Trust, Transparency, and Complexity*

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Abstract

This paper develops a theory that generates an equilibrium relationship between product/project complexity, transparency, and trust in firms. Complexity, transparency, and the evolution of trust are all endogenous, and the equilibrium involves non-monotonic transparency. The least-trusted firms choose the lowest product complexity, remain opaque, and substitute ex ante third-party verification for information disclosure and trust. Firms with intermediate trust levels choose intermediate levels of complexity and transparency through disclosure. Among these firms, those more trusted choose more complex products and disclose less information. The most-trusted firms choose maximum complexity while remaining opaque, eschewing both verification and disclosure. This generates a cross-sectional relationship between product complexity, transparency, and trust. It also implies that firms will initially start with low product complexity and high information disclosure, and adopt increasing complexity as their reputation for trust increases.

Keywords: Trust, Information, Information Disclosure, Transparency, Opacity, Verification

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1 Introduction

Due to the advent of mass customization (Blecker, Abdelkafi, Kaluza, and Kreutler (2007)) and the explosion of financial innovation (Allen (2012)), there is increasing complexity in both physical and financial products (e.g. Brunnermeier and Oehmke (2009) and Lusardi and Mitchell (2014)). This has elevated the role of trust in enabling adoption of these products. Customers—who may not fully comprehend all relevant product attributes—have to trust the producers in order to buy their products, and investors have to trust these producers in order to invest in them. Transparency (disclosure) and verification (auditing) are viewed as common tools for building trust (e.g. Offermann and Rosh (2012)).[1] The goal of this paper is to examine the interaction betweent trust, transparency, and verification in a model of endogenous product complexity and transparency.

Trust is often regarded as a lubricant of economic exchange, as it reduces transaction costs, mitigates contracting frictions, increases investor participation, and fosters economic growth (see, for example, Zak and Knack (2001), Guiso, Sapienza, and Zingales (2006, 2008), Ring (1996), and Wilson and Kennedy (1999)). Trust in society is often linked to the notion of "social capital", which contributes positively to economic growth (e.g., Algan and Kahue (2013), Fehr (2009), and Son (2016)).[2] The empirical evidence indicates a strong causal effect of trust on growth; see Bjornskov (forthcoming) for a review of this literature.[3]

The importance of trust has led to much discussion about how it is built, and a prominent mechanism that is proposed for building trust is transparency achieved through information

[1]Transparency and verification may also reduce corporate misconduct, which can build trust. Thanassoulis (2021) develops a model to examine what sorts of misconduct may be sustained in different competitive settings.

[2]Consistent with this, Zak and Knack (2001) develop a theoretical model which predicts that higher levels of trust lead to higher investments and higher economic growth. Guiso, Sapienza, and Zingales (2008) present a model in which higher levels of trust lead to higher stock market participation rates. Cline and Williamson (2016) argue that trust reduces the need for formal enforcement of rules, so trust and formal institutions become substitutes. Similarly, Aghion, Algan, Cahuc, and Shleifer (2010) and Pinotti (2008) argue that trust reduces the demand for regulatory-mandated firm disclosures. Boix and Posner (1998) provide an overview of the mechanisms through which social trust affects the quality of formal institutions and policy making.

[3]For example, Knack and Keefer (1997) document that trust is associated with stronger economic performance, and that trust is stronger in countries that more effectively protect property and contract rights.

disclosure. The argument is that more information disclosure leads to greater transparency, and this leads to greater trust.[4] For example, Schnackenberg and Tomlinson (2014) write: "Many have argued that organizational transparency is a salve for many maladies and helps re-establish trust." In a financial market context, this suggests that greater information disclosure should lead to more transparency and a lower cost of capital for the firm.[5] Apart from improving transparency, information disclosure may also positively affect real managerial decisions; Lunaway, Shields, and Waymire (2021) provide experimental evidence that reporting causes managers to make decisions that are better aligned with investors' interests. This has led to a large literature on voluntary information disclosure and regulatory disclosure requirements.[6] One conclusion of this research is that disclosure incentives are stronger when firms have to rely on external financing (e.g. Seo (2021)). It has also been suggested that greater information disclosure can help the buyers of financial products deal with increasing product complexity, suggesting that the demand for transparency may also depend on product/information complexity (e.g. Brunnermeier and Oehmke (2009)).

Various strands of the literature have thus indicated a link from information disclosure to transparency to building trust in product sellers, thereby helping buyers cope with complexity. However, the empirical evidence is mixed. While there is evidence that greater transparency is associated with a lower cost of capital (e.g., Andrade, Bernile, and Hood (2013)), there is little direct evidence on the relationship between transparency and trust in the cross-section. Anecdotal evidence suggests that greater transparency need *not* be associated with greater trust.[7] Some of the most trusted institutions often disclose less information

[4]Nayar (2009) notes: "[...] and one of the most uncomplicated ways of seeding trust is by 'stretching the envelope of transparency'," See also Federal Trade Commission (2013). See also Bennis, Goleman, and O'Toole (2008), Fombrun and Rindova (2000), and Perotti and von Thadden (2005).

[5]Greater transparency means lower adverse selection costs. Theoretical models in which this effect is encountered are Lambert, Leuz, and Verrachia (2006) and Thakor (2015); see also Andrade, Bernille, and Hood (2008) and Foucault, Pagano, and Roell (2013).

[6]See, for example, Boot and Thakor (2001) and Fishman and Hagerty (1992). These papers show that greater information disclosure by firms can weaken incentives for speculators to become informed, thereby creating tension between the greater transparency created directly by disclosure and the reduced transparency created indirectly through the altered incentives of informed investors.

[7]This may be true even when there is a benevolent regulator overseeing a monitor (like a bank) with reputational concerns. In such a setting, Marinovic and Szydlowski (2020) show that the regulator may not

than their less-trusted counterparts.[8] For example, Vural (2018) provides empirical evidence on the disclosure practices of publicly-listed Swedish family firms in which controlling owners have a strong influence on the corporate governance decisions of the firm, including corporate disclosure. The paper documents that these firms, in which the usual owner-manager agency problems are less severe (which is consistent with these firms being more trusted), disclose less information in annual reports than non-family firms do. de Fine Licht (2011) provides evidence that transparent decisionmaking weakens general trust in healthcare.

In an environment in which product/information complexity makes transparency economically meaningful, what is the relationship between transparency and trust? We address this question with a simple model in which both transparency—achieved through information disclosure—and product complexity are endogenously co-determined. In contrast to what is commonly believed, in our model, transparency does not build trust *per se*—in the sense that becoming more transparent does not directly lead to the firm becoming more trusted—but rather it *substitutes* for trust when product complexity is chosen to not be too high.[9] For high product complexity, only trust enables trade. Thus, high product complexity can be pursued only by the most trusted producers, and they choose opacity. Our analysis thus provies an economic rationale for the evidence that transparency and trust are sometimes negatively associated.

The model specifics are as follows. A firm makes a choice of projects that it finances with outside equity, where a project can be thought of as the development and marketing of a product.[10] It can choose between a good project the investors will fund, and a project that

provide transparency through disclosure because doing so destroys the monitor's reputational incentives.

[8]Consider Berkshire Hathaway as an example. It routinely stockpiles billions of dollars in cash, a practice that activist investors would frown upon in companies managed by less trusted executives than Warren Buffett. Yet the company's annual reports (and Buffett's letter to shareholders) reveal little about its plans for the use of the cash.

[9]This is the result in our base model which is static. In a dynamic extension, we show that greater transparency facilitates the evolution of the firm's reputation for trust, but *only* when the firm makes good project choices.

[10]We will use the terms "product" and "project" interchangeably. Project is a more general term in that, for any given product, say a swap contract or a payment system, there can be many different projects representing different ways of developing the product, different product attributes and different levels of complexity.

investors do not like because it yields the manager a private benefit but gives nothing to outside investors. Thus, there is a classic agency conflict between a controlling inside shareholder and non-controlling outside shareholders. Trust in a firm is the probability investors attach to the firm investing in the good project they like,[11] which could be interpreted as a reputation for being trustworthy, similar to Diamond's (1989) creditworthiness reputation.

Firms can disclose information. The information being disclosed in our model is forward-looking and soft, and is voluntary (see, e.g. Versano (2021) for a theoretical examination of forward-looking information disclosure). Greater information disclosure has two opposing effects. The functional aspect of disclosure is that it increases transparency by increasing the precision of the signal investors receive about the firm's project choice—this reduces the firm's cost of capital. The dysfunctional aspect is that it is directly costly. The costs can include both "disclosure processing costs" (e.g. Blankespoor, de Haan, and Marinovic (2020)), and those arising due to the "two-audience signaling" problem, which involves cash flow impairment due to the competitive reactions triggered by its information disclosure (Bhattacharya and Ritter (1982)).[12] Optimal disclosure balances these two forces.

We then introduce an "information complexity" parameter, which is meant to capture how complex the disclosed information is and how costly it would be for investors to process it. The idea is that firms differ in terms of the nature of the projects that they may undertake, or the products that they sell, with some being more complex than others—e.g. a firm that produces phone books versus one that sells highly customized swaps or engages in complex derivative transactions. Some information can be readily communicated at a low cost by firms, while other information may be very costly for the sender to communicate or costly

[11] This is consistent with the notion of trust in earlier research. For example, Gambetta (2000) views trust as "the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action." Lewis and Weigert (1985) state: "Although trust in general is indispensible in social relationships, it always involves an unavoidable element of risk and potential doubt." Morrison and Wilhelm (2015) characterize trust as something that does not rely upon the threat of punishment to achieve commitment.

[12] There is a significant banking literature that studies the pros and cons of information disclosure by banks and regulators in the context of stress tests, and this literature highlights other costs of greater disclosure. See Dang, Gorton, and Holmstrom (2017), Goldstein and Leitner (2018), Leitner and Yilmaz (2019), and Thakor (2015).

for the receiver to process (see Sobel (2012)). Complexity can also be functional in that it represents welfare-enhancing innovation, or dysfunctional in that it is obfuscation that increases the seller's rent while possibly making the buyer worse off (e.g. Gabaix and Laibson (2006)). We focus on the functional aspect of complexity and assume that the expected (first-best) payoff on the good project is increasing in its information complexity.[13] Finally, in the cross-section, firms differ in the trust that investors place in them ex ante.

With this model, we establish the aforementioned relationship between trust, transparency, and complexity, and also show that trust has a positive externality. A greater presence of trusted firms in the cross-section induces more self-interested firms to behave as if they are trustworthy. There are some products, however, that are "inherently opaque" but using disclosure to achieve transparency is either infeasible or too costly relative to alternative mechanisms. For example, fintech payment systems like Alipay and WeChat Pay are clearly not transparent to users, but are widely used. Why? The answer is verification: a friend, co-worker, or family member tries it and it works, and thus you are willing to use it. To accomodate this, we include ex ante third-party verification.[14] Such verification is ubiquitous—examples include inspections with real estate transactions, ratings issued by credit rating agencies, and public audits of firms' financial statements.

To model direct project choice verification, we assume the firm hires a monitor who incurs a private cost to discover the firm's project choice, and reports it to investors. To account for the monitor's incentive to shirk and misreport, we take two approaches to modeling the provision of incentives to verify. The first takes its cue from financial intermediaton theories (e.g. Diamond (1984) and Ramakrishnan and Thakor (1984)) and involves giving the monitor "skin-in-the-game" in the form of equity. In the second approach, we follow Rahman (2012) and solve for the optimal contracts needed to resolve the problem. With both approaches, we find that verifiability substitutes for disclosure-induced transparency for low levels of

[13] Any project for which this is not true—that is, it has higher information complexity and a lower expected value than another project—will be strictly dominated and not in the firm's efficient investment opportunity set.

[14] This is distinct from the ex post costly state verification analyzed by Townsend (1979).

project complexity, but is dominated by disclosure for higher levels of complexity. This paints a picture of *non-monotonic transparency*—for very simple projects, the firm chooses verifiability while remaining opaque, and then switches to disclosure and transparency for higher levels of complexity, with disclosure diminishing as complexity increases. Eventually, the most complex projects are managed only by the most trusted firms, which disclose nothing. In a sense, trust eliminates the need to unravel complexity, which echoes Lewis and Weigert's (1985) observation that a function of trust is the reduction of "perceived complexity". Our result that, for simple projects, verifiability through monitoring substitutes for transparency achieved via disclosure is in line with the evidence in Nagar and Schoenfel (2021) that firms reduce disclosure when there is a large shareholder who contractually binds management to share information and uses it for monitoring.

The model is parsimonious. It rests primarily on only two frictions—private information about the manager's trustworthiness and hidden project choice that proxies for unknown product attributes—and two key properties of complexity, namely that higher complexity adds more value, but also involves more complex information that is more difficult to process. With this, the analysis generates a trust-based hierarchy of firms' choices. At the lowest level of trust, firms choose the least complexity but remain opaque and use ex ante third-party verification. For intermediate levels of trust, firms choose greater complexity with transparency, but transparency declines as complexity increases. For high levels of trust, firms choose maximum complexity but return to being opaque. Complexity endogenously increases with trust. Intertemporally, firms that disclose more information experience a stochastically faster evolution of their trust reputation.

Despite the modeling parsimony, the intuition underlying the model is quite general. In a theory in which transparency is costly to achieve and the cost of disclosure increases with complexity, there will be a complexity high enough at which the firm forgoes transparency. Think of an investment bank with a highly complex portfolio of derivative contracts that include customized swaps as well as numerous other businesses like merger advisory services, all of which involve proprietary, soft, and confidential client information that is not only costly for the bank to disclose, but also costly for investors to process.[15] The cost generated by the resulting opacity can deter participation by the firm (bank) if it is sufficiently high. Trust acts as a mediating variable in determining this cost—the higher the trust, the lower the cost of opacity to the firm. Consequently, there is a complexity threshold below which disclosure dominates opacity and above which no-disclosure opacity is preferred. But even in the region below this complexity threshold, disclosure need not always be optimal. When the product/service is quite simple, having information verified by a third party may involve such a low cost that it is even cheaper than the cost of disclosure.[16] So when complexity is very low, the firm remains opaque and relies on verification, leaving disclosure-based transparency to operate only for intermediate levels of complexity.

