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.

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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.,

$$u_h - u_l > c. \qquad (1)$$

Furthermore, we assume that

$$u_l \leq I, \qquad (2)$$

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

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

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.

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[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.

[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

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

[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

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

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

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

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

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.

"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.
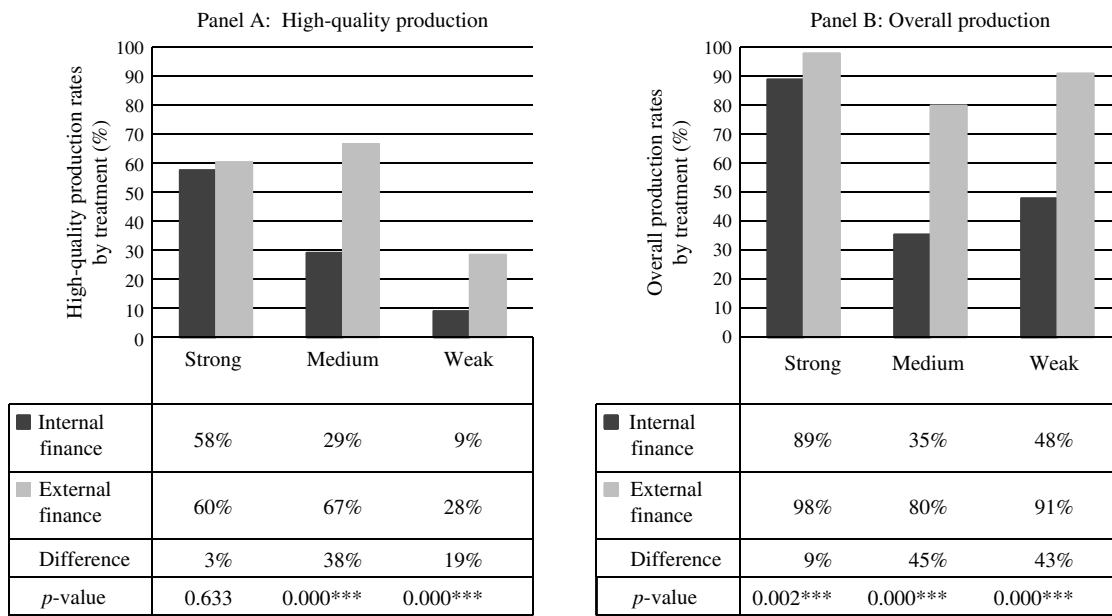
4.2. Overall Production Rates
We expect financing with short-term equity to raise production rates. This effect should be observed under the moderate and weak parameterizations, where external financing should sustain higher rates of production than internal financing. To assess the effects of external 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.
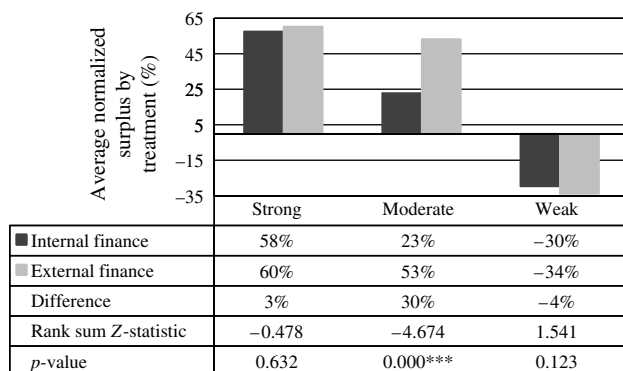
4.4. Defection Rates
Under the moderate parameterization, short-term equity financing should discourage defection in pe-

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
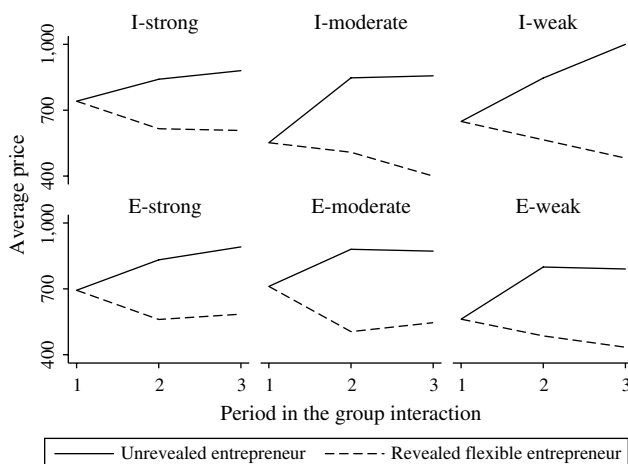
Table 5   Censored Normal Regressions for Consumer and Investor Behavior

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.

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

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

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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Proofs of Statements and Experimental Instructions

EC.1.   Proofs of Statements

Proof of Proposition 1:   Suppose the entrepreneur produces until period n and raises capital by issuing short-term equity. Let α^* represent investors' equilibrium profit share in period n and let p^* represent the good's price in period n. Now consider a type-F entrepreneur's period n decision: his payoff from producing a low quality good is $(1 - \alpha^*)p^*$, which is higher than his payoff from producing a high quality good, $(1 - \alpha^*)(p^* - c)$. Therefore, the entrepreneur's best response is to produce low quality. Next consider equilibria in which the entrepreneur finances his investment with traditional equity. Let δ^* represent investors' equilibrium profit share and let p^* represent the product's price in period n. The entrepreneur's payoff from producing a low quality good in period n is $(1 - \delta^*)p^*$, which is higher than his payoff from producing a high quality good, $(1 - \delta^*)(p^* - c)$. Once again, it follows that the entrepreneur's best response is to produce low quality. Finally, consider equilibria where the entrepreneur finances production internally. The entrepreneur's period n payoff from producing a low quality good is $p^* - I$ which is greater than $p^* - c - I$, his payoff from producing high quality. This concludes our proof. $\square$

LEMMA EC-1. *In any equilibrium, once it is common knowledge that the entrepreneur is type-F, consumers will only pay u_l for the good.*

Proof of Lemma ec-1:   If the entrepreneur produces low quality in every period, the consumers' best response is to pay u_l. Moreover, if consumers pay u_l in each period, the entrepreneur's best response is to produce low quality. This establishes that there is an equilibrium for a subgame following the revelation that the entrepreneur is type-F in which consumers pay u_l in every period.

