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Product Market Efficiency: The Bright Side of Myopic, Uninformed, and Passive External Finance

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We model the effect of external financing on a firm's ability to maintain a reputation for high-quality production. Producing high quality is first best. Defecting to low quality is tempting because it lowers current costs while revenue remains unchanged because consumers and outside investors cannot immediately observe the defection. However, defection to low quality impairs the firm's reputation, which lowers cash flows and inhibits production over the long term. Financing via short-term claims discourages defection to low quality because the gains from defection are mostly captured by outside investors through an increase in the value of their claims. Therefore, if the firm relies on short-term external financing, it is more likely to produce over the long run, produce high-quality goods, and enjoy high profitability. The aggregate results from a laboratory experiment generally accord with these predictions.

Key words: adverse selection; financing; reputation
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1. Introduction

In a world with asymmetric information, corporate reputations are valuable.[1] As demonstrated by Kreps and Wilson (1982) and Milgrom and Roberts (1982), to build its reputation, a firm must forsake short-term gains and focus on the long-term implications of its decisions. However, many researchers argue that reliance on financing from outside investors leads firms to eschew long-term gains in favor of short-term profit.[2] Inducement of firm myopia is not the only dark side of external finance identified in the literature. The dilution resulting from the mispricing of securities by uninformed outside investors has also been identified as a cause of inefficient firm policies. For example, Myers and Majluf (1984) demonstrate that firms may underinvest when faced with the possibility of dilution losses arising from the issuance of mispriced securities to uninformed outside investors. In short, the literature in corporate finance stresses the inefficiencies associated with external finance, particularly when outside investors are uninformed. In this paper, we depart from the literature and demonstrate that external financing from uninformed outside investors via short-term claims promotes efficiency and *encourages* firms to form long-run reputations for high-quality products.

Our conclusions are drawn from a model that combines a product-market-reputation game with an asymmetric information capital-raising game. In our model, a long-lived entrepreneur can choose the quality of his firm's output. He can finance production by raising funds from outside investors. Producing high-quality goods is more costly, but the cost of increased quality is more than compensated by the increase in value it creates. Thus, the entrepreneur would like to commit to producing high-quality goods. However,

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[1] For example, reputable firms are consistently more profitable (Roberts and Dowling 2002), have higher market valuations (Billett et al. 2012, Black et al. 2000), and receive better financing terms (Billett et al. 2012, Srivastava et al. 1997). Benefits of reputation are estimated to account for up to 63% of firm value (Gaines-Ross 2008).

[2] Classic models of CEO short termism, such as Narayanan (1996), involve CEOs who boost current stock prices at the expense of long-term gains to increase their value in the managerial labor market. Insider diversion of investment funds that would generate long-term gains if properly invested is frequently modeled, as in Myers (2000). Empirical studies, such as Roychowdhury (2006), provide evidence that real earnings manipulation, involving pushing sales and earnings forward to meet earning targets, is common.

the entrepreneur's quality decision is not directly observable by consumers and outside investors, who are uncertain about the entrepreneur's commitment to high-quality production. They only learn about a good's quality after they buy it, ensuring that current period prices are not affected by the entrepreneur's current quality choices. This generates a temptation to increase short-term profits by lowering quality and costs. The entrepreneur trades off these short-term gains from reduced quality against the long-term loss of reputation and consequent loss of future profits.

We consider the effect of financing on this trade-off. Specifically, we compare three types of financing: internal financing, long-term external financing via (traditional) equity, and short-term external financing.[3] Here, as an example of short-term external finance, we use "short-term equity," a proportional claim on the firm's current period cash flow that is extinguished at the end of the period. It is similar to a profit participation loan, commonly used in private equity and real-estate finance, where investors receive a fixed fraction of firm (or project) profit over a limited period (Giddy 2010). Relative to internal financing or long-run outside financing (e.g., traditional equity), short-term outside financing transfers more of the immediate gains from reducing quality to the outside investors. Furthermore, short-run claimants bear none of the long-run costs of damaging the firm's reputation. All of these costs are born by the entrepreneur. Thus, short-term financing reduces incentives for taking short-term gains and encourages the development of a long-run reputation for high-quality production. The key issue is that the short-term nature of the financing effectively "taxes" opportunism. To the extent that the cash flow pattern from short-term risky debt mirrors that of the short-term equity we model here, short-term risky debt claims also encourage long-run reputation building.[4] Issuing a claim on distant future cash flows alone (e.g., a long-term zero-coupon bond without dividend protection) would have the opposite effect on incentives. The entrepreneur could capture the entire short-term gain from lowering quality whereas reductions in long-term firm value are born partially by the long-term bondholder (through the increased chance of default). Thus, in our analysis, the maturity structure of claims issued to outside investors is the critical determinant for reputation formation.

Our model predicts that a firm's financial structure should be related to its product quality, product prices, and profitability. Specifically, managers should prefer financing with external short-term claims over either traditional equity or internal finance. Moreover, reliance on short-term claims should mitigate conflicts of interest in the product market and result in firms that are more profitable in the long run. Some features of corporate financial policies are consistent with these predictions, for example, the high propensity of valuable firms to employ short-term financing.[5] However, these assertions are untested and some are also consistent with alternative theories rationalizing short-term finance (e.g., Easterbrook 1984, Jensen 1986, Hart and Moore 1990, Diamond 1991, among others). Developing a conclusive empirical test that discriminates between our explanation and these alternative theories is a daunting task.[6] Therefore, we leave empirical validation to future research and instead try to validate the behavioral salience of the incentives identified in our analysis through laboratory experiments.

We tested our model in a laboratory experiment using human subjects. Acting as investors, entrepreneurs, and consumers, subjects made financing, product quality, and pricing decisions. In some treatments, investment was financed by short-term outside finance and with internal funds in others. In these experiments, reliance on short-term external finance increased economic welfare, raised output, and improved product quality. Subject behavior did not correspond to theoretical predictions exactly. The effect of previous period product quality on

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[3] Note that in our context, a "short-term" security is not necessarily a security that matures in less than a year (i.e., "current" securities). Instead, it is a security with a maturity similar to the length of a product cycle that, of course, may vary by industry and is often longer than a year. A security is also short term relative to the firm, which lasts for a number of product cycles.

[4] We prove this result in the paper's e-companion (available at http://dx.doi.org/10.1287/mnsc.1120.1534).

[5] Between 1990 and 2008, the ratio of the sum of notes payable and trade credit to total assets averaged approximately 24% for nonfinancial firms in the Compustat database. Although this ratio varied based on firm size as measured by total assets, the average value of this ratio for the largest tercile of firms on Compustat during this period also averaged approximately 24%.

[6] Empirical tests are likely to be confounded by measurement, observability, and endogeneity issues. For example, by its nature, a strategy to exploit consumers would have to be kept secret, making it unobservable. Moreover, it is not easy to measure product quality, governance, or verifiability, all of which are crucial to differentiating between our model and competing explanations. Controlling for endogeneity is also likely to be a challenge because capital structure is endogenous and determined simultaneously with factors thought to affect conflicts of interest in the firm (Jensen 1986). Finally, it is difficult to control for the distribution of private (and, hence, unobservable) information to distinguish between our model and others. For example, using a mechanism nearly opposite ours, Easterbrook (1984) argues that external finance helps resolve internal agency conflicts. His model requires information production for external finance to mitigate conflicts. We require information asymmetry between insiders and outsiders. In Easterbrook (1984), informed intermediaries who take long-term positions are ideal mitigators. In our analysis, uninformed agents with short-term positions are best.

consumers' assessments of quality in the following period was less extreme than predicted by the Bayesian Nash equilibrium and outside investors tended to overvalue claims. However, low-quality production still led to significantly lower future prices and, because both opportunistic and nonopportunistic firms were overvalued, overvaluation did not eliminate the short-term claim tax on opportunism. Thus, entrepreneurs in the experiment, facing qualitatively similar incentives to those predicted by the model, responded in the expected fashion: they opted for high-quality production more frequently when investment was financed by short-term claims issued to outsiders.

Our analysis is related to the literature on corporate reputation, the literature on corporate myopia, and the literature on financing under information asymmetry. Following the central features of the two-agent models of reputation formation in Kreps and Wilson (1982) and Milgrom and Roberts (1982), we assume that agents have differing intrinsic characteristics about which they are privately informed. This uncertainty about an agent's type generates an incentive for informed agents (entrepreneurs) to manipulate uninformed agents' beliefs about their type. We depart from the Kreps and Wilson (1982) and Milgrom and Roberts (1982) model by introducing a third set of agents: external investors. Our analysis shows that the introduction of external investors helps weaken entrepreneurs' incentives to exploit uninformed consumers. Equivalently, our analysis demonstrates that introducing a new market (in our case the capital market) remedies the incentive problems in the first (product) market. It also complements a number of papers that demonstrate how the introduction of a second incentive problem in a single-market setting (instead of a second market) lowers adverse effects produced by the initial problem (e.g., Mookherjee and Png 1995, Noe and Rebello 1996). Maksimovic and Titman (1991) also investigate a reputation model for a firm operating in both product and capital markets. In their analysis, the firm's initial capital structure is exogenous and outside claims are long-lived. In our analysis, capital structure is endogenous and outsider claims can be short-lived. Moreover, we focus on how the maturity structure of outsiders' claims affects reputation formation, whereas Maksimovic and Titman (1991) emphasize the effect of outside claim priority and control rights.

