Quantifying the Benefits of Securities Regulation*

Naveen Durvasula
nkd2126@columbia.edu
Columbia University
New York, New York, USA

Tim Roughgarden
tim.roughgarden@gmail.com
Columbia University & a16z crypto
New York, New York, USA

Abstract

This paper carries out a quantitative analysis of the benefits of securities regulation. For the primary issuance of a security, we consider a principal-agent model; asymmetric information and moral hazard problems both threaten the realization of full efficiency. Absent regulation, at equilibrium in our model, these two sources of inefficiency can be viewed as additive, with greater degrees of moral hazard and greater uncertainty about the project's viability each leading to increased loss in social welfare. We interpret "regulation" in our model as mandating full disclosure, which restores some but not all of the lost gains from trade.

For the trading of a security in a secondary market, we adopt an Akerlof-style model in which a buyer and a seller contemplate the exchange of an asset of uncertain quality. With asymmetric information, trade may occur when it is not socially efficient and, due to adverse selection, trade may not occur when it would be socially efficient. We provide a tight characterization of the expected amount by which the uninformed buyer overpays as a function of the model's parameters. We examine the implications of this characterization for the regulation of digital assets associated with mature blockchain systems.

CCS Concepts

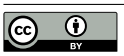
• **Applied computing** → **Economics**.

Keywords

Market regulation, Securities, Adverse selection, Moral hazard, Welfare loss, Digital assets, CLARITY Act

ACM Reference Format:
Naveen Durvasula and Tim Roughgarden. 2026. Quantifying the Benefits of Securities Regulation. In *Symposium on Computer Science and Law (CSLAW '26), March 03–05, 2026, Berkeley, CA, USA.* ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3788646.3789530

*We thank Merritt Fox, Lawrence Glosten, and Miles Jennings for helpful discussions. The research of the second author at Columbia University is supported in part by NSF award CNS-2212745. The second author is also Head of Research Team at a16z crypto (for general a16z disclosures, see https://www.a16z.com/disclosures/). Notwithstanding, the ideas and opinions expressed herein are those of the authors, rather than of a16z or its affiliates. The second author also advises companies on marketplace and incentive design, including token design. Any errors or omissions remain the sole responsibility of the authors.



This work is licensed under a Creative Commons Attribution 4.0 International License.
CSLAW '26, Berkeley, CA, USA
© 2026 Copyright held by the owner/author(s).
ACM ISBN 979-8-4007-2447-3/2026/03
https://doi.org/10.1145/3788646.3789530

1 Introduction

The goal of this paper is to investigate, through microeconomic analysis, some of the prevailing intuitions about the role of regulation in financial markets, and specifically in the regulation of the issuance and trading of securities. Proponents of such regulation generally argue that it increases overall social welfare, for example by mitigating market failures caused by asymmetric information. A well-known debate between Romano [17, 18] and Fox [9] illustrates this point. Fox [9], defending the benefits of the existing federal-level regulation of securities markets, writes

> …theory clearly demonstrates that issuer choice will lead to a social welfare shortfall correctable by regulation.

("Issuer choice" refers to a proposed system of state-by-state securities regulation, with each corporation free to choose its regulatory regime from a menu of options, including any of the fifty states.) Romano [17, p. 2373], arguing in favor of issuer choice over federal-level regulation via an informal cost-benefit analysis, writes

> There is little tangible proof of the claim that corporate information is "underproduced" in the absence of mandatory disclosure, or that the benefits to investors from information that firms would not produce in the absence of mandatory disclosure actually outweigh their costs.

This paper pursues a quantitative analysis of the benefits of securities regulation. We believe that this study is useful for at least four reasons. First, formal economic modeling can help clarify the assumptions necessary and sufficient for prevailing intuitions to hold true (e.g., that absent disclosure costs, reducing information asymmetry between buyers and sellers increases overall welfare), and debate can then focus on the extent to which those assumptions hold in a scenario of interest. Second, mathematical modeling can be used to uncover *quantitative* relationships, such as how some quantity of interest (e.g., gains for trade) depends on one or more model parameters (e.g., the degree of information asymmetry between buyers and sellers). Such an analysis can suggest which properties of a given scenario are most salient to the analysis's conclusions. Third, no serious assessment of proposed regulation via a cost-benefit analysis can be carried out without quantifying its benefits (as done here) and its costs. Fourth, in addition to providing an analysis of the benefits of existing regulation of relatively well-understood markets, a general economic model can be used also to reason quantitatively about alternative approaches to regulation and emerging markets. For example, as we discuss further in Section 4, we believe that some of our models may serve as a useful starting point for the analysis of the current proposals for the regulation of digital assets in the United States (the GENIUS

Act, signed into law in July 2025, and the CLARITY Act, passed by the House in July 2025 and currently under debate by the Senate).[1]

1.1 Summary of Results

We distinguish between the case of the primary issuance of a security (regulated by the Securities Act of 1933) and secondary sales of a security (regulated by the Securities Exchange Act of 1934). In our model of primary sales (Section 2), we consider an investor who is contemplating an investment in a founder of a new project in exchange for partial ownership of that project—arguably, the minimal model in which all prongs of the Howey test are explicitly present.[2] In our model, market inefficiency—investment occurring when it is not socially efficient, or not occurring when it would be socially efficient—can occur for two different reasons. The first is asymmetric information, where the investor is potentially less informed about the project's viability than the founder The second is moral hazard, where the founder is potentially tempted to shirk effort or "run off with the money" after the sale rather than maximize the project's value. Asymmetric information and the moral hazard problem result in overly cautious buyers, deterring what would be socially efficient investment when the potential value of a project is not sufficiently high. Absent regulation, at equilibrium in our model, these two sources of inefficiency can be viewed as additive, with greater degrees of moral hazard and greater uncertainty about the project's viability each leading to increased loss in social welfare. We interpret "regulation" in our model as mandating full disclosure (enforcing the condition that the investor and founder are equally informed) which, at equilibrium in our model, restores some but not all of the lost gains from trade.

Secondary markets for securities have long served as an example of a "market for lemons" in the sense of Akerlof [1]. In Section 3, we accordingly adopt an Akerlof-style model in which a buyer and a seller contemplate the exchange of an asset of uncertain quality. The seller may be better informed than the buyer about the asset's quality and, for a given quality level, the buyer and seller may have different values for it (with gains from trade occurring if and only if the buyer's value is higher than the seller's). Because there is no moral hazard problem—in a secondary market, the buyer has no future expectations for the seller—market inefficiency arises in our model only due to asymmetric information. With asymmetric information, trade may occur when it is not socially efficient and, due to adverse selection, trade may not occur when it would be socially efficient. Here, we characterize the expected amount by which the uninformed buyer overpays for the asset; this overpayment, which would be avoided were the seller compelled by mandatory full disclosure, can then be interpreted as a quantitative measure of investor protection– one of the stated goals of the regulation. Our key finding is that the expected buyer overpayment is upper bounded by the product of the gap between the buyer's valuation for the high and low quality asset and the variance of the buyer's prior over the quality of the asset. Thus, if the buyer is well informed (that is, nearly as certain as the seller about the quality of the asset), or if the seller's information does not materially impact the buyer's valuation of the asset, the buyer's expected overpayment is small. We interpret this result in the context of the CLARITY Act, and to what extent mature blockchain systems might "auto-disclose" value-relevant information, in Section 4.

1.2 Related Work

There is a large literature debating the extent to which different forms of disclosure can mitigate undesirable impacts from asymmetric information and moral hazard problems, albeit without the present work's focus on parameterized bounds on welfare loss. The works of Romano [17, 18] and Fox [9] cited earlier both incorporate the economic analysis in Dye [8], which shows how either asymmetric information or moral hazard problems can create incentives for a corporation to withhold non–proprietary information from the public. More generally, the mitigation of moral hazard problems is a central theme in corporate finance (e.g., [20]); Jensen and Meckling [14] is an early and influential example.