Now we establish the uniqueness of this outcome. Consider the case where the entrepreneur relies on internal financing. Arguments that are virtually identical to those we employ in the proof of Proposition 1 establish that, if the entrepreneur's future payoff is not sensitive to his quality choice, his best response is to produce low quality. Moreover, given the entrepreneur will produce low quality, the consumers' best response is to pay u_l. Now consider the possibility that the price of the good varies over time. The entrepreneur can only be induced to produce high quality and the consumer to pay more than u_l when the entrepreneur expects to incur a sufficiently large drop in his payoff if he produces low quality. It is clear from the proof of Proposition 1 that the entrepreneur will produce low quality in period n and consumers will pay u_l in period n. Thus in period $n - 1$, the entrepreneur can produce low quality without incurring any change in his future expected payoff, and because producing low quality is his best response to any price p^* in period $n - 1$, the entrepreneur will produce low quality. It is clear that the consumers' best response in period $n - 1$ is to pay u_l. By induction, it is clear that the entrepreneur will not produce high

quality in any period subsequent to the revelation that he is type-F. Moreover, consumers will pay only u_l in every period. A simple extension of this argument establishes the desired result in the cases where the entrepreneur employs either short-term or traditional equity financing. $\quad\square$

Proof of Proposition 2: First, we show that (8) is a necessary and sufficient condition for a reputation equilibrium when the entrepreneur finances internally. Then we demonstrate that, when (8) is satisfied, the reputation equilibrium with internal financing is unique. We conclude the proof by establishing our claims regarding the reputation equilibrium when the entrepreneur employs traditional equity financing.

Internal financing Let $Y^+ = u_h - c - I$ and $\bar{Y} = \bar{p} - I$. Suppose that the entrepreneur has only produced high quality until there are $k > 1$ periods remaining. Then the entrepreneur's expected payoff from producing high quality goods until the final period equals

$$(k-1)\,Y^+ + \bar{Y}. \tag{ec-1}$$

In contrast, if he switches to producing low quality in period $n - k$, the entrepreneur will be identified as F. From Lemma ec-1 it follows that he will not be able to profitably undertake the project in any future period. Consequently, the present value of his payoffs through period n equals $Y^+ + c$. It follows that producing high quality goods in all periods before n is a best response if and only if

$$\min_{1 < k \le n} \left[(k-1)\,Y^+ + \bar{Y}\right] > Y^+ + c. \tag{ec-2}$$

First note that (ec-2) must be satisfied for period $n - 1$, i.e., $k = 2$. In this case (ec-2) reduces to (8), establishing that (8) is a necessary condition for a reputation equilibrium. To see that (8) is sufficient for the existence of a reputation equilibrium, note that the left hand side of (ec-2) is increasing in k since $Y^+ > 0$ by Assumption (3). Thus, (ec-2) is satisfied whenever (8) is satisfied. This, concludes our sufficiency proof when the entrepreneur finances internally.

Now we establish uniqueness by means of a contradiction. Suppose there exists an equilibrium where type-F produces low quality prior to period n. Note that, so long as type-H earns a profit in every period, in any equilibrium in which type-F randomizes before period n it must be the case that the posterior probability of H conditioned on high quality output in all remaining periods must be greater than π. For this reason, even though low quality is a strictly dominant strategy for type-F in period n, it must be the case that the probability of high quality production must be more than π. Thus, the equilibrium price in period n, $p^* > \bar{p}$. Let ρ^* represent the equilibrium period n probability of type-H on which consumers base their purchase price.

For type-F to be willing to defect from high quality production in period $n - 1$, the gain from defection must be at least as large as the cost of defection, i.e., $p^* - c - I \le 0$. Note however, that

because $p^* > \bar{p}$, this contradicts our maintained assumption (8). Thus, type-F will not defect from high quality production in period $n-1$. Now consider period $n-2$. Once again, the entrepreneur will only opt for low quality production if the gain from producing low quality more than offsets the loss of future profits, i.e., $Y^+ + p^* - c - I \leq 0$. Note however that, this condition is violated because (8) is satisfied demonstrating that, once again, type-F will not defect from high quality production in period $n-2$. Now note that, based on the argument we have just employed, while the gain from deviating from high quality production remains unchanged at c as we move backward in time, the cost of deviating increases so long as (8) is satisfied. Thus, when defection from high quality production is not optimal in period $n-2$, it will not be optimal in any period earlier than $n-2$. Consequently, there cannot exist an equilibrium where type-F will defect from high quality production prior to period n.

Traditional equity financing   Suppose the entrepreneur employs traditional equity financing and has only produced high quality until there are $k > 1$ periods remaining. Then the entrepreneur's expected payoff from producing high quality goods until the final period equals

$$(1-\delta)[(k-1)(Y^+ + I) + (\bar{Y} + I)]. \tag{ec-3}$$

In contrast, if he switches to producing low quality in period $n - k$, the entrepreneur will be identified as F. From Lemma ec-1 it follows that he will not be able to profitably undertake the project in any future period. He will however be able to enjoy a $1-\delta$ share of the uninvested capital $(k-1)I$. Therefore, the present value of his payoffs through period n equals $(1-\delta)[(Y^+ + I + c) + (k-1)I]$. It follows that producing high quality goods in all periods before n is a best response if and only if

$$\min_{1 < k \leq n} (1-\delta)\left[(k-1)(Y^+ + I) + (\bar{Y} + I)\right] > (1-\delta)[(Y^+ + I + c) + (k-1)I], \tag{ec-4}$$

or equivalently,

$$\min_{1 < k \leq n} \left[(k-1)Y^+ + \bar{Y}\right] > Y^+ + c. \tag{ec-5}$$

The above condition is equivalent to (ec-2). Therefore, (8) is both necessary and sufficient for a reputation equilibrium with traditional equity financing. The proof of the uniqueness of this equilibrium follows from a minor extension of the uniqueness proof for internal financing after noting that the terms of the equity financing are fixed at time 0 ensuring that the entrepreneur has to give up a fixed share of both the benefits and costs of defecting to producing low quality goods.   □

