium J_B^* it is $W(J_B^*) = \mathbb{E}\left[\theta K\left(J_B^*\right)\right]/2 - c(1+\gamma)$.

Suppose equilibrium J_S^* is the payoff dominant equilibrium which implies $\mathbb{E}\left[\theta K\left(J_S^*\right)\right] > \mathbb{E}\left[\theta K\left(J_B^*\right)\right]$. Because $c < c(1+\gamma)$ it follows that $W(J_S^*) > W(J_B^*)$. Hence, if the firm's payoff-dominant equilibrium is J_S^*, then it always renders greater investment efficiency than J_B^*.

Suppose equilibrium J_B^* is the payoff dominant equilibrium. We compare investment efficiency at the interval bounds $U^U(J^B) - U_0 \geq c > U^U(J^S) - U_0$ for both equilibria.

First, consider $c \to U^U(J^B) - U_0$ and plug it into $\Delta W(c) \equiv W(J_B^*) - W(J_S^*) = \mathbb{E}\left[\theta K\left(J_B^*\right)\right]/2 - \mathbb{E}\left[\theta K\left(J_S^*\right)\right]/2 - \gamma c = \frac{\mathbb{V}}{2}\left(\left[\beta_A^S(J^B) + \gamma\beta_A^U(J^B)\right] - \left[\beta_A^S(J^S) + \gamma\beta_A^U(\varnothing)\right]\right) - c\gamma$. Evaluating $\Delta W(U^U(J^B) - U_0) = \frac{\mathbb{V}}{2}[\beta_A^S(J^B) - \beta_A^S(J^S)] < 0$. It is negative, because J^S

uniquely maximizes $\beta_A^S(J)$. Hence, at $c \to U^U(J^B) - U_0$ the payoff dominant equilibrium J_B^* is never investment efficient.

Second, consider $c \to U^U(J^S) - U_0$. Evaluating $\Delta W(U^U(J^S) - U_0) = \frac{\mathbb{V}}{2}\left(\beta_A^S(J^B) + \gamma\beta_A^U(J^B)\right) - \frac{\mathbb{V}}{2}\left(\beta_A^S(J^S) + \gamma\beta_A^U(J^S)\right) > 0$ to be positive follows from the fact that J^B uniquely maximizes $\mathbb{E}\left[\theta K\left(J_B^*\right)\right] = \mathbb{V}[\beta_A^S(J^B) + \gamma\beta_A^U(J^B)]$. Hence, at $c \to U^U(J^S) - U_0$ the payoff dominant equilibrium J_B^* is always investment efficient.

Due to the strict monotonicity of $W(c)$ in c, we establish the existence of a threshold value $W(\overline{c}) = 0$. Hence, for $c > \overline{c}$ equilibrium J_B^* is not investment efficient while for $c < \overline{c}$ equilibrium J_B^* is investment efficient. ■

Proof of Proposition 4:

The proposition consists of 2 statements, which we will prove sequentially. Before we start, we introduce helpful notation. Let

$$W(J_B^*) = \frac{\mathbb{V}}{2}\left(\beta_A^S(J^B) + \gamma\beta_A^U(J^B)\right) = \frac{\mathbb{V}}{2}\left(\frac{\mathbb{V}}{\mathbb{V} + \sigma_\varepsilon V_{JB}^S} + \gamma\frac{\mathbb{V}}{\mathbb{V} + \sigma_\varepsilon V_{JB}^U}\right) \tag{16}$$

and

$$W(J_S^*) = \frac{\mathbb{V}}{2}\left(\beta_A^S(J^S) + \gamma\beta_A^0\right) = \frac{\mathbb{V}}{2}\left(\frac{\mathbb{V}}{\mathbb{V} + \sigma_\varepsilon V_{JS}^S} + \gamma\frac{\mathbb{V}}{\mathbb{V} + \sigma_\varepsilon V_0^U}\right), \tag{17}$$