As mentioned earlier, Akerlof [1] is the classic reference on losses from adverse selection due to information asymmetries between a seller and a buyer. Many works extend Akerlof's original model; we single out Levin [16], which parameterizes the precision of the seller's information—and hence the degree of asymmetry between the information known to the seller and the buyer—as measured by the monotone information order of Athey and Levin [3]. Levin's analysis, in contrast to the present work, focuses primarily on non-monotonicities in the probability of trade, as a function of the amount of information known to the seller. Other recent papers in a similar vein include Zhu [23], Bar-Isaac et al. [5], Glode and Opp [11], and Akkar [2]. More distantly related are several works in the field of information design [7] that analyze rich classes of possible information structures, typically with the goal of characterizing the set of outcomes that can arise under some such structure; Bergemann et al. [6] and Kartik and Zhong [15] are exemplars of this approach. Another line of work in the finance literature provides commentary on whether certain market behaviors/interventions lead to "better" or "worse" social outcomes in the secondaries market. The seminal work of Glosten and Milgrom [12] analyzes the effects of informed trading on liquidity. Fox et. al [10] and Baldauf and Mollner [4] study the effects of high frequency trading on market outcomes such as price accuracy and liquidity.

In Section 4 we interpret our buyer overpayment bound for secondary markets in the context of the currently proposed legislation for the regulation of digital assets (the CLARITY Act), and in particular that expected buyer overpayment in secondary markets is plausibly low for digital assets associated with "mature blockchain systems" for which no person or group of persons has significant control. There are some parallels between this argument and the "Bahamas Test" of Henderson and Raskin [13]. The latter, however, is proposed in the context of primary sales (initial coin offerings, or ICOs) rather than secondary trading.

[1] Weighing the pros and cons of securities regulation requires also quantifying the costs of such regulation, such as the costs borne by corporations to meet mandatory disclosure rules. This is an important topic but it is outside the scope of this paper. Our results quantifying the benefits of securities regulation can be interpreted as identifying the maximum cost for which regulation would continue to be socially desirable.

[2] The Howey Test defines the conditions under which an asset is classified as a security (and hence subject to the rules of the Securities Act of 1933); see Section 2 for additional details.

2 Asymmetric Information and Moral Hazard in Primary Sales

The Securities Act of 1933, also known as the "Truth in Securities" Act, was the first in a two-part solution for combating securities fraud. It principally regulates the *issuance* of new securities, as opposed to the trading of existing securities (the latter is regulated by the Securities Exchange Act of 1934, discussed in the next section). New securities are issued by a firm and are sold to investors. Intermediaries such as underwriters and dealers help make public sales. The Securities Act aims to mitigate fraud on the part of issuers, underwriters, and dealers by compelling disclosure at the federal level. At a high level, the Act

(1) Requires that securities being solicited to public investors are federally registered, with information such as the company's directors, financials, risks, and other material information being disclosed to the SEC (and consequently the public) under a specific time schedule prior to sale.
(2) Contains anti-fraud clauses that prevent these registration statements from containing false information or omitting material information.

Together, the act aims to mitigate information asymmetries between issuers and investors [21]. In the years after the Securities Act of 1933 was signed into law, the scope of the act was further refined by case law. Under current precedent, assets are classified as securities (and therefore must undergo the aforementioned registration process with the SEC) based on the *Howey* test, as established in *SEC v. W.J. Howey Co.* by the U.S. Supreme Court [19]. Under *Howey*, a transaction constitutes an investment contract subject to regulation under the Securities Act of 1933 if it involves:

(1) An investment of money
(2) In a common enterprise
(3) A reasonable expectation of profit
(4) Derived from the efforts of others

The goal of this section is to quantify the improvements that idealized disclosure regulation makes to social welfare for an asset that would pass all four Howey criteria.

A complete analysis of social welfare would also characterize the costs of regulation. We leave these costs unmodeled in our analysis. Our results can therefore be interpreted as a claim that disclosure regulation is welfare maximizing if the costs of disclosure do not exceed the benefits, as established by our results.

2.1 Summary of Results and Interpretation

We consider a stylized model with two agents: an *investor* who has capital but cannot produce anything with it, and a *founder* who has no capital but the ability to transform capital into a project. The project may be *good*, in that it would yield positive value if the founder were to work on it, or the project may be *bad*, in that the project will yield no value regardless of the founder's efforts. After the investor chooses whether to invest or pass on the opportunity, the founder then chooses whether to work to realize the project's potential value or shirk and extract some fraction of the initial investment for personal gain. We model behavior without regulation by considering equilibria of the game when the founder knows whether project is good or bad, but the investor only has access to a prior belief. We model behavior with idealized regulation by considering equilibria of the game when both the founder and the investor have perfect knowledge about the quality of the project. In Section 2.2, we formally describe this model and show how it corresponds directly to the four prongs of the *Howey* test.

Losses to efficiency at equilibrium arise in our model for two fundamentally different reasons:

(1) *Asymmetric information.* In the asymmetric information setting (Section 2.5) modeling behavior without regulation, the investor has only partial knowledge about the quality of the project. This causes two different types of welfare loss:
   - The investor may invest in a bad project (when it wouldn't otherwise), because the expected value of the (uncertain) investment is sufficiently high.
   - The investor may not invest in a good project (when it otherwise would), because the expected value of the investment is not sufficiently high.
(2) *Moral hazard.* Even in the symmetric information case (i.e. under idealized regulation), the loss caused by a shirking founder is borne in part by the investor. As a result, a founder may benefit from shirking even when it is socially undesirable.

Our results clearly show the effects of these two phenomena. In Section 2.3, we analyze efficient investment decisions. In Section 2.4, we analyze investment decisions at symmetric information equilibrium, modeling behavior with disclosure. In Section 2.5, we analyze investment decisions at asymmetric information equilibrium, modeling behavior without disclosure. Section 2.6 analyzes the impact that symmetric information has on social welfare. Figure 1, shows the high-level outcomes of this analysis.

When the project is good, there are four regimes, depending on the multiple on invested capital V^*/I of the project. When the multiple is below 1 (i.e. the project is less valuable than the initial investment), investment is not efficient and does not occur in either symmetric or asymmetric equilibrium. However, although investment is efficient for any multiples greater than 1, investment still does not occur at symmetric equilibrium until the multiple is sufficiently large. This is because moral hazard may occur even when the investor is perfectly informed about the quality of the project. Thus, to protect themselves from a founder who shirks after investment, an investor will invest only when the profit margin of the investment is sufficiently large, so that the investor can be assured that the founder's profits from working exceed their profits from shirking extracting the initial investment for personal gain (see Theorem 2.3 for the formal argument). This can be seen in Figure 1, where there is no investment until the multiple on invested capital is at least $1 + r$, where r is the fraction of the initial investment that can be extracted by the founder. When the investor further has imperfect information regarding the quality of the project, she will only begin to invest when the multiple on invested capital is even higher (see Theorem 2.4 for the formal argument). We find that the increase to the multiple is given by $\frac{1-q}{q}$, which corresponds to the relative odds that the project is bad over the odds that the project is good, according to the investor's prior belief. When the project is good, regulation can restore investment between the mulitples $1 + r$ and $1 + r + \frac{1-q}{q}$ (the zone labeled "Adverse Selection" in Figure