Proof of Proposition 3: Suppose that the entrepreneur has only produced high quality until there are period $k > 1$ periods remaining. Then the entrepreneur's expected payoff from producing high quality goods until the final period equals

$$(k-1)\,(1-\alpha^+)\,(Y^+ + I) + (1 - \bar{\alpha})\,(\bar{Y} + I). \tag{ec-6}$$

In contrast, if he produces a low quality, the entrepreneur will be identified as F. Thus, because Lemma ec-1 establishes that in any period revenue can only equal u_l, if $u_l < I$ investors will refuse to finance the project while if $u_l = I$, they will demand 100% of the equity. In either case the entrepreneur's expected future payoff is 0. Consequently, the present value of his payoffs through period n equals $(1 - \alpha^+)\,(Y^+ + I + c)$. Producing high quality for all periods before n is a best response if and only if

$$\min_{1 < k \leq n}\ \left[(k-1)\,(1-\alpha^+)\,(Y^+ + I) + (1-\bar{\alpha})\,(\bar{Y}+I)\right] > (1-\alpha^+)\,(Y^+ + I + c). \tag{ec-7}$$

First note that (ec-7) must be satisfied for period $n-1$, i.e., $k = 2$. In this case (ec-7) reduces to (9), establishing that (9) is a necessary condition for a reputation equilibrium. Next note that the left hand side of (ec-7) is increasing in k since $(1 - \alpha^+)\,(Y^+ + I) = Y^+ > 0$. Thus, (ec-7) is satisfied for all periods when (9) is satisfied, establishing sufficiency.

We conclude the proof by establishing the uniqueness of this equilibrium. For a mixed strategy equilibrium, let α_t^* represent the equilibrium level of α in period t; let ρ_t^* represent the period t posterior probability that the entrepreneur is type-H; let p_t^* represent the equilibrium price in period t. Note that, so long as type-H earns a profit in every period, in any equilibrium in which type-F randomizes before period n it must be the case that $\rho_n^* > \pi$ and $p_n^* > \bar{p}$. Because, in equilibrium, α is decreasing in the probability of high quality production, it must be the case that in period n,

$$\alpha_n^* < \bar{\alpha}, \tag{ec-8}$$

and in any mixed strategy equilibrium

$$\alpha_{n-1}^* > \alpha^+. \tag{ec-9}$$

Thus, (ec-8) and $p_n^* > \bar{p}$ imply that

$$(1 - \alpha_n^*)\,p_n^* > (1 - \bar{\alpha})\,\bar{p}, \tag{ec-10}$$

and (ec-9) implies that

$$(1 - \alpha_{n-1}^*)\,c < (1 - \alpha^+)\,c. \tag{ec-11}$$

Randomization in period $n-1$ requires that

$$(1 - \alpha_n^*)\,p_n^* - (1 - \alpha_{n-1}^*)\,c \leq 0. \tag{ec-12}$$

However, as (ec-10) and (ec-11) show, (ec-12) cannot be satisfied if (9) is satisfied. Thus, type-F will not randomize in period $n-1$. This implies that in period $n-1$, type-F must follow the pure strategy of producing high quality.

Now consider period $n-2$. Randomization in period $n-2$ requires that

$$(1-\alpha^+)\,(p^+ - c) + (1-\alpha_n^*)\,p_n^* - (1-\alpha_{n-2}^*)\,c \leq 0. \tag{ec-13}$$

However, because, in equilibrium, α is decreasing in the probability of high quality production $(1-\alpha_{n-2}^*)\,c < (1-\alpha^+)\,c$. Further, because $p_n^* > \bar{p}$ and $\alpha_n^* < \bar{\alpha}$

$$(1-\alpha^+)\,(p^+ - c) + (1-\alpha_n^*)\,p_n^* > (1-\alpha^+)\,(p^+ - c) + (1-\bar{\alpha})\bar{p}, \tag{ec-14}$$

and because, as we have just demonstrated, when (9) is satisfied

$$(1-\alpha^+)\,(p^+ - c) + (1-\bar{\alpha})\,\bar{p} > (1-\bar{\alpha})\,\bar{p}. \tag{ec-15}$$

Thus (ec-13) cannot be satisfied when (9) is satisfied. This establishes that F will not randomize in period $n-2$. The case for $t < n-2$ follows by induction. Thus, when (9) holds, there will not exist an equilibrium where type-F defects to low quality in any period $t < n$.   □

Proof of Proposition 4:   First note that, if the entrepreneur finances internally or employs traditional equity financing, producing high quality for all periods before n is a best response if and only if (ec-2) is satisfied. Similarly, if the entrepreneur is restricted to short-term equity finance, producing high quality for all periods before n is a best response if and only if (ec-7) is satisfied. Thus, to show that the set of parameters that supports reputation equilibria with short-term equity finance contains the set of parameters that supports reputation equilibria with internal finance and traditional equity financing, we have to demonstrate that (ec-7) is satisfied whenever (ec-2) is satisfied, i.e.,

$$(1-\bar{\alpha})\,(\bar{Y} + I) - (1-\alpha^+)\,c > \bar{Y} - c, \tag{ec-16}$$

for all $k < n$. For this condition to hold, we need to show that

$$\alpha^+\,c > (\bar{\alpha}(\bar{Y} + I) - I). \tag{ec-17}$$

Now note that

$$\frac{\alpha^+\,c}{I} = \frac{c}{u_h - c} \tag{ec-18}$$

$$\frac{\bar{\alpha}(\bar{Y} + I) - I)}{I} = \frac{c\,\pi}{\pi\,u_h + (1-\pi)\,u_l - \pi\,c}. \tag{ec-19}$$