where we define

$$V_0^U = N, \tag{18}$$

$$V_{JB}^U = N - (1 - 4^{1-\kappa^U/J^B})J^B, \tag{19}$$

$$V_{JB}^S = N - (1 - 4^{1-\kappa^S/J^B})J^B, \tag{20}$$

$$V_{JS}^S = N - (1 - 4^{1-\kappa^S/J^S})J^S. \tag{21}$$

The coefficient is decreasing in V_{IJ}, i.e., $\frac{\partial\beta_{IJ}}{\partial V_{IJ}} < 0$. Inspecting each V_{IJ} function we establish a natural ordering of $N = V_0^U > V_{JB}^U > V_{JB}^S > V_{JS}^S > 0$. To see this, recognize that $\kappa_I/J > 1$. Hence, $4^{1-\kappa_I/J} \in (0,1)$ and, therefore, $1 - 4^{1-\kappa_I/J} \in (0,1)$. Moreover, $4^{1-\kappa_I/J}$ decreases in κ_I and increases in J. Because $N > J$, it follows that $N \geq V_{IJ} \geq 0$. As $\kappa^S > \kappa^U$ we establish $V_0^U > V_{JB}^U > V_{JB}^S$. Lastly, we have $V_{JB}^S > V_{JS}^S \geq 0$. To see the last inequality, consider that the function $N - (1 - 4^{1-\kappa^S/J})J$ is uniquely minimized at J^S. Hence, $V_{JB}^S > V_{JS}^S$.

Recognize that $W(J) = Cov(\theta, K(J^*)) - c(\gamma F_U + F_S)$ in (16) and (17) only varies in σ_ε within the maximum value function $Cov(\theta, K(J^*))$ for their respective equilibrium. Hence, the Envelope Theorem applies. Partially differentiate (16) and (17) to obtain

$$\frac{dW(J_B^*)}{d\sigma_\varepsilon} = \frac{\mathbb{V}}{2}\left(-\frac{\mathbb{V}\,V_{JB}^S}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^S)^2} - \gamma\frac{\mathbb{V}\,V_{JB}^U}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^U)^2}\right) < 0, \tag{22}$$

$$\frac{dW(J_S^*)}{d\sigma_\varepsilon} = \frac{\mathbb{V}}{2}\left(-\frac{\mathbb{V}\,V_{JS}^S}{(\mathbb{V}+\sigma_\varepsilon V_{JS}^S)^2} - \gamma\frac{\mathbb{V}\,V_0^U}{(\mathbb{V}+\sigma_\varepsilon V_0^U)^2}\right) < 0, \tag{23}$$

and both are strictly negative.

Consider now Δ and how it varies with σ_ε. Observe that it can be written as $\Delta(\sigma_\varepsilon) = [\mathrm{Cov}(\theta, K(J_B^*)) - \mathrm{Cov}(\theta, K(J_S^*))]$. Hence, to evaluate the change of $\Delta(\sigma_\varepsilon)$ in σ_ε, the Envelope Theorem applies to both maximum value functions. Differentiating yields and rearranging yields

$$\frac{d\Delta(\sigma_\varepsilon)}{d\sigma_\varepsilon} = \mathbb{V}\left(\frac{\mathbb{V}\,V_{JS}^S}{(\mathbb{V}+\sigma_\varepsilon V_{JS}^S)^2} - \frac{\mathbb{V}\,V_{JB}^S}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^S)^2} + \gamma\left(\frac{\mathbb{V}\,V_0^U}{(\mathbb{V}+\sigma_\varepsilon V_0^U)^2} - \frac{\mathbb{V}\,V_{JB}^U}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^U)^2}\right)\right).$$

where $Z_1 \equiv \frac{\mathbb{V}\,V_{JS}^S}{(\mathbb{V}+\sigma_\varepsilon V_{JS}^S)^2} - \frac{\mathbb{V}V_{JB}^S}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^S)^2}$ and $Z_2 \equiv \frac{\mathbb{V}\,V_0^U}{(\mathbb{V}+\sigma_\varepsilon V_0^U)^2} - \frac{\mathbb{V}\,V_{JB}^U}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^U)^2}$. The parameter γ determines the sign of the derivative. Both effects cancel when $Z_1 = -\overline{\gamma}_H Z_2$ or in the notation of the proof when

$$\overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right) = -\frac{Z_1}{Z_2} = \frac{V_{JB}^S/(\mathbb{V}+\sigma_\varepsilon V_{JB}^S)^2 - V_{JS}^S/(\mathbb{V}+\sigma_\varepsilon V_{JS}^S)^2}{V_0^U/(\mathbb{V}+\sigma_\varepsilon V_0^U)^2 - V_{JB}^U/(\mathbb{V}+\sigma_\varepsilon V_{JB}^U)^2}.$$

Recall that equilibrium additionally requires

$$\gamma > \overline{\gamma}_L = \frac{\frac{\mathbb{V}}{\sigma_\varepsilon V_{JS}^S+\mathbb{V}} - \frac{\mathbb{V}}{\sigma_\varepsilon V_{JB}^S+\mathbb{V}}}{\frac{\mathbb{V}}{\sigma_\varepsilon V_{JB}^U+\mathbb{V}} - \frac{\mathbb{V}}{\sigma_\varepsilon V_0^U+\mathbb{V}}}.$$