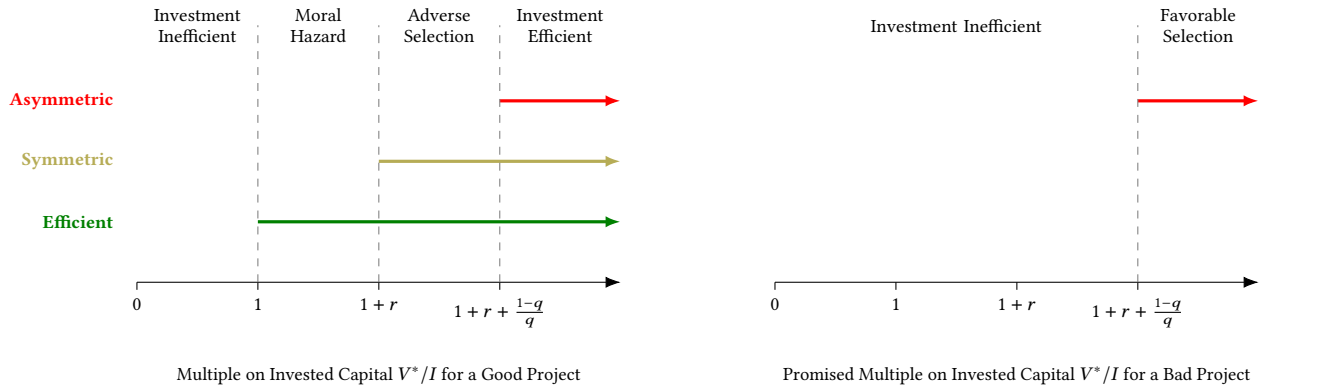


Figure 1: First-Best and Equilibrium Behavior for Primary Investment. We show investment decisions that (i) are efficient, (ii) occur at symmetric equilibrium, and (iii) occur at asymmetric equilibrium. On the left, we show decisions that occur for good projects, and on the right, we show decisions that occur for bad projects. Decisions are parameterized V^*/I, or the multiple on invested capital. When the project is good (i.e. in the left figure), this refers to the true multiple. When the project is bad (i.e. on the right figure), this refers to the multiple that the investor believes would be realized if the project were good and the founder were to work.

1). However, it cannot fully restore the first-best outcome due to moral hazard.

When the project is bad, investment is inefficient since the true multiple on invested capital is zero, regardless of the promised multiple on invested capital V^*/I that would be realized if the project were good. It is never efficient to invest in a bad project, and investment further never occurs when there is symmetric information. However, when there is asymmetric information, investment occurs at the same threshold $1 + r + \frac{1-q}{q}$ as when the project was good, since the investor must make her decision to invest without knowing the true quality of the project. Thus, when the project is bad but the promised multiple on invested capital is sufficiently high, there is excess investment without regulation when the multiple is above $1 + r + \frac{1-q}{q}$ (the zone labeled "Favorable Selection" in Figure 1). Disclosure can restore investment decisions to the first-best outcome when the project is bad.

A consequence of these findings is that compelling disclosure improves social welfare for more valuable (i.e. higher multiple) projects when moral hazard is higher (i.e the founder faces fewer costs in extracting the initial investment), Compelling disclosure restores investment in good projects for a broader range of multiples when investors have stronger beliefs that the project will be bad, and fully prevents excess investment in bad projects.

2.2 A Model based on *Howey*

As described in the summary, in our model there is an investor and a founder. We consider a proposed contract under which the founder will sell an $f \in [0, 1]$ fraction of the project to the investor in exchange for $I > 0$ dollars.

We now consider a game that terminates in at most two stages. In the first stage, the investor chooses whether to accept the contract and invest I dollars in the project or pass on the offer. If the investor chooses to invest in the first stage, then there is a second stage in which the founder chooses whether to work towards building the project as promised, or shirk and attempt to extract as much of the investment for personal gain as possible. We denote by $r \in [0, 1]$ the fraction of the investment that the founder can extract when they shirk. Legally-binding fiduciary duties of the founder, for example, may make it more costly to extract the investment for personal gain, causing r to be less than 1. The project itself also has a *type* $\theta \in \{\text{good}, \text{bad}\}$ denoting whether the project, if built, would have value. The founder knows the project type – i.e. whether the project is good or bad. The investor only has access to a prior that the project is good (i.e. $\theta = \text{good}$) with probability q and bad with probability $1 - q$. The potential value $V := V^* \cdot \mathbf{1}[\theta = \text{good}]$ (in dollars) of the project is a parameter V^* if the project has the type $\theta = \text{good}$, and zero if the project has the type $\theta = \text{bad}$. Whether this potential value is ultimately realized depends on the founder's decision to work or shirk in the second stage.

The final payoffs for founder and investor are therefore as follows. If the investor chooses not to invest, then the both the investor and the founder receive a payoff of 0. If the investor invests and the founder works, then the investor receives a payoff of $f \cdot V - I$, and the founder receives a payoff of $(1 - f) \cdot V$. If the investor invests and the founder shirks, then the investor receives a payoff of $-I$ and the founder receives a payoff of $r \cdot I$ from extracting an r fraction of the investment.

Observe that each of the four prongs of the *Howey* test are clearly present in the model:

(1) *An investment of money.* This is represented by the investment I, and the "$-I$" in the investor's payoff function.
(2) *In a common enterprise.* This is represented by the joint ownership in the ultimate value of the project that is split with an f fraction appearing in the investor's payoff and a $1 - f$ fraction appearing in the founder's payoff.
(3) *A reasonable expectation of profit.* This is captured by the investor's freedom to invest or not, with the investor's payoff

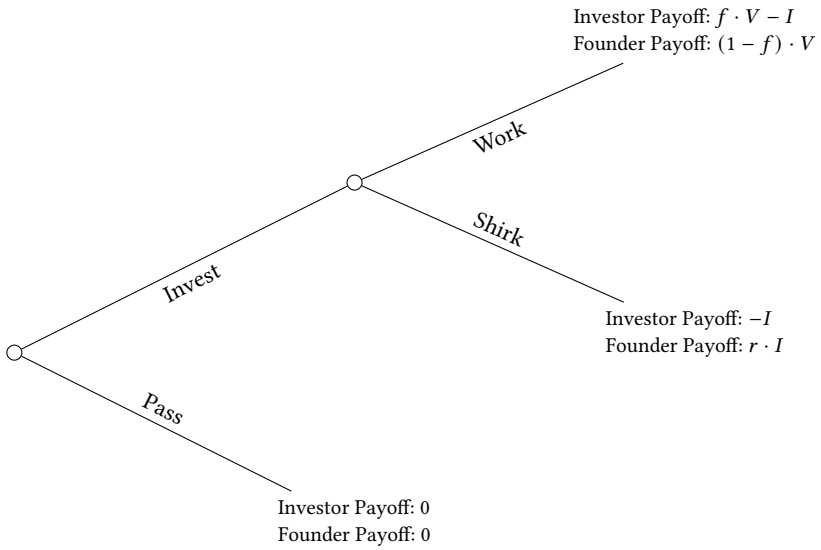


Figure 2: A two-stage game of primary investment. In the first stage, the investor chooses whether to purchase an f fraction of the project in exchange for I dollars. In the second stage, the founder chooses to either work to realize the potential value V of the project or shirk and extract a fraction r of the initial investment. The payoffs of both players are shown in each case.

function incentivizing her to invest if and only if the expected profit is positive.

(4) *Derived from the efforts of others.* This is captured by the fact that a project can have nonzero value only if the founder chooses to work instead of shirking in the second stage.