Because

$$\pi(u_h - c) - (\pi\,u_h + (1-\pi)\,u_l - \pi\,c) = -(1-\pi)\,u_l \tag{ec-20}$$

we see that

$$\alpha^+ c > (\bar{\alpha}(\bar{Y} + I) - I) \tag{ec-21}$$

must hold which implies, *a fortiori* that (ec-17) holds. □

Proof of Proposition 5: If condition (8) is satisfied then by Propositions 2 and 3 equilibrium production strategies and thus expected firm payoffs are the same, i.e.,

$$x_t^f(q_t^*, \tau) = x_t^*(\tau) = \begin{cases} p^+ - c & \text{if } t < n \\ \bar{p} - c & \text{if } t = n \text{ and } \tau = H \\ \bar{p} & \text{if } t = n \text{ and } \tau = F \end{cases} \quad f = \text{TEq}, \text{STEq}, \text{ or INT.} \tag{ec-22}$$

Let X^* represent total expected payoffs at date 0:

$$X^*(\tau) = \sum_{t=1}^{n} x_t^*(\tau). \tag{ec-23}$$

Let $V^f(\tau)$ represent the total expected value of claims issued to outsiders by type-τ conditioned on the information available at date 0 given financing plan f and given the equilibrium product quality strategy; let $v_t^f(\tau)$ represent the expected value of payments to outsiders at date t by type-τ conditioned on date 0 information and financing form f. Then. the equilibrium expected payoff at date 0 to type-τ under external financing regime f can be expressed as

$$X^*(\tau) - V^f(\tau) = X^*(\tau) - n I + (n I - V^f(\tau)). \tag{ec-24}$$

If the firm finances internally the expected equilibrium date 0 payoff to insiders is given by

$$X^*(\tau) - V^f(\tau) = X^*(\tau) - n I. \tag{ec-25}$$

Since the cash flows to H types are always smaller than the cash flows to F types, and in expectation claim value always equals the funds required for investment, claims issued by F types will always be overvalued, i.e. for both financing regimes

$$I - V^f(H) > 0. \tag{ec-26}$$

Comparing (ec-26) and (ec-25) we see that the payoff to type-F is always higher under external finance that it is under internal finance. Next we compare traditional with short-term equity. From (ec-25) we see that type-H will prefer the plan that produces the greatest overvaluation it its claim, $n I - V^f(\tau)$. To determine overvaluation first note that

$$V^f(\tau) = \sum_{t=1}^{n} v_t^f(\tau). \tag{ec-27}$$

The fact that the capital market is competitive implies that

$$\pi V^f(F) + (1 - \pi)V_f(H) = n I. \tag{ec-28}$$

(ec-28) implies that undervaluation gain to H is given by

$$nI - V^f(H) = (1 - \pi)\left(V^f(F) - V^f(H)\right). \tag{ec-29}$$

In the reputation equilibrium, cash flow for the two types are the same in the first $n - 1$ periods. Thus, from (ec-27) we see that the mispricing gain is given by

$$(1 - \pi)\left(V^f(F) - V^f(H)\right) = (1 - \pi)\left(v_n^f(F) - v_n^f(H)\right). \tag{ec-30}$$

Next note that

$$(1 - \pi)\left(v_n^{\text{TEq}}(F) - v_n^{\text{TEq}}(H)\right) = (1 - \pi)\,\pi\,\bar{\alpha}c \tag{ec-31}$$

$$(1 - \pi)\left(v_n^{\text{STEq}}(F) - v_n^{\text{STEq}}(H)\right) = (1 - \pi)\,\pi\,\delta c. \tag{ec-32}$$

Thus, the overvaluation gain to F will be larger under short-term equity if and only if $\delta < \bar{\alpha}$. Next note that, in fact, $\delta < \bar{\alpha}$. This follows from simple computation; the value of $\bar{\alpha}$ is given by (6). The value of δ is computed from the competitive market condition for traditional equity, (7), using the equilibrium behavior in the reputation formation equilibria. Thus δ is fixed by the following equation

$$n\,I = \delta\left((n - 1)(p^+ - c) + (\bar{p} - \pi\,c)\right). \tag{ec-33}$$

Thus,

$$\delta = \frac{I}{\frac{n-1}{n}(p^+ - c) + \frac{1}{n}(\bar{p} - \pi\,c)} < \frac{I}{\bar{p} - \pi\,c} = \bar{\alpha}. \tag{ec-34}$$

□

Proof of Proposition 6: The existence and uniqueness of the equilibria follows directly from Propositions 2 and 3. The product and capital market prices follow directly from the equilibrium outcomes described in these propositions. □

Proof of Proposition 7: First we will establish that no equilibria in pure strategies exist. Then we will establish our claim regarding pooling equilibria.

Note that, given (10), there cannot exist equilibria where type-F only produces low quality or switches from producing low quality to producing high quality. We now demonstrate that, given (11), there cannot exist equilibria in which type-F switches from high quality to low quality. Combined with Proposition 1 this ensures that there cannot exist any equilibria where type-F produces high quality.

Suppose there exists an equilibrium where, type-F produces high quality until period $t \leq n$, and then switches to producing low quality. Also suppose that type-H continues to produce. Given that consumers will price the product based on their priors in period t, it follows from (11) that type-H

will find production uneconomic. This contradiction proves that there cannot exist an equilibrium in which type-H produces in the period in which type-F is expected to switch to low quality. Now suppose that there exists an equilibrium where, type-F produces high quality until period $t \leq n$, and then switches to producing low quality. Also suppose that type-H does not produce in period t. Then in period t the product will be priced at u_l. However, from (10) it follows that production is uneconomic for type-F. Thus, there cannot exist such equilibria. It follows that the only potential equilibria are ones where type-F produces high quality until some period t and then ceases production. However, these equilibria are ruled out by Proposition 1.