We show that $\frac{d\Delta(\sigma_\varepsilon)}{d\sigma_\varepsilon}$ varies with the size of σ_ε. Specifically, let $0 < \sigma_\varepsilon < \sqrt{\mathbb{V}^2/(V_0^U\,V_{JB}^U)}$. Given $V_0^U = N > V_{JB}^U > V_{JB}^S > V_{JS}^S > 0$, we obtain $Z_1 < 0$ and $Z_2 > 0$, and moreover $\overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right) > \overline{\gamma}_L$. Thus $\frac{d\Delta}{d\sigma_\varepsilon} > 0$ when $\gamma > \overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right) > \overline{\gamma}_L$, whereas $\frac{d\Delta}{d\sigma_\varepsilon} < 0$ when $\overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right) > \gamma > \overline{\gamma}_L$.

Consider $\sqrt{\mathbb{V}^2/(V_0^U\,V_{JB}^U)} < \sigma_\varepsilon < \sqrt{\mathbb{V}^2/(V_{JB}^S\,V_{JS}^S)}$. Here $Z_1 < 0$ and $Z_2 < 0$, implying $\frac{d\Delta}{d\sigma_\varepsilon} < 0$ for all admissible γ.

Finally, let $\sigma_\varepsilon > \sqrt{\mathbb{V}^2/(V_{JB}^S\,V_{JS}^S)}$. In this case, $Z_1 > 0$ and $Z_2 < 0$, and moreover $\overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right) < \overline{\gamma}_L$. Since equilibrium requires $\gamma > \overline{\gamma}_L$, it follows that $\frac{d\Delta}{d\sigma_\varepsilon} < 0$.

Consequently, Δ increases in σ_ε when $\sigma_\varepsilon < \overline{\sigma}_\varepsilon = \sqrt{\mathbb{V}^2/(V_0^U\, V_{JB}^U)} = \mathbb{V}(V_0^U\, V_{JB}^U)^{-1/2}$, and additionally $\gamma > \overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right)$, so that $d\Delta/d\sigma_\varepsilon > 0$; otherwise Δ decreases in σ_ε when $\overline{\gamma}_H\left(\sigma_\varepsilon^\Delta\right) > \gamma > \overline{\gamma}_L$ so that $d\Delta/d\sigma_\varepsilon < 0$. Additionally, Δ decreases in σ_ε when $\sigma_\varepsilon > \overline{\sigma}_\varepsilon$ so that $d\Delta/d\sigma_\varepsilon < 0$. ■

Proof of Corollary 2:

Differentiate the unsophisticated investor's incremental benefit of installing processing capacity, $U^i(J) - U_0^i$, with respect to σ_ε to obtain

$$\frac{\mathbb{V}}{2}\left(\left[\frac{\mathbb{V}\, V_0^U}{(\mathbb{V}+\sigma_\varepsilon V_0^U)^2} - \frac{\mathbb{V}\, V_{JB}^U}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^U)^2}\right] - \frac{\mathbb{V}\,\sigma_\varepsilon}{(\mathbb{V}+\sigma_\varepsilon V_{JB}^U)^2}\left(\frac{\partial V_{JB}^U}{\partial J^B}\right)\left(\frac{\partial J^B}{\partial \sigma_\varepsilon}\right)\right).$$

The part in brackets has a root at $\sigma_\varepsilon = \mathbb{V}/\sqrt{V_{JB}^U \cdot V_0^U}$, where this expression is the maximizing value. The additional term signs negative as $\frac{\partial J^B}{\partial \sigma_\varepsilon} > 0$ and $\frac{\partial V_{JB}^U}{\partial J} > 0$. The function V_J^i is strictly convex in J and is minimized at $J = J^i$. Since V_{JB}^U is minimized at $J = J^U$ and $J^B > J^U$ in the relevant region, it follows that $\frac{\partial V_{JB}^U}{\partial J} > 0$.