2.3 Analysis of the First-Best Outcome

We now analyze the socially efficient outcome within our two-stage game. The payoffs of both players depend on the sequence of actions (i.e. history) selected, and the type θ of the project. We use the ex-post welfare-maximizing game history (i.e. the welfare given the realization of the project type) as a benchmark for socially efficient behavior. Formally, the welfare depends on the type θ of the project, and which history h among the three possible histories $\mathcal{H} := \{[\text{Pass}], [\text{Invest, Work}], [\text{Invest, Shirk}]\}$ was jointly selected by the players. Given the project type θ, let $U_I^\theta : \mathcal{H} \to \mathbb{R}$ denote the payoff of the investor at the end of the game, and $U_F^\theta : \mathcal{H} \to \mathbb{R}$ denote the payoff of the founder at the end of the game. The *welfare* $W^\theta : \mathcal{H} \to \mathbb{R}$ at the end of the game is given by the sum of investor and founder payoffs $W^\theta := U_I^\theta + U_F^\theta$.

Proposition 2.1. *If the project type $\theta = \mathsf{good}$, then investment (with a working founder) is uniquely socially efficient (i.e. $[\text{Invest, Work}] = \operatorname{argmax}_{h\in\mathcal{H}} W^\theta(h)$) if and only if $V^* > I$. If the project type $\theta = \mathsf{bad}$, then passing is socially efficient (i.e. $[\text{Pass}] \in \operatorname{argmax}_{h\in\mathcal{H}} W^\theta(h)$).*

Proof. See Appendix A. □

2.4 Analysis of Equilibria with Symmetric Information

We now analyze the welfare attained at subgame perfect equilibria when the investor knows the project type θ. These equilibria model behavior under idealized regulation, where the founder and investor have equal information. If the project is bad, then the equilibrium behavior is trivially socially efficient, with the investor passing on the investment as she knows that the project is bad.

Proposition 2.2. *If the project type $\theta = \mathsf{bad}$, then the investor passes at the unique equilibrium history, and the equilibrium is socially efficient.*

Proof. Since the investor knows that the project is bad, she knows that she will lose I dollars if she invests, regardless if the founder works or shirks. However, if she passes, she will receive a payoff of 0. As this is also the first-best outcome by Proposition 2.1, the desired result follows. □

If the project is good, however, equilibrium behavior is more nuanced, and may not necessarily be socially efficient. Even when there are no information asymmetries, efficient investments may not occur at equilibrium because enticing the investor to invest requires selling so much of the project that the founder no longer has sufficient incentive to follow through and actually build the project. This occurs when a founder can extract a non-zero fraction $r > 0$ of the initial investment I when shirking. There are then cases for which investment would be socially efficient but will not occur at equilibrium: namely, whenever V^* is bigger than I but less than $(1 + r) \cdot I$.

Theorem 2.3. *If the project type $\theta = \mathsf{good}$, the history $[\text{Invest, Work}]$ is an equilibrium if (for suitable f) and only if $V^* \geq (1 + r) \cdot I$. The history $[\text{Pass}]$ is the unique equilibrium if $V^* < (1+r) \cdot I$. Equilibrium behavior is not socially efficient if $I < V^* < (1 + r) \cdot I$.*

Proof. See Appendix A. □

2.5 Analysis of Equilibria under Asymmetric Information

We now analyze perfect Bayesian equilibrium behavior when the investor only has access to a prior that the project has type $\theta =$ good with probability q, and $\theta =$ bad with probability $1-q$. The founder, however, knows the true type of the project. As such, it is now possible for a rational investor to invest in a bad project (or not invest in a good project), as her behavior may not depend on project's type. These equilibria model behavior without regulation, when the founder is more informed than the investor.

Theorem 2.4. *The history* [*Invest, Work*] *is an equilibrium if (for suitable f) and only if $V^* \geq (1 + r + \frac{1-q}{q}) \cdot I$ and the project type $\theta =$ good. The history* [*Invest, Shirk*] *is an equilibrium if (for suitable f) and only if $V^* \geq (1 + r + \frac{1-q}{q}) \cdot I$ and the project type $\theta =$ bad. The history* [*Pass*] *is the unique equilibrium if $V^* < (\frac{1}{q} + r) \cdot I$. If the project type $\theta =$ good, then equilibrium behavior is not socially efficient if $I < V^* < (1 + r + \frac{1-q}{q}) \cdot I$. If the project type $\theta =$ bad, then equilibrium behavior may not be socially efficient if $V^* \geq (1 + r + \frac{1-q}{q}) \cdot I$.*

Proof. See Appendix A. □

2.6 Analysis of Welfare Improvements from Regulation

The welfare improvements from regulation can be analyzed in two meaningful ways. In the first, we consider the ex-post improvements to equilibrium welfare given the project type θ. In the second, we consider the ex-ante expected improvements to equilibrium welfare given the investor's prior probability q for the project type having a $\theta =$ good realization. We consider both methods in this section.

2.6.1 Ex-Post Welfare Improvements. When project has type $\theta =$ good, there are welfare improvements from regulation when the multiple on invested capital V^*/I is between $1 + r$ and $1 + r + \frac{1-q}{q}$. In this regime, trade does not occur when there is asymmetric information although it is socially efficient. With symmetric information, however, trade does occur in this regime. Regulation does not improve welfare otherwise.

Corollary 2.5. *Suppose the project type $\theta =$ good. Suppose that an f is chosen such that investment will occur at equilibrium, if such an f exists, and an arbitrary f is chosen otherwise. Let h^*_{sym} be a welfare-maximizing equilibrium history under symmetric information, and let h^*_{asym} be a welfare-maximizing equilibrium history under asymmetric information. Then,*

$$W^{\text{good}}(h^*_{sym}) - W^{\text{good}}(h^*_{asym}) = \begin{cases} 0 & 0 \leq V^*/I < 1 + r \\ V^* - I & 1 + r \leq V^*/I < 1 + r + \frac{1-q}{q} \\ 0 & else \end{cases}$$

Proof. See Appendix A. □

When the project has type $\theta =$ bad, there are welfare improvements to regulation when the multiple on invested capital V^*/I (if the project were good) is above $1 + r + \frac{1-q}{q}$. In this regime, trade does occur when there is asymmetric information even though it is not socially efficient, since the high potential return incentivizes the investor to invest, despite the risks of adverse selection. Regulation does not improve welfare otherwise.

Corollary 2.6. *Suppose the project type $\theta =$ bad. Suppose that an f is chosen such that investment will occur at equilibrium, if such an f exists, and an arbitrary f is chosen otherwise. Let h^*_{sym} be a welfare-maximizing equilibrium history under symmetric information, and let h^*_{asym} be a welfare-maximizing equilibrium history under asymmetric information. Then,*

$$W^{\text{bad}}(h^*_{sym}) - W^{\text{bad}}(h^*_{asym}) = \begin{cases} 0 & 0 \leq V^*/I < 1 + r + \frac{1-q}{q} \\ (1 - r) \cdot I & else \end{cases}$$

Proof. Applying Theorems 2.3 and 2.4, we can see that investment occurs in the asymmetric equilibrium regardless of the project's type, when $V^*/I \geq 1 + r + \frac{1-q}{q}$. Under the symmetric equilibrium, no investment occurs whenever the project is bad. The desired result follows. □

2.6.2 Ex-Ante Welfare Improvements. The ex-ante expected improvement to equilibrium welfare is given by the average of the ex-post improvements given the investor's prior. Notice that even though the investor's decision to invest under asymmetric information may not depend on the project's type θ, the corresponding equilibrium that arises does depend on θ, since the founder's decision to work or shirk may depend on the project's type.