The short horizon of outside investors has often been offered as an explanation for firm myopia (Blinder 1992, Porter 1992, Thurow 1993).[7] Bolton

et al. (2006) demonstrate that, when a firm's stock price can deviate from its fundamental value because of investor bias, optimal compensation schemes for executives may induce them to act myopically. Our analysis does not explicitly account for investor myopia. However, we demonstrate that a firm will prefer to issue short-term claims, which would be preferred by myopic outside investors because the payoffs on these claims are concentrated in the near-term.[8] However, by issuing these short-term claims, the firm is more likely to eschew myopic behavior.

In our model, the pricing of claims by the capital market follows Myers and Majluf (1984) in that the market prices of financial claims are based only on public information and the firm's financing decisions. This can result in undervaluation or overvaluation. In contrast to Myers and Majluf (1984), a firm's type does not directly determine the value of its financial claims in our context. Rather, a firm's type determines its willingness to undertake a hidden action—underinvestment in product quality—which affects the value of claims. Moreover, whereas Myers and Majluf (1984) demonstrate that dilution associated with the mispricing of claims issued to outside investors can result in inefficient underinvestment, we demonstrate that the potential dilution associated with short-term external financing reduces the gains to insiders from underinvestment in product quality and thus encourages high-quality production. Flannery (1986) and Diamond (1991) also demonstrate that firms have an incentive to finance with short-term claims when outside investors may misprice their securities. In these papers, short-term finance dissipates firm value. It may also signal firm value (Flannery 1986). In contrast, in our analysis, short-term finance actually *suppresses* rather than signals information because it encourages opportunistic firms to eschew opportunism.[9] Moreover, by discouraging dissipative behavior, short-term debt financing *improves* social welfare, whereas in costly signaling models short-term finance may lower welfare.

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[7] Considerable evidence suggests that investors have short horizons. For example, Benartzi and Thaler (1995), find that the equity premium puzzle can be explained by investor behavior consistent

with myopic loss aversion. Studies on corporate research and development and the market for corporate control document patterns consistent with institutional investors encouraging firms to behave myopically (Bushee 1998, Gaspar et al. 2005).

[8] It is commonly accepted that myopic investors prefer investing in assets with short maturities. For example, textbook explanations of the term structure of interest rates rely on precisely this matching between investor horizons and bond maturities (e.g., Bodie et al. 2008).

[9] In the context of our model, the incentive to issue short-term claims is obvious. Firms that are identified as opportunistic cannot obtain financing at all. Therefore, as in Fulghieri and Lukin (2001), opportunistic firms will be forced to mimic the financing choices of nonopportunistic firms, which will prefer short-term finance.

In the next section, we describe the framework for our analysis and derive the predictions for our experimental study. Section 3 contains a description of our experimental procedures. In §4, we describe the outcomes of our experiments. We conclude the paper with an overview of our results in §5. Proofs of all claims and experimental instructions appear in the e-companion. There, we also demonstrate how short-term debt can help the firm build its reputation.

2. Model

Consider an n-period world populated by an entrepreneur, investors, and consumers. All agents are risk neutral, survive for n periods, and discount cash flows at a risk-free rate of zero. The entrepreneur can be one of two types: flexible (F) or high quality (H). A high-quality, type-H entrepreneur can only produce high-quality (h) goods. Therefore, a type-H entrepreneur produces a high-quality good in each period if he has sufficient funds to produce. In contrast, a flexible, type-F entrepreneur can choose to produce either a high- or low-quality (l) good each period.[10] The entrepreneur's type, $\tau \in \{H, F\}$, and his quality decisions are private information. Both consumers and investors have a prior distribution on the entrepreneur's type. At time zero, they believe the entrepreneur is type-H with probability π.

The entrepreneur can produce one unit of a good after making an investment of I at the start of a period. He can obtain the investment capital either internally or externally from investors who operate in a competitive capital market. The good is sold at a price p to consumers who operate in a competitive product market. Consumers place a value of u_h on a high-quality good and $u_l < u_h$ on a low-quality good. They can observe quality only after purchasing and consuming the good. The entrepreneur only needs to invest I to produce a low-quality good. To produce a high-quality good he has to incur an incremental cost of c. He has to incur this incremental cost in each period in which he produces high quality. The cost is paid at the end of the period, when the good is sold to the consumer.

We restrict attention to the case where the expected increase in a consumer's utility from improved product quality exceeds the incremental cost of producing high quality, i.e.,

$$u_h - u_l > c. \tag{1}$$

[10] This entrepreneur-type structure is identical to that in Maksimovic and Titman (1991). As Maksimovic and Titman (1991) point out, consumers are frequently uncertain whether a given producer has a viable low-quality production option. For example, in 2008, infant formula consumers in China found out that formula producers had the ability to substitute poor-quality ingredients while leaving the product's appearance unchanged. It is reasonable to conjecture that, ex ante, consumers might be uncertain whether producers had access to such ingredients.

Furthermore, we assume that

$$u_l \leq I, \tag{2}$$

to ensure that production does not generate a positive net present value (NPV) so long as the good sells for u_l. Finally, we assume that high-quality production generates a positive NPV so long as investors and consumers (outsiders) believe that the probability of a high-quality product is no lower than π, their prior probability that the entrepreneur is type-H, i.e., we assume that

$$\pi u_h + (1 - \pi)u_l - c - I > 0. \tag{3}$$

If the entrepreneur finances internally, he keeps the end-of-period cash flow, i.e., the revenue net of the production cost. If he relies on external financing, the entrepreneur shares the end-of-period cash flow with investors according to the terms of the claim he issued to the investors. We restrict attention to short-term equity and traditional equity financing.[11] If the entrepreneur chooses short-term equity financing, he has to issue a new claim in each period entitling investors to α percent of the end-of-period cash flow. Each short-term equity claim expires at the end of the period in which it is issued.[12] If the entrepreneur chooses (traditional) equity, he issues only one claim. He issues this claim at time zero, raises sufficient capital for investment in each of the n periods, nI, and gives investors δ percent of the end-of-period cash flows in all n periods.

We employ the Bayesian Nash equilibrium concept. The entrepreneur maximizes payoffs in each subgame given consumer and investor responses. Investors and consumers base their financing and product pricing decisions on a system of beliefs that are conditioned on the past actions of the entrepreneur. These beliefs, whenever possible, must be consistent with Bayes' rule.

[11] It is difficult to distinguish security designs within the context of the simple cash flow distributions we assume. In the e-companion, using a more complex cash flow distribution, we demonstrate that because risky short-term debt cash flow patterns mirror the cash flow patterns for short-term equity we model here, short-term risky debt claims also encourage long-run reputation building. We do not attempt to identify optimal security designs because the main point of our analysis is that a broad range of short-term financial claims, even those not optimized to deter opportunism, still have a positive deterrent effect.

[12] Myopic investors, who only value the cash flows received in the current period, would assign the same value to a short-term equity claim as the long-lived investors. Thus, short-term equity financing is feasible in a world of myopic investors. However, traditional equity is likely to be undervalued because the myopic investors will not fully account for cash flows in future periods. Because we do not want to bias our comparison of short-term and traditional equity, we have assumed that investors are long-lived.

2.1. Pricing Goods and Financing Claims

At each date t, a type-F entrepreneur chooses a strategy that determines whether he produces a good and, contingent on producing, the probability with which he produces a high-quality good. Let q represent this choice, with $q \in [0, 1]$ representing the probability of high-quality production and $q = N$ representing the decision not to produce in the period. Then, the entrepreneur's strategy can be represented by $q_t^* \in N \cup [0, 1]$. This strategy will be conditioned on the past history of the game.