This paper is related to the literature on information disclosure and transparency discussed earlier. Consistent with the firm's choices modeled in this paper, these papers have provided evidence that firms trade off monitoring of the manager against disclosure (e.g. Nagar and Schoenfeld (2021)), that disclosure influences managerial decisions (e.g. Lunawat, Shields, and Waymire (2021)), and that there are costs associated with communicating and processing information (e.g. Sobel (2012), and Blankenspoor, de Haan, and Marinovic (2020)).[17] A novel aspect of our analysis relative to this is our introduction of the role of trust as a mediating variable in the firm's choice and the endogenization of product complexity along with disclosure and verification.

Our paper is also related to the literature on trust and economic outcomes discussed

[15]Boot and Thakor (2001) model the idea that information may differ in the cost incurred by receivers to process it, although they do not discuss disclosure complexity. Jin, Luca, and Martin (2020) provide evidence that receivers make more errors in processing more complex information. Blankenspoor, de Haan, and Marinovic (2020) provide a review.

[16]For example, think of mobile payment apps. The one maintaining the app may conclude that there is no need to disclose information when users can (almost) costlessly verify its reliability by asking their friends. Or consider a widget manufacturer who hires a third party to certify to the customer that the product meets quality and specification standards. The customer can check on the third party's diligence quite easily by randomly sampling some widgets to inspect.

[17]Blankenspoor, de Haan, and Marinovic (2020) state: "We conclude that disclosure processing costs have implications for a wide array of accounting research, but we are only just beginning to understand their effects."

earlier. Prominent contributions include Knack and Keefer (1997) and La Porta, Lopez de Silanes, Shleifer, and Vishny (1997).[18] Trust can emerge due to the quality of the legal system and strategic interactions (Axelrod (1984)) or optimal investment in social capital (Glaeser, Laibson, and Sacerdote (2002)); Guiso, Sapienza, and Zingales (2006) provide a survey. Thakor and Merton (2021) show that trust insulates lenders against the adverse reputational consequences of bad credit outcomes in some states of the world, thereby facilitating continued access to low-cost financing. Morrison and Wilhelm (2015) view trust as an extralegal commitment device that affects how investment banks function. None of these papers examines the relationship between trust, complexity, and transparency. Moreover, in contrast to the previous literature, in our base model transparency and verification are substitutes for, not necessarily builders of, trust, consistent with the reported lack of empirical correlation between trust and transparency.

Our paper is also related to the literature on seller-chosen product complexity. Financial products have become increasingly complex—see, for example, Celerier and Vallee (2017) and Ghent, Torous, and Volkanov (2017). A burgeoning literature examines the dysfunctional aspect of complexity. It points out that product complexity, rather than serving more finely differentiated customer needs, may be due to intentional obfuscation of undesirable product attributes by firms selling to unsophisticated customers.[19] See Gabaix and Laibson (2006), Carlin (2009), and Pagano and Volpin (2012). The common element in all these papers is that this obfuscation allows rent extraction from unsophisticated customers.

In contrast to this literature, we focus on the functional aspect of complexity and assume that innate product value is increasing in complexity (as in Allen (2012), and Oehmke and Zawadowski (2019)).[20] Moreover, we focus on different tradeoffs in the choice of complexity—

[18] Trust also affects international trade. Guiso, Sapienza, and Zingales (2009) use data on bilateral trust between European countries to document that lower bilateral trust leads to less trade between two countries, less portfolio investment, and less direct investment.

[19] See Spiegler (2016) for a survey of this literature.

[20] A recent theoretical contribution by Aghamolla and Smith (2021) explores how managers strategically choose the complexity of their disclosures. They make the point that disclosure complexity is non-monotonic in firm performance, and that an endogenously-chosen complex disclosure can be chosen after observing either positive or negative news.

namely that between the higher profitability of a more complex product and the higher cost of external financing—and examine how trust influences this tradeoff.

A recent paper in this strand of the literature examines some issues similar to those we examine. Asriyan, Foarta, and Vanasco (forthcoming, "AFV" henceforth) develop a model to analyze the incentives of product designers to "complexify" products and the implications of this for product quality. The endogenous variables in this model are product complexity and quality, both chosen by the product designer, who interacts with consumers who buy the product. Complexity determines how difficult it is for consumers to determine product quality. The analysis shows that an increase in "alignment" between the consumer and the designer leads to more complex but better quality products, whereas higher product demand or lower competition among designers leads to lower quality products.

While our paper also addresses product complexity, there are numerous differences between the two papers.[21] First, unlike AFV, our main focus is on the firm's choice between (third-party) verification and degrees of information disclosure, its choice of product complexity, and the interaction between these endogenous choices as a function of the initial trust *investors* have in the firm. AFV do not analyze verification and information disclosure as firm choices. Second, we examine how trust *evolves* in response to the firm's endogenous choices, which AFV do not. Third, the role of complexity is starkly different in the two models, so the tradeoffs that determine complexity in the two models are entirely different. In AFV, there is *no* link between product attributes and complexity—the only role of complexity is to reduce the consumer's reliance on his own noisy signal, not to enhance the product's utility to the customer. In our model, products are more complex not because the designer wants obfuscation to discourage consumers from producing information about them, but rather because they are more finely tailored to customer needs—complexity is

[21] A direct comparison of the results in the two models is difficult because, apart from the difference in issues of focus across them, we analyze the interaction between the financiers/investors who are always *indifferent* to the firm's choice of verification, disclosure, and product complexity, so all the costs and benefits of these choices are absorbed by the firm, whereas AFV have *no* external financing and examine firm-consumer interactions in which both interacting parties care about the firm's choices of product complexity and quality.

functional and value enhancing. Consequently, the first best in AFV is the high-quality (G) product with simplicity, whereas in our model the first best is the most complex G product with *no* disclosure or verification. Fourth, while complexity emerges in AFV as part of the firm's randomized strategy *both* when the product designer has high trust and low trust, in our model complexity is encountered only when trust is high. Finally, in AFV, as product demand increases, product quality falls and complexity rises. In sharp contrast, in our model, complexity always increases with trust, as does quality as measured both by higher value to the consumer and a higher likelihood of the high-quality G product being chosen. In a nutshell, ours is the first paper to examine the interaction between product complexity, transparency and trust in a setting in which all are endogenously determined in equilibrium.

The rest of the paper is organized as follows. Section 2 develops the base model. Section 3 provides the analysis. Section 4 introduces the alternative of ex ante verification. Section 5 examines model robustness issues. Section 6 discusses empirical implications and examples that correspond to our results. Section 7 concludes. All proofs are in the Appendix.

2 The Model

Consider an economy in which all agents are risk neutral and the riskless rate of interest is zero. Imagine a penniless firm wholly-owned by a manager who needs $\$I$ to invest in a project at date $t = 0$ that will pay off at $t = 1$. All external financing is raised using equity.[22]

The manager must first irreversibly choose the project he wishes to invest in and then seek financing. However, absent any information disclosure by the firm, investors cannot tell what type of project the manager has chosen from the set $\{G, B\}$. The G project pays off a random cash flow $\tilde{x}$ that takes a value $X \in \mathbb{R}_+$ at $t = 1$ with probability q and a value of 0 with probability $1 - q$. This payoff at $t = 1$ is pledgeable and contractible. Thus, it can be used to compensate investors for the equity investment they make at $t = 0$. The B project gives the manager a private benefit of $\tilde{\beta}$ which takes a value of $\overline{\beta} \in \mathbb{R}_+$ with probability

[22]The results are not sensitive to whether external financing is raised using debt or equity.

$r \in (0,1)$ and a value of 0 with probability $1-r$.[23] The manager observes the realization of $\tilde{\beta}$ before making a project choice. This project produces no pledgeable cash flow that can be used to compensate investors.[24]

2.1 Managerial Types

There are two types of managers: trustworthy (T) and non-trustworthy (N). Each manager privately knows his own type. The trustworthy managers always choose G. The type-N managers are self interested and choose the project that maximizes their expected utility. The prior probability is $p \in \left[\underline{p}, 1\right)$ that the manager is type T and $1-p$ that he is type N, where $\underline{p} > 0$ is a lower bound. This prior probability is common knowledge and can be viewed as the manager's ex ante reputation for being trustworthy.[25] This setup is similar to Diamond (1989), where some firms are locked into choosing a safe project, some are locked into choosing a lower-valued risky project, and moral hazard exists with one type of firm that can choose between safe and risky projects with its choice determining the evolution of its reputation in the credit market. Our analysis differs, however, in that it is not concerned with the evolution of reputation, but rather with how this reputation affects a firm's choices of product complexity, whether to rely on disclosure or verification, and how much to reveal about the product.

[23] This private benefit has multiple interpretations. It could just be a non-contractible rent available to the manager when he invests, in the spirit of perquisites consumption in Jensen and Meckling (1976). Alternatively, it may represent the cost of personal effort for the manager in producing $\tilde{x}$ plus some non-contractible rents for the manager.

[24] When we examine robustness of the model in Section 5, we show that relaxing the assumption that the B project produces no pledgeable cash flow does not qualitatively affect the analysis.

[25] The idea that a completely trustworthy person (type T above) acts in accorance with the collective good reflects Lewis and Weigert's (1985) remark: "Trust exists in a social system insofar as the members of that system act according to and are secure in the expected futures constituted by the presence of each other in their symbolic representations." Yet, Lewis and Weigert (1985) also recognize that trust is not absolutle, and that when we trust someone, we take the risk that that trust may not be warranted, stating: "We would not have to accept this risk if there were some functional alternative to trust."

2.2 External Financing

At $t = 0$, the manager selects the project, and how much information to disclose about it to investors. At $t = 1$, based on the firm's disclosure policy, investors receive a noisy but informative signal about the project that enables them to update their beliefs about the manager's trustworthiness (i.e. reputation for trust evolves). At this date, the firm raises I from outside shareholders in exchange for a fraction $1 - f$ of ownership, where $f \in [0, 1]$ is the fraction retained by the owner-manager. The fraction $1 - f$ is endogenously determined based on investors' revised beliefs about the manager's trustworthiness and project type. At $t = 2$, outside shareholders receive $1 - f$ of the pledgeable cash flow of the project. There are no other assets in place. Equity is priced to yield investors an expected return of zero.

2.3 Project Complexity

The G project can vary in complexity. For example, it may simply be an extension of what the firm is currently doing, in which case it would have low complexity. Alternatively, it could represent a new, highly innovative R&D project to develop a new product that has substantial complexity and is unfamiliar to those outside the firm. For a financial institution, a low-complexity investment may be expanding its branch network or offering a variant of an existing financial product, whereas a high-complexity project may be getting into a new business involving complex financial instruments and potential risk exposures.

We model this choice of complexity in a simple way. Suppose there are two extremes: at one extreme is high simplicity (s) and at the other is high complexity (c). The firm's choice of complexity is a parameter $\theta \in [0, 1]$ that we call the "degree of complexity", and it is the weight attached to c. Higher values of θ denote greater complexity. The highly complex project has a payoff $X = X_c$ and the highly simple project has a payoff $X = X_s$, with $X_c > X_s > 0$. The actual payoff $X(\theta)$ corresponding to a choice of θ is $X(\theta) = \theta X_c + [1-\theta] X_s$. Thus, more complex projects have higher payoffs conditional on success. The idea is that these involve products with, say, greater customization for customers, and hence generate greater utility, allowing them to be sold at higher prices. Although our model does not deal with the interaction between the firm that designs and produces the product and the customer who buys it, we view more complex products as producing higher payoffs for the customer, with the complexity-driven increase in the payoff being shared between the selling firm and the customer. Thus, in our set-up, higher product complexity benefits both the product seller and the buyer *ceteris paribus*. In this regard, our view of complexity—namely that it is functional—is in sharp contract to the obfuscation view of complexity that it is dysfunctional.[26]

It will be assumed throughout that, regardless of project complexity, G is always socially preferred to B, i.e.,

$$qX_s > \overline{\beta} \tag{1}$$

2.4 Information Disclosure

Outside investors cannot tell *a priori* which project was selected by the manager. To help investors discern the manager's project choice, the manager can disclose information at $t = 0$ represented by $\eta \in [0, \overline{\eta}]$. Investors can observe the firm's η after the firm chooses it. This disclosure costs the firm $\psi(\eta) \in \left[0, \overline{\psi}\right]$, with $\psi' > 0$, $\psi'' > 0$, $\psi(0) = 0$, $\psi'(0) = 0$, and $\psi\left(\overline{\eta}\right) = \overline{\psi} > 0$. These costs could come from a variety of sources. For example, they could represent the firm's investment in communication skills/capacity, as in Sobel (2012), that is undertaken prior to raising financing, so it is a cost to the firm that is incurred pre-project-cash-flow, and thus not shared by investors. This is the interpretation in the formal model. Alternatively, they could be the direct physical losses due to the "two-audience signaling" problem, wherein information disclosure to investors also inadvertently reveals it to the firm's product market competitors (e.g. Bhattacharya and Ritter (1982)), in which case the cost would be a reduction in the project cash flow that is shared by investors. Although the formal

[26] An alternative view of complexity is that it is not really a matter of choice for the producer, and that each product is exogenously endowed with an optimal degree of complexity. In such a setup, $X(\theta)$ would not be increasing in θ. In Section 5, we show that such an interpretation makes our results even stronger.

model does not use this interpretation, we have done the analysis with this interpretation. All the results hold. The equilibrium value of η is endogenous. Note that we are assuming that ψ does not depend on θ. In reality, it may be more costly to disclose information about more complex products, in which case ψ would be increasing in θ for any given η. Adding this feature only strengthens our results.

When information is disclosed, it produces a noisy but informative signal $\phi \in \{G, B\}$ about the project choice that investors (outsiders) observe at $t = 1$. The probability is $C_s(\eta) \in [0.5, 1]$ that the signal will be correct (i.e., that investors will correctly identify the firm's project choice) with the highly simple project, and the probability is $C_c(\eta) \in [0, 1]$ that they will identify it correctly with the highly complex project. We assume $C_s(0) = 0.5$, $C_s(\overline{\eta}) < 1$, $C_s'(\eta) > C_c'(\eta)\ \forall\, \eta \in [0, \overline{\eta}]$. For simplicity, we normalize $C_c(\eta) = 0.5\ \forall\, \eta$ and let $C_s(\eta) > C_c(\eta)\ \forall\, \eta > 0$, $C_s'(\eta) > 0$, $C_s''(\eta) < 0$, in order to satisfy the condition that investors find it easier to correctly identify the firm's project choice when it is highly simple than when it is highly complex.[27] That is, when the firm chooses a disclosure η, investors receive a signal ϕ about the firm's project choice that has precision dependent on η:

$$C_s(\eta) = \Pr(\phi = G \mid G, \eta) = \Pr(\phi = B \mid B, \eta) \tag{2}$$

$$1 - C_s(\eta) = \Pr(\phi = G \mid B, \eta) = \Pr(\phi = B \mid G, \eta) \tag{3}$$

This specification captures in a simple way the idea that investors have greater difficulty in processing information about more complex projects. Further, it also means that the marginal effectiveness of disclosure by the firm in improving investors' ability to discern the firm's project choice is lower when complexity is higher. Note that since equilibrium project choices are correlated with the manager's type, observing ϕ also enables investors to update their beliefs about the manager's type. The posterior belief about the manager's type can

[27] In the context of Sobel's (2012) model, this would be the case if the information processing cost of the receiver (investors) with the complex project is so high that they choose the smallest information processing capacity. In the context of the Blankenspoor, de Haan, and Marinovic (2020) discussion, "disclosure processing costs" are very high with the complex project.

then be written as $\mu(\phi, p)$. Thus, the manager's reputation for trustworthiness ("trust" for short) evolves.