Now we will establish our claim regarding pooling equilibria. First we show that consumer prices are consistent with rational expectations: Given that only type-F is capable of producing low quality and given that type-F never produces high quality after producing low quality, the consumer belief that all goods produced subsequent to the production of low quality are low quality is consistent with rational expectations. Moreover, such a belief supports the prices specified following the first instance of low quality production. Now, consider prices when low quality has not been produced in a previous period. First consider period 1. Because the entrepreneur is producing high quality with probability 1, the consumer's belief that the market is producing high quality with probability 1 is consistent with rational expectations and justifies the price specified in the equilibrium. In period 2, if type-F produces high quality with probability 3/5 and type-H with probability 1, given the prior that the entrepreneur is type-H is 3/4, the probability of high quality production in period 2 must equal 0.90. This implies a price of $u_h(0.90) + u_l(0.10) = 940$, the price specified in the equilibrium. Now consider the last period; Bayes rule implies that consumers assesses the likelihood that an entrepreneur producing high quality in periods 1 and 2 is type-F at

$$\frac{\frac{1}{4} \times \frac{3}{5}}{\frac{1}{4} \times \frac{3}{5} + \frac{3}{4}} = \frac{1}{6}. \tag{ec-35}$$

Thus, rational expectations requires that consumers offer

$$\frac{5}{6}u_h + \frac{1}{6}u_l = 900, \tag{ec-36}$$

exactly the price specified in the equilibrium.

Next we show that, given consumer offers, type-F's strategies are sequentially rational. First consider the last period, period 3. In this period low quality is clearly optimal for type-F. Moreover, if the entrepreneur has ever failed to produce high quality in a previous period, then the price that will be offered for his goods, which equals 400 (u_l) is less than the production cost of 500, hence the entrepreneur's payoff is maximized by shutting down as specified in the equilibrium. It only remains to consider quality decisions of type-F given that he has never failed to produce high

quality in a previous period. First consider period 2. In period 2, high quality production costs $c + I = 900$ while low quality production costs $I = 500$. Thus, switching to low quality will yield a gain of $c = 400$. The cost of low quality is that profits from period 3 production will be lost. These profits equal the period 3 price less the cost of low quality production, i.e., they equal $900 - I = 400$. Thus, type-F is indifferent between high and low quality. This payoff structure rationalizes the equilibrium strategy of randomizing in period 2. Now consider period 1. Producing low quality in period 1 saves the entrepreneur $c = 400$ in operating costs. The loss is the foregone profit from producing in periods 2 and 3, which equals $940 - 500 = 440$ Thus, producing high quality in period 1, as specified in the equilibrium is rational for type-F. $\square$

Proof of Proposition 8:   The existence and uniqueness of the equilibria follows directly from Proposition 3. The product and capital market prices follow directly from the equilibrium outcomes described in Proposition 3. $\square$

Proof of Proposition 9:   First note that if production occurs in period $t > 1$, the market price must at least equal 900 for entrepreneurs that produce high quality in all previous periods. We establish this result by means of a contradiction. Suppose the period t price is less than 900 if an entrepreneur produced high quality in all prior periods. Because the price is lower than the production cost for type-H, type-H will not produce. This implies that the price must be $400 = u_l$. However, at this price, because $400 < I$, even type-F will not produce. Further, by Proposition 1, type-F will have produced low quality in period $t - 1$ as it was his last period of production.

For a price of 900 or above to satisfy rational expectations, there must be no more than a $\frac{1}{6}$ probability that the low quality is produced. Consider a candidate equilibrium and let, σ_t be the likelihood that type-F produces low quality at date $t = 1, 2$ given that he has never failed in the past to produce high quality. Bayes rule implies that, for the likelihood of low quality (conditioned on no failure to produce high quality in the past) to at least equal $\frac{1}{6}$ in periods 1, 2, and 3, given that the prior probability of an entrepreneur being type-F is $\frac{3}{4}$ as is assumed by Parameterization 3, the following inequalities must be satisfied:

$$\frac{3\sigma_1}{4} \leq \frac{1}{6} \tag{ec-37}$$

$$\frac{3(1-\sigma_1)\sigma_2}{4\left(\frac{3(1-\sigma_1)}{4} + \frac{1}{4}\right)} \leq \frac{1}{6} \tag{ec-38}$$

$$\frac{3(1-\sigma_1)(1-\sigma_2)}{4\left(\frac{3}{4}(1-\sigma_1)(1-\sigma_2) + \frac{1}{4}\right)} \leq \frac{1}{6} \tag{ec-39}$$

$$\sigma_1 \in [0,1] \tag{ec-40}$$

$$\sigma_2 \in [0,1]. \tag{ec-41}$$

However, no solution to this system of inequalities exists. Thus, there exists no equilibrium in which production occurs.

At the same time note that an equilibrium does exist in which production fails in all periods. To see this note that if, in period 3, consumers offer a price less than 900, production will cease because type-H will lose from producing. So to show that an equilibrium exists in which no production occurs we need only rationalize a price less than 900 at all nodes of the game. After low quality production, a price of less than 900 can always be rationalized by the belief that the good is being offered by type-F who will produce low quality. The problem is how to rationalize low prices after high quality production.

Bayes rule implies that, for the likelihood of low quality (conditioned on no failure to produce high quality in the past) to be greater than $\frac{1}{6}$ in periods 1, 2, and 3, given that the prior probability that an entrepreneur is type-F is $\frac{3}{4}$ as given in Parameterization 3, the following inequalities must be satisfied:

$$\frac{3\sigma_1}{4} > \frac{1}{6} \tag{ec-42}$$

$$\frac{3(1-\sigma_1)\sigma_2}{4\left(\frac{3(1-\sigma_1)}{4} + \frac{1}{4}\right)} > \frac{1}{6} \tag{ec-43}$$

$$\frac{3(1-\sigma_1)(1-\sigma_2)}{4\left(\frac{3}{4}(1-\sigma_1)(1-\sigma_2) + \frac{1}{4}\right)} > \frac{1}{6} \tag{ec-44}$$

$$\sigma_1 \in [0,1] \tag{ec-45}$$

$$\sigma_2 \in [0,1]. \tag{ec-46}$$

This system of equations has many solutions, e.g., $\sigma_1 = \frac{3}{8}$ and $\sigma_2 = \frac{5}{16}$. Given this pattern of randomization by type-F, rational prices are less than 900. This implies that type-H cannot profit from production at any node, thus production fails and there is no output at any date or history of the game. $\square$