Because $U^i(J) - U_0^i$ is zero when $\sigma_\varepsilon \to 0$ and $\sigma_\varepsilon \to \infty$, and its first-order derivative has only one root, there exists a unique maximum in σ_ε^*. ■

Proof of Proposition 5:

The proposition consists of 2 statements, which we will sequentially prove. The first claim is $dW(J_B^*)/dt > 0$ and $dW(J_S^*)/dt > 0$. For any equilibrium $J^* \in \{J_B^*, J_S^*\}$ the investment efficiency depends on the responsiveness coefficients and can be written as

$$W(J,t) = \frac{\mathbb{V}}{2}\left(\frac{\mathbb{V}}{\mathbb{V}+\sigma_\varepsilon\, V_S^J(t)} + \gamma\frac{\mathbb{V}}{\mathbb{V}+\sigma_\varepsilon\, V_U^J(t)}\right) - c.$$

Recognizing that the Envelope Theorem applies and thus partially differentiating with respect to t gives,

$$\frac{dW(J,t)}{dt} = -\frac{\sigma_\varepsilon\,\mathbb{V}\,\frac{\partial V_S^J(t)}{\partial t}}{(\mathbb{V}+\sigma_\varepsilon\, V_S^J(t))^2} - \gamma\frac{\sigma_\varepsilon\,\mathbb{V}\,\frac{\partial V_U^J(t)}{\partial t}}{(\mathbb{V}+\sigma_\varepsilon\, V_U^J(t))^2}.$$

From the structural expressions for the V-terms $V_S^J(t) = N - J + J\,4^{1-\left(p^S+(1-a)t\right)/J}$ and $V_U^J(t) = N - J + J\,4^{1-\left(p^U+at\right)/J}$, we infer that $\frac{\partial V_S^J(t)}{\partial t} < 0$ and $\frac{\partial V_U^J(t)}{\partial t} < 0$ for both $J = J^B$ and

$J = J_S^*$. Therefore, each of the two summands above is strictly positive and consequently $dW(J,t)/dt > 0$ for $J = J_B^*$ and $J = J_S^*$.

Consider now the variation of Δ in t. By definition

$$\Delta(t) = \mathbb{V}\left(\frac{\mathbb{V}}{\mathbb{V}+\sigma_\varepsilon V_S^{J^B}(t)} + \gamma\frac{\mathbb{V}}{\mathbb{V}+\sigma_\varepsilon V_U^{J^B}(t)} - \left(\frac{\mathbb{V}}{\mathbb{V}+\sigma_\varepsilon V_S^{J^S}(t)} + \gamma\frac{\mathbb{V}}{\mathbb{V}+\sigma_\varepsilon V_U^{0}}\right)\right).$$

Using the model expressions for the derivatives and recognizing that we study technology implementation at the margin, i.e., $t \to 0$ the sign condition $\Delta'(t)$ becomes equivalent to the inequality

$$\lim_{t\to 0}\Delta'(t) = (1-a)\frac{4^{1-p^S/J^B}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^B})^2} + a\,\gamma\frac{4^{1-p^U/J^B}}{(\mathbb{V}+\sigma_\varepsilon V_U^{J^B})^2} - (1-a)\frac{4^{1-p^S/J^S}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^S})^2}.$$

Consider the right-hand side as a function of $a \in (0,1)$. Evaluating the limits gives

$$\lim_{a\to 0}\text{R.H.S.} = \frac{4^{1-p^S/J^B}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^B})^2} - \frac{4^{1-p^S/J^S}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^S})^2} < 0,$$

and

$$\lim_{a\to 1}\text{R.H.S} = \gamma\frac{4^{1-p^U/J^B}}{(\mathbb{V}+\sigma_\varepsilon V_U^{J^B})^2} > 0.$$

Since the R.H.S is affine, hence, monotone in a it crosses zero exactly once in $(0,1)$. Denote the unique root by a_L. Solving the equality for a yields the threshold

$$a_L = \frac{-\dfrac{4^{1-p^S/J^B}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^B})^2} + \dfrac{4^{1-p^S/J^S}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^S})^2}}{-\dfrac{4^{1-p^S/J^B}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^B})^2} + \dfrac{4^{1-p^S/J^S}}{(\mathbb{V}+\sigma_\varepsilon V_S^{J^S})^2} + \gamma\dfrac{4^{1-p^U/J^B}}{(\mathbb{V}+\sigma_\varepsilon V_U^{J^B})^2}}.$$

Equivalently, expressing the variances through the responsiveness coefficients β leads to

$$a_L = \frac{4^{1-p^S/J^B}\left(\left(\beta_S^{J^S}\right)^2 - \left(\beta_S^{J^B}\right)^2\right)}{4^{1-p^S/J^B}\left(\left(\beta_S^{J^S}\right)^2 - \left(\beta_S^{J^B}\right)^2\right) + \gamma\,4^{1-p^U/J^B}\left(\beta_U^{J^B}\right)^2}.$$

Because the $\lim_{t\to 0}\Delta'(t)$ is strictly increasing in a, we conclude that for $0 < a < \overline{a}$, the derivative $\Delta'(t)$ is negative, whereas for $\overline{a} < a < 1$, we have $\Delta'(t) > 0$. ■

Proof of Corollary 3:

The payoff dominance condition is defined by $\Delta(t)$ and its derivative $\Delta(t)'$ has been signed in the proof of Proposition 5.