For a choice of complexity θ, the probability that investors will correctly identify the firm's project choice is:

$$\begin{aligned} C(\eta, \theta) &\equiv \theta C_c(\eta) + [1-\theta]C_s(\eta) \\ &= [1-\theta]\left[C_s(\eta) - 0.5\right] + 0.5 \end{aligned} \tag{4}$$

There are two closely-related ways to think about this set-up. One is to think about η simply as the *volume* of information disclosed; this corresponds to the way the model has been described thus far. That is, the firm can communicate that it has a G project with aggregate cash flows over the next 10 years totaling, say, \$50 million. A more voluminous communication would provide additional detail by giving annual cash flow forecasts that include detailed pro-forma financials with supporting assumptions and the (verifiable) data backing these assumptions.

Another interpretation is to think about η as the firm's choice of "information communication capacity", with greater capacity representing a more complex information communication system that permits information to be communicated more precisely. This is the perspective in Sobel (2012), and in Appendix A we show how this approach can be used to model η. With this approach, communication about G is based on the realization of a project attribute, say $a \in \mathbb{A}$, with η representing how precisely a can be communicated to investors and hence how precisely they can tell that the project is indeed G. That is, η represents how $\mathbb{A}$ is partitioned and hence the coarseness with which a is communicated. A higher η connotes a finer partition and greater precision of communication.

These two interpretations are related, of course. Providing more voluminous information typically permits more precise inferences.

In what follows, the firm's choice of θ will be endogenized as well. Like η, the choice of θ is also commonly observed, and we assume that a firm can invest in only one project. Further, the B project can be dressed up to look identical to a G project in complexity. This means observing η and θ does not allow investors to distinguish G from B.

2.5 Summary of Timeline and Sequence of Events

Figure 1 is the summary of the timeline and events.

Figure 1: Timeline of Events

$t = 0$	$t = 1$	$t = 2$
► Manager irreversibly chooses project: either B or G and the complexity θ of the project. Outsiders do not observe which project (G or B) was chosen, but they do observe θ. ► Manager chooses to disclose information η about project choice. Investors observe η.	► The disclosure produces a signal ϕ about project choice that investors receive. Investors update their beliefs about the project and the manager's type based on ϕ. ► Manager issues equity and surrenders ownership $1 - f$ to raise I for the project, where the revision of investors' beliefs based on the signal ϕ determines $1 - f$ endogenously in a market equilibrium	► Project payoff is observed ► Investors collect fraction $1 - f$ of observed payoff and manager keeps fraction f

Note that the manager chooses his information disclosure policy before he knows the project cash flow. This specification seems natural to us since information disclosure—whose purpose is to improve investors' information about the project they are financing—must precede the raising of external financing, and external financing naturally preceds investment in the project. Because the future project cash flow is stochastic at the time the project is chosen (which is prior to the investment), the manager is assumed to know only the cash flow distribution, and not the actual project cash flow, when he chooses the project. However, we show in Section 5 that our results do not change even if the manager could take an informative peek at the project cash flows prior to choosing the project.

3 Analysis

3.1 First-best

The first best in this model is straightforward. It is to choose the G project with maximum complexity ($\theta = 1$), so that $\tilde{x} = X_c$ with probability q, and to choose $\eta = 0$.

3.2 Second-best with θ Fixed and $\eta = 0$

To set a benchmark, let us first examine the case in which there is no choice of θ and no information disclosure by the firm. In this case, investors cannot tell what type of project has been selected by the firm. Let $\alpha(p) \in [0, 1]$ represent the probability investors assign to the event that the firm has chosen G. Then it is easy to show that the market equilibrium condition that determines f, call it f_0 in this case, is given by:

$$[1 - f_0]\, \alpha(p) q X(\theta) = I \tag{5}$$

which is the outside shareholders' breakeven condition at a riskless rate of 0 and no disclosure ($\eta = 0$). Throughout, the equilibrium concept we use is Bayesian Perfect Nash equilibrium (BPNE). Now, assuming $\overline{\beta}$ is small enough, it can be shown that:

$$\alpha(p) = \begin{cases} p + [1 - p][1 - r] & \text{if } f_0 q X \in \left(0, \overline{\beta}\right) \\ 1 & \text{if } f_0 q X \geq \overline{\beta} \end{cases} \tag{6}$$

To interpret (6), note that $f_0 q X$ is the manager's share of the payoff on G. When this share is less than $\overline{\beta}$, the manager will choose G when $\tilde{\beta} = 0$ and will select B when $\tilde{\beta} = \overline{\beta}$. Hence, the probability that G will be chosen is p (the probability that the manager's type is T) plus $[1 - p][1 - r]$, which is the probability that the manager's type is U and the manager selects G because $\tilde{\beta} = 0$. However, when $f_0 q X$ exceeds $\overline{\beta}$, both T and U unconditionally select G, so the probability is 1 that G will be chosen. This now leads to the first result.

Figure 2: Ownership Retained by the Manager as a Function of β

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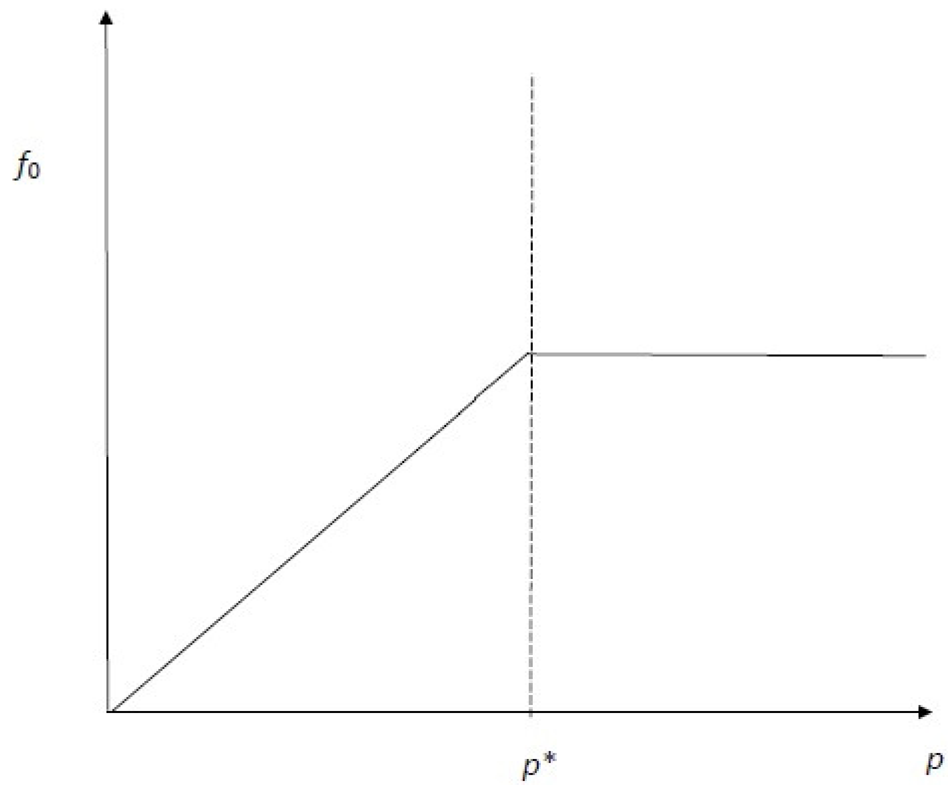


Proposition 1 (Positive Trustworthiness Externality): *Holding θ and η fixed and assuming $\overline{\beta}$ is small enough, there exists a $p*\in(0,1)$ such that the firm is always considered trustworthy when the prior belief that the manager is trustworthy exceeds $p*$. In this case, both the type T and type N managers select G. For $p<p*$, N acts as a self-interested manager and selects B with probability r. Thus, the fractional ownership the manager retains, f_0, is increasing in p for all $p<p^*$ and then unaffected by p for all $p\geq p^*$.*

The intuition comes straight from (6), which shows that $\alpha(p)$ is increasing in p as long as $f_0qX\in\left(0,\overline{\beta}\right)$. Since $1-f_0$ can be shown to be decreasing in p (see the proof of Proposition 1), we see that f_0 is increasing in p in this range. Once f_0qX goes above $\overline{\beta}$, the firm is always choosing G, so the ownership fraction that must be sold to raise I no longer depends on p. *Figure 2* depicts the ownership retained by the manager as a function of β.

This result highlights the "spillover" effect or externality generated by other firms seeking financing, if we view p as reflecting rational expectations on the part of investors about the proportion of trustworthy firms in the cross-section. When the market is populated by sufficiently many trustworthy firms, investors act as if all firms are trustworthy, even though they know that not all are (note that $p* < 1$). Thus, trustworthy firms generate a positive social externality for *all* firms.

The intuition for this result is that when p increases, f also increases, so the manager encounters "cheaper" equity financing and is able to raise I by surrendering a smaller ownership fraction. This increases the value of G to him and the associated incentive effect reduces the agency cost associated with the type-N manager choosing B. In a sense, trust begets trustworthy behavior.

Having an interior p^* rests on the assumption that $\overline{\beta}$ is not too large. If $\overline{\beta}$ were large enough, then it would be the case that the type N manager would always prefer B over G when $\tilde{\beta} = \overline{\beta}$. Henceforth, we will assume this is the case, so the severity of moral hazard does not depend only on investors' prior beliefs. The rest of the analysis relies on the following assumptions about exogenous parameters in order to focus on the cases of interest (these are sufficiency conditions only for the results).

Parametric Assumption 1: The type N manager always prefers B to G when $\tilde{\beta} = \overline{\beta}$:

$$qX(\theta) - I < \frac{1 - C(\overline{\eta}, \theta)}{C(\overline{\eta}, \theta)} \overline{\beta} \, \forall \, \theta \tag{7}$$

Parametric Assumption 2: No financing if manager is believed to be type N with probability 1:

$$[1 - r] qX_c < I \tag{8}$$

Parametric Assumption 3: Complexity is not too valuable relative to simplicity:

$$I < X_S < X_c < 2X_S - \frac{I}{q} \tag{9}$$

As for the last assumption, if product complexity were arbitrarily more valuable than product simplicity, it would disrupt a key economic tradeoff in the model and push all firms into a corner solution of maximum complexity.[28]

3.3 Optimal Choice of Information Disclosure for Fixed Product Complexity

We now fix θ and examine the firm's optimal information disclosure policy. Given (6), we know from (5),

$$\begin{aligned} \alpha(p) &\equiv p + [1-p][1-r] \\ &= 1 - r[1-p] \end{aligned} \tag{10}$$

Let $\overline{p}$ be the solution to:

$$[1 - r\,[1-\overline{p}]]\, qX_c = I \tag{11}$$

Then for any $p < \overline{p}$, it is impossible for the firm to raise external financing for its project with no information disclosure (i.e., $\eta = 0$). For $p \geq \overline{p}$, external financing without disclosure is possible. In what follows, we will assume $p < \overline{p}$. Then we will see how the analysis changes for $p \geq \overline{p}$.

Since $p < \overline{p}$, some information disclosure is necessary for the firm to raise external financing. How much is needed? To see this, let $\overline{\overline{\eta}}(\theta)$ be the critical disclosure such that

[28]There are other implications as well. One cost of disclosing less information to investors is that, *ceteris paribus*, the firm has to give up a bigger ownership fraction to raise financing, and the benefit is a lower disclosure cost. Arbitrarily more valuable complexity magnifies the cost of disclosing less information to the firm.

financing is available with $\phi = G$, given $\bar{\bar{\eta}}(\theta)$, i.e.,

$$(1-f)\Pr\left(G \mid \phi = G, \bar{\bar{\eta}}(\theta), p\right) qX(\theta) = I \tag{12}$$

where

$$\Pr\left(G \mid \phi = G, \eta, p\right) = \frac{C\left(\eta,\theta\right)\left[1 - r[1-p]\right]}{C\left(\eta,\theta\right)\left[1 - r[1-p]\right] + \left[1 - C\left(\eta,\theta\right)\right] r[1-p]} \tag{13}$$

It is straightforward to verify that

$$\frac{\partial \Pr\left(G \mid \phi = G, \eta, p\right)}{\partial \eta} > 0 \tag{14}$$

Thus, given θ and p, external financing will be available, conditional on $\eta \geq \bar{\bar{\eta}}(\theta)$ and $\phi = G$.

We now employ a parametric assumption to guarantee that the firm will be willing to choose disclosure $\bar{\bar{\eta}}(\theta)$ to raise external financing, i.e.,

Parametric Assumption 4:

$$C\left(\bar{\bar{\eta}},\theta\right)\left[qX(\theta) - I\right] - \frac{\left[1-\alpha(p)\right]\left[1 - C\left(\bar{\bar{\eta}},\theta\right)\right] I}{\alpha(p)} > \psi\left(\bar{\bar{\eta}}\right) \quad \forall\, p < \overline{p} \,\text{and}\, \forall\, \theta \tag{15}$$

This assumption is simply sufficient to ensure that, for every θ, it is both feasible and desirable for the firm to raise external financing. We now have the following intuitive result:

Lemma 1: *Given $\eta > \bar{\bar{\eta}}(\theta)$,no financing will be available if $\phi = B$.*

Thus, financing will be available only when $\phi = G$ and $\eta > \bar{\eta}(\theta)$. Now the maximization program of the type-T manager is:

$$\max_{\eta} C(\eta,\theta) f(\eta) qX(\theta) - \psi(\eta) \tag{16}$$

subject to

$$\left[1 - f(\eta)\right]\Pr\left(G \mid \phi = G, \eta, p\right) qX(\theta) = I \tag{17}$$

Note that since financing is only available when $\phi = G$, the type T manager—who always chooses G—recognizes that the probability of securing financing is $C(\eta, \theta)$, and the share of the expected payoff ($qX(\theta)$) retained by the firm is $f(\eta)$, where $f(\eta)$ is determined by the pricing constraint (17). Any disclosure η imposes a cost $\psi(\eta)$ on the firm. We now have an intuitive result:

Lemma 2: *The type T manager will always choose $\eta > \bar{\bar{\eta}}(\theta)$, given θ.*

Next we characterize the behavior of the type N manager.