Proof of Proposition 10: Let p_t represent the equilibrium price in period t for output from "unrevealed entrepreneurs," entrepreneurs who have never failed to produce high quality. Let q_t represent the probability in period t that an unrevealed entrepreneur produces low quality. Let σ_t be the probability that type-F produces low quality in period $t = 1, 2, 3$ even when he is unrevealed. Let α_t represent the fraction of the entrepreneur's cash flow demanded by the investor in exchange for providing financing. Next note that, at unrevealed nodes, rational expectations on the part of consumers is satisfied if and only if

$$p_t = p(q_t), \quad t = 1, 2, 3. \tag{ec-47}$$

The competitive capital market and rational expectations for investors is satisfied if and only if

$$\alpha_t = \alpha(q_t) \quad t = 1, 2, 3. \tag{ec-48}$$

Bayes rule is satisfied if and only if (given the prior probability of type-F is 3/4)

$$q_1 = \frac{3}{4}\sigma_1, \tag{ec-49}$$

$$q_2 = \frac{3\left(1-\sigma_1\right)\sigma_2}{4\left(\frac{3}{4}\left(1-\sigma_1\right)+\frac{1}{4}\right)}, \tag{ec-50}$$

$$q_3 = \frac{3\left(1-\sigma_1\right)\left(1-\sigma_2\right)}{4\left(\frac{3}{4}\left(1-\sigma_1\right)\left(1-\sigma_2\right)+\frac{1}{4}\right)}. \tag{ec-51}$$

Randomization is a best response for an unrevealed type-F in both period 1 and period 2 if and only if

$$\left(\left(1-\alpha_t\right)\left(p_t - c\right) + \left(1 - \alpha_{t+1}\right)p_2\right) - \left(1 - \alpha_t\right)p_t = 0, \quad t = 1, 2 \tag{ec-52}$$

In period 3, the strategy of always producing low quality ($\sigma_3 = 1$) is clearly the unique best response for type-F.

We aim to verify the existence of an equilibrium with the following properties: at all revealed histories of the game, histories subsequent to a failure of the entrepreneur to produce high quality, consumers price the good at $u_l = 400$. At all such histories, the investor refuses to provide funding. At unrevealed histories, the actions of consumers, entrepreneurs and capitalists are defined as follows: First, let x^* represent the unique real number in the interval $(0, 1)$ which solves the equation

$$-42450 + 376491\,x - 1298865\,x^2 + 2377271\,x^3 -$$
$$2535761\,x^4 + 1591842\,x^5 - 547880\,x^6 + 80000\,x^7 = 0; \tag{ec-53}$$

and let y^* represent the unique real number in the interval $(0, 1)$ which solves the equation

$$-3804480 + 21742776\,y - 57235260\,y^2 + 91050246\,y^3 -$$
$$91564373\,y^4 + 56230563\,y^5 - 18789162\,y^6 + 2753440\,y^7 = 0. \tag{ec-54}$$

Define candidate actions at unrevealed histories as follows:

$$\sigma_1^* = \frac{4}{3}x^*, \quad \sigma_2^* = y^*, \quad \sigma_3^* = 1$$
$$q_1^* = \frac{3}{4}\sigma_1^*, \quad q_2^* = \frac{3\left(1-\sigma_1^*\right)\sigma_2^*}{4\left(\frac{3}{4}\left(1-\sigma_1^*\right)+\frac{1}{4}\right)}, \quad q_3^* = \frac{3\left(1-\sigma_1^*\right)\left(1-\sigma_2^*\right)}{4\left(\frac{3}{4}\left(1-\sigma_1^*\right)\left(1-\sigma_2^*\right)+\frac{1}{4}\right)}$$
$$p_t^* = 400\,q_t^* + 1000\left(1-q_t^*\right) \quad t = 1, 2, 3$$
$$\alpha_t^* = \frac{5}{2(3-q_t^*)} \quad t = 1, 2, 3. \tag{ec-55}$$

A numerical approximation to this exact solution is given by

$$\sigma_1^* = 0.364, \sigma_2^* = 0.589, \sigma_3^* = 1.000,$$
$$q_1^* = 0.273, q_2^* = 0.387, q_3^* = 0.440,$$
$$p_1^* = 836.367, p_2^* = 768.055, p_3^* = 736.244,$$
$$\alpha_1^* = 0.917, \alpha_2^* = 0.957, \alpha_3^* = 0.976.$$

(ec-56)

The reader can verify that (ec-55) satisfies the equilibrium conditions, (ec-47), (ec-48), (ec-49), (ec-50), (ec-51), (ec-52). Verification can be effected either by substituting the exact solution (ec-55) into a symbolic algebra programming language, e.g., Mathematica, or by substituting the approximate solution, (ec-56) into the same equations in which case the equalities will only be approximately satisfied. □

EC.2. Debt Financing

In the existing model, the entrepreneur has perfect information regarding the firm's future cash flows, and knows that the firm will either default with probability 0 or with probability 1. Under the standard absolute priority assumption, the entrepreneur will never issue debt if he knows the probability of default is 1, ensuring that he will only issue debt when the default probability is 0. If the firm never defaults, then the value of the debt claim will be independent of the entrepreneur's private information ensuring that his actions will not affect the value of outsiders' claims. It follows that the value of debt will not vary with product quality choices. Therefore, when the entrepreneur does not face uncertainty about default, short-term debt finance will not affect product quality. Consequently, for interesting results, there must be uncertain default. Therefore, we present a modified model with a production shock that includes this possibility and demonstrate that our results are robust to this change. The modification we make generates the necessary uncertainty in the most tractable manner possible.