The incremental benefit of installing processing capacity is proportional to $\beta_A^U(t, J_B(t)) - \beta_0$, hence the sign of its change in t is the sign of the total derivative

$$\frac{d}{dt}\beta_U(t, J_B(t)) = \underbrace{\frac{\partial \beta_A^U}{\partial t}}_{>0} + \underbrace{J_B'(t)\frac{\partial \beta_A^U}{\partial J^B}}_{<0},$$

We have established in Proposition 5 that

$$\lim_{t\to 0}\frac{\partial \beta_A^U}{\partial t} = \frac{a\sigma_\varepsilon \mathbb{V}\log(4)4^{\frac{J^B+p^U}{J^B}}}{\left((\mathbb{V}+\sigma_\varepsilon(N-J^B))4^{\frac{p^U}{J^B}}+4\sigma_\varepsilon J^B\right)^2} > 0.$$

Corollary 1 indirectly that is positive, i.e., $J_B'(t) > 0$, as t enhances both κ^U and κ^S. However, using implicit differentiation and then considering the marginal shock, we obtain

$$\lim_{t\to 0}\frac{dJ^B}{dt} = 2J^B\log(4)\frac{A}{B},$$

where

$$A = \frac{(a-1)p^S\log(4)4^{-\frac{p^S}{J^B}}}{(\sigma_\varepsilon V_S^{J^B}+\mathbb{V})^2} + \frac{(a-1)\sigma_\varepsilon J^B 2^{1-\frac{4p^S}{J^B}}\left(J^B\left(4^{\frac{p^S}{J^B}}-4\right)-4p^S\log(4)\right)}{(\sigma_\varepsilon V_S^{J^B}+\mathbb{V})^3} \tag{24}$$

$$- \frac{a\gamma\sigma_\varepsilon J^B 2^{1-\frac{4p^U}{J^B}}\left(J^B\left(4^{\frac{p^U}{J^B}}-4\right)-4p^U\log(4)\right)}{(\sigma_\varepsilon V_U^{J^B}+\mathbb{V})^3} - \frac{a\gamma p^U\log(4)4^{-\frac{p^U}{J^B}}}{(\sigma_\varepsilon V_U^{J^B}+\mathbb{V})^2} \tag{25}$$

$$B = -\frac{p^{S^2}\log^2(4)2^{1-\frac{2p^S}{J^B}}}{(\sigma_\varepsilon V_S^{J^B}+\mathbb{V})^2} + \frac{\sigma_\varepsilon J^B 2^{-\frac{4p^S}{J^B}}\left(J^B\left(4^{\frac{p^S}{J^B}}-4\right)-4p^S\log(4)\right)^2}{(\sigma_\varepsilon V_S^{J^B}+\mathbb{V})^3} \tag{26}$$

$$- \frac{\gamma p^{U^2}\log^2(4)2^{1-\frac{2p^U}{J^B}}}{(\sigma_\varepsilon V_U^{J^B}+\mathbb{V})^2} + \frac{\gamma\sigma_\varepsilon J^B 2^{-\frac{4p^U}{J^B}}\left(J^B\left(4^{\frac{p^U}{J^B}}-4\right)-4p^U\log(4)\right)^2}{(\sigma_\varepsilon V_U^{J^B}+\mathbb{V})^3}. \tag{27}$$

Observe that $\lim_{t\to 0}\frac{dJ^B}{dt}$ is monotone in a just through A. The expression $\frac{\partial \beta_A^U}{\partial J^B} < 0$ because

$$\beta_U^{(0,1)}(t, J_B) = -\frac{\sigma_\varepsilon \mathbb{V}\frac{\partial V_U^{JB}(t,J_B)}{\partial J_B}}{(\mathbb{V}+\sigma_\varepsilon V_U^{JB})^2},$$

with

$$\frac{\partial V_U^{JB}(t,J_B)}{\partial J_B} = -1 + 4^{1-\frac{p^U}{J_B}} + \frac{4^{1-\frac{p^U}{J_B}} p^U \log 4}{J_B}.$$