When the entrepreneur produces, the firm's cash flow equals the revenue from selling the good less its production cost. Therefore, the realized cash flow is $p - c$ when the firm produces high quality in the period and p when it produces low quality. When the firm does not produce, its cash flow equals the capital the entrepreneur has raised from external investors to finance production in the current period.[13] Let the expected firm cash flow in period t be represented by x_t, then it follows that

$$x_t(q, \tau)$$

$$= \begin{cases} q(p - c) + (1 - q)p & \text{if } \tau = F \text{ and } q \neq N, \\ I & \text{if } \tau = F \text{ and } q = N, \\ p - c & \text{if } \tau = H. \end{cases} \quad (4)$$

If the entrepreneur issues short-term equity in period t, competition between investors will restrict their share of the period's cash flow to α_t, where

$$I = \alpha_t E_t \{x(\tilde{\tau}, q_t^*)\}, \quad (5)$$

and the expectation over τ at date t is updated using Bayes' rule. Let ρ represent the probability that $\tau = H$. Then, the expected cash flow equals $p(\rho, q) - c(\rho, q)$, where

$$p(\rho, q) = \rho u_h + (1 - \rho)(q u_h + (1 - q)u_l),$$

$$c(\rho, q) = \rho c + (1 - \rho)q c.$$

It follows that the investors' profit share is given by

$$\alpha(\rho, q) = \frac{I}{p(\rho, q) - c(\rho, q)}. \quad (6)$$

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[13] Our assumptions regarding payout policy, i.e., that operating profits are paid out as dividends in the period they occur and that when the firm does not operate it pays out the investment required for operation, are made for convenience in the case of traditional equity. The only incentive effect from traditional equity comes from the terms of the initial issue and these terms will not vary with the payout policy. In the case of short-term equity, some restriction forcing payout of profits has to be imposed lest insiders simply retain profits within the firm and eliminate payouts to outsiders. The most natural restriction is that all profits must be paid out. For consistency, and to avoid developing a separate notation related to payout policy, we impose the same restriction on traditional equity contracts.

Assumption (3) ensures that $\alpha < 1$ so long as investors and consumers share the belief that the entrepreneur is type-H with probability $\rho \geq \pi$. Thus, so long as $\rho \geq \pi$, the entrepreneur can issue short-term equity to finance production.

With traditional equity financing, competition between investors will restrict their share of the firm's future cash flows to δ, where

$$nI = \delta E_0 \left\{ \sum_{t=1}^{n} x(\tilde{\tau}, q_t^*) \right\}, \quad (7)$$

and $E_0\{\sum_{t=1}^{n} x(\tilde{\tau}, q_t^*)\}$ represents investors time zero expectations of future firm profits. Note that this expression implies that the entrepreneur will pay out I in any period in which he does not produce. As discussed earlier, this assumption is made for convenience. Our results are unchanged if we change the timing of the payout of uninvested capital. Note also that the entrepreneur will be able to raise nI via traditional equity because Assumption (3) ensures that investment is always positive NPV from a time zero perspective.

To simplify the exposition, when outsiders believe that the entrepreneur is type-H with probability π and type-F will not produce high quality, let the good's price in the period be represented by $\bar{p} = p(\pi, 0)$ and the investors' share of end-of-period profits from short-term equity be given by $\bar{\alpha} = \alpha(\pi, 0)$. In contrast, if outsiders believe that the entrepreneur is type-H with probability π and type-F will produce high quality with probability one, let the price consumers will pay be represented by $p^+ = p(\rho, 1) = u_h$ and the investors' profit share from short-term equity be represented by $\alpha^+ = \alpha(\rho, 1)$.

2.2. Reputation Equilibria

Consider the entrepreneur's choice in the final period. Fixing consumer beliefs, because consumers cannot observe quality until after purchasing a good, a type-F entrepreneur can lower quality without affecting prices. Moreover, in the final period, the entrepreneur's decision cannot affect future cash flows. Because a low-quality good costs less to produce, a type-F entrepreneur maximizes his payoff by opting for low quality in the final period. This is the case whether or not he raises outside financing.

PROPOSITION 1. *In all equilibria in which type-F produces until period n, he produces low quality in period n.*

Proposition 1 demonstrates that the entrepreneur will always act opportunistically and produce low quality in the final period. Therefore, a lower bound on opportunism is achieved by equilibria in which the entrepreneur does not act opportunistically until the

last period. These *reputation equilibria* maximize welfare by minimizing opportunism because our parameter restrictions ensure that the entrepreneur's gain from opportunism is always less than the consumer's loss from inferior product substitution.

A type-*F* entrepreneur has the incentive to choose low quality in earlier periods. If his type is not known to consumers or investors, by switching to low quality, the entrepreneur can save on the cost of producing high quality. However, there is a cost associated with this switch—the loss of potential future profits that the entrepreneur could earn by producing high quality and thus keeping his type hidden from consumers and investors. Specifically, switching to low quality before the final period reveals to consumers and investors that the entrepreneur is type-*F*. This ensures that the entrepreneur earns a zero payoff for the remaining periods. On the other hand, if the entrepreneur continues producing high-quality goods until the penultimate period, he can earn a positive payoff because consumers pay more than the incremental cost of producing high quality. Thus, the gain from opportunism is an immediate one-time saving of the cost of producing high quality. The loss is identification as type-*F* and thus the future loss of the quality premium earned by pooling with type-*H*.

In some instances this cost may be sufficiently high to prevent the entrepreneur from taking advantage of uninformed consumers; there can exist reputation equilibria in which type-*F* produces high quality in *all* periods before period *n*. In these reputation equilibria, investors and consumers correctly anticipate that only high-quality production will be undertaken until period *n*, at which point type-*F* will switch to low quality. Thus, in these equilibria the good's price equals p^+, the value of a high-quality good until period *n*. In period *n* the price falls to $\bar{p}$, the good's expected value when type-*F* is expected to produce low quality with certainty. As the next proposition demonstrates, a necessary and sufficient condition for the existence of reputation equilibria when the entrepreneur finances production internally is that the reputation cost of low-quality production in the penultimate period exceeds the incremental cost of producing high quality. The same condition is also necessary and sufficient for the existence of reputation equilibria when the entrepreneur employs traditional equity financing.

PROPOSITION 2. (i) *If the entrepreneur employs internal finance, there exists a reputation equilibrium in which only high quality is produced until period n if and only if*

$$\bar{p} - c - I > 0. \tag{8}$$

This reputation equilibrium is the only equilibrium supported by parameter values satisfying (8).

(ii) *If the entrepreneur employs traditional equity finance, there exists a reputation equilibrium in which only high quality is produced until period n if and only if* (8) *is satisfied. This reputation equilibrium is the only equilibrium supported by parameter values satisfying* (8).

The reputation equilibria described in Proposition 2 are sustained by the profitability of high-quality production in period *n*. This period *n* profitability ensures that a type-*F* entrepreneur stands to earn a large profit if he maintains his reputation until period *n* and then switches to low quality. The logic underlying the equilibrium with internal financing is quite transparent: The entrepreneur's benefit from defecting to low quality in the penultimate period is his cost savings in that period. The cost of defecting is the lost period *n* profit, which is larger than the benefit from defecting. In every earlier period, the benefit of defecting remains limited to the entrepreneur's cost savings in that period. The cost of defection, however, grows with the distance from the final period because the loss is the cumulative profit dissipated by the destruction of the entrepreneur's reputation. Thus, the incentive to deviate to low quality diminishes with distance from period *n*. When the entrepreneur finances with traditional equity, he earns a fixed share of all future cash flows. Therefore, he captures the same fixed proportion of both the benefit and cost of deviation to low-quality production. Consequently, reputation equilibria with traditional equity financing exist whenever there exist reputation equilibria with internal financing.

Reputation equilibria also exist when the entrepreneur employs short-term equity financing. In these equilibria, until period *n*, the investors' share of cash flows equals α^+, which allows them to break even when the entrepreneur produces a high-quality good regardless of his type. In period *n*, their cash flow share equals $\bar{\alpha}$, which is sufficient to ensure their expected cash flow when type-*F* produces low quality with certainty equals their capital contribution of *I*. The underlying logic behind the existence and uniqueness of these reputation equilibria with short-term equity is identical to that sustaining the reputation equilibrium with internal financing or traditional equity: the short-term benefit from producing low quality is smaller than the reputation gain from sustaining high-quality production until period *n*. However, as we demonstrate in the next proposition, the exact condition ensuring these reputation equilibria is different from the condition ensuring reputation equilibria with either internal or traditional equity financing.

PROPOSITION 3. *Suppose that the entrepreneur finances with short-term equity, a reputation equilibrium in which*

only high quality is produced until period n exists if and only if

$$(1 - \bar{\alpha})\bar{p} - (1 - \alpha^+)c > 0. \qquad (9)$$

This reputation equilibrium is the only equilibrium supported by parameter values satisfying (9).

Propositions 2 and 3 demonstrate that reputation equilibria can be feasible whether the entrepreneur relies on external or internal financing. However, the entrepreneur's financing choice determines the feasibility of these reputation equilibria as the necessary and sufficient condition for reputation equilibria with short-term equity financing is different than the condition for reputation equilibria with traditional equity or internal financing ((9) and (8), respectively).