Until he incurs a production shock, a high quality, type-H, entrepreneur can only produce high quality (h) goods and a flexible, type-F, entrepreneur has the option of producing either high or low quality (l) goods each period. The production shock is observed by consumers and investors and, thus, its occurrence is common knowledge. Once the entrepreneur experiences a shock, regardless of his type, he is unable to produce high quality output in the current period and all future periods. The production shock is stochastic and, regardless of the entrepreneur's type, occurs with probability $1 - \theta$ in each period. The production shock occurs after the entrepreneur's production choice and the investment for the period have been made but before production occurs. Therefore, the possibility of a production shock ensures that payments to outsiders are risky conditioned on the entrepreneur's information and production choice.

To ensure that the expected increase in a consumer's utility from improved product quality exceeds the incremental cost of producing high quality, we restrict attention to

$$c < \theta(u_h - u_l). \tag{ec-57}$$

To ensure that high quality production has a positive NPV so long as investors and consumers 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

$$\theta \bar{p} + (1 - \theta) u_l - c - I > 0. \tag{ec-58}$$

The entrepreneur can employ internal financing, short-term equity financing, or short-term debt financing. If the entrepreneur has not experienced a production shock in the current or past periods, the price consumers pay for the good can be represented by $p(\rho, q)$, where

$$p(\rho, q) = \rho\, u_h + (1 - \rho)\,(q\, u_h + (1 - q)\, u_l). \tag{ec-59}$$

Let $p^+ = p(\rho, 1) = u_h$ $(\bar{p} = p(\pi, 0))$ continue to denotes the price consumers pay when they assess probability π to the entrepreneur being type H and believe that type F will (will not) produce high quality.

If investors and consumers believe that the entrepreneur is type H with probability ρ and will produce high quality with probability q contingent on being type F, investors will demand a profit share of

$$\alpha(\rho, q) = \frac{I}{\theta\, p(\rho, q) + (1 - \theta)\, u_l - (1 - (1 - \rho)\,(1 - q))\, c}, \tag{ec-60}$$

when the entrepreneur raises short-term equity, and a promised repayment $D(\rho, q)$, where

$$D(\rho, q) = \frac{I - (1 - \theta)[u_l - (1 - (1 - \rho)\,(1 - q))\, c]}{\theta} > u_l, \tag{ec-61}$$

when the entrepreneur issues short-term debt. Thus, so long as investors and consumers share the belief that the entrepreneur is type H with probability $\rho \geq \pi$, the entrepreneur will default on his debt obligation if he incurs a production shock but will be able to replay his debt in full if he does not incur a production shock. Investors will not finance the entrepreneur if they believe that consumers will pay u_l for the good as the investment has a negative NPV.

Let $\alpha^+ = \alpha(\pi, 1)$ $(\bar{\alpha} = \alpha(\pi, 0))$ continue to denote the investors' profit share when both consumers and investors assess probability π to the entrepreneur being type H and believe that type F will (will not) produce high quality. Similarly, let $D^+ = D(\pi, 1)$ $(\bar{D} = D(\pi, 0))$ denote the investors' promised payment when both consumers and investors assess probability π to the entrepreneur being type H and believe that type F will (will not) produce high quality.

Despite the modification to our model, as we demonstrate in the following propositions, there continue to exist reputation equilibria where the entrepreneur produces high quality until period n or until he suffers a production shock. Reputation equilibria are supported by internal, short-term equity and, short-term debt financing. External short-term financing supports reputation equilibria over a larger parameter set than internal financing.

PROPOSITION EC.1. *If the entrepreneur employs internal finance, there exists a reputation equilibrium in which only high quality is produced until period n or until a production shock is observed, if and only if*

$$\theta \left[\theta \bar{p} + (1 - \theta) u_l - I \right] - c > 0. \tag{ec-62}$$

Further, this reputation equilibrium is the only equilibrium supported by parameter values satisfying (ec-62).

Proof of Proposition EC.1: First, we show that (ec-62) is a necessary and sufficient condition for a reputation equilibrium. We conclude the proof by demonstrating that, when (ec-62) is satisfied, the reputation equilibrium is the unique equilibrium.

Let $Y^+ = \theta u_h + (1 - \theta) u_l - c - I$ and $\bar{Y} = \theta \bar{p} + (1 - \theta) u_l - I$. Suppose that the entrepreneur has not experienced a production shock and has only produced high quality until period $n - k - 1$. Then, in period $n - k$, by producing high quality until the final period the entrepreneur's expected payoff equals

$$\sum_{j=0}^{k-1} \theta^j Y^+ + \theta^k \bar{Y}. \tag{ec-63}$$

In contrast, if he switches to producing low quality in period $n - k$, the entrepreneur will be identified as F. Thus, he will not be able to profitably undertake the project. Consequently, the present value of his payoffs through period n equals $Y^+ + c$. It follows that producing high quality for all periods before n is a best response if and only if

$$\min_{1 \leq k < n} \left[\sum_{j=1}^{k-1} \theta^j Y^+ + \theta^k \bar{Y} \right] > c. \tag{ec-64}$$

First note that (ec-64) must be satisfied for period $n - 1$. However, in this case (ec-64) reduces to (ec-62), establishing that (ec-62) is a necessary condition for a reputation equilibrium.

To see that (ec-62) is sufficient for the existence of a reputation equilibrium, note that the left hand side of (ec-64) is increasing in k if and only if

$$Y - (1 - \theta) \bar{Y}$$
$$= \theta p^+ + (1 - \theta) u_l - c - I - (1 - \theta) \left[\theta \bar{p} + (1 - \theta) u_l - I \right] > 0. \tag{ec-65}$$

However, noting that $p^+ = \bar{p} + (1 - \pi)(u_h - u_l)$, it follows that

$$\theta \, p^+ + (1 - \theta) \, u_l - c - I - (1 - \theta) \, [\theta \, \bar{p} + (1 - \theta) \, u_l - I]$$
$$= \theta \, [\theta \, \bar{p} + (1 - \theta) \, u_l - I] - c + \theta \, (1 - \pi) \, (u_h - u_l) > 0. \tag{ec-66}$$

This result follows because (ec-62) is satisfied and the last set of terms in this expression is positive. Thus, (ec-65) is satisfied whenever (ec-62) is satisfied. This, concludes our sufficiency proof because it establishes that (ec-64) is satisfied whenever (ec-62) is satisfied.