Lemma 3: *In a BPNE, the type N manager will choose the same η for any θ as the type T manager. This equilibrium survives the Cho and Kreps (1987) Intuitive Criterion.*

The intuition for this result is that the type-T manager is always going to choose G and hence the project complexity and information disclosure that corresponds to that project choice, rationally anticipating the reaction of investors to that choice in setting $1 - f$. Hence, if a type-N manager who is investing (unobservably) in B deviates from those (observable) choices of θ and η, he will be unambiguously identified as choosing B and no funding will be available. Next we have:

Proposition 2: *Given $p < \bar{p}$, there exists a unique value of η, call it $\eta^*(\theta)$, chosen by both types of firms in equilibrium for every θ. Moreover, firms with higher values of θ (more complex projects) choose lower values of η^* (disclosure level).*

This proposition shows that a firm that has a more complex project chooses to disclose less information and be more opaque. That is, more complex projects have less complex information disclosures. The intuition is as follows. Greater project complexity makes it more difficult for investors to process the information disclosed by the firm. Formally, the *marginal* impact of disclosure on the precision of the signal about project choice received by the investors is smaller when project complexity is greater. Consequently, the marginal benefit of greater disclosure in changing the cost of external finance is smaller when project complexity is higher. However, the marginal cost of information disclosure in reducing the project payoff is unchanged. Hence, less information is disclosed when project complexity is higher.[29] Next we turn to how the equilibrium disclosure choices of firms affect the evolution of trust.

Corollary 1: *Managers of firms that adopt more complex products (higher θ) experience a smaller expected increase in their reputation for trust, conditional on choosing G.*

The intuition follows from two facts. The first is the result in Proposition 2 that firms with higher values of θ choose lower values of η. The second is that a lower η means that the expected increase in the manager's reputation for trust (as assessed by investors) is smaller, conditional on choosing G. This is because the signal ϕ is informative in equilibrium, so a manager choosing G is more likely to generate $\phi = G$, but benefits less from this reputationally because investors put less weight on it.

3.4 The Optimal Choice of Project Complexity ($p < \overline{p}$)

Finally, we solve the full problem in which the firm chooses project complexity, θ. All that is exogenously fixed now is the initial ($t = 0$) reputation for trustworthiness, p. The manager solves the following problem:

$$\max_{\eta \in [0,\overline{\eta}], \theta \in [0,1]} C(\eta, \theta) f(\eta) q X(\theta) - \psi(\eta) \tag{18}$$

subject to

$$[1 - f(\eta)] \Pr\left(G \mid \phi = G, \eta, p\right) q X(\theta) = I \tag{19}$$

Analysis of this maximizaiton problem leads to the following result:

[29] Our approach to modeling the cost of disclosure should be contrasted with Boot and Thakor (2001). In that model, there are two types of investors: naive and sophisticated. Disclosure helps the sophisticated investor more than the naive one, and thus represents a cost. In our setup, this effect would get stronger with complexity, so the benefit of disclosure will become smaller as complexity increases. So incorporating that feature of the Boot and Thakor (2001) model will further strengthen our results.

Proposition 3: *For $p < \overline{p}$,there exists a unique optimal value of product complexity, θ, call it θ^*, that is strictly increasing in p, the prior probability that the manager is type T.*

This proposition says that more trustworthy firms choose greater complexity. Combining this with Proposition 2, we see that it means that more trustworthy firms are are not only more complex, but they disclose *less* information and are *intentionally* more opaque. This result sheds light on the empirical evidence discussed in the Introduction.

The intuition is that when the firm is more trusted, the marginal cost of disclosing less information in terms of the consequent increase in its cost of external finance (i.e. $1 - f$) is smaller. The marginal benefit of disclosing less information (which is a lower disclosure cost) is the same. This means it is less costly at the margin for a more trusted firm to disclose less information. Since it is optimal to disclose less information when project complexity is greater (Proposition 2), a more trusted firm finds it optimal to choose a more complex project with its higher first-best expected value.[30]

3.5 The Optimal Choice of Project Complexity ($p > \overline{p}$)

So far we have assumed that $p < \overline{p}$, so financing cannot be raised with $\eta = 0$ (at the prior beliefs of investors). We now examine what happens with $p \geq \overline{p}$.

Proposition 4: *When $p \geq \overline{p}$, there exists a $\hat{p}^*$ such that financing can be obtained at prior beliefs (with $\eta = 0$) for $p \in [\overline{p}, \hat{p}^*)$, but not if $\eta > 0$ and $\phi = B$ is observed by investors. For $p \in [\overline{p}, \hat{p}^*)$, firms choose $\eta > 0$ in equilibrium. For $p \geq \hat{p}^*$, a firm can raise financing with*

[30]It is useful to compare our analysis here to Thakor and Merton's (2021) theory which is built around model uncertainty. In one model of the world—referred to as Model I—agents are viewed as being trusted, so they always choose G regardless of circumstances. In another model of the world—referred to as Model II—agents choose G only if it is utility-maximizing to do so under the circumstances. In our context, there may be two observationally distinct groups of firms at the outset. Those in Model I would all choose $\theta = 1$ and $\eta = 0$. Those in Model II would choose $\theta = 1$ and $\eta = 0$ if $p \geq \hat{p}^*$, and would choose $\theta < 1$ and $\eta > 0$ with η decreasing in θ for all $p < \hat{p}^*$. In the multiperiod setting of Thakor and Merton (2018), project failure at the end of the first period would not affect the trusted firms described by Model I, but the firms in Model II—particularly those with p just above $\hat{p}^*$—may be forced to switch to simpler projects and become more transparent.

$\eta > 0$ for both $\phi = G$ and $\phi = B$. In equilibrium, a firm with $p \geq \hat{p}^*$ chooses $\eta = 0$ and $\theta = 1$.

The reason why firms choose $\eta > 0$ even when financing can be raised at prior beliefs with $\eta = 0$ is that disclosing information leads to a lower cost of financing when $\phi = G$ is observed by investors. So a firm choosing G prefers to have an informative signal produced about its project choice than have investors rely only on their priors. However, when p is so high that any $\eta > 0$ will lead to investors financing the project regardless of whether $\phi = G$ or $\phi = B$, the manager optimally chooses $\eta = 0$.[31] That is, the firm goes completely dark, with no disclosure. With $\eta = 0$, the cost of choosing higher product complexity goes away, so the firm optimally chooses maximum complexity ($\theta = 1$). See *Figure 3* below.

3.6 The Evolution of Trust

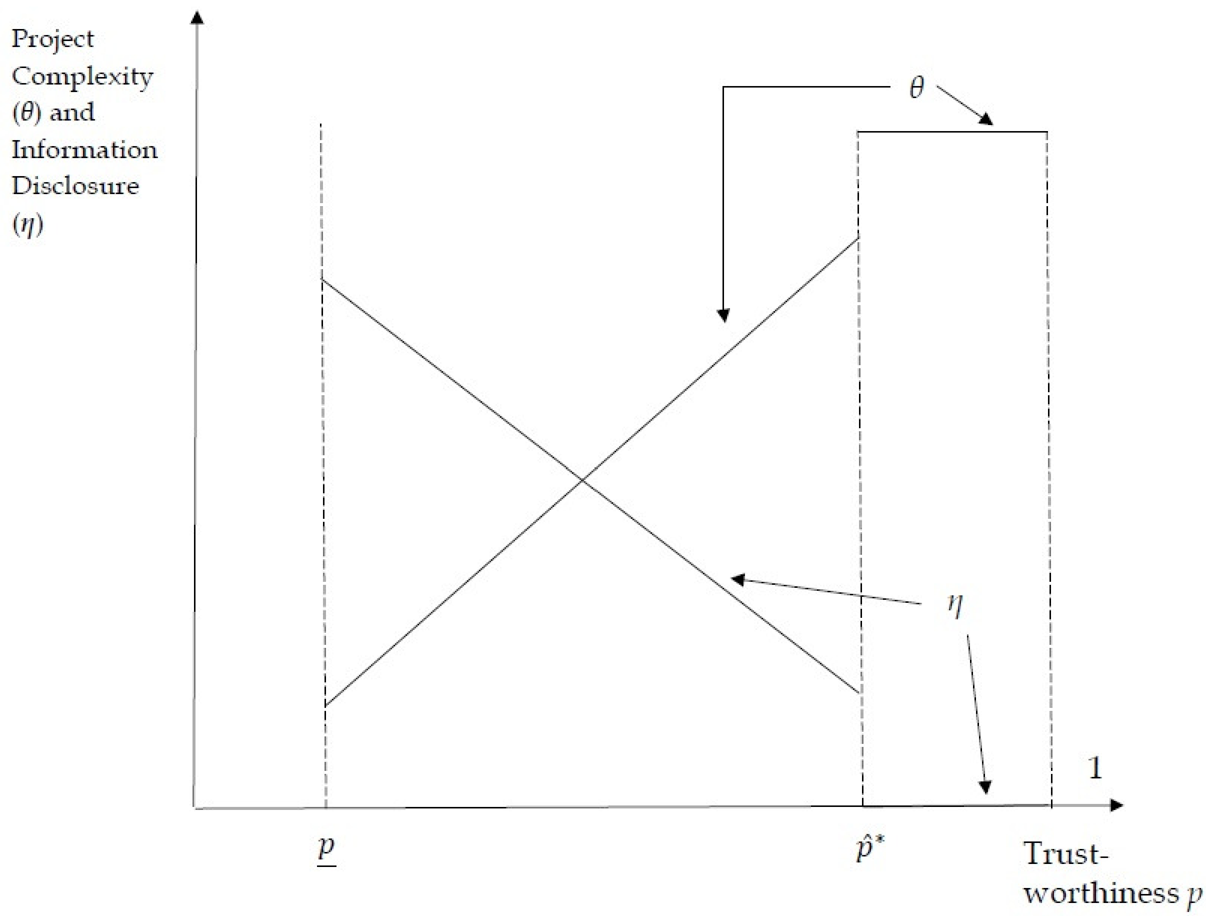
We now present additional results on the evolution of trust.

Corollary 2: *For a fixed product complexity θ and $p \leq \hat{p}^*$, as p, investors' prior belief that the manager is type T, increases, the expected equilibrium increase in trust reputation for a firm choosing G is smaller.*

This result says that the better the manager's prior reputation for trust, the smaller is the expected increase in trust reputation for a manager choosing G. That is, there is a sort of "diminishing return for investing" in building trust. The intuition comes from the equilibrium relationship emerging from the model—a higher p leads to a higher θ, and a higher θ is associated with a lower η. With a lower η, investors' signal precision is lower, so they attach a lower weight to $\phi = G$ in coming up with their posterior belief about the

[31] This result is not obvious. Even when financing can be obtained regardless of the signal investors observe, the realized value of the signal affects the terms of financing. That is, a good signal leads to better financing terms for the firm than a bad signal. What this result shows is that this is not enough to induce costly disclosure. What is needed to induce disclosure is the threat of financing being cut off contingent on a bad signal.

Figure 3: Trust, Complexity, and Disclosure



manager's type. Thus, a manager choosing G experiences a smaller expected increase in his reputation for trust after choosing G.

We now turn to dynamics and life cycle effects in the evolution of trust. Suppose the manager makes two choices of product complexity and information disclosure, one at $t = 0$ (first period) and another at $t = 2$ (second period). The only connection between the choices in the two periods is through the evolution of the manager's reputation for trust. Investors observe the manager's first-period choice of η, call it η_1, and product complexity θ, call it θ_1. Then they observe the signal ϕ_1 and update their beliefs about the manager's project choice and his type. Additional updating of beliefs occurs when the realized cash flow on the first-period project is observed. This updated belief then becomes the prior belief for investors who observe the second-period choices η_2 and θ_2, and outcomes ϕ_2 and the second-period project cash flow, to further revise their beliefs. This leads to our next result.

Proposition 5: *Relative to a static setting, in a multi-period setting with endogenous trust evolution, firms choose higher levels of* η.

The intuition is as follows. By choosing G in the first period, the manager experiences an increase in his expected reputation for trust in the first period, so as to benefit from a lower cost of financing in the first period. This leads to a benefit from choosing a higher η that is encountered in both the static and multi-period settings. But there is an additional benefit of a higher η in the multi-period setting. Because of a higher η_1 in the first period, the manager who chooses G in the first period expects to start with a higher reputation for trust in the second period than he did in the first period (p). The proof shows that the manager's expected utility is increasing in investors' prior belief that the manager is type T. Thus, a higher η_1 leads to a higher expected utility for the manager in the second period. While we show this result in a two-period setting, it generalizes quite readily to an arbitrarily large (finite) number of time periods. This leads the manager to choose a higher level of information disclosure in a multi-period setting than in a static setting.

4 Verifiability and Regulation

Thus far we have shown that transparency achieved through information disclosure is a *partial* substitute for trust. However, the efficacy of information disclosure declines when project complexity increases, so the most complex firms are the most opaque and this makes trust essential for them to operate. That is, absent trust, firms cannot undertake very complex projects. In this section we discuss alternatives to trust: verifiability and regulation.

4.1 Verifiability via Monitoring

Our previous analysis shows that information disclosure by firms is one way to address investors' lack of information. However, the analysis also shows that disclosure is optimally incomplete, so the information gap between the firm and investors is never bridged completely. This leaves room for other mechanisms to complement direct disclosure. We now examine one such mechanism—verification, which involves monitoring of the firm to verify project choice.

There are two type of verifiability—ex post and ex ante. Our base model already incorporates ex post verifiability of the project cash flow, and contracts are conditional on that verifiability.[32] The actual project choice is not verifiable ex post, but this does not matter. This is because we have limited liability, so when $\tilde{x} = 0$ and it is determined ex post that the firm invested in B at $t = 0$, there is nothing investors can do. Thus, adding ex post verifiability of project choice to the model would not change anything.