Because $\frac{\partial V_U^{J}(t,J)}{\partial J}$ is minimized for $J = J^U$ but $J^B > J^U$, we can conclude that that $\frac{\partial V_U^{JB}(t,J_B)}{\partial J^B} > 0$, and thus,

$$\lim_{t\to 0} \beta_U^{(0,1)}(t,J_B) = -\frac{\sigma_\varepsilon \mathbb{V}\left(4^{1-\frac{p^U}{J^B}} + \frac{p^U \log(4) 4^{1-\frac{p^U}{J^B}}}{J^B} - 1\right)}{\left(\sigma_\varepsilon\left(J^B 4^{1-\frac{p^U}{J^B}} - J^B + N\right) + \mathbb{V}\right)^2} < 0.$$

Observe that $\lim_{t\to 0} \beta_U^{(0,1)}$ does not depend on a because J^B defined by the first order condition does not depend on a for marginal technology shocks where $t \to 0$.

To determine the sign of $\frac{d}{dt}\beta_U(t, J_B(t))$ inspect its limits.

$$\lim_{\substack{t\to 0 \\ a\to 0}} \frac{d}{dt}\beta_U(t, J_B(t)) = J_B'(t)\,\frac{\partial \beta_A^U}{\partial J^B} < 0$$

as $J_B'(t)$ remains finite and $\frac{\partial \beta_A^U}{\partial J^B}$ is not impacted by a. Considering

$$\lim_{\substack{t\to 0 \\ a\to 0}} \frac{d}{dt}\beta_U(t, J_B(t)) = \frac{\partial \beta_A^U}{\partial t} + J_B'(t)\,\frac{\partial \beta_A^U}{\partial J^B} > 0$$

the sign is positive. We deduce the sign as follows. We know that for $dCov(K(J_B^*), \theta)/dt > 0$ the Envelope Theorem applies, so that

$$\begin{aligned}\lim_{t\to 0} \frac{dCov(K(J_B^*)}{dt} &= \lim_{t\to 0}\left(\frac{d\beta_A^S}{dt} + \gamma\frac{d\beta_A^U}{dt}\right) = \lim_{t\to 0}\left(\frac{\partial \beta_A^S}{\partial t} + \gamma\frac{\partial \beta_A^U}{\partial t}\right) \\ &= (1-a)\frac{4^{1-p^S/J_B}}{(\mathbb{V} + \sigma_\varepsilon V_S^{J_B})^2} + a\,\gamma\frac{4^{1-p^U/J_B}}{(\mathbb{V} + \sigma_\varepsilon V_U^{J_B})^2}.\end{aligned}$$

Taking the limit $a \to 1$, the coefficient $\frac{\partial \beta_A^S}{\partial t} \to 0$. All the variation in $dCov(K(J_B^*), \theta)/dt > 0$ is driven by $\frac{\partial \beta_A^U}{\partial t} > 0$.

Combining monotonicity with the opposite endpoint signs established above, the intermediate value theorem implies there exists a unique $a_H \in (0,1)$ such that

$$\lim_{t\to 0} \frac{d}{dt}\,\beta_U(t, J_B(t))|_{a=a_H} = 0$$

and the sign of $\lim_{t\to 0} \frac{d}{dt}\beta_U$ is negative for $0 < a < a_H$ and positive for $a_H < a < 1$. ■

Proof of Proposition 6:

We consider a situation where $\Delta > 0$, so J_B^* is implemented, and it is also not investment efficient, i.e., $c > \overline{c}$. The possibility to intermediate information adds another layer to the unsophisticated investor's decision, i.e., it can decide to purchase information, $F_i = p$, install processing capacity $F_i = 1$, or not learn from disaggregated information at all $F_i = 0$, formally $F_i \in \{0, 1, p\}$. The equilibrium derived in Proposition 1 considers the case where $\sigma_y \to \infty$. The pure strategy space of unsophisticated investors has to be adjusted by the sub-game of purchasing information.