Corollary 2.7. *Suppose that an f is chosen such that investment will occur at equilibrium, if such an f exists, and an arbitrary f is chosen otherwise. Let h^{good}_{sym} and h^{bad}_{sym} be welfare-maximizing equilibrium histories under symmetric information given that the project has type $\theta =$ good and $\theta =$ bad respectively. Similarly, let h^{good}_{asym} and h^{bad}_{asym} be welfare-maximizing equilibrium histories under asymmetric information given that the project has type $\theta =$ good and $\theta =$ bad respectively. Then,*

$$\mathbb{E}_{\theta \sim q}\left[W^\theta(h^\theta_{sym}) - W^\theta(h^\theta_{asym})\right] = \begin{cases} 0 & 0 \leq V^*/I < 1 + r \\ q \cdot (V^* - I) & 1 + r \leq V^*/I < 1 + r + \frac{1-q}{q} \\ (1 - q) \cdot (1 - r) \cdot I & else \end{cases}$$

Proof. This follows immediately from Corollaries 2.5 and 2.6. □

As the project is more likely to be good (i.e. as q increases), the benefits of regulation that compel disclosure increase in the regime where there is underinvestment due to adverse selection. Correspondingly, the benefits decrease in the regime where there is overinvestment due to adverse selection.

3 Asymmetric Information in Secondary Sales

After securities have been issued by a firm, individuals may resell or exchange them for other assets. The Securities Exchange Act of 1934 principally regulates the market for secondary sales of securities. In this section, we aim to quantify the benefits of securities regulation within the context of secondaries trading. Secondaries trading differs from primary issuance (as discussed in the previous section) in two fundamental ways:

(1) *Idiosyncratic values.* A necessary condition for trade to occur in a secondaries market is that the buyer and seller have different values for the asset. Differences in valuation may exist, for example, due to differing tolerance for risk, differing expectations of the future resale value of the asset, or differing auxiliary assets that are held by the buyer and seller that may be correlative or anti-correlative with the asset being sold. This contrasts with the common value model in the previous section on primary sales, where both the investor and the buyer receive fractions of the same ultimate value of the project.
(2) *No moral hazard.* Unlike the investor in the primaries model, the buyer of the asset does not purchase the asset with the expectation that the ultimate value of the asset depends on the seller's efforts, and therefore does not need to reason about the seller's actions after the sale when considering whether to buy the asset at a certain price.

The problem of asymmetric information, however, remains for secondaries trading. In particular, buyers must make their decision to purchase from sellers who may be insiders or otherwise have privileged information about the value of the asset. Like the Securities Act of 1933, the Securities Exchange Act of 1934 aims to prevent these information asymmetries by means of disclosure. However, unlike the registration for primary issuance which occurs just once, firms are required under the Exchange Act to regularly disclose material information that may affect the value of the security they issued. In particular, the Act requires that

(1) Firms with publicly listed securities must file annual and quarterly reports, and further disclose important events (e.g. bankruptcy, acquisitions, changes in corporate governance, etc.).
(2) Sellers of securities must abide by broad anti-fraud regulation preventing them from making any "device, scheme, or artifice to defraud" or misstatement/omission of material facts that an investor would think is important in making the decision to transact on the security [22].

Akerlof's "market for lemons" is a standard economic model for understanding the effects of information asymmetries on bilateral trade [1]. We model the idealized effect of the Securities Exchange Act of 1934 as removing information asymmetries between the buyer and the seller.

How should we assess whether a secondaries market is "working well"? In the law and economics literature, price accuracy and liquidity are emphasized as useful proxies for welfare [10]. Inaccurate share prices may incentivize firms to pursue inefficient projects, if those projects require additional primary investment. Lower liquidity may increase the transaction costs associated with primary investment. However, the exact externalities that secondaries trading imposes on the process of primary investment and the greater economy is complex, and we are unaware of a comprehensive welfare model for secondaries trading upon which there is consensus approval among experts. This is evidenced by nuanced discussions on the tradeoffs of informed trading, which increases price accuracy but decreases liquidity due to the corresponding adverse selection on market-makers [12].

We focus on the effect of regulation for secondaries markets on the expected amount by which the buyer overpays for the asset. This metric can be thought of as a generalization of price accuracy to cases where information asymmetry distorts whether trade occurs. Expected buyer overpayment can also be interpreted as the extent by which ideal regulation protects investors.

3.1 Model and Summary of Results

We consider a model with two agents: a *buyer* who is potentially interested in purchasing an asset, and a *seller* who owns an asset and is potentially interested in selling it. The asset has a type $\theta \in \{X, Y\}$ denoting which of two possible states it is in. If the asset has the type $\theta = X$, then the seller and buyer have valuations $v_S^X . v_B^X \geq 0$ for the asset respectively. If instead the asset has the type $\theta = Y$, then the seller and buyer have valuations $v_S^Y, v_B^Y \geq 0$ for the asset respectively. While the seller knows the true type θ of the asset, the buyer only has access to a prior that the asset is in state $\theta = X$ with probability q and in the state $\theta = Y$ with probability $1 - q$ (i.e., there is asymmetric information between the seller and the buyer). Without loss of generality, we assume that the seller weakly prefers the asset in state X over state Y– i.e. $v_S^X \geq v_S^Y$. We do not necessarily assume that the buyer agrees with this relative ordering: we analyze both cases $v_B^X \geq v_B^Y$ and $v_B^X < v_B^Y$. We consider a proposed contract in which the seller will sell the asset to the buyer for the price of $p > 0$ dollars. We consider a game in which both the buyer and seller can choose to either accept or reject this contract. The results of this section are agnostic to whether the accept and reject decisions are made simultaneously, or in some sequence. If both the buyer and seller accept the contract, then the buyer receives a payoff of $v_B^\theta - p$ and the seller receives a payoff of p. Otherwise, the buyer receives a payoff of 0 and the seller receives a payoff of v_S^θ. This model can be seen as a generalized version of Akerlof's model in which we drop the traditional assumptions that gains from trade exist under both asset types and that the buyer's value is positively correlated with the seller's value. This generality allows the model to capture a broader variety of ways in which the privileged information known only to the seller may affect the buyer's decision-making.

We focus on the expected buyer overpayment, which we define as the expected amount by which the buyer is willing to overpay at an asymmetric information equilibrium.

Definition 3.1 (Expected Buyer Overpayment). For a given instance of the above setup, the expected buyer overpayment ρ is defined as

$$\delta := \mathbb{E}_{\theta \sim q}\left[\max\left(p^*(\theta) - v_B^\theta, 0\right)\right], \tag{1}$$

where $p^*(\theta)$ denotes the highest price at which a trading equilibrium exists, given that the asset has a realized type of θ. If trading does not take place at any price for a realization θ of the asset, then we define $p^*(\theta) = 0$, so that the term inside the expectation evaluates to 0.

The buyer overpayment ρ is related to price accuracy in the following sense. Price accuracy is well defined when there are both gains from trade given symmetric information, and some trading equilibrium exists with asymmetric information. In this case, we can define the price distortion to be the maximum gap between a price at which trade occurs under asymmetric information, and the

region of trade under symmetric information. Because the seller is fully informed, prices at which a trading equilibrium exists under asymmetric information may not be below the seller's value for the asset. Thus, our definition of buyer overpayment coincides with price distortion in these cases. However, asymmetric information may also cause trade to occur when it wouldn't with symmetric information or vice-versa. Buyer overpayment remains well defined in these cases, as we can still say that the buyer overpaid if trading occurs when it otherwise would not have with symmetric information. Similarly, the buyer does not overpay if trade would have occurred with symmetric information but did not with asymmetric information.

Buyer overpayment (and losses to efficiency, more generally) arise in this model only due to asymmetric information. The buyer may be willing to buy the asset at a price above her valuation because the expected value of the purchase is sufficiently high.[3] In Section 3.2 we observe that with idealized regulation (i.e., symmetric information), the buyer never overpays.