Consider now ex ante verifiability of project choice. By assumption, investors cannot observe this choice. That is, suppose investors can hire a monitor to verify the firm's project choice ex ante. This role is routinely played by entities such as auditors. Even credit rating agencies play this role by specifying the firm's default risk through the rating given to the firm, which is an indication of project choice. A question this raises is: who will monitor the

[32]This means we are not in the type of setting considered by Townsend (1979), where ex post cash flows are unobservable and can be verified only at a cost.

monitor, given that the monitor will have incentives to shirk? That is, if ex ante verification is costly for the monitor and the monitor's output itself—verification of the firm's project choice—is not verifiable, then how does one ensure that the monitor will do the job? In a dynamic setting, reputational considerations will influence the monitor, but we take two different approaches here.[33]

4.1.1 Approach 1: Financial Intermediaries as Monitoring/Screening Entities

The seminal theories of financial intermediation provide one approach. In Diamond (1984), entrepreneurs' ex post project cash flows are unobservable, so investors who fund entrepreneurs would have to incur costs in collecting repayments. They can provide financing at a lower cost by channeling funds through an intermediary that acts as a "delegated monitor". This intermediary collects funds from investors in the form of deposits and is incentivized to collect repayments because it suffers a non-pecuniary penalty if it defaults on its deposit obligations. The expected cost of this penalty is driven to zero through diversification. In Ramakrishnan and Thakor (1984), verification of the creditworthiness of entrepreneurs is provided by individual screening agents inside a financial intermediary who are compensated based on the payoffs of the projects they "certify". Optimal compensation contracts are thus used for incentivizing the screening agents in the intermediary. Even though the screening agents are risk averse and their compensation is risky, this risk is asymptotically driven to zero through unfettered diversification by the intermediary.

In these theories, agents are either risk averse in their primitive preferences (as in Ramakrishnan and Thakor (1984)), or have "induced" risk aversion because they have financial claims that are concave in project payoffs (as in Diamond (1984)). This is what leads to welfare gains due to the formation of a large intermediary that diversifies across many projects with i.i.d. payoffs.[34] In our setting, there is universal risk neutrality and no benefits from

[33]Such incentives are examined by Marinovic and Szydlowski (2020), as discussed earlier.

[34]This can be justified by the fact that it is primarily the idiosyncratic risk of the projects that are of prime importance.

risk reduction.

Nonetheless, an implication of these theories is that the monitor can be provided the appropriate incentive to monitor by giving it some sort of skin in the game, either by making it a residual claimant to project outputs (as in Diamond (1984)) or by designing payoff-sensitive compensation contracts (as in Ramakrishnan and Thakor (1984)). This insight provides a useful approach for ensuring that the monitor does not shirk in our context.

Suppose investors give the monitor a fraction $f_m \in (0, 1)$ of ownership in the firm and delegate monitoring to it (e.g. as in Nagar and Schoenfeld (2021)). Investors will "gross up" their own equity ownership in the firm, $1 - f$, to satisfy their participation constraint, so the cost of paying the monitor is borne in equilibrium by the owner-manager of the firm. The monitor is asked by the investors to verify the firm's project choice. It costs the monitor $K(\theta) > 0$ to do the verification and the monitor privately observes whether the cost of verification was actually incurred. We assume $K' > 0$ and $K'' > 0$. If the cost is incurred, the monitor can determine the firm's project choice at date $t = 0$ without error. The presumption therefore is that, unlike investors who are only able to make noisy inferences from the firm's disclosure, the monitor either has access to priveleged information (as in Nagar and Schoenfeld (2021)) or special expertise. If the cost is not incurred, nothing is learned.[35]

Investors want to set f_m so that the monitor will be incentivized to monitor. The incentive compatibility (IC) constraint is:

$$f_m q X(\theta) - K(\theta) \geq f_m \alpha(p) q X(\theta) \tag{20}$$

[35] A further refinement to just giving the monitor an equity stake as incentive could be to create a tailored contingent claim on the project/firm which has payoffs in the regions on which one wants the verification to take place. An analogy would be with ratings agencies—if the desired focus is on default probabilities and losses and not on how large the upside might be, then having a contract like a (partial) loan guarantee written by the verifier would provide a stronger incentive on the part of the contract that is important (downside), and thereby would be a more efficient incentive contract.

where $\alpha(p)$ is given in (10). Solving (20) as an equality yields:

$$f_m = \frac{K(\theta)}{qX(\theta)\,[1-\alpha(p)]} \tag{21}$$

Let us now compare the type T owner-manager's utility with verification and disclosure. Using (7) and (15) and simplifying, we can write the owner-manager's utility from disclosure, call it U_d, as:

$$CqX(\theta) - CI - \frac{[1-C][1-\alpha(p)]I}{\alpha(p)} - \psi(\eta) \tag{22}$$

Similarly, with verification, the owner-manager's utility, call it U_v, is:

$$U_v = [f - f_m]\,qX(\theta) \tag{23}$$

where f_m is given by (21) and f is given by:

$$[1-f]\,qX(\theta) = I \tag{24}$$

Substituting (24) in (23) and simplifying gives us:

$$U_v = qX(\theta) - I - \frac{K(\theta)}{[1-\alpha]} \tag{25}$$

This leads to the following result:

Lemma 4: *Suppose $U_v > U_d$ at $p = \underline{p}$, so verification dominates disclosure at $p = \underline{p}$. Then $U_v - U_d$ is decreasing in p, so with $K\left(\theta\left(\underline{p}\right)\right)$ large enough, there exists an interior critical value of p such that verification is preferred for values of p lower than that critical value and disclosure is preferred for values of p higher than that critical value.*

The intuition is as follows. The advantage of verification over disclosure is that verification eliminates the probability of the B project being selected, although it incurs a cost $K(\theta)$, whereas disclosure is associated with a non-zero probability of B being selected. As p, the probability of type T, increases, for any given disclosure level, the likelihood of investing in B declines, which shrinks the advantage of verification over disclosure. So, if verification is preferred at the lowest value of p, then there will be a p high enough at which disclosure is preferred.

4.1.2 Approach 2: Contracting with Monitor for Randomized Verification

One potential inefficiency in the arrangement analyzed above is that the cost of verification, $K(\theta)$, is incurred with probability 1. Since this cost is essentially a deadweight loss, it is worth asking whether an arrangement is possible that lowers the incidence of this cost by randomizing verification.

Rahman (2012) provides a theoretical framework that examines this problem. The basic idea is as follows. The monitor is asked by investors to verify the firm's project choice with probability $\sigma \in [0, 1]$ at $t = 0$. Thus, the key for investors is to ensure that the monitor actually verifies the firm's project choice. So investors ask the firm to choose G with probability $\mu \in [0, 1]$ and B with probability $1 - \mu$. The firm does not know *when* the monitor is asked to monitor, and the monitor does not know which project the firm has been asked to choose. As in the previous analysis, the cost of monitoring is $K(\theta)$ (observed privately by the monitor), with $K' > 0$ and $K'' > 0$, and monitoring reveals the firm's project choice perfectly.

There is moral hazard at two levels. First, the firm may not choose G. Second, the monitor may report a project choice without verification. In equilibrium, two incentive compatibility conditions are satisfied: the firm always chooses the project it is asked to and the monitor always verifies project choice when asked to. Given this and non-negativity restrictions on payments, the contracts offered by investors are as follows:[36]

[36] There is a third moral hazard problem. The investors—who privately know what they asked the firm to choose—may not pay the monitor even when a correct report is provided, claiming that the firm was asked to make a different choice. The structure of contracts below takes care of this moral hazard problem.

Firm: The firm is given financing I and paid a share $f_1 \in (0, 1)$ of the final payoff if there is no monitoring or if there is monitoring, the firm was asked to choose project $i \in \{G, B\}$ at $t = 0$, and the monitor reported that the firm chose the project i at $t = 0$ it was asked to.

Monitor: The monitor is paid nothing if not asked to monitor. It is paid M_1 if asked to monitor, the firm is asked to choose G, the monitor reported G at $t = 0$ and the project payoff at $t = 1$ is $X(\theta)$. The monitor is paid M_2 if asked to monitor, the firm is asked to choose B, the monitor reported a choice of B at $t = 0$, and the project payoff is zero at $t = 1$.

At $t = 0$: Thus, the sequence of events is as follows. Investors announce the probabilities σ and μ publicly. Then they privately instruct the firm to choose B or G, and privately instruct the monitor to verify project choice or not. If the monitor was *not* asked to verify the firm's project choice or if the monitor reports to investors that the firm chose the project that coincides with what the investors had instructed the firm to choose, then the firm is given financing I. The firm is denied financing if the monitor reports a project choice other than what the firm was asked to make. Since the project payoff with B as well as in the failure state with G is zero, the firm will need to raise $I + M_2$ at $t = 0$ and keep M_2 as a verifiable deposit beyond the reach of the manager or investors until $t = 1$.

At $t = 1$: The project payoff is publicly observed, so the total amount available for payouts is the project payoff plus M_2.

We now consider the relevant incentive IC constraints. We start by considering the monitor's incentives. If the monitor verifies project choice at a cost K, its expected payoff is

$$\mu q M_1 + [1 - \mu] M_2 - K \tag{26}$$

If the monitor does not verify project choice and reports G, the expected payoff is:

$$\mu q M_1 \tag{27}$$

If the monitor does not verify project choice and reports B, the expected payoff is:

$$\mu[1-q]M_2 + [1-\mu]M_2 \tag{28}$$

The two IC constraints for the monitor to invest K in verification are that (26) is no smaller than (27), and that (27) is no smaller than (28). Since these two constraints are binding in equilibrium, the solutions yield

$$M_2 = K\left[1-\mu\right]^{-1} \tag{29}$$

$$M_1 = K[1-\mu q]\left\{\mu q[1-\mu]\right\}^{-1} \tag{30}$$

Since K is a deadweight cost, the socially efficient solution is obtained in the limit as $\sigma \to 0$, $\mu \to 1$. However, as (29) and (30) reveal, as $\mu \to 1$, $M_1 \to \infty$ and $M_2 \to \infty$. In practice, there may be upper bounds on how big M_1 and M_2 can be. Let $\hat{M}_2$ be the maximum feasible value of M_2. This yields the equilibrium value of μ, call it μ^*, as:

$$\mu^* = 1 - K(\theta)\left[\hat{M}_2\right]^{-1} \tag{31}$$

where we assume that $\hat{M}_2$ is large enough to ensure that $K(\theta)\left[\hat{M}_2\right]^{-1} < 1$. Thus the equilibrium M_1, call it M_1^*, is given by:

$$M_1^* = K(\theta)\left[1-\mu^* q\right]\left\{\mu^* q\left[1-\mu^*\right]\right\}^{-1} \tag{32}$$

The IC constraint for the firm to choose G when it is asked to is:

$$\sigma\left\{f_1 q\left[X(\theta) - M_1^* + \hat{M}_2\right]\right\} + [1-\sigma]\left\{f_1 q\left[X(\theta) + \hat{M}_2\right]\right\} \geq \sigma[0] + [1-\sigma]\overline{\beta} \tag{33}$$

The left-hand side (LHS) of (33) is the firm's expected payoff from G and the right-hand side (RHS) is its expected payoff from B. The probability is σ that the monitor is asked to verify, and in this case, the firm's expected payoff is the term multiplying σ. If there is no verification (probability $1-\sigma$), the expected payoff is higher by M_1^*, the amount that does not need to be paid to the monitor. The RHS reflects the fact that if the firm chooses B and the monitor verifies the choice, no financing is provided, whereas if there is no verification, financing is provided and the manager enjoys the private benefit of $\overline{\beta}$. Here f_1 is chosen to ensure that the participation constraint of investors to provide $I + \hat{M}_2$ at the equilibrium choices is satisfied. Since (33) is binding in equilibrium, we have

$$\sigma = \frac{f_1 q \left[X(\theta) + \hat{M}_2\right] - \overline{\beta}}{q f_1 M_1^* - \overline{\beta}} \tag{34}$$

where M_1^* and $\hat{M}_2$ are given in (31) and (32). In what follows, as assume $2\mu q > 1$. This is sufficient for $X + \hat{M}_2 > M_1^*$.

4.2 Comparison of Ex Ante Verification to Disclosure

The efficiency loss from the verification approach is:

$$\mathcal{L}(\theta) = \sigma \left\{ \mu q M_1^* + [1-\mu]\hat{M}_2 \right\} + [1-\mu] q X(\theta) \tag{35}$$

The efficiency loss is related to both the deadweight costs of verification and the loss from permitting investment in B. Note that $\mathcal{L}(\theta)$ is increasing in $K(\theta)$ and $X(\theta)$. This leads to the next result.