Consider this sub-game and suppose an unsophisticated investor has purchased information. We calculate the unsophisticated investor's payoff from purchasing the signal vector $\mathbf{R}$ parallel to the main text, hence we derive it equivalent to (7), so that the investor's ex ante benefits payoff for the purchase is

$$U^U(\hat{J}; F = p) \equiv \mathbb{E}\left[\mathbb{E}\left[U_i|A, \mathbf{R}\right]\right] = \frac{\mathbb{V}}{2}\frac{\mathbb{V}}{\mathbb{V} + (N - \hat{J}) \cdot \sigma_\varepsilon + \hat{J}\frac{\sigma_\varepsilon(\sigma_y + \sigma_\omega^S)}{\sigma_\varepsilon + \sigma_y + \sigma_\omega^S}} = \frac{\mathbb{V}}{2}\beta_A^R(\hat{J}),$$

where σ_ω^S is a function of $\hat{J}$. Observe that $\beta_A^R(\hat{J})$ decreases monotonically in σ_y; and that for $\sigma_y = 0$ we have $\beta_A^R(\hat{J}) = \beta_A^S(\hat{J})$ or equivalently $U^U(\hat{J}; F = p) = U^S(\hat{J})$ and for $\sigma_y \to \infty$ we have $\beta_A^R(\hat{J}) = \beta_A^0$ or equivalently $U^U(\hat{J}; F = p) = U_0$. Recall that when installing processing capacity the payoff is $U^U(\hat{J}; F = 1) = \frac{\mathbb{V}}{2}\beta_A^U(\hat{J})$ and for not installing capacity $U^U(\hat{J}; F = 0) = \frac{\mathbb{V}}{2}\beta^0$.

To construct equilibria, we follow Proposition 1 and first take investor decisions and then evaluate the firm's choice.

Investors. Suppose investors conjecture $\hat{J} = J^B$. Absent intermediation, unsophisticated investors choose $F = 1$, see Proposition 1. To make unsophisticated investors purchase information, sophisticated investor must set P so that $U^U(J^B; F = p) - P = U^U(J^B; F = 1) - c$ yielding $P = P_B \equiv c + U^U(J^B; F = p) - U^U(J^B; F = 1)$. A condition for sophisticated investors to sell information is $U^S(J^B) + \gamma P > U^S(J^B)$. Thus $P_B > 0$ is required to sell information. Because P_B decreases monotonically in σ_y through lowering $U^U(J^B; F = p)$. There exists an $\sigma_y = \overline{\sigma}_{y1}$, where $P_B = 0$. To see existence of $\overline{\sigma}_{y1}$ consider $\sigma_y \to \infty$ causing $U^U(J^B; F = p) \to U_0$ and the price is $P_B \equiv c + U_0 - U^U(J^B; F = 1) < 0$ because

we inspect a situation with an investment inefficient equilibrium requiring $U^U(J^B) - U_0 \geq c > U^U(J^S) - U_0$. To the contrary, when $\sigma_y \to 0$ causing $U^U(J^B; F = p) \to U^S(J^B)$ and the price is $P_B \equiv c + U^S(J^B) - U^U(J^B; F = 1) > 0$ because $U^S(J^B) > U^U(J^B; F = 1)$. By the intermediate value theorem $\overline{\sigma}_{y1}$ exists. Thus, when $P_B > 0$, then the sophisticated investor offers intermediation and the unsophisticated investors purchase it, $F = p$. When $P_B < 0$, the sophisticated investor does not offer intermediation unsophisticated investor installs capacity $F = 1$.

Suppose investors conjecture $\hat{J} = J^S$. Absent intermediation, unsophisticated investors choose $F = 0$, see Proposition 1. To make unsophisticated investors purchase information, sophisticated investor must set P so that $U^U(J^S; F = p) - P = U_0$ yielding $P = P_S \equiv U^U(\hat{J}^S; F = p) - U_0 > 0$. Because, $P_S > 0$ regardless of σ_y, the sophisticated investor always offers intermediation and the unsophisticated investors purchase it, $F = p$.

To summarize, investors always engage in intermediation when J^S is conjectured and when engage in intermediation when J^B is conjectured if $\sigma_y < \overline{\sigma}_{y1}$. If $\sigma_y > \overline{\sigma}_{y1}$ investors do not engage in intermediation.

Firm. Choice of optimal number of reported net income determinants. First, suppose the firm conjectures intermediation to occur in equilibrium, i.e., $F = p$. Firm's payoff is $Cov(\theta, K(J)|p) = \mathbb{V}(\beta_A^S(J) + \gamma\beta_A^R(J))$ and its maximized by $J = J^S$.

Second, suppose the firm conjectures intermediation not to occur in equilibrium, i.e., $F = 1$. Firm's payoff is $Cov(\theta, K(J)) = \mathbb{V}(\beta_A^S(J) + \gamma\beta_A^U(J))$ and it is maximized by $J = J^B$.

Note that, $F = 0$, does not occur, as intermediation is strictly better for both investors.

Equilibrium. We have to consider two cases.