Section 3.3 presents our main result for secondary sales (Theorem 3.3): the expected buyer overpayment is upper bounded by

$$\delta \leq \underbrace{q \cdot (1-q)}_{\text{Prior Variance}} \cdot \underbrace{\left|v_B^X - v_B^Y\right|}_{\text{Valuation Gap}}. \tag{2}$$

This would suggest that the benefits from regulation are maximized when the seller possesses information that the buyer is both very uncertain about (e.g., $q \approx \frac{1}{2}$), and that dramatically impacts the buyer's valuation of the asset (i.e., $\left|v_B^X - v_B^Y\right| \gg 0$). Put differently, this bound suggests that if the buyer is well informed (with $q \approx 0$ or $q \approx 1$), or if the uncertain information is not overly pertinent to a buyer's value (meaning $v_B^X \approx v_B^Y$), then the benefit of regulation in our model is small. In Section 4.1, we interpret the upper bound in (2) in the context of the regulation of digital assets.

3.2 Analysis with Symmetric Information

It is straightforward to analyze the equilibrium of our model of secondaries trading in the special case of symmetric equilibrium. There are four possible strategy profiles

$$\Sigma := \{[\text{Accept, Accept}], [\text{Accept, Reject}], [\text{Reject, Accept}], [\text{Reject, Reject}]\}$$

in this game, where we'll use the convention that the first entry corresponds to the action taken by the buyer and the second entry corresponds to the action taken by the seller.

We now analyze overpayment at Nash equilibria when the buyer also knows the true type θ. These equilibria model behavior under idealized regulation, where the buyer and seller have equal information. In this regime, we see that the buyer never overpays at any selling price p at which trade is an equilibrium.

Proposition 3.2. *Trade* [*Accept, Accept*] *is an equilibrium if and only if* $v_B^\theta \geq p \geq v_S^\theta$. *In particular, the buyer never overpays at a trading equilibrium.*

[3]The buyer also may not be willing to buy an asset at a price below her valuation because the expected value of the purchase is not sufficiently high, though such distortions do not contribute towards the expected buyer overpayment ρ.

Proof. It is a dominant strategy for the seller to accept the contract if and only if $p \geq v_S^\theta$. It is a dominant strategy for the buyer to accept the contract if and only if $p \leq v_B^\theta$ (this implies no overpayment for the buyer). Putting the two together, a trading equilibrium implies that $v_S^\theta \leq v_B^\theta$. Similarly, a p exists such that trade will be an equilibrium if $v_S^\theta \leq v_B^\theta$. □

3.3 Analysis of Equilibria with Asymmetric Information

We now analyze buyer overpayment at Bayesian-Nash equilibria when the buyer is uncertain about the true type θ (believe it to be X with probability q and Y with probability $1-q$). These equilibria model trading outcomes without regulation, when the seller is more informed than the buyer. Due to asymmetric information, a rational buyer may be willing to buy (or alternatively not willing to buy) the asset for a price that is above (below) the value conferred to the buyer from ownership of the asset. We now prove our main result of this section:

Theorem 3.3.

$$\delta \leq q \cdot (1-q) \cdot \left|v_B^X - v_B^Y\right|.$$

Proof. Expanding out from our definition of buyer overpayment (1), we can write

$$\delta = q \cdot \max\left(p^*(X) - v_B^X, 0\right) + (1-q) \cdot \max\left(p^*(Y) - v_B^Y, 0\right). \tag{3}$$

We now separately analyze the cases $\theta = X$ and $\theta = Y$, combining to yield the final result. We begin with the case $\theta = X$, when the seller's preferred asset type is realized.

Lemma 3.4.

$$p^*(X) \leq q \cdot v_B^X + (1-q) \cdot v_B^Y$$

Proof. Fixing buyer and seller valuations (v_B^X, v_B^Y, v_S^X, and v_S^Y) and the buyer's prior q, the seller agrees to the contract if and only if $p \geq v_S^X$. Since it may not be determined from such a p whether the asset has type X or Y conditional on the seller accepting the contract, the buyer's expected payoff from accepting the contract is given by

$$q \cdot (v_B^X - p) + (1-q) \cdot (v_B^Y - p)$$

This is non-negative if and only if $p \leq q \cdot v_B^X + (1-q) \cdot v_B^Y$. It follows that

$$p^*(X) = \begin{cases} q \cdot v_B^X + (1-q) \cdot v_B^Y & q \cdot v_B^X + (1-q) \cdot v_B^Y \geq v_S^X \\ 0 & \text{else} \end{cases}$$

The desired result follows. □

Next, we analyze the case $\theta = Y$, which is slightly more nuanced due to the existence of screening equilibrium, where a low price communicates to the buyer that the asset may only be traded in the seller's non-preferred state.

Lemma 3.5.

$$p^*(Y) \leq \max(q \cdot v_B^X + (1-q) \cdot v_B^Y, v_B^Y)$$

Proof. Fixing buyer and seller valuations (v_B^X, v_B^Y, v_S^X, and v_S^Y) and the buyer's prior q, the seller agrees to the contract if and only if $p \geq v_S^Y$. There are now two cases to consider. If $v_S^Y \leq p \leq v_S^X$, then the buyer knows that if the seller chooses to accept the contract, then the asset must have type $\theta = Y$. Thus, in this, case the buyer will choose to accept the contract if and only if $p \leq v_B^Y$. If instead, $p \geq v_S^X$, then the buyer may not be certain of the asset's type conditional on the seller accepting the contract. As such, the buyer will choose to accept if and only if

$$q \cdot (v_B^X - p) + (1-q) \cdot (v_B^Y - p) \geq 0$$

which is equivalent to $p \leq q \cdot v_B^X + (1-q) \cdot v_B^Y$. Putting these two cases together, we find that

$$p^*(Y) = \begin{cases} q \cdot v_B^X + (1-q) \cdot v_B^X & q \cdot v_B^X + (1-q) \cdot v_B^Y \geq \max(v_S^X, v_B^Y) \\ v_B^Y & v_B^Y \geq \max(v_B^X, v_S^Y) \\ 0 & \text{else} \end{cases}$$

The desired result follows. □

Putting these two lemmas together, we find, continuing from (3), that

$$\begin{aligned} \delta &= q \cdot \max\left(p^*(X) - v_B^X, 0\right) + (1-q) \cdot \max\left(p^*(Y) - v_B^Y, 0\right) \\ &\leq q \cdot \max\left(q \cdot v_B^X + (1-q) \cdot v_B^Y - v_B^X, 0\right) \\ &\qquad + (1-q) \cdot \max\left(q \cdot v_B^X + (1-q) \cdot v_B^Y - v_B^Y, 0\right) \\ &= q \cdot \max\left((1-q) \cdot (v_B^Y - v_B^X), 0\right) + (1-q) \cdot \max\left(q \cdot \left(v_B^X - v_B^Y\right), 0\right) \\ &= q \cdot (1-q) \cdot \left|v_B^X - v_B^Y\right| \end{aligned}$$

where in the first inequality we apply both lemmas, absorbing the maximum in the upper bound for $p^*(Y)$ into the maximum in the definition of δ. In the final equality, we use that if $v_B^X \geq v_B^Y$, then the left term equals zero, and the right term equals zero otherwise. □

4 Discussion

This paper provides methods for quantifying the benefits of regulation of primary issuance and secondaries trading. For primary issuance, we find that efficiency loss relative to the first-best outcome occurs due to both moral hazard and asymmetric information. Moral hazard results in investment in good projects only occurring at a premium that increases linearly with the magnitude of moral hazard, as parameterized by the fraction of the initial investment that a founder can extract for personal gain. Asymmetric information results in investment in good projects only occurring at an even greater premium that increases (according to a precise function) with the rarity of good projects. It further results in inefficient investment into bad projects. Regulation, in the form of mandatory full disclosure, removes the additional premium on investment into good projects due to asymmetric information as well as the inefficient investment into bad projects, but does not mitigate the premium from moral hazard. For secondaries trading, we find that buyer overpayment relative to the first-best outcome occurs only due to asymmetric information as in a market for lemons. Without regulation, the expected buyer overpayment is upper bounded by the product of the buyer's variance in their prior and the absolute gap in the buyer's valuation for the asset across the possible realized states.