Proposition 6: *A firm with a reputation for trust parameter $p > \hat{p}^*$ will never choose ex ante verification, and will choose maximum complexity $\theta = 1$ and no disclosure $\eta = 0$. For firms with $p < \hat{p}^*$, if disclosure dominates verification at $p = \underline{p}$, no firm will choose verification and the equilibrium will be as described in Proposition 3. If verification dominates disclosure* *at $p = \underline{p}$ but $K(\theta)$ becomes sufficiently large at a θ corresponding to some $p < \hat{p}^*$, then there will exist a $\tilde{p} \in \left(\underline{p}, \hat{p}^*\right)$ such that all firms with $p \in \left[\underline{p}, \tilde{p}\right)$ will choose verification and no disclosure, firms with $p \in [\tilde{p}, \hat{p}^*)$ choose complexity increasing in p and disclosure that is decreasing in p, and all firms with $p \geq \hat{p}^*$ choose $\theta = 1$ and $\eta = 0$.*

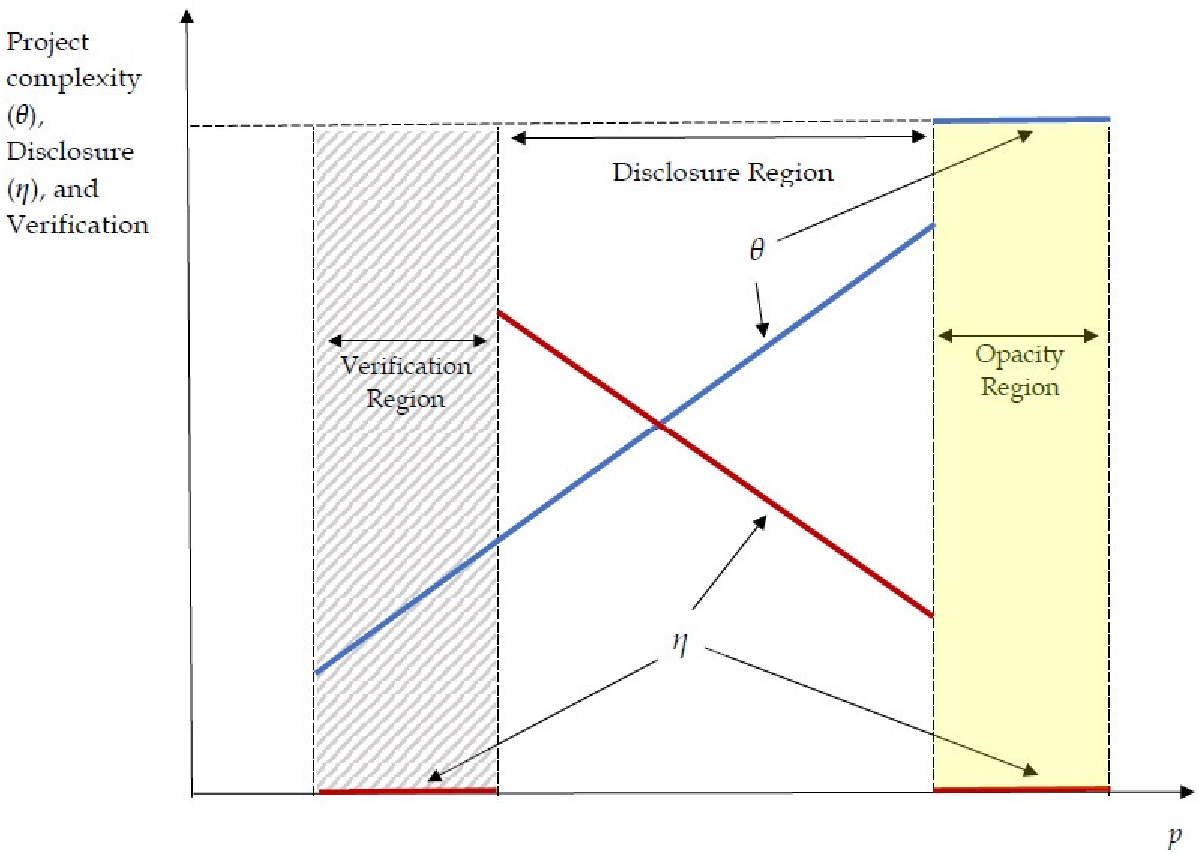
Thus, we see that we get qualitatively the same result—verification for low values of p and disclosure for intermediate values of p—whether we use Approach 1 or Approach 2 to model verification. The intuition for this result in this case, however, is slightly different from that in Approach 1. Here *both* verification and disclosure involve a non-zero probability of investing in B, so verification no longer has that advantage over disclosure. What happens is that, holding η and θ fixed, an increase in p increases the owner-manager's utility with disclosure. So, the utility at p_1 is lower than the utility at p_2 if $p_2 > p_1$ and η and θ are held fixed at their optimal values corresponding to p_1. This means that if η and θ are chosen optimally, the utility is higher at p_2 than at p_1. In contrast, the utility from verification is affected by p only through the effect of p on θ, and θ is increasing in p, whereas the loss from verification is also increasing in θ.

Thus, relative to verification, disclosure is least desired at $p = \underline{p}$, when η takes its highest value. This means that if disclosure is preferred at $p = \underline{p}$, it will be preferred for all $p > \underline{p}$. But if verification is preferred at $p = \underline{p}$ and $K(\theta)$ rises with θ (and hence with p) sufficiently rapidly, firms with some $p = \tilde{p} < \hat{p}^*$ will switch to disclosure after initially choosing verification. *Figure 4* depicts this situation.

Transparency is thus seen to be non-monotonic. For the simplest projects, there is verification and no disclosure, so there is opacity. These projects are undertaken by firms with the lowest reputations for being trustworthy. For intermediate levels of trustworthiness, moderately complex projects are chosen and there is transparency, achieved through information disclosure. The most complex projects are undertaken only by those with the strongest reputations for trustworthiness, and these firms disclose nothing, so there is again opacity.

This analysis hinges on upper bounds on M_1 and M_2. If there were no bounds, the effi-

Figure 4: Trust, Complexity, Disclosure, and Verification



ciency losses from verification can be asymptotically made to vanish. In this case, verification will dominate disclosure until $p = \hat{p}^*$.

4.3 Regulation

With Approach 2, the losses with ex ante verifiability arise from the cost of verification, $K(\theta)$, and the efficiency lost due to sometimes asking the firm to choose B. A trusted regulator can eliminate the loss from asking the firm to choose B. The cost K will still remain. However, a trusted regulator, by eliminating one of the two efficiency losses with verifiability, can facilitate replacing disclosure with verification in more circumstances than possible without a regulator. This moves Approach 2 closer to Approach 1, but possibly without the need for explicit compensation-based incentives. Consequently, regulation can help reduce both verification and disclosure costs and permit firms to disclose less because the word of the trusted regulator substitutes (at least partially) for direct disclosure by the regulated firm.

5 Model Robustness

In this section, we examine the robustness of the model and key results to changes in some assumptions.

5.1 Complexity and Higher Cash Flows

We have assumed that complexity leads to higher cash flows—in other words, a higher value of θ leads to a higher cash flow, conditional on success. This is motivated by our focus on functional complexity, i.e., complexity that benefits the customer and the product seller, in line with the idea that greater complexity is generated by a newer technology or greater product customization. However, suppose each product has an endogenously given optimal degree of complexity, so there is no hard-wired relationship between X and θ, i.e., $X'(\theta) = 0$.

Corollary 3: *Suppose the project cash flow is unaffected by project complexity, i.e.,* $X'(\theta) = 0$*, and each project has an optimal exogenously given degree of complexity. Then the rate at which* η *declines with* θ *in equilibrium is higher when* $X'(\theta) = 0$ *than when* $X' > 0$*, so at each* θ*, the firm will choose a lower* η *than in the base model. Hence, the manager's reputation for trust will evolve at a slower rate than in the base model for firms choosing* G*.*

The intuition is as follows. In the base model, the rate at which the equilibrium η declines with θ depends on the firm's tradeoff between the lower marginal benefit of η in affecting C at higher values of θ and the higher marginal benefit of giving investors a smaller ownership in the firm (with a higher η) at the higher values of $X(\theta)$ associated with higher values of θ. But when $X'(\theta) = 0$, the latter effect vanishes, so the tradeoff shifts in favor of a lower η as θ increases.

5.2 Knowledge of Cash Flows and Disclosure

As we indicated earlier, we believe it is natural to assume that the manager chooses η before observing the project cash flow realization. But what if the manager was able to take a peek at the cash flow and then choose η? That is, the manager makes his project choice (irreversibly), observes $\tilde{x}$, and then chooses η. We now examine this asymmetric-information case.

Corollary 4: *Suppose the manager chooses* η *after observing* $\tilde{x}$ *but before raising* I*. Then in a BPNE, the type* T *manager chooses* $\eta_T^* > 0$ *and seeks financing when* $\tilde{x} = X$*, while avoiding financing when* $\tilde{x} = 0$*. The type* N *manager adopts the same disclosure and financing strategy if he has chosen project* G*. If the type* N *manager has chosen* B*, then he chooses* $\eta_T^* > 0$ *and unconditionally seeks financing. Moreover,* η_T^* *is larger than the* η *the type* T *manager chooses in the base model*

The intuition is straightforward. When the type T manager can observe $\tilde{x}$ before choosing η, he clearly has an incentive to raise financing only when $\tilde{x} = X > 0$. If the type N manager has chosen G, then his incentives are the same as the type T manager's. But when the type N manager has chosen B, there is no pledgeable cash flow realization, so in order to secure financing, he must masquerade as a manager who has chosen G and observed $\tilde{x} = X$.

The reason why η_T^* is higher in the base model is that $\tilde{x} = X$ is higher than the *expected* cash flow in the base model. So the cost of giving up ownership is higher now, and a higher η is chosen by the type T manager to make investors' signal more precise and thereby surrender a smaller fraction of ownership.

5.3 Pledgeability of the Project B Cash Flows

For modeling parsimony, we have assumed that project B has no pledgeable cash flow. Alternatively, we could assume that the project is dominated by G from a social welfare standpoint but has a pledgeable cash flow. Clearly, it cannot have a pledgeable cash flow other than $X(\theta)$, because if it did, then investors would know unambiguously ex post in some states that B was chosen, and forcing contracts could be used ex ante to prevent B from being chosen. So we could assume that B has a pledgeable cash flow $X(\theta)$ with probability $s \in (0, q)$,and zero with probability $1 - s$. It turns out that all of our results are qualitatively sustained in this case since the cash flow distributions of B and G have a common support and the choice of B remains shrouded from investors.

Corollary 5: *As long as project B has a lower social value that project G, an expected pledgeable cash flow that would be insufficient to raise financing and investors are unwilling to finance a firm known with probability 1 to have a type N manager, all our results are qualitatively sustained even if project B produces $X(\theta)$ with some positive probability.*

6 Empirical Implications and Examples

In this section, we discuss the empirical implications of our analysis and provide some examples to illustrate our results.

6.1 Empirical Implications

First, our analysis has implications for disclosure peer effects. Seo (2021) documents that such peer effects exist empirically and are stronger for firms that rely more on external financing. While our model does not explain why such peer effects exist, if we take these peer effects as given, then it generates the nuanced prediction that, holding all else fixed, these peer effects will be weaker for more trusted firms and those with more complex business models and products.

Second, our analysis is consistent with the evidence that there is a reduction in disclosure when there is more monitoring of the manager by shareholders (Nagar and Schoenfeld (2021)), but it adds the nuance that this relationship will be strongest for the firms with the simplest products and business designs.

Third, the most trusted firms will offer the most complex products and be the most opaque. While this is consistent with some of the motivating evidence cited in the Introduction, a direct test of this prediction awaits future empirical research.

Fourth, if we view p as an evolving reputation for being trustworthy, then the implication is that firms will disclose less and less as their trustworthiness reputation improves.

Finally, the improvement in the manager's reputation for being trustworthy will be stochastically lower when product complexity is higher.

6.2 Examples

Example 1: *Retail Financial Advice and Technology in Consumer Finance.*

Retail financial advice provides a good example of verification in a world of financial products involving technology (e.g. Willis (2011)). One reason why retail investors may turn to financial advisors is provided by our model. The technology involved in many of these financial products—how they do what they are designed to do—is opaque to retail investors. There is no reason for investors to trust the technology developed by technology providers. So retail investors turn to financial advisors to provide third-party verification of the technology and its usefulness in delivering the services associated with the product, much like the intermediary with Approach 1, assuming that the advisor has skin in the game in the sense that customers will give the advisor more business the better the performance attributable to the advice. The advisor can rely on past analyses (such as using spreadsheets) as a benchmark against which to verify the superiority of the black box representing the new technology. This assures retail customers who end up using the technology despite not necessarily trusting the seller or having transparency.

Example 2: *Disclosures Improve Transparency in Credit Markets.*

There are numerous papers that have documented how disclosures—even those that are unverifiable—improve transparency and lower the cost of financing. For instance, Michels (2012) provides an example in the context of P2P lending. Other examples are disclosures made by firms that are raising capital through IPOs. In these examples, there may be some level of trust that investors have in those seeking financing but it is not high enough to ensure financing at terms attractive to issuers. Transparency substitutes for trust and lowers the cost of financing.

Example 3: *Trusted Opaque Firms.*

There are numerous examples of firms whose track records enabled them to build trust and they thus needed neither transparency nor verification. We discussed some of these in the Introduction. Firms like Berkshire Hathaway, Apple, and Microsoft report billions of dollars in cash on their balance sheet, but rarely disclose much information about specific intended uses. Goldman Sachs has a highly complex portfolio of activities and typically discloses far less information about its businesses and their profitability than most of its competitors (e.g. Hoffman (2020)).

Example 4: *Bilateral Shareholder Information Contracts with Firms*

Nagar and Schoenfeld (2021) study contracts that specify information rights that enable the contracting shareholder to be entitled to receive specific information privately from management. They interpret these contracts as enabling the contracting shareholder to act like a monitor on behalf of the other shareholders, and document that firm performance improves and public disclosure drops after such a contract is signed. This is exactly the role played by the monitor with verification in Approach 1, and thus our theory provides an explanation for this.

Example 5: *IPOs*

Private firms in the U.S. do not disclose much information, in general, prior to going public—many of them are not well-known to investors, and thus can be considered low-p types in our model. The investment bank that underwrites the IPO provides third-party verification, and has considerable skin in the game that included reputational and possibly litigation costs. This would be an example of verification along the lines of Approach 1.

7 Conclusion

This paper theoretically examined the extent to which information transparency achieved through information disclosure can substitute for trust. This analysis produces the following main results. First, the presence of trustworthy firms produces a positive externality for other firms that may be purely self-interested in the sense that it can lower the cost of capital for these firms enough to induce them to act in the same manner as trusted firms. Second, firms that have more complex projects choose to disclose less information to investors. Third, firms that are more trusted optimally choose more complex projects, disclose less information, and choose to be more opaque. These results reverse the usual causality that greater transparency leads to more trust. Rather, firms that are more trusted optimally choose greater complexity and lower transparency. Fourth, firms that choose to be more transparent by disclosing more nonetheless experience a stochastically faster evolution of their reputation for being trustworthy, but in equilibrium this improvement is smaller when the manaer's prior reputation for being trusted is higher.

We also examine the role of verification by a monitor as an alternative to disclosure. We account for the challenge of motivating the monitor to verify at a personal cost and report project choice truthfully to investors, and we characterize the resulting efficiency losses. We show that there are circumstances in which transparency is non-monotonic in the firm's underlying reputation for being trustworthy—firms with weak reputations choose simple projects, opt for verifiability, and remain opaque, firms with intermediate reputations choose information disclosure with intermediate complexity projects, and the firms with the strongest reputations choose the most complex projects with no disclosure.

In closing, the marginal contribution of our paper is that it is the first to theoretically examine the interaction between product complexity, transparency and trust in a setting in which all are endogenously determined in equilibrium. This explains previously-unexplained stylized facts and also generates novel empirical predictions.

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Appendix A: Alternative Modeling Approach to Disclosure

Here we provide an alternative way to model η, based on Sobel's (2012) theory of complexity of information communication, and show how this can lead to the same specification that we have in the model.