In the following proposition, we demonstrate that the condition for the existence and uniqueness of reputation equilibria with short-term equity is less restrictive than the corresponding condition with internal or traditional equity financing. The logic underlying the result is straightforward. If production is financed internally, because the entrepreneur is the only claimant on the firm's cash flows, when he switches to low quality, he appropriates the entire cost savings. Furthermore, he also loses the entire amount of the future profit stream that could have resulted had he kept his type hidden by producing high quality. The same condition supports reputation equilibria with traditional equity financing because the entrepreneur loses and investors capture the same fixed proportion of the benefits and costs from the entrepreneur's defection to low-quality production. In contrast, if the entrepreneur relies on short-term equity, investors share in the gain from defection to low-quality production but take only a small share of the loss from the defection. This follows because the short-term equity is priced anew in each period and, with the exception of period n, leaves the entrepreneur with the entire surplus from the period's production. Although a type-F entrepreneur's equity is undervalued in period n, the loss from undervaluation is always smaller than the share of the gain from defection to low quality captured by investors. Therefore, there exist parameters where reputation formation will occur if and only if the entrepreneur relies on short-term equity.

PROPOSITION 4. *The parameter set that supports reputation equilibria when the entrepreneur employs internal finance or traditional equity is a subset of the set of parameters that supports reputation equilibria when the entrepreneur employs short-term equity finance.*

Not only are reputation equilibria supported by a larger parameter set when the entrepreneur finances externally, but, as we demonstrate in the following proposition, even when reputation equilibria with

internal or traditional equity finance are feasible, the equilibrium payoff to type-H is highest with short-term equity. This result is important because type-F cannot profitably produce if its type is revealed. Thus, the standard logic of equilibrium refinements literature dictates that type-F must mimic the security choice of type-H in a model with endogenous security choice. It follows that the preferences of type-H should determine the financing choice. In such a situation we expect both H and F to pool using the H-preferred financing method.

The reason type-H prefers short-term equity financing is interesting. In the final period, n, type-H always loses in the product market when type-F pools because F's product quality is lower than H's. At the same time, because type-F's opportunism increases profits, the value of claims issued by F is higher than the value of claims issued by H in period n. Thus, in the goods market, the output of H is undervalued; in the capital market, the securities issued by H are overvalued. This capital market overvaluation is never large enough to compensate for product market undervaluation in the sense that type-H is always worse off in equilibrium than it would be in a world without type-F producers. However, capital market overvaluation to some extent compensates H for product market undervaluation. Thus, H prefers issuing the security that produces the largest overvaluation in the capital market. Because short-term equity issued in period n is more sensitive to the period's cash flow than traditional equity, and because in the reputation equilibria, the last period is the only period that H's capital market claims are mispriced, short-term equity is preferred by type-H.

PROPOSITION 5. *When* (8) *is satisfied, the ex ante payoff to a type-H entrepreneur is always higher with external finance than internal finance and higher with short-term equity than with long-term equity.*

2.3. Parameterizations Used in Experiments

We now provide further insight into the relation between production and financing decisions by examining the effect of varying the three factors that drive the superiority of short-term equity financing—the production cost (c), the capital investment required to undertake production (I), and consumers' and investors' prior assessment of the entrepreneur's type (π). The differential effect of the production cost is the most transparent. The entrepreneur's gain from opportunism is his share of the cost savings from switching to low-quality production. When the firm is internally financed, the entrepreneur captures the entire cost savings. With external financing, he has to share the cost savings with outside investors, and the outside investors' share of the cost savings is largest when the firm is financed with short-term

Table 1   **Parameterizations**

Parameterization	π	I	u_h	u_l	c
Strong	0.50	400	1,000	400	200
Moderate	0.75	500	1,000	400	400
Weak	0.25	500	1,000	400	400

equity. Moreover, the larger the cost savings, the greater the investors' gain and hence the tax on the entrepreneur's defection to low quality when the firm is financed with short-term equity. The investment level determines the amount of funding required from external investors and thus their share, α or δ, of any gains from entrepreneur opportunism; i.e., the investment level in effect determines the tax rate on opportunism. Finally, a higher prior probability raises the mispricing loss incurred by an opportunistic entrepreneur, discouraging defection to low-quality production.

We provide insights into the effect of variations in c, I, and π by characterizing equilibrium outcomes for three parameterizations of our model. These equilibrium outcomes provide benchmarks against which we gauge subject behavior and outcomes in our experiments because they are calibrated using the same parameterizations. To demonstrate the superiority of short-term financing, we alter the entrepreneur's incentive to act opportunistically across the three parameterizations. We focus on comparing outcomes under internal financing with those under short-term equity financing because the necessary and sufficient conditions for the existence of reputation equilibria with traditional equity financing are equivalent to those for reputation equilibria with internal financing. Moreover, the computations required of the subjects in our experiments are simplified if we only allow subjects to finance internally or with short-term equity (rather than expanding choices to traditional equity or short-term debt). Table 1 presents details of the three parameter sets. For each set, the number of periods, n is 3.[14]

2.3.1. Strong Reputation Formation Incentives. We refer to the first parameterization as the "strong" parameterization because it provides the strongest incentives for reputation formation. This parameter set satisfies the necessary and sufficient conditions for reputation equilibria with both internal and short-term equity financing ((9) and (8)). As a result, it only supports pure strategy equilibria where type-F produces high quality until the final period, at which point he switches to low quality. Thus, the entrepreneur's actions and product market prices are

[14] To test the robustness of our results, we also ran experimental sessions with n ranging from one to four.

not dependent on his financing decision. The good's price remains at 1,000 for the first two periods and drops to 700 in the final period. Investors demand half of the profits in the first two periods. In the final period, they demand two-thirds of the profit.

PROPOSITION 6. *In all equilibria supported by the strong parameterization, type-F produces high quality until period n. In period n, type-F produces low quality. The good is priced at $p^+ = 1,000$ until period n and at $\bar{p} = 700$ in period n. Investors demand $\alpha^+ = 1/2$ of the profits until period n and $\bar{\alpha} = 2/3$ of the profits in period n. If the entrepreneur produces low quality prior to period n, in all subsequent periods, consumers pay $u_l = 400$ for the good and investors demand $I/u_l = 100\%$ of the profits.*

2.3.2. Moderate Reputation Formation Incentives. The "moderate" parameterization, provides weaker incentives for reputation formation than the strong parameterization because it incorporates three changes that combine to encourage entrepreneur opportunism: (1) the investment expense is higher at 500; (2) the incremental cost of producing high quality, 400, is twice as large; and (3) the likelihood of the entrepreneur being type-H is 50% higher at 0.75. The moderate parameterization highlights the role of short-term equity in limiting opportunism as this parameter set only supports reputation equilibria when the entrepreneur employs short-term equity financing.

With the increased capital investment, production is no longer economically viable if consumers price the good as if it were low quality because

$$u_l = 400 < 500 = I. \tag{10}$$

Consequently, type-F will only produce if his type is hidden from consumers. The increased investment may also make production uneconomic for type-H; if consumers believe the entrepreneur is type-F with the prior probability of π and type-F will only produce low quality, the good's price will not cover the incremental cost of high-quality production, i.e.,

$$\bar{p} = 0.75 \times 1,000 + 0.25 \times 400 = 850 < 500 + 400 = I + c. \tag{11}$$

Because type-H cannot profit from producing high quality under these conditions, there exists no pure strategy equilibrium in which production occurs with internal financing. However, there exists an equilibrium in which type-F employs mixed strategies. In this equilibrium, type-F uniformly produces high-quality goods in the first period. In the second period, he randomizes between high and low quality. In the final period, he produces only low-quality goods. Early defection to low quality is induced

by prices that decline over time in response to the decline in the average quality of goods. Early defection results in the stoppage of future production, thereby increasing the conditional probability that an entrepreneur is type-H. This mixed strategy equilibrium exists because, by the final period, the conditional probability of type-H is sufficiently high to ensure that consumers pay at least 900 for goods. This renders production by type-H economically viable.

PROPOSITION 7. *Under the moderate parameterization, with internal finance there do not exist pure strategy equilibria that support production. However, there exists a mixed strategy equilibrium in which type-F follows the following strategy*:

1. *In period 1, always produce high quality.*

2. *In period 2, if high quality was produced in period 1, produce high quality with probability 3/5 and low quality with probability 2/5; if high quality was not produced in period 1, shut down.*

3. *In period 3, if high quality was produced in periods 1 and 2, produce low quality with probability 1; if not, shut down.*

Consumers price as follows: *If the entrepreneur failed to produce high quality in any preceding period, offer $u_l = 400$. Otherwise, in period 1, offer $p^+ = 1{,}000$; in period 2, offer 940; and in period 3, offer 900.*

Under the moderate parameterization, because the incremental cost of high-quality goods is higher, type-F has more to gain from opportunistic behavior than under the strong parameterization. However, the increase in I ensures that the tax on the entrepreneur's gain from opportunism generated by short-term equity financing is sufficiently large to deter him from acting opportunistically, i.e., (9) is satisfied. Thus, with short-term equity financing type-F will eschew low-quality production until the final period.