First, intermediation occurs for choice of J^B, i.e., if, $\sigma_y < \overline{\sigma}_{y1}$. Because unsophisticated investors are indifferent between purchasing information and their outside option for both J^S and J^B, they will purchase the information in each case. As for $F = p$, the firm's payoff is maximized by $J = J^S$, the firm chooses J^S. Hence, J^S is the unique equilibrium.

Second, no intermediation for J^B if $\sigma_y > \overline{\sigma}_{y1}$. When unsophisticated investors install capacity $F = 1$, then the firm chooses $J = J^B$ as J^B maximizes $Cov(\theta, K(J))$. When $J = J^B$, then unsophisticated investors install capacity, $F = 1$ as $U^U(J^B; F = 1) - c > U^U(J^B; F = 0)$ for the investment inefficient equilibrium case we focus on. Hence, it yields one equilibrium.

When unsophisticated investors purchases information $F = p$, then the firm chooses $J = J^S$ as J^S maximizes $Cov(\theta, K(J)|p)$. When $J = J^S$, then the unsophisticated investor purchases information, $F = p$, as he is indifferent between this and his next best option, i.e., rely on the aggregate measure. Hence, we have another equilibrium.

Firm payoff dominance is used to solve it. The firm chooses J^B over J^S when $Cov(\theta, K(J^B)) = \mathbb{V}(\beta_A^S(J^B)+\gamma\beta_A^U(J^B)) > \mathbb{V}(\beta_A^S(J^S)+\gamma\beta_A^R(J^S)) = Cov(\theta, K(J^S)|p)$. This condition is satisfied when $\sigma_y \to \infty$, as $\beta_A^R(\hat{J}) = \beta_A^0$ because we consider cases where $\Delta > 0$. For some threshold $\overline{\sigma}_{y2}$, we obtain by monotonicity in σ_y that $\mathbb{V}(\beta_A^S(J^B) + \gamma\beta_A^U(J^B)) = \mathbb{V}(\beta_A^S(J^S) + \gamma\beta_A^R(J^S))$. Thus for some $\sigma_y < \overline{\sigma}_{y2}$, the inequality reverses so that $Cov(\theta, K(J^B) < Cov(\theta, K(J^S)|p)$. Thus, when $\sigma_y > \overline{\sigma}_{y2}$, the equilibrium is J^B without intermediation. When $\sigma_y < \overline{\sigma}_{y2}$, the equilibrium is J^S with intermediation.

Because J^B occurs if and only if both conditions $\sigma_y > \overline{\sigma}_{y1}$ and $\sigma_y > \overline{\sigma}_{y2}$ hold simultaneously, this is equivalent to $\max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$ implying that $\max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$ is the unique threshold to distinguish between equilibrium choice J_B^* without intermediation and J_S^* with intermediation.

Investment efficiency. When $\sigma_y > \max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$, we remain in the investment inefficient region as the equilibrium strategies do not change. When $\sigma_y < \max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$, then equilibrium strategies change, and an unsophisticated investor does not install capacity anymore, and J^S is reported. Investment efficiency is given by $W(J^S|p) = Cov(\theta, K(J^S)|p)/2 - c = \mathbb{V}(\beta_A^S(J^S) + \gamma\beta_A^R(J^S))/2 - c$. Observe that $Cov(\theta, K(J^S)|p) \geq Cov(\theta, K(J^S))$ and that decreases $Cov(\theta, K(J^S)|p)$ monotonically in σ_y. When $\sigma_y \to \infty$ we have $\beta_A^R(\hat{J}) = \beta_A^0$ and $Cov(\theta, K(J^S)|p) = Cov(\theta, K(J^S))$, implying that for any finite σ_y investment efficiency satisfies $W(J^S|p) > W(J^S)$. Because $c > \overline{c}$ we have have $W(J^S) > W(J^B)$. Hence, lowering σ_y sufficiently such that $\sigma_y < \max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$ enhances investment efficiency.

Pareto improvements and dominance. When $\sigma_y > \max(\overline{\sigma}_{y1}, \overline{\sigma}_{y2})$ then unsophisticated investors payoff satisfies $U^U(J^B; F = 1) - c > U^U(\hat{J}; F = 0)$. Lowering σ_y such that $\sigma_y < \overline{\sigma}_{y2}$ yields for unsophisticated investors $U^U(\hat{J}; F = p) = U^U(\hat{J}; F = 0)$. Hence, lowering σ_y does not yield Pareto improvements to unsophisticated investors nor does it yield a Pareto-dominant equilibrium. ■

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