4.1 Application to Digital Assets

We next interpret our buyer overpayment bound for secondaries markets (Theorem 3.3) in the context of the CLARITY Act, which is proposed legislation for the regulation of digital assets, and in particular for "network tokens" associated with "mature blockchain systems."[4] One component of the proposed legislation (in Section 202(a)(1)) is the following addition (among others) to Section 4(a) of the '33 Act (on "exempted transactions"):

> …the offer or sale of an investment contract involving units of a digital commodity by its digital commodity issuer (including all entities controlled by or under common control with the issuer), if …the blockchain system to which the digital commodity relates, together with the digital commodity, is certified as a mature blockchain system…

where, according to Section 101(31) of the CLARITY Act:

> The term 'mature blockchain system' means a blockchain system, together with its related digital commodity, that is not controlled by any person or group of persons under common control.

What would be a possible justification for exempting digital assets related to a mature blockchain system from the disclosure requirements for traditional securities? Recall our upper bound (2) on our measure of the benefit of regulation in a secondaries market, the expected overpayment by a buyer:

$$\underbrace{q \cdot (1-q)}_{\text{Prior Variance}} \cdot \underbrace{\left|v_B^X - v_B^Y\right|}_{\text{Valuation Gap}}.$$

This bound is small whenever the uncertain information has little effect on a buyer's value (that is, $v_B^X \approx v_B^Y$) or the buyer is well informed (that is, $q \approx 0$ or $q \approx 1$). We next outline two examples of value-relevant information for which, in a sufficiently mature blockchain system, buyers might plausibly be well informed (and hence the expected buyer overpayment close to zero).

Example #1: Protocol modifications. If the underlying protocol is modified in any substantive way, including additional features, the buyer of the blockchain's network token may change her preferences for owning the asset. In particular, if we let the asset type $\theta = X$ correspond to the reality in which the modification is taken, and the asset type $\theta = Y$ correspond to the reality in which the modification is not taken, the buyer of the asset might strongly prefer one of these two states (and so $\left|v_B^X - v_B^Y\right| \gg 0$). Suppose that a seller of the asset knows with certainty whether the modification will be carried out; we argue that a typical buyer is then likely to be well informed. In a typical mature blockchain system, protocol changes are adopted only if a large number of stakeholders, such as blockchain validators, agree to accept the modification. A buyer privy to a representative set of the communications between validators would plausibly be well informed about whether the modification will take place (with $q \approx 0$ if the modification

[4] See https://www.congress.gov/bill/119th-congress/house-bill/3633/text for the full text.

is unlikely to take place, or $q \approx 1$ if the modification is likely to take place). If the blockchain protocol is permissionless, with new entrants able to join the validator set without explicit permission, it would seem difficult to debate and coordinate on protocol modifications without publicly visible communications. The bound in (2) therefore suggests that the expected buyer overpayment would close to zero in this case.

Example #2: Protocol exploits. If a protocol has an unannounced exploit (or otherwise does not satisfy the properties that is widely thought to possess), the buyer of a network token may also have a large valuation gap. Suppose that: (i) the protocol is open-source, as required by the CLARITY Act to qualify as a "mature blockchain system"; and (ii) the protocol has been subject to an appropriate amount of security audits. In this case, buyers are plausibly well informed about whether the protocol is sound, in which case the expected buyer overpayment would be small.[5]

We do not claim that these two examples cover all possible scenarios with value-relevant buyer uncertainty, but they do highlight some of the idiosyncratic properties of mature blockchain systems and the assets associated with them, and why those properties may justify a novel regulatory approach.

4.2 Extensions

Our models can be extended in several a number of ways. First, our model for primary issuance can be modified to incorporate the opportunity cost the founder faces for working rather than shirking. This would further increase the moral hazard premium on investment for good projects. Both our models for primary issuance and secondaries trading could be amended to allow for an arbitrary large (but finite) number of possible states, rather than considering just two states. For our primary issuance model, having some possibilities where there is residual value in the ultimate value of the project may decrease the premium on investment. For the secondaries model, the price p will split between states where the seller would sell the asset and states where the seller would hold the asset. Finally, a richer version of both the primaries and secondaries models could be considered where intermediate levels of disclosure are considered (e.g. the investor/buyer learns the true type of the project/asset with some probability before making the decision to invest/buy). This would lower the premium on investment in good projects or the trading premium/discount due to information asymmetry in a way that depends on the probability of disclosure.

Another meaningful extension of our secondaries model would be analyzing the impact of disclosure regulation on other proxies for the gains from trade of secondary markets. We study buyer overpayment in this paper, but other metrics such as price accuracy, liquidity, the allocation of risk, or even a unified term that encapsulates all of these may be compelling to consider.

References

[1] George A. Akerlof. 1970. The Market for Lemons: Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics* 84, 3 (1970), 488––500.

[2] D. Carlos Akkar. 2025. The (Mis)use of Information in Decentralised Markets. (2025). arXiv:2506.06848v4.

[3] Susan Athey and Jonathan Levin. 2018. The value of information in monotone decision problems. *Research in Economics* 72, 1 (2018), 101–106.

[4] Markus Baldauf and Joshua Mollner. 2020. High-frequency trading and market performance. *The Journal of Finance* 75, 3 (2020), 1495–1526.

[5] H. Bar-Isaac, I. Jewitt, and C. Leaver. 2021. Adverse Selection, Efficiency and the Structure of Information. *Economic Theory* 72 (2021), 579––614.

[6] Dirk Bergemann, Benjamin Brooks, , and Stephen Morris. 2015. The Limits of Price Discrimination. *American Economic Review* 105, 3 (2015), 921––957.

[7] Dirk Bergemann and Stephen Morris. 2019. Information Design: A Unified Perspective. *Journal of Economic Literature* 57, 1 (March 2019), 44––95.

[8] Ronald A. Dye. 1985. Disclosure of Nonproprietary Information. *Journal of Accounting Research* 23, 1 (1985), 123–145.

[9] Merritt B. Fox. 2001. The Issuer Choice Debate. *Theoretical Inquiries in Law* 2, 2 (July 2001), 563–612.

[10] Merritt B Fox, Lawrence R Glosten, and Gabriel V Rauterberg. 2015. The new stock market: Sense and nonsense. *Duke LJ* 65 (2015), 191.

[11] Vincent Glode and Christian C. Opp. 2019. Over-the-Counter versus Limit-Order Markets: The Role of Traders' Expertise. *The Review of Financial Studies* 33, 2 (June 2019), 866—-915.

[12] Lawrence R Glosten and Paul R Milgrom. 1985. Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. *Journal of financial economics* 14, 1 (1985), 71–100.

[13] M. T. Henderson and M. Raskin. 2019. A Regulatory Classification of Digital Assets: Toward an Operational Howey Test for Cryptocurrencies, ICOs, and Other Digital Assets. *Columbia Business Law Review* 2 (2019), 443—-493.

[14] Michael C. Jensen and William H. Meckling. 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3 (October 1976), 305–360.

[15] Navin Kartik and Weijie Zhong. 2025. Lemonade from Lemons: Information Design and Adverse Selection. (2025). arXiv:2305.02994v2.