PROPOSITION 8. *Under the moderate parameterization, when the entrepreneur uses short-term equity finance, only high quality is produced until period 3. In period 3, type-F switches to low quality. The good is priced at $p^+ = 1{,}000$ in periods 1 and 2, and at $\bar{p} = 850$ in period 3. Investors demand $\alpha^+ = 5/6$ of the profits until period 3 and $\bar{\alpha} = 10/11$ of profits in period 3. If an entrepreneur produces low quality prior to period 3, in all subsequent periods consumers pay $u_l = 400$ and investors demand $I/u_l = 5/4$ of the profits; i.e., they refuse to finance the entrepreneur.*

One interesting aspect of Proposition 8 is that, in the final period, the equilibrium price of 850 is *lower* than the break even price of 900 for producing high-quality goods. Nevertheless, a type-H entrepreneur financed with short-term equity continues producing in the face of prices below the overall break-even level because he earns a fraction of the net cash flow of

$850 - 400 = 450$. Investors incur a loss of $(10/11)(850 - 400) - 500 = -90.91$ conditional on financing type-H. However, they are willing to finance entrepreneurs because, in expectation, they break even as their expected profit from financing type-F exactly offsets the expected loss from financing type-H.

2.3.3. Weak Reputation Formation Incentives. The only difference between moderate and weak parameterizations is a much lower prior probability of the entrepreneur being type-H in the latter. This lowers expected product quality sufficiently to ensure that production is not sustainable if the entrepreneur uses internal financing.

PROPOSITION 9. *Under the weak parameterization, there exists no equilibrium in which internally financed entrepreneurs produce.*

Even when the entrepreneur finances with short-term equity, he resorts to low-quality production prior to the final period. The incentive to act opportunistically is strong enough to ensure that type-F will not follow the pure strategy of producing only high-quality goods until the final period. Instead, there exist mixed strategy equilibria, where type-F randomly begins producing low-quality goods from period 1 itself. Once again, early defection to low-quality production is facilitated by price declines that reflect the declining average quality of output over time, and type-H continues to operate despite receiving prices lower than the break-even price of 900.

PROPOSITION 10. *Under the weak parameterization, when entrepreneurs raise short-term equity financing, there exists a mixed strategy equilibrium in which type-F uses the following strategy*:

1. *In period 1, produce high quality with probability 0.636 and low with probability 0.364.*

2. *In period 2, if high quality was produced in period 1, produce high quality with probability 0.411 and low with probability 0.589; if high quality was not produced in period 1, shut down.*

3. *In period 3, if high quality was produced in periods 1 and 2, produce low quality with probability 1; if not, shut down.*

Consumers price according to the following strategy: *If the entrepreneur failed to produce high quality in any preceding period, offer $u_l = 400$. Otherwise, in period 1, offer 836.4; in period 2, offer 768.1; and in period 3, offer 736.2.*

Investors use the following strategy: *If the entrepreneur failed to produce high quality in any preceding period, refuse to finance, i.e., demand more than 100% of profits. Otherwise, in period 1, demand 91.7%; in period 2, demand 95.7%; and in period 3, demand 97.6% of profits.*

Table 2 Equilibrium Predictions by Period for Experimental Parameterizations

Parameterization	Financing	Unrevealed firm product price			Unrevealed firm financing terms (%)			High-quality production rates for unrevealed flexible firms		
		p_1	p_2	p_3	α_1	α_2	α_3	q_1	q_2	q_3
Strong	Internal	1,000	1,000	700	N/A	N/A	N/A	1.000	1.000	0.000
Strong	External	1,000	1,000	700	50.0	50.0	66.7	1.000	1.000	0.000
Moderate	Internal	1,000	940	900	N/A	N/A	N/A	1.000	0.600	0.000
Moderate	External	1,000	1,000	850	83.3	83.3	90.9	1.000	1.000	0.000
Weak	Internal				No equilibrium with production					
Weak	External	836	768	736	92.7	95.7	97.6	0.636	0.411	0.000

2.3.4. Summary of Predictions. Table 2 summarizes the equilibrium predictions from Propositions 6–10. When the financing method matters, external financing encourages more production, higher-quality production, higher prices, and higher profitability. The firm receives better financing terms when its expected profits are higher.

Overall, our results show that short-term financing by uninformed investors can alter reputational incentives. Specifically, because entrepreneurs have to pass on a large portion of the gains from opportunistic actions to investors, they have weaker incentives to act opportunistically when they receive short-term financing. As a result, they tend to produce higher-quality goods even though consumers are uninformed about the quality of goods at the time of purchase. Because short-term financing raises the average quality of goods, it also raises the profitability of entrepreneurs that are wedded to producing high-quality goods, enabling them to sustain production. This, in turn, ensures the vitality of the product market, which demonstrates that capital market access also boosts production.

3. Experimental Design

Paid subjects acted as investors, entrepreneurs, and consumers in our experimental sessions. We employed a 2×3 design, running one internal financing and one short-term equity financing session for each parameterization in Table 1. Treatment labels are presented in Table 3. With the exception of the E-moderate treatment, where one subject left for unknown reasons, we have 48 observations in each treatment with each observation consisting of a three-period set of subject interactions. We summarize the procedures here. The e-companion contains subject instructions.

3.1. Common Design Features

Subjects came from a volunteer subject pool of undergraduate and M.B.A. students in University of Iowa business classes. They were asked to attend a session that would last up to three hours and were paid a $5 show up fee. The experimental currency was

"francs," converted to dollars at the known exchange rate of $0.002 per franc at the end of each session. Sessions typically lasted less than three hours. Payments to subjects (including the $5 show up fee) ranged between $21.90 and $37.02, and averaged $28.52.

Upon arrival, subjects sat at separate computer terminals and received a set of instructions, experimental forms, and receipts to be filled in during the session. The sessions themselves were not computerized, but each subject had a "trial" spreadsheet available on the computer to calculate payoffs to all players after the subject entered hypothetical decisions for all players. The instructions were read aloud and all questions were answered in public before each session began.

3.2. Internal Finance Games

Subjects were randomly assigned the roles ("green" player (consumer) or "blue" player (entrepreneur)) and to groups (six groups, each consisting of one consumer and one entrepreneur).[15] The three-period games were run simultaneously for all groups. Each group remained constant during the three-period game. Similar to DeJong et al. (1985), Camerer and Weigelt (1988), and King (1996), subjects kept their roles throughout a session, but they were randomly reassigned to new groups after each three-period game. Each subject started each period with a fixed initial endowment of funds that varied with his or her role so as to equalize expected profits across roles.

Each entrepreneur was assigned a type: R for restricted or F for flexible. An entrepreneur's type was only revealed to him. Based on the parameterization, exactly half, on average one-quarter, or on average three-quarters of the entrepreneurs were assigned type F. Types remained constant for an entire set of group interactions but were randomly reassigned when groups were reassigned. All players knew the assignment rules and fractions of R and F entrepreneurs in the population.

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[15] Although here we will refer to the players as consumers, entrepreneurs, and (later) investors, these terms were not used during the experiment to avoid value-laden connotations.

Table 3 **Experimental Design**

Parameterization	Internal financing		External financing	
	Treatment	Observations	Treatment	Observations
Strong	I-strong	48	E-strong	48
Moderate	I-moderate	48	E-moderate	40
Weak	I-weak	48	E-weak	48

3.2.1. Consumer Choices and the Product Market.

The product market was designed to elicit the competitive price the consumer would be willing to pay for a good before knowing its quality.[16] We adapted a Becker et al. (1964) procedure (hereafter, "BDM procedure") to elicit the highest price the consumer was willing to pay for the good.[17] After the consumer set this "established price," the experimenter bought the good from the entrepreneur at this price. Then, the experimenter randomly drew a "discounted price" (from a known uniform distribution on 400–1,000) and resold the good to the consumer only if the discounted price fell below the established price. This resale procedure preserved the incentive compatibility of the BDM procedure, ensured that the entrepreneur was paid the consumer established price, and allowed the game to continue even if the consumer did not buy the item. In the results below, we report consumer established prices.

When production occurred and the consumer purchased the item, she received a payoff equal to her endowment plus the value of the item minus the discounted price. When the consumer "sat out" because of the BDM procedure or production was halted, she received her endowment. In either case, she received an ex post report showing the quality of the item and the discounted price.

3.2.2. Entrepreneur Choices and Internal Finance.

The entrepreneur effectively made two choices: (1) whether to produce and (2) product quality. Whereas flexible entrepreneurs could choose between producing "round" (high-quality) and "square" (low-

quality) goods, restricted entrepreneurs could only produce high-quality goods.[18]

The experimenter actually implemented the production choice. He first subtracted the capital investment from the potential profit on the item's sale. He stopped production if the profits were lower than the capital investment. Otherwise, he permitted production to proceed. This made the experimenter and subject designated as an entrepreneur together act like an entrepreneur who (i) knew the cost of production and funded it; (ii) determined the quality type produced each period; and (iii) given the good's price and his quality commitment, chose to halt production if revenues did not cover capital costs.[19] When production occurred, the entrepreneur received a payoff at the end of the period equal to his endowment plus the profit on the sale of the good minus the capital investment. When production was halted, the entrepreneur received his endowment. Whether or not production was halted, the entrepreneur received an ex post report of the outcomes.