As in the main model, outside investors can observe the project complexity θ but cannot tell a priori whether the project selected by the manager is G or B. We can think of each project as having a number of attributes, $a \in \mathbb{A}$. Nature randomly picks one of these attributes which is privately revealed to the firm. If disclosed precisely by the firm, this attribute realization would reveal to investors whether the project is G or B with the highest probability, which may be less than 1. However, following Sobel (2012), we assume that it costs more to build up the "communication capacity" to communicate information more precisely.[37] That is, if the firm chooses an integer η as its capacity, then it limits itself to η messages that it can communicate, regardless of $\mathbb{A}_N$, the cardinality of $\mathbb{A}$. This means that the higher η is, the more precisely the firm can disclose/describe the realization that reveals its project type.

Formalizing this along the lines of Sobel (2012), let $\mathbb{P}$ be the set of partitions of $\mathbb{A}$ with cardinality at most η. The firm chooses η before it observes its specific realization of $a \in \mathbb{A}$. A generic element of $\mathbb{P}$ is $P = (P_1, ..., P_\eta)$, where the P_i are disjoint subsets of $\mathbb{A}$ with $\cup_{i=1}^{\eta} P_i = \mathbb{A}$. In the equilibrium of the communication game, given an optimal P^*, the firm sends message m if and only if $m \in P_m^*$ $(m = 1, ..., \eta^*)$. Essentially, absent communication capacity costs as well as any costs for investors to process received information, the firm would be able to assemble the most complex communication process and disclose precisely what it observes as the realized a. But when such complexity is costly and the firm chooses $\eta < \mathbb{A}_N$,

[37] If one thinks of each piece of information as a digit, then communicating more digits is costly. As Sobel (2012) states: "For example, S [the sender] may pay a cost to describe each successive digit of θ and R [the receiver] may need to pay the be able to understand each digit sent by S."

then coarseness is introduced in the communication. Suppose $\eta = 2$, so $\mathbb{A}$ is partitioned into $\mathbb{A}_1$ and $\mathbb{A}_2$ with $\mathbb{A}_1 \cup \mathbb{A}_2 = \mathbb{A}$. Then if the attribute realization that distinguishes G from B, say $\tilde{a}$, lies in $\mathbb{A}_1$, all that the firm can communicate to investors is that $\tilde{a} \in \mathbb{A}_1$. Thus, greater communication complexity, as reflected in a larger η, permits a finer partitioning of $\mathbb{A}$ and hence more precise communication. We will assume that investors choose their own information processing capacity (their analog of η) after observing the firm's choice of η. Thus, from Proposition 2 in Sobel (2012), it follows that the equilibrium communication capacity choices will be unique and the firm will communicate as much as possible given capacity constraints.

In Sobel (2012), η takes integer values, whereas in our model it lies in a continuum for the simple project. We can specify

$$\hat{C}_S(\eta) = 0.5 + \frac{\eta - 1}{2\left[\mathbb{A}_N - 1\right]}, \tag{A.1}$$

with $\bar{\eta} < \mathbb{A}_N$, and then to avoid non-differentiability problems, view $C_S(\eta)$ as the convex hull of $\hat{C}_S(\eta)$.

Appendix B: Proofs

Proof of Proposition 1: Using (6) and rearranging (5) gives us:

$$\begin{aligned} f_0 &= \frac{qX\left\{p + [1-p][1-r]\right\} - I}{qX\left\{p + [1-p][1-r]\right\}} \\ &= 1 - \frac{I}{qX\alpha(p)} \end{aligned} \tag{A.2}$$

where

$$\alpha(p) \equiv p + [1-p][1-r] \tag{A.3}$$

Now, $\partial\alpha/\partial p = r > 0$, and $\partial f_0/\partial\alpha > 0$, which means $\partial f_0/\partial p > 0$. Note that, the manager will select G when $\tilde{\beta} = \overline{\beta}$ as long as $f_0 qX > \overline{\beta}$, which (upon substituting for f) means:

$$qX\left\{1 - \frac{I}{\alpha qX}\right\} > \overline{\beta} \tag{A.4}$$

Note that the left-hand side of (A.4) is increasing in p. The critical value of p, call it p^*, at which (A.4) becomes an equality is a solution to

$$qX - \frac{I}{p^* + [1-p^*]\,[1-r]} = \overline{\beta} \tag{A.5}$$

Solving (A.5) yields

$$p^* = \frac{I}{r\left[qX - \overline{\beta}\right]} - \frac{1-r}{r} \tag{A.6}$$

When $p > p^*$, (A.4) holds and the manager chooses G when $\tilde{\beta} = \overline{\beta}$, and thus G is chosen for all $\tilde{\beta}$. Consequently, once p exceeds p^*, further increases in p have no effect on f_0. When $p < p^*$, the inequality in (A.4) is reversed and the manager chooses B when $\tilde{\beta} = \overline{\beta}$. Finally, it is straightforward to verify that, given (4), $p^* \in (0,1)$. ■

Proof of Lemma 1: We need to show that

$$\Pr\left(G \mid \phi = B, \eta > \bar{\bar{\eta}}(\theta), p\right) < [1 - r[1-p]] < [1 - r[1-\bar{p}]] \tag{A.7}$$

since financing is not available when the belief that the G project has been chosen is less than $\alpha\left(\bar{p}\right)$. Now,

$$\Pr\left(G \mid \phi = B, \eta > \bar{\bar{\eta}}(\theta), p\right) = \frac{[1 - C(\eta,\theta)]\,[1 - [1-p]r]}{[1-C]\,[1-[1-p]r] + C[1-p]r} \tag{A.8}$$

Thus, showing that (A.7) holds means proving that $1 - C < [1-C][1-[1-p]r] + C[1-p]r$, which holds since, for any $\eta > 0$, $C(\eta,\theta) = [1-\theta][C_S(\eta) - 0.5] + 0.5 > 0.5$. ■

Proof of Lemma 2: If the type T manager chooses $\eta < \bar{\eta}(\theta)$, then financing is not available even with $\phi = G$ (and hence not with $\phi = B$ either), so the firm's payoff is 0. With $\eta > \bar{\bar{\eta}}(\theta)$, it will be

$$C(\eta, \theta) f(\eta) q X(\theta) - \psi(\eta) \tag{A.9}$$

After substituting (17) into (A.9), we see that given (15), $\exists\, \eta > \bar{\bar{\eta}}(\theta)$ for every θ such that (A.9) is strictly positive. Thus, the type T manager will choose $\eta \geq \bar{\bar{\eta}}(\theta)$. ■

Proof of Lemma 3: Fix a θ. First we prove that it cannot be a BPNE for the type T and type N managers to choose different values of η. Suppose that η_T is the optimal choice of η by the type T manager. The utility of the type T manager is

$$U_T^0 = C(\eta_T, \theta) f_T q X(\theta) - \psi(\eta_T) \tag{A.10}$$

Substituting in (A.10) from (17), we can write

$$U_T^0 = C(\eta_T, \theta) \left\{ 1 - \frac{1}{\Pr\left(G \mid \phi = G, \eta_T, p\right)} \right\} - \psi(\eta_T) \tag{A.11}$$

where (from (13))

$$\Pr\left(G \mid \phi = G, \eta_T, p\right) = \frac{C\left(\eta_T, \theta\right)\left[1 - r[1-p]\right]}{C[1 - r[1-p]] + [1 - C][1-p]r} \tag{A.12}$$

if investors believe η_T is chosen by both types of managers. By (15) we know that $U_T^0 > 0$. Now if the type N manager chooses $\eta = \eta_T$, the manager's utility is (after simplification),

$$U_N^0 = U_T^0 + r\left\{ [1 - C(\eta_T, \theta)]\, \overline{\beta} - C(\eta_T, \theta) f q X(\theta) \right\} \tag{A.13}$$

From (7) we know that

$$[1 - C(\eta_T, \theta)]\, \overline{\beta} - C\left(\eta_T, \theta\right) f q X(\theta) > 0 \tag{A.14}$$

Thus,

$$U_N^0 > 0 \tag{A.15}$$

if the type-N manager chooses $\eta = \eta_T$.

Now suppose counterfactually that the type N manager chooses $\eta_N \neq \eta_T$ in equilibrium. Given this equilibrium choice, investors will believe that a firm choosing η_N is run by a type N manager with probability 1. Given (8), they will not provide any financing. Thus, the manager's utility is 0. Consequently, in a BPNE the manager will prefer $\eta = \eta_T$ over $\eta \neq \eta_T$.

We now prove that the pooling equilibrium in which both managers choose $\eta = \eta_T$ is a BPNE. Given that investors believe that both types will choose $\eta = \eta_T$, we have already shown that both types of managers will choose $\eta = \eta_T$. And given this, investors' beliefs are validated in equilibrium. If a firm deviates from this and chooses $\eta \neq \eta_T$, investors can adopt the out-of-equilibrium belief that $\Pr(\text{manager is type } N \mid \eta \neq \eta_T) = \mu\left(N \mid \eta \neq \eta_T\right) = 1$. Given this, no financing is provided to the deviating firm. Thus, this is a BPNE.

Now, to show that this BPNE survives the Cho and Kreps Intuitive Criterion, consider step 1 of the Intuitive Criterion. Consider a firm choosing $\eta \neq \eta_T$. Suppose the out-of-equilibrium belief is that $\Pr\left(\text{manager is type } T \mid \eta \neq \eta_T\right) = \mu\left(T \mid \eta \neq \eta_T\right) = 1$. Then investors will ignore the signal ϕ (since they know T always selects G). But given this, *both* types of managers choose to defect from the equilibrium. Thus, *no* type can be unconditionally (independently of investors' out-of-equilibrium beliefs) ruled out as a potential defector in step 1 of the Intuitive Criterion, and consequently the BPNE survives the Intuitive Criterion. ■

Proof of Proposition 2: Take the firm's maximization program in (16)-(17) and substitute (17) in (16) to write the problem as that of choosing η to maximize:

$$qX(\theta)C(\eta,\theta) - \frac{\left\{C(\eta,\theta)\alpha(p) + [1 - C(\eta,\theta)]\,[1 - \alpha(p)]\right\} I}{\alpha(p)} - \psi(\eta) \tag{A.16}$$

where $\alpha(p) \equiv p + [1-p][1-r]$. The first-order condition (FOC) for the optimal η is:

$$C_S'(\eta)[1-\theta]\left\{\frac{\alpha(p)[qX(\theta)-I]+[1-\alpha(p)]\,I}{\alpha(p)}\right\} - \psi' = 0 \tag{A.17}$$

The second-order condition is clearly satisfied:

$$SOC \equiv C_S''(\eta)[1-\theta]\left\{\frac{\alpha(p)[qX(\theta)-I]+[1-\alpha(p)]\,I}{\alpha(p)}\right\} - \psi'' < 0 \tag{A.18}$$

Thus, there is a unique η^* that is the optimal information disclosure chosen by the firm.

Next, we prove that $d\eta^*/d\theta > 0$. Totally differentiating the FOC (A.17) yield:

$$\frac{d\eta^*}{d\theta} = \frac{C_S'(\eta)\left\{qX(\theta) - I + [1-\alpha(p)]\,[\alpha(p)]^{-1}\,I - [1-\theta]qX'(\theta)\right\}}{SOC} < 0 \tag{A.19}$$

since (9) guarantees that $qX(\theta) - I - [1-\theta]qX'(\theta) > 0$. ■

Proof of Corollary 1: Consider a manager who has chosen G. Then the manager's expected reputation for trust after ϕ is observed is

$$\begin{aligned}\mathbb{E}\left[\Pr(T \mid \phi)\right] &= \Pr\left(\phi = G \mid G\right)\Pr\left(T \mid \phi = G, \eta\right) + \Pr\left(\phi = B \mid G\right)\Pr\left(T \mid \phi = B, \eta\right)\\ &= C(\eta,\theta)\Pr\left(T \mid \phi = G, \eta\right) + [1 - C(\eta,\theta)]\Pr\left(T \mid \phi = B, \eta\right)\\ &= C\left\{\frac{Cp}{Cp + \{[1-r]C + r[1-C]\}[1-p]}\right\} + [1-C]\left\{\frac{[1-C]p}{[1-C]p + \{[1-r][1-C] + rC\}\,[1-p]}\right\}\end{aligned} \tag{A.20}$$

where we have suppressed the arguments of $C(\eta,\theta)$ for compactness. Now, we know that $\partial C/\partial\eta > 0$. So we compute (defining $DEN_1 \equiv Cp + [1-p]\left\{[1-r]C + r[1-C]\right\}$):

$$\frac{\partial \Pr\left(T \mid \phi = G, \eta\right)}{\partial C} = \left\{pr[1-p]\right\}/\left[DEN_1\right]^2 > 0 \tag{A.21}$$

Moreover,

$$\Pr\left(T \mid \phi = G, \eta\right) > \Pr\left(T \mid \phi = B, \eta\right) \tag{A.22}$$

Thus, as η increases and C increases as a consequence, the weight attached to

$$\Pr\left(T \mid \phi = G, \eta\right) = \frac{Cp}{Cp + \{[1-r]C + r[1-C]\}\,[1-p]} \tag{A.23}$$

increases and the weight attached to

$$\Pr\left(T \mid \phi = B, \eta\right) = \frac{[1-C]p}{[1-C]p + \{[1-r][1-C] + rC\}\,[1-p]} \tag{A.24}$$

decreases. Thus,

$$\frac{\partial \mathbb{E}\left[\Pr(T \mid \phi)\right]}{\partial \eta} > 0. \tag{A.25}$$

Since $d\eta^*/d\theta < 0$, as θ increases, the equilibrium η^* decreases. Thus, $\mathbb{E}\left[\Pr(T \mid \phi)\right]$ experiences a smaller increase conditional on choosing G when θ is higher. ■

Proof of Proposition 3: Consider the maximization problem in (18)-(19). Note that

$$C(\eta,\theta)f = C(\eta,\theta) - \frac{I\left\{C(\eta,\theta)\alpha_1(p) + [1-C(\eta,\theta)]\,[1-\alpha_1(p)]\right\}}{qX(\theta)\alpha_1(p)} \tag{A.26}$$

Thus, suppressing the arguments of $C(\eta,\theta)$, we can substitute (A.26) in (18) to write:

$$qX(\theta)\left\{C - \frac{\{C\alpha_1(p) + [1-C]\,[1-\alpha_1(p)]\}\,I}{qX(\theta)\alpha_1(p)}\right\} - \psi(\eta) \tag{A.27}$$