[16] Jonathan Levin. 2001. Information and the market for lemons. *RAND Journal of Economics* 32, 4 (2001), 657––666.

[17] Roberta Romano. 1998. Empowering Investors: A Market Approach to Securities Regulation. *The Yale Law Journal* 107, 8 (June 1998), 2359–2430.

[18] Roberta Romano. 2001. The Need for Competition in International Securities Regulation. *Theoretical Inquiries in Law* 2, 2 (July 2001), 387–562.

[19] Supreme Court of the United States. 1946. SEC v. W. J. Howey Co. https://supreme.justia.com/cases/federal/us/328/293/ 328 U.S. 293.

[20] Jean Tirole. 2006. *The Theory of Corporate Finance.* Princeton University Press.

[21] United States Congress. 1933. Securities Act of 1933. *Pub. L.* 73-22, 48 Stat. 74 (codified as amended at 15 U.S.C. §§ 77a *et seq.*). See https://www.law.cornell.edu/wex/securities_act_of_1933 for a summary..

[22] United States Congress. 1934. Securities Exchange Act of 1934. *Pub. L.* 73-291, 48 Stat. 881 (codified as amended at 15 U.S.C. §§ 78a *et seq.*). See https://www.law.cornell.edu/wex/securities_exchange_act_of_1934 for a summary..

[23] Haoxiang Zhu. 2012. Finding a Good Price in Opaque Over-the-Counter Markets. *The Review of Financial Studies* 25, 4 (April 2012), 1255—-1285.

[5] If (i) or (ii) does not hold, a typical buyer may have significant uncertainty about the soundness of the protocol, whereas a sophisticated seller may have full knowledge of its soundness (e.g., through its own discovery of an exploit). In this case, regulation may substantively reduce buyer overpayment.

A Missing Proofs from Section 2

A.1 Proof of Proposition 2.1

Proof. If the project type is good, the welfare is equal to $V^* - I$ under investment with a working founder. If investment takes place with a shirking founder, welfare is instead $-(1-r)\cdot I$. Finally, welfare is zero if the investor passes on investment. If $V^* > I$, then investment with a working founder maximizes welfare. If $V^* < I$, then passing maximizes welfare uniquely, unless $r = 1$, in which case both passing and investing with a shirking founder both yield zero welfare. If $V^* = I$, then investment with a working founder yields equal welfare to passing, and both maximize welfare. If $r = 1$, then investment with a shirking founder maximizes welfare in this case as well. The first part of the result therefore follows.

If the project type is bad, then the welfare is equal to 0 under investment with a working founder, $-(1-r)\cdot I$ under investment with a shirking founder, and 0 if the investor passes on investment. It follows that passing is among the socially efficient options. □

A.2 Proof of Theorem 2.3

Proof. We can identify equilibrium behavior by working backwards. Starting with the second stage of the game, supposing that the investor chose to invest, notice that the founder will choose to work if

$$U_F^{\text{good}}([\text{Invest, Work}]) \geq U_F^{\text{good}}([\text{Invest, Shirk}]) \iff (1-f)\cdot V^* \geq r\cdot I \iff f \leq 1 - \frac{r\cdot I}{V^*} \tag{4}$$

and will shirk otherwise. The investor will choose to invest in the first stage if (i) the founder will work in the second stage, and (ii) the investor prefers investing under a working founder to not investing– i.e.

$$U_I^{\text{good}}([\text{Invest, Work}]) \geq U_I^{\text{good}}([\text{Pass}]) \iff f\cdot V^* - I \geq 0 \iff f \geq \frac{I}{V^*} \tag{5}$$

Putting together Equations 4 and 5, we find that if [Invest, Work] is an equilibrium, then

$$\frac{I}{V^*} \leq f \leq 1 - \frac{r\cdot I}{V^*} \implies V^* \geq (1+r)\cdot I \tag{6}$$

It follows that the history [Invest, Work] is an equilibrium if (for suitable f) and only if $V^* \geq (1+r)\cdot I$, and the history [Pass] is the unique equilibrium if $V^* < (1+r)\cdot I$. Recall that by Proposition 2.1, [Invest, Work] is uniquely socially efficient if and only if $V^* > I$. The desired result therefore follows. □

A.3 Proof of Theorem 2.4

Proof. As in the symmetric information case, we can reason about the equilibrium by working backwards. If the project type $\theta = \mathsf{bad}$ and the investor chooses to invest, then the founder will shirk to obtain a payoff of $r\cdot I$. If instead the project type $\theta = \mathsf{good}$ and the investor invests, the founder will choose to work if

$$U_F^{\text{good}}([\text{Invest, Work}]) \geq U_F^{\text{good}}([\text{Invest, Shirk}]) \iff (1-f)\cdot V^* \geq r\cdot I \iff f \leq 1 - \frac{r\cdot I}{V^*} \tag{7}$$

and will shirk otherwise (this is identical to Equation 4 from the symmetric information case). This is a necessary condition for [Invest, Work] to be an equilibrium. Assuming that f is chosen such that the founder will work given that the project is good, then the investor will choose to invest if

$$q\cdot U_I^{\text{good}}([\text{Invest, Work}]) + (1-q)\cdot U_I^{\text{bad}}([\text{Invest, Shirk}]) \geq q\cdot U_I^{\text{good}}([\text{Pass}]) + (1-q)\cdot U_I^{\text{bad}}([\text{Pass}]) \tag{8}$$

$$\iff q\,(f\cdot V^* - I) + (1-q)(-I) \geq 0 \tag{9}$$

$$\iff f \geq \frac{I\cdot\left(1+\frac{1-q}{q}\right)}{V^*} \tag{10}$$

It follows, combining Equations 7 and 10 that the investor chooses to invest if and only if

$$\frac{I\cdot\left(1+\frac{1-q}{q}\right)}{V^*} \leq f \leq 1 - \frac{r\cdot I}{V^*} \implies V^* \geq \left(1+r+\frac{1-q}{q}\right)\cdot I \tag{11}$$

As this investment decision is made without knowledge of the project's type, it follows that the history [Invest, Work] is an equilibrium if (for suitable f) and only if $V^* \geq (1+r+\frac{1-q}{q})\cdot I$ and the project type $\theta = \mathsf{good}$. The history [Invest, Shirk] is further an equilibrium if (for suitable f) and only if $V^* \geq (1+r+\frac{1-q}{q})\cdot I$ and the project type $\theta = \mathsf{bad}$, and the history [Pass] is the unique equilibrium if $V^* < (\frac{1}{q}+r)\cdot I$.

Invoking Proposition 2.1, we can see that if the project type $\theta = \mathsf{good}$, then equilibrium behavior is not socially efficient if $I < V^* < (1+r+\frac{1-q}{q})\cdot I$, since the investor will pass at equilibrium in this regime, but the welfare maximizing history is [Invest, Work]. If the project type is bad, we similarly see that welfare is maximized by passing (yielding zero welfare), but for an appropriate f, the investor will choose to invest if $V^* \geq (1+r+\frac{1-q}{q})\cdot I$. This will yield the equilibrium history [Invest, Shirk], yielding welfare $-(1-r)\cdot I$. If $r < 1$, then this is not socially efficient. □

A.4 Proof of Corollary 2.5

Proof. Applying Theorems 2.3 and 2.4, the welfare-maximizing equilibrium welfare over all possible f differs under symmetric versus asymmetric information only in the regime where $1 + r \leq V^*/I < 1 + r + \frac{1-q}{q}$. In this regime, no investment occurs under asymmetric information, whereas investment occurs under symmetric information. As such, the welfare gap is given by $V^* - I$, the total social surplus from investment. □

Received 20 February 2007; revised 12 March 2009; accepted 5 June 2009