3.3. External Finance Games

To create a capital market, a "red" player (investor) was added to each group. The external finance experiments were different from the internal finance ones in two other respects: (1) entrepreneurs only made quality choices and (2) the production/financing rate choice was made in an external capital market by an investor. In addition, we also ran one-, two-, and four-period external finance games as robustness checks as discussed in §4.6.

3.3.1. Investor Choices and the External Capital Market.

The external capital market's role is to supply capital in exchange for a competitive share of the profits.[20] As with the product market, we implemented the capital market by adapting a BDM procedure. The investor submitted an "established percentage" of the profits as a financing charge. The experimenter provided capital to the entrepreneur if the established percentage was less than 100% and charged the entrepreneur the established percentage. Then, the experimenter randomly drew a

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[16] Bidding on a good before its quality is known is common (e.g., Miller and Plott 1985), and the quality choice is sometimes endogenous (e.g., DeJong et al. 1985, King 1996). Our implementation differs from prior research and the combination of capital and product markets here is unique.

[17] See the instructions in the e-companion for details. Recent research shows that, on average, the BDM procedure elicits risk-neutral valuations (Berg et al. 2005) that, here, correspond to competitive prices. Through this procedure, we elicit a competitive price from a single subject. Further, it was fast to implement, it avoided complications from auction procedures (e.g., overbidding as in Kagel and Levin 1993), and it did not require prespecifying a limited set of allowable prices (e.g., Forsythe et al. 1999).

[18] Although here we will refer to these as high- and low-quality items, these terms were not used during the experiment to avoid value-laden connotations.

[19] Although this enforces some rationality and foresight on the entrepreneur's actions, it was the minimum design change necessary to create an integrated financing/production decision as opposed to separate decisions as outlined in the next section. This integrated decision reflects the important aspects of the entrepreneur's decision while allowing us to isolate it completely from confounding effects of other design changes.

[20] This portion of the design is similar to that employed in Cadsby et al. (1990, 1998) but differs in implementation. Goswami et al. (2007), Asparouhova (2006), and Camerer and Weigelt (1988) have also studied financing decisions in different contexts.

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"marked up percentage." If the marked up percentage exceeded the established percentage, the experimenter took the capital from the investor in exchange for the marked up percentage of profits. Again, this preserved incentive compatibility, charged the entrepreneur the investor established capital charge, and allowed the game to continue regardless of the random draw. By setting an established percentage greater than or equal to 100%, the investor could halt production for the period.[21] The entrepreneur knew the established percentage before he made his quality choice.

When production occurred, the investor received a payoff equal to the marked up percentage of the entrepreneur's profits on the sale of the item. Her endowment was used to cover the capital cost. When an investor "sat out" because of the BDM procedure or halted production, she received her endowment. In either case, she received an ex post report showing the quality of the item, the established price, and firm profitability.

The other procedures for the external finance experiments were identical to those for the internal finance treatment. Product markets were implemented in exactly the same manner as in the internal finance treatments. Entrepreneurs could make the same quality choices as in the internal finance treatments. However, their payoffs reflected the cost of external finance as they had to give up the established percentage of the profits on the sale of the item.

4. Experimental Outcomes
We examine how short-term equity financing affected the experimental outcomes along four dimensions: production quality, likelihood of production, economic surplus produced, and defection to low-quality production prior to the final period.

4.1. High-Quality Production Rates
Based on Propositions 6–10, we expect financing with short-term equity to encourage high-quality production by (1) promoting production by high-quality entrepreneurs and (2) encouraging reputation formation by flexible entrepreneurs. This benefit of external financing should be observed under moderate and weak parameterizations. We examine the incidence of high-quality production in each treatment to identify the effect of external financing. Panel A of Figure 1

plots the average incidence of high-quality production in each treatment and contains a data table with statistical tests of the effect of external financing.

Short-term financing does encourage high-quality production. The frequency of high-quality production is uniformly higher in treatments with short-term equity financing. This increase is significant under the moderate and weak parameterizations as predicted. Moreover, in unreported tests, we find that for these parameterizations, increases are also significant on a period-by-period basis.
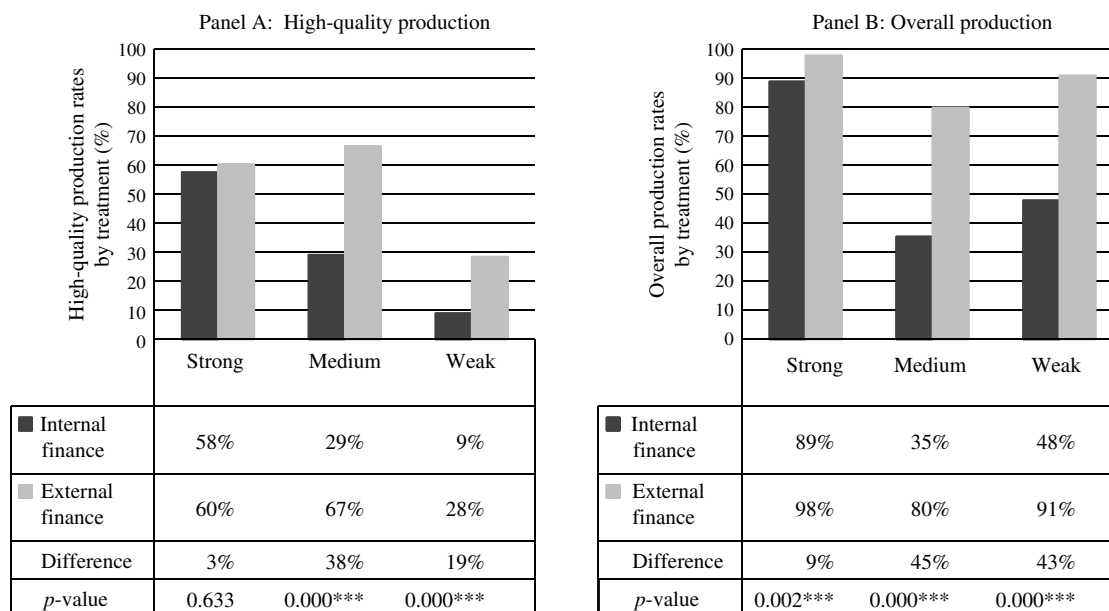
4.2. Overall Production Rates
We expect financing with short-term equity to raise production rates. This effect should be observed under the moderate and weak parameterizations, where external financing should sustain higher rates of production than internal financing. To assess the effects of external financing on production, we examine the frequency with which production was undertaken in each treatment. Panel B of Figure 1 illustrates the average production rate in each treatment and contains a data table with statistical tests for the effect of external financing on production rates. External financing boosted production significantly under all three parameterizations. In unreported tests, we also find that short-term equity finance boosts production significantly in period 1 for the strong parameterization, and in all three periods for the moderate and weak parameterizations.

4.3. Economic Surplus
In our context, production of high-quality goods always increases economic surplus. However, under moderate and weak parameterizations, production of low-quality goods reduces surplus. By encouraging high-quality production and sustaining production by high-quality firms that would not occur with internal financing, short-term equity financing should raise economic surplus. Once again, the beneficial effects of external financing should be concentrated under moderate and weak parameterizations. We assess the effect of external financing on economic surplus by computing the average proportion of the maximum achievable surplus attained under each treatment. To compute these averages, we divide the surplus generated each period by the (Pareto optimal) surplus associated with the high-quality item. This normalized surplus is one if a high-quality item is produced and zero if no item is produced. These measures of economic surplus are shown in Figure 2 along with a data table containing statistical tests to detect the effect of external financing.[22]

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[21] This was explicitly stated and given as an option in treatments E-moderate and E-weak. Because it is not an optimal equilibrium response in treatment E-strong, halting production was not discussed explicitly. However, if the investor did not feel that profits would be sufficient to cover costs, she could ask for 100% of the profits. This effectively allowed the investor to opt out of the process according to the BDM procedure. This would halt production in real environments, so we count it as a production halt here.

[22] Results using *t*-tests are the same.

Figure 1   High-Quality and Overall Production Rates by Treatment

Panel A: High-quality production

	Strong	Medium	Weak
■ Internal finance	58%	29%	9%
■ External finance	60%	67%	28%
Difference	3%	38%	19%
p-value	0.633	0.000***	0.000***

Panel B: Overall production

	Strong	Medium	Weak
■ Internal finance	89%	35%	48%
■ External finance	98%	80%	91%
Difference	9%	45%	43%
p-value	0.002***	0.000***	0.000***

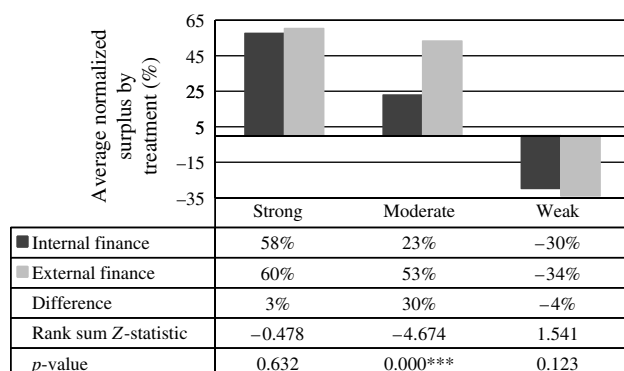***Denotes significance at the 99% level of confidence.