Using the Envelope Theorem and the fact that $X(\theta) = \theta X_C + [1-\theta]X_S$, we can write the FOC on θ as:

$$q\left[X_C - X_S\right]C(\eta,\theta) - qX(\theta)\left[C_S - 0.5\right] + I\left[C_S - 0.5\right] - \frac{[1-\alpha(p)]}{\alpha(p)} I\left[C_S - 0.5\right] = 0$$

which can be simplified to:

$$C(\theta)q\left[X_C - X_S\right] - qX(\theta)\left[C_S - 0.5\right] + I\left[C_S - 0.5\right]\frac{\left[2\alpha(p) - 1\right]}{\alpha(p)} = 0 \tag{A.28}$$

The second-order condition is clearly met:

$$SOC_\theta \equiv -2q\left[C_S - 0.5\right]\left[X_C - X_S\right] < 0 \tag{A.29}$$

Finally, we will prove that $d\theta^*/dp > 0$. Totally differentiating the FOC (A.28) gives us:

$$\frac{d\theta^*}{dp} = \frac{-r\left[C_S - 0.5\right]\left[\alpha(p)\right]^{-2}}{SOC_\theta} > 0 \tag{A.30}$$

■

Proof of Proposition 4: By the definition of $\overline{p}$, it is clear that the firm can raise financing with $\eta = 0\ \forall\ p > \overline{p}$. Now suppose that, given a $p > \overline{p}$, the firm chooses $\eta > 0$. Given that financing is available at investors' prior beliefs (i.e., with $\eta = 0$), it is clear that financing will also be available with $\eta > 0$ and $\phi = G$. With $\phi = B$,

$$\Pr\left(G \mid \phi = B, \eta > 0\right) = \frac{[1 - C]\alpha(p)}{[1 - C]\alpha(p) + [1 - \alpha(p)]C} \tag{A.31}$$

Clearly,

$$\Pr\left(G \mid \phi = B, \eta > 0\right) < \alpha(p) \tag{A.32}$$

Moreover,

$$\begin{aligned}\frac{\partial \Pr\left(G \mid \phi = B, \eta > 0\right)}{\partial p} &= [1 - C]\alpha(p)C + C[1 - C][1 - p] \\ &> 0 \end{aligned} \tag{A.33}$$

It is clear that (A.32) implies that at $p = \overline{p}$, no external financing will be available if $\eta > 0$ and $\phi = B$ (since financiers are indifferent between providing financing and denying it when $\eta = 0$, and $\Pr(G \mid \phi = B, \eta > 0)$ is less than the prior belief that G would be chosen). Thus, given (A.33), $\exists\ \hat{p}^* > \overline{p}$ such that $\forall\ p \in [\overline{p}, \hat{p}^*)$, financing would be available with $\eta = 0$, but with $\eta > 0$ it would only be available if $\phi = G$.

Next, we verify that $\eta^* > 0\ \forall\ p \in [\overline{p}, \hat{p}^*)$. This follows from the fact that as long as financing is available with $\phi = G$ and not with $\phi = B$, the FOC for the optimal η is still (A.17), which yields a unique $\eta^* > 0$ as the optimal choice.

Further, at $p = 1$, we know that financing is available regardless of the signal ϕ. Thus, by continuity $\exists\ \hat{p}^*$ such that financing is available with $\eta > 0$ for $\phi = G$ and $\phi = B$ as long as $p \geq \hat{p}^*$. The question now is: what η will be chosen when p lies in $[\hat{p}^*, 1]$?

When financing is available regardless of ϕ, the maximization program becomes

$$\max_{\eta} C f_G(\eta) q X(\theta) + [1 - C] f_B(\eta) q X(\theta) - \psi(\eta) \tag{A.34}$$

subject to

$$\Pr(G \mid \phi = G) \left[1 - f_G(\eta)\right] q X(\theta) = I \tag{A.35}$$

$$\Pr(G \mid \phi = B) \left[1 - f_B(\eta)\right] q X(\theta) = I \tag{A.36}$$

where f_G and f_B are the ownership fractions retained by the firm conditional on $\phi = G$ and $\phi = B$ respectively. Substituting for f_G and f_B from (A.35) and (A.36) and recalling that

$$\Pr(G \mid \phi = G) = \frac{C\alpha(p)}{C\alpha(p) + [1 - C][1 - \alpha(p)]} \tag{A.37}$$

$$\Pr(G \mid \phi = B) = \frac{[1 - C]\alpha(p)}{[1 - C]\alpha(p) + C[1 - \alpha(p)]} \tag{A.38}$$

the FOC on η is:

$$\begin{aligned} qX(\theta)C' - \frac{C'\alpha(p)I}{\alpha(p)} + \frac{C'[1-\alpha(p)]I}{\alpha(p)} - qX(\theta)C' \\ +C'I - \frac{C'[1-\alpha(p)]I}{\alpha(p)}I - \psi' \quad &(A.39) \\ = -\psi' < 0 \quad &(A.40) \end{aligned}$$

Thus, the firm chooses $\eta^* = 0$.

Now, given that $\eta^* = 0$ is the optimal choice for $p \geq \hat{p}^*$, it is clear that the optimal $\theta = 1$ since there is no cost to choosing higher product complexity. ■

Proof of Corollary 2: We will prove that $\frac{\mathbb{E}[\Pr(T|\phi)]-p}{p}$ is decreasing in p. We begin by proving that $\partial\mathbb{E}\left[\Pr(T \mid \phi)\right]/\partial C > 0$. Using the expression for $\mathbb{E}\left[\Pr(T \mid \phi)\right]$ from (A.20), we use (A.21) to note that $\partial \Pr(T \mid \phi = G)/\partial C > 0$. Moreover, in (A.20), $\Pr(T \mid \phi = G) > \Pr(T \mid \phi = B)$. Thus, as C increases, $\mathbb{E}\left[\Pr(T \mid \phi)\right]$ increases because the weight attached to $\Pr(T \mid \phi = G)$ increases. That is,

$$\frac{\partial\mathbb{E}\left[\Pr(T \mid \phi = G)\right]}{\partial C} > 0 \tag{A.41}$$

Now,

$$\begin{aligned} \frac{\partial\mathbb{E}\left[\Pr(T \mid \phi = G)\right]}{\partial p} &= \frac{\partial\mathbb{E}\left[\Pr(T \mid \phi)\right]}{\partial C}\frac{\partial C}{\partial \eta}\frac{d\eta^*}{d\theta}\frac{d\theta^*}{dp} \\ &< 0 \end{aligned}$$

since $\frac{\partial C}{\partial \eta} > 0$, $\frac{d\eta^*}{d\theta} < 0$, and $\frac{d\theta^*}{dp} > 0$. Thus, we have proven that as p increases, the gain in reputation, $\frac{\mathbb{E}[\Pr(T|\phi)]-p}{p}$, is smaller. ■

Proof of Proposition 5: Let U_d^t be the manager's expected utility from disclosure in period $t \in \{1, 2\}$. Let $\mu\left(T \mid \phi_1, \eta_1, x_1\right)$ be the posterior belief of investors about the manager's type after the first-period signal ϕ_1,outcome x_1 (if observable prior to the second-period investment) and disclosure η_1. The manager's second-period choices will depend on μ. The manager's maximization program for η is

$$\max_{\eta} \left\{ U_d^1 + U_d^2 \right\} \tag{A.42}$$

subject to the pricing constraints. That is,

$$\begin{aligned} &\max_{\eta_1} \left[\left\{ C(\eta_1, \theta)\, qX(\theta) - C(\eta_1, \theta)\, I - \frac{I\left[1 - C(\eta_1, \theta)\right]\left[1 - \alpha(p)\right]}{\alpha(p)} - \psi(\eta_1) \right\} \right. \\ +\mathbb{E} &\left[C(\tilde{\eta}_2^*, \theta)\, qX(\theta) - IC(\tilde{\eta}_2^*, \theta) - \frac{I\left[1 - C(\tilde{\eta}_2^*, \theta)\right]\left[1 - \mu\left(T \mid \tilde{\phi}_1, \eta_1, \tilde{x}_1\right)\right]}{\mu\left(T \mid \tilde{\phi}_1, \eta_1, \tilde{x}_1\right)} - \psi(\tilde{\eta}_2^*) \right] \end{aligned} \tag{A.43}$$

where, in the usual backward induction manner, the manager first solves for the optimal $\tilde{\eta}_2^*$, which depends on the first-period outcomes, and is thus random at $t = 0$ when the first period choices are being made; hence, we write this as $\tilde{\eta}_2^*$.

Now, it is clear that U_d^2, which is the term inside the expectation operator $\mathbb{E}[\cdot]$ in (A.43), is strictly increasing in $\mu\left(T \mid \tilde{\phi}, \eta_1, \tilde{x}_1\right)$, and $\mathbb{E}\left[\mu\left(T \mid \tilde{\phi}, \eta_1, \tilde{x}_1\right)\right]$ is increasing in η_1 conditional on G being chosen in the first period. Thus, it follows that η_1^* will be higher in the two-period case than when there is only a single period, as in the base model. ■

Proof of Lemma 4: Now using (22) and (23), we have:

$$U_v - U_d = \left\{ [1 - C][qX(\theta) - I] - \frac{K(\theta)}{[1 - \alpha(p)]} + C + \frac{[1 - C]\left[1 - \alpha(p)\right] I}{\alpha(p)} + \psi(\eta) \right\} \tag{A.44}$$

Now hold θ and η fixed. We then have that $\partial\left[U_v - U_d\right]/\partial p < 0$. Moreover, since $K' > 0$, it is clear that allowing θ to increase with p, while holding η fixed, also leads to $\partial\left[U_v - U_d\right]/\partial p < 0$. Thus, if the firm chooses η optimally, U_d increases while leaving U_v unaffected, which means $U_v - U_d$ is decreasing in p when θ and η are chosen optimally. Thus, if verification dominates disclosure at $p = \underline{p}$, there exists a critical p high enough such that disclosure dominates verification for all values of p exceeding that critical value. ■

Proof of Proposition 6: The result that firms with $p > \hat{p}^*$ will choose $\theta = 1$ and avoid both verification and disclosure follows from Proposition 4. If disclosure dominates verification at $p = \underline{p}$, then it will also dominate it for $p > \underline{p}$ because θ increases with p, $\mathcal{L}(\theta)$ in (35) is increasing in θ, and the owner-manager's utility from disclosure, holding η and θ fixed, is increasing in p, and is thus increasing in p when η and θ are optimally chosen. This follows from the Envelope Theorem because the owner-manager's utility for any p when η and θ are optimally chosen for that p is at least as large as the utility when η and θ are fixed at possibly sub-optimal levels. Thus, no verification occurs in this case. If verification dominates disclosure at $p = \underline{p}$, but $K(\theta)$ becomes sufficiently large at a θ corresponding to some $p < \hat{p}^*$, it follows that disclosure will dominate verification for p high enough since $\mathcal{L}(\theta)$ is increasing in θ and U_d in (22) is increasing in θ as well. ■

Proof of Corollary 3: Totally differentiating the FOC (A.17) in the proof of Proposition 2, we can obtain:

$$\begin{aligned}\frac{d\hat{\eta}^*}{d\theta} &= \frac{C_S'(\eta)\left\{qX(\theta) - I + I\left[1-\alpha(p)\right]\left[\alpha(p)\right]^{-1}\right\}}{SOC} \\ &< 0 \end{aligned} \tag{A.45}$$

where we use the hat in $\hat{\eta}^*$ to denote that the optimal solution here differs from that in Proposition 2. Comparing (A.19) and (A.45) we see that

$$\left|\frac{d\hat{\eta}^*}{d\theta}\right| > \left|\frac{d\eta^*}{d\theta}\right| \tag{A.46}$$

Thus, $\hat{\eta}^*$ declines faster as θ increases than η^* does. Given the earlier-established position association between η and the increase in the manager's trust reputation (conditional on choosing G), it follows that trust will increase at a stochastically lower rate for firms choosing G when $X^{'}(\theta) = 0$. ■

Proof of Corollary 4: Consider the type T manager first. It is clear that the manager will not seek financing when he observes $\tilde{x} = 0$. When $\tilde{x} = X$, the manager solves the following problem in choosing η:

$$\max_{\eta} C(\eta, \theta) f X(\theta) - \psi(\eta) \tag{A.47}$$

subject to

$$[1 - f] \Pr(\tilde{x} = X \mid \text{financing sought}, \phi = G) X(\theta) = I \tag{A.48}$$

where it is assumed that financing is available only when $\phi = G$; we know from Proposition 4 that $\eta = 0$ when financing is available for both $\phi = G$ and $\phi = B$. From (A.48), we have

$$f = 1 - \frac{I}{\Pr(\tilde{x} = X \mid \text{financing sought}, \phi = G)} \tag{A.49}$$

where

$$\Pr(\tilde{x} = X \mid \text{financing sought}, \phi = G) = \frac{C\{q\alpha(p) + [1 - p]r\}}{C\{q\alpha(p) + [1 - p]r\} + [1 - C]\{1 - q\alpha(p) - [1 - p]r\}} \tag{A.50}$$

Using (A.49) and (A.50), we can write:

$$C(\eta, \theta) f = C - \frac{I\{C[q\alpha + [1 - p]r] + [1 - C][1 - q\alpha - [1 - p]r]\}}{X[q\alpha + [1 - p]r]} \tag{A.51}$$

From (A.26) in the proof of Proposition 3, we know that in the base model,

$$C(\eta, \theta) f = C - \frac{I\{C\alpha + [1-C][1-\alpha]\}}{qX\alpha} \tag{A.52}$$

It can be shown that

$$\frac{C[q\alpha + [1-p]r] + [1-C][1-q\alpha - [1-p]r]}{X[q\alpha + [1-p]r]} < \frac{C\alpha + [1-C][1-\alpha]}{qX\alpha} \tag{A.53}$$

This means that $C(\eta, \theta) f X(\theta) - \psi(\eta)$ in (A.47) is higher than $C(\eta, \theta) f q X(\theta) - \psi(\eta)$ in the base model. Thus, a higher optimal value of η, call it η_T^*, is chosen when the manager observes $\tilde{x}$ before choosing η than in the base model.

As for the N manager, if he chooses G, then it is clear that his behavior is identical to that of the T manager. If he chooses B, then it is clear he always wants funding. As established earlier, the only way to ensure this is to choose $\eta = \eta_T^*$. ■

Proof of Corollary 5: If $(1-r)sX(\theta) < I$, then investors will be unwilling to provide financing if they know that the manager of the firm is type$N$ with probability 1. Moreover, if $(1-r)sX(\theta) + r\overline{\beta} < I$, then we also know that project B is socially inefficient and dominated by project G. These conditions are sufficient to sustain all of our results. ■