We find that, as expected, economic surplus rose significantly with external financing for the moderate parameterization. However external financing did not have a significant effect on economic surplus for the other parameterizations. Although external financing increased production of high-quality (positive surplus) items for the weak parameterization, it also increased production of low-quality (negative surplus) items resulting in roughly offsetting effects on surplus. Further analysis of surplus reveals an unexpected result: external financing shifts the distribution of surplus significantly away from entrepreneurs for the strong parameterization and toward consumers for the moderate and weak parameterizations.

4.4. Defection Rates
Under the moderate parameterization, short-term equity financing should discourage defection in pe-riod 2 but have no effect in period 1. External financing should have no effect on defection rates under the strong parameterization. Although there is no production with internal financing under the weak parameterization, we should only observe early defection with external financing.

Table 4 shows the percentage of flexible entrepreneurs previously revealed as flexible (by prior low-quality production) going into periods 2 and 3 under each treatment. It also presents χ^2 statistics for the effect of external finance on defection rates. Consistent with our predictions, we find that defection rates do not vary significantly with the mode of financing for the strong parameterization. Further, for the moderate parameterization, the defection rates differ little with financing going into period 2, but differ significantly going into period 3 as predicted.

Figure 2   Average Normalized Surplus Levels by Treatment

	Strong	Moderate	Weak
■ Internal finance	58%	23%	−30%
■ External finance	60%	53%	−34%
Difference	3%	30%	−4%
Rank sum *Z*-statistic	−0.478	−4.674	1.541
p-value	0.632	0.000***	0.123

***Denotes significance at the 99% level of confidence.

Table 4   Percentage of Flexible Firms Revealed by Defection at the Start of Periods 2 and 3

	Parameterization		
	Strong	Moderate	Weak
Going into period 2			
Internal finance (%)	50.00	75.00	88.89
External finance (%)	66.67	77.78	86.11
$\chi^2(1)$ statistic	1.3714	0.0219	0.1270
p-value	0.242	0.882	0.722
Going into period 3			
Internal finance (%)	75.00	100.00	97.22
External finance (%)	91.67	77.78	97.22
$\chi^2(1)$ statistic	2.4000	2.9474	0.000
p-value	0.121	0.086*	1.000

*Denotes significance at the 90% level of confidence.

4.5. Behavioral Observations

Consistent with the behavior of idealized rational Bayesian agents, short-term external finance increased the quality and quantity of production in our experiments. However, as is the case with other experimental tests of reputation games, e.g., Camerer and Weigelt (1988) and Brandts and Figueras (2003), subjects' actions did not conform completely with the behavior of idealized agents. For example, the entrepreneurs defected to low-quality production earlier and more often than theory predicts. Thus, our experimental outcomes demonstrate that our directional predictions are robust to non-Bayesian behavior of the experimental subjects.

Despite their non-Bayesian behavior, the responses of consumers and investors in our experiments still forced the entrepreneurs to trade off short-run benefits of opportunism against long-run costs. Although the costs of opportunism in the experiments was not as large as our theory predicts, they remained. Moreover, outside capital still dampened the short-run gains from defection by siphoning off gains to outside investors. Although the amount siphoned off was not as high as predicted, it was sufficient to have a significant deterrent effect.

One of the long-run costs of opportunism is lower prices in later periods. Under each treatment, Figure 3 shows how average prices evolved through the histories of quality outcomes. In period 1, we expect consumers to set prices based on the expectation of only high-quality production under the strong and moderate parameterizations. Subsequently, consumers should punish entrepreneurs revealed to be flexible with prices equal to low-quality values. Figure 3 clearly shows that they did not. Instead, consumers appear to have followed an anchor and adjust process. Prices appear to reflect (accurate) expectations that many or most of the flexible entrepreneurs

will defect early. Prices adjust upward after consumers observed high quality and downward after low quality (but not all the way to 400, the low-quality value). So, although subjects did not start at our predicted price nor adjust fully, they did reward firms that produced high quality early in the game and punish firms that produced low quality early.

Table 5 presents a regression modeling price dynamics across all treatments simultaneously. We use a censored normal regression (to account for censoring limits at 400 and 1,000) with robust standard errors clustered by subject (to account for repeated measures and other sources of heterogeneity). The variables of interest include the fraction of flexible firms (which reflects the number of firms that have the opportunity to defect); dummy variables that capture the period and whether the entrepreneur has been revealed as flexible; and *lagged pseudo buyer surplus*, a variable that reflects the consumer's most recent experience. This variable represents the consumer's profit or loss had he purchased the item the entrepreneur committed to produce at the established price in the prior period; i.e., it equals zero in the first period of a group interaction and otherwise equals the value of the item minus the established price in the previous period (regardless of whether production occurred or whether the subject would have purchased the item). The regressions mirror Figure 3. Subjects start at an overall average price of 651. Prices increased significantly in later periods for entrepreneurs whose type remained hidden and decreased for those revealed as flexible. In unreported analysis, we also find that the effect of prior experience is stronger when consumers actually purchased the product through the BDM procedure than when they merely observed the product quality by reading ex post reports.

Investors should respond to early opportunism by demanding higher profit shares and/or shutting down production (demanding 100% or more of the profits) when the entrepreneur is revealed to be flexible. As with consumers, investors appear to follow an anchor and adjust process. Table 5 presents a regression modeling the profit share demanded by investors (censored at one, with one representing shutdown). Again, we used a censored normal regression (to account for censoring limits at zero (never binding) and one), with robust standard errors clustered by subject (to account for repeated measures and other sources of heterogeneity). The variables of interest include the fraction of flexible firms (which reflects the number of firms who have the opportunity to defect); dummy variables that capture the period and whether an entrepreneur has been revealed as flexible; and *lagged pseudo return on capital*, a variable that represents what the return on capital investment would have been in the prior period

Figure 3   Average Prices for Revealed Flexible and Unrevealed Entrepreneurs Under Each Treatment by Period
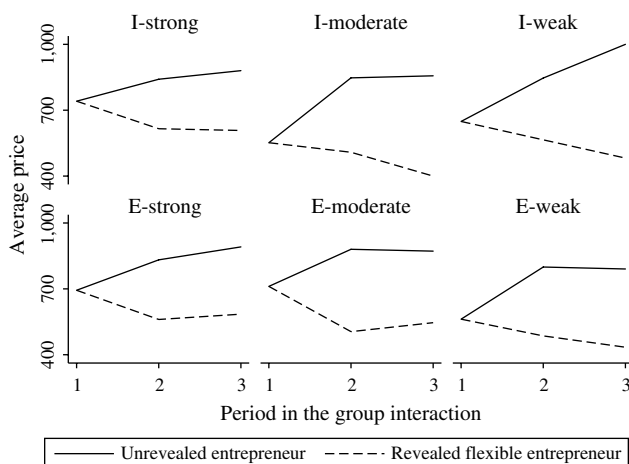
Table 5   Censored Normal Regressions for Consumer and Investor Behavior

Panel A: Regressions						
Observations	Consumer regression 840			Investor regression 408		
Dependent variables:	Max. price willing to pay			Min. % of profits demanded		
	Coeff.	Std. err.	*t*-stat.	Coeff.	Std. err.	*t*-stat.
Constant (period 1)	650.72	10.79	13.82‡	82.2	6.66	12.35‡
Period 2 unrevealed dummy	334.43	7.18	6.56‡	17.3	4.02	4.30‡
Period 2 revealed dummy	−235.30	−4.46	−3.45‡	27.6	3.34	8.26‡
Period 3 unrevealed dummy	303.84	10.18	8.88‡	24.5	4.67	5.25‡
Period 3 revealed dummy	−211.87	−4.99	−3.53‡	26.5	4.41	6.00‡
Lagged pseudo buyer surplus	−0.45	−3.73	−2.43‡			
Lagged pseudo profit ratio (%)				−17.3	2.01	−8.62‡
% flexible	18.26	0.20	−1.72	−13.3	14.40	−0.92

Panel B: Tests for differences between unrevealed and revealed firm coefficients						
	Diff.	*F*(1,836)	Prob. > *F*	Diff. (%)	*F*(1,402)	Prob. > *F*
Differences in period 2 coefficients	−569.73	46.75	0.000‡	10.3	9.71	0.002‡
Differences in period 3 coefficients	−515.71	79.11	0.000‡	2.0	0.56	0.454

‡Denotes significance at the 99% level of confidence.

had investors allowed production, i.e., it equals zero in the first period of a group interaction and otherwise equals the difference between the prior period's established price and production costs divided by the required capital investment (regardless of whether production occurred or whether the investor provided capital to the entrepreneur).

The regression estimates indicate that investors started by demanding low profit shares, but increased their demands through time whether or not an entrepreneur was revealed as flexible. In period 2, investors punished entrepreneurs that acted opportunistically in period 1 by demanding larger profit shares as predicted. Investors also responded strongly to the prior profitability of the firm, lowering their demanded profit shares for more profitable firms. In unreported analysis, we also find that investors' reactions were stronger when they actually financed the entrepreneur through the BDM procedure than when they merely observed the outcomes by reading ex post reports.

We predict that, when a flexible entrepreneur's type is hidden, he is more likely to produce high quality earlier in the game when the short-run cost of high-quality production is small and the long-run benefit of maintaining his reputation is high. In Table 6 we present the estimate of a logistic regression modeling entrepreneurs' quality choice (1 = high quality, 0 = low). We report robust standard errors clustered by subject to control for repeated measures and session effects (because each subject participated in only one session). We use period 3 (where all flexible entrepreneurs should defect) as our base line.

Variables of interest include dummy variables representing earlier periods and whether the entrepreneur was revealed as flexible going into period 2, the short-run cost of high-quality production, and the long-run benefit from reputation. We define the short-run cost of high-quality production as the difference in the profits that would have been realized if the entrepreneur switched from high quality to low quality. At each node in the game, we define the long-run benefits of reputation formation by computing the average payoffs to each continuing strategy within the session. Then, we take the difference between the highest-average-payoff continuing strategy after high-quality production and the highest-average-payoff strategy continuing after low-quality production at the current node. These variables effectively control for the benefits and opportunity costs of entrepreneur decisions at each node in the game, even though the opportunity costs are not directly observable by the entrepreneur.

Table 6   Logistic Regression for the Quality Choices of Entrepreneurs

Variable	Coefficient	Std. err.	*t*-statistic
Constant (period 3)	−0.9577	0.7925	−1.21
Period 1 dummy	0.8090	0.3967	2.04†
Period 2 unrevealed dummy	1.5778	0.4516	3.49‡
Period 2 revealed dummy	0.4616	0.4095	1.13
Short-run cost	−0.0156	0.0037	−4.26‡
Long-run benefit	0.0041	0.0017	2.48†
% of flexible firms in population	−0.4564	1.3386	−0.34
Observations		423	

‡ and † denote significance at the 99% and 95% level of confidence, respectively.

The estimates are in line with our expectations. Flexible entrepreneurs produced higher quality if their type remained hidden going into period 2. They were slightly less likely to produce high quality in period 2 when revealed (a $\chi^2(1)$-test for the difference in period 2 coefficients is 3.04, $p = 0.0813$). Higher short-run costs of high-quality production reduced average quality whereas higher long-run benefits of reputation increased it. Therefore, although entrepreneurs did not behave like Bayesian rational agents, they appear to have responded to the incentive structure as predicted.

4.6. Assessment and Robustness Checks
We ran several sessions based on the strong parameterization to check our procedures and assess the robustness of our results. We describe these briefly here.

To assess the stage game with the modified BDM procedures, we ran single period games with 50% flexible entrepreneurs. Not allowing reputation formation simplifies the game considerably. Flexible entrepreneurs have a dominant strategy—produce low quality each period. With no reputations to consider, the consumer's problem is simply to determine the frequency with which entrepreneurs will produce low quality and price accordingly. The investor's problem is to demand an appropriate share given the quality distribution and expected prices. Again, there are no reputation issues. In the experiments, flexible entrepreneurs generally defected, producing low quality, 85% of the time.[23] Risk-neutral consumers should price at 700 in theory. If their prices correctly reflected actual defection rates, they should have paid 745. The actual prices averaged 757, significantly higher than the 700 theoretical prediction, but not significantly different from the price based on correctly conjectured entrepreneur behavior. Investors should demand 67% of the proceeds in theory. Because the average profit on the sale of goods was 642, if they correctly conjectured profits, investors should have demanded 62% to break even. In reality, they demanded an average of 71% and made an average profit of 52 francs, significantly higher than zero. We conclude that, in a simpler environment, entrepreneurs generally avoid dominated strategies and the modified BDM procedure yields empirically risk-neutral prices. However, there is a slight upward bias in demanded returns to investors. We conclude that the behavioral deviations from theory observed in other treatments do not result from issues with the stage game or the BDM procedure.

Although three periods per group are sufficient to study reputation formation and early versus late defection, we also ran two-periods-per-group and four-periods-per-group games. Finally, we ran sessions where participants had prior experience in two ways. One session included subjects with experience in two-period games immediately before participating in three-period games. Another session included subjects who had participated in previous sessions. Both sessions produced similar results to each other and to the other three-period game sessions. In all of these sessions, results mirrored the three-periods-per-group treatments reported here. Most firms defect in the final period and many defect earlier. Average prices roughly reflect average values and respond to defections in the predicted direction but by less than the predicted amount. Investors transfer wealth to consumers overall but respond in the predicted directions to defections and past profitability. The only significant difference was that, with experience, investors made positive profits on average. Thus, with experience, investors learn to ask for higher profit shares.

5. Concluding Comments
We highlight an unrecognized benefit of short-term financing by examining the effect of introducing capital markets into a production-market-reputation model. We demonstrate that short-term external finance taxes the short-term gains from opportunistic product quality reductions and thereby increases the ability of firms to commit to high-quality standards in a world where quality is not contractible. Commitment to high-quality standards increases firm profits, investment, and overall welfare.

We then conducted experiments to compare internal and short-term external financing using three parameterizations of our model. The results confirmed the positive effect of external short-term finance on production quality. The propensity to produce high-quality goods increased uniformly when entrepreneurs relied on short-term external financing. For two parameterizations, the likelihood of high-quality production more than doubled when entrepreneurs employed external financing. Moreover, for the parameterization where external financing was predicted to have the greatest impact, the incidence of high-quality production rose from 29% with internal financing to 67% with external financing. Overall production levels also increased uniformly when entrepreneurs relied on external financing. For two parameterizations, the frequency with which entrepreneurs produced goods approximately doubled when they employed external financing. Because it increased the incidence of high-quality production, external financing also increased

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[23] This level remained fairly steady. It was 83% in the first half of the session and 87% in the second half.

economic surplus significantly for one parameterization though it did not have a significant impact for the remaining two.

In the experiments, the mechanism supporting increased reputation building was similar to that underpinning our theoretical predictions. Opportunistic short-term quality-reducing actions resulted in short-term gains coupled with significant reductions in reputation. With short-term external financing, a large fraction of the short-term gain from opportunism was captured by outside claim holders. In fact, the actual tax on opportunism produced in the experiments closely matched the predicted tax. For example, for a parameterization in which high-quality production can only be supported in equilibrium with external short-term financing, the predicted fraction of opportunism gains accruing to insiders, 16.7%, closely matched the actual fraction, 14%. Thus, although subject behavior often differed from our theoretical predictions, the experimental outcomes demonstrate that the incentives driving benefits of short-term finance are robust to the sort of deviations from Bayesian rationality frequently exhibited by human subjects.[24]

In our experiments, investors, entrepreneurs, and consumers all respond to incentives and the trade-offs identified by our theory. However, instead of anticipating equilibrium firm behavior, they appeared to anchor their initial decisions at a focal point and adjust ex post through experience. Moreover, actual experience with opportunistic behavior has a larger effect on behavior than merely observing opportunism. For this reason, we would expect that, in practice, the cost of opportunism to be higher for firms that make repeat sales to the same consumers than for firms that make one-time sales, even if in the one-time case, consumers could observe the losses of other consumers. However, overall, the behavioral response to short-term financing predicted in theory—reduced opportunism—is reflected in behavior. In the final analysis, the tax on opportunism imposed by short-term outside claims in both theory and laboratory experiment reduced opportunistic behavior. As well as being robust to behavioral deviations, we believe the core results of our basic modeling framework are robust to changes in modeling assumptions so long as these changes maintain the flavor of a repeated game in which opportunistic behavior is rewarded

by short-term gains and discouraged by long-term losses, e.g., in an oligopoly model of coordinated production restrictions backed by the threat of switching to Cournot strategies if a member of the cartel exceeds its production quota. However, short-term finance might be an impediment to commitment for other agency and moral hazard problems; ones in which the firm's problem is committing to eschew strategies that involve large short-term losses compensated by small long-term gains, e.g., investment in research and development by an entrepreneur reaping positive but small long-term private benefits from very costly short-term investments in research and development.

Electronic Companion

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[24] Deviations from Nash predictions in our experiments mirror those identified in previous research. As in Camerer and Ho (1999), reputation formation in the experiments was motivated more on experienced rewards from previous rounds of play than by backward induction of optimal actions. As in Brandts and Figueras (2003), deviations from Nash behavioral predictions in our experiments did not eliminate the incentive to sacrifice short-term gains to form reputations.

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