Now we establish uniqueness by means of a contradiction. Suppose there exists an equilibrium where type F produces low quality prior to period n. Note that, so long as type H earns a profit in every period, in any equilibrium in which type F randomizes before period n it must be the case that the posterior probability of H conditioned on high quality output in all remaining periods must be greater than π. For this reason, even though low quality is a strictly dominant strategy for type F in period n, it must be the case that the probability of high quality production must be more than π. Thus, the equilibrium price in period n, $p^* > \bar{p}$. Let ρ^* represent the equilibrium period n probability of type H on which consumers base their purchase price.

For type F to be willing to defect from high quality production in period $n - 1$, the gain from defection must be at least as large as the cost of defection, i.e., $\theta \, (\theta \, p^* + (1 - \theta) \, u_l - I) - c \leq 0$. Note however, that because $p^* > \bar{p}$, this contradicts our maintained assumption (ec-62). Thus, type F will not defect from high quality production in period $n - 1$. Now consider period $n - 2$. Once again, the entrepreneur will only opt for low quality production if the gain from producing low quality more than offsets the loss of future profits, i.e., $\theta \, Y^+ + \theta^2 \, (\theta \, p^* + (1 - \theta) \, u_l - I) - c \leq 0$. Note however that, because (ec-62) is satisfied,

$$\theta \, Y^+ + \theta^2 \, (\theta \, p^* + (1 - \theta) \, u_l - I) - \theta \, (\theta \, p^* + (1 - \theta) \, u_l - I)$$
$$\theta \, p^+ + (1 - \theta) \, u_l - c - I - (1 - \theta) \, [\theta \, p^* + (1 - \theta) \, u_l - I]$$
$$= \theta \, [\theta \, p^* + (1 - \theta) \, u_l - I] - c + \theta \, (1 - \rho^*) \, (u_h - u_l) > 0. \tag{ec-67}$$

Thus,

$$\theta \, Y^+ + \theta^2 \, (\theta \, p^* + (1 - \theta) \, u_l - I) > \theta \, (\theta \, p^* + (1 - \theta) \, u_l - I) > c, \tag{ec-68}$$

demonstrating that, once again, type F will not defect from high quality production in period $n - 2$. Now note that, based on the argument we have just employed, while the gain from deviating from high quality production remains unchanged at c as we move backward in time, the cost of deviating increases so long as (ec-62) is satisfied. Thus, when defection from high quality production is not optimal in period $n - 2$, it will not be optimal in any period earlier than $n - 2$. Consequently, there cannot exist an equilibrium where type F will defect from high quality production prior to period n. $\square$

PROPOSITION EC.2. *(i) Suppose that the entrepreneur finances production by raising capital from outside investors in exchange for a share of the period's profits (i.e., by using short-term equity), a reputation equilibrium in which only high quality is produced until period n or until a production shock is observed exists if and only if*

$$\theta\,(1-\bar{\alpha})\,[\theta\,\bar{p}+(1-\theta)\,u_l]-(1-\alpha^+)\,c>0. \tag{ec-69}$$

Further, this reputation equilibrium is the only equilibrium supported by parameter values satisfying (ec-69).

(ii) Suppose that the entrepreneur finances production by issuing single-period debt to outside investors, a reputation equilibrium in which only high quality is produced until period n or until a production shock is observed exists if and only if

$$\theta\,(\bar{p}-\bar{D})-c>0. \tag{ec-70}$$

Further, this reputation equilibrium is the only equilibrium supported by parameter values satisfying (ec-70).

Proof of Proposition EC.2: First, we establish our claims regarding external equity financing. Then we establish our claims regarding outside short-term debt financing.

Equity financing Suppose that the entrepreneur has only produced high quality until period $n-k-1$. In period $n-k$, by producing high quality until the final period the entrepreneur's expected payoff equals

$$\sum_{j=0}^{k-1}\theta^j\,(1-\alpha^+)\,(Y^++I)+\theta^k\,(1-\bar{\alpha})\,(\bar{Y}+I). \tag{ec-71}$$

In contrast, if he switches to producing low quality in period $n-k$, the entrepreneur will be identified as F. Thus, revenue can only equal $u_l \leq I$ and investors will either refuse to finance the project or demand 100% of the equity. In either case the entrepreneur's expected future payoff is 0. Consequently, the present value of his payoffs through period n equals $(1-\alpha^+)\,(Y^++I+c)$. Producing high quality for all periods before n is a best response if and only if

$$\min_{1<k<n}\left[\sum_{j=1}^{k-1}\theta^j\,(1-\alpha^+)\,(Y^++I)+\theta^k\,(1-\bar{\alpha})\,(\bar{Y}+I)\right]>(1-\alpha^+)\,c. \tag{ec-72}$$

First note that (ec-72) must be satisfied for period $n-1$. However, in this case (ec-72) reduces to (ec-69), establishing that (ec-69) is a necessary condition for a reputation equilibrium. Next note that the left hand side of (ec-72) is increasing in k if and only if

$$(1-\alpha^+)\,(Y+I)-(1-\theta)\,(1-\bar{\alpha})\,\bar{Y}$$

$$=(1-\alpha^+)(\theta\,p^++(1-\theta)\,u_l-c)-(1-\theta)(1-\bar{\alpha})(\theta\,\bar{p}+(1-\theta)\,u_l)>0. \tag{ec-73}$$

Note that

$$(1 - \alpha^+)(\theta\, p^+ + (1 - \theta)\, u_l - c) - (1 - \theta)(1 - \bar{\alpha})(\theta\, \bar{p} + (1 - \theta)\, u_l)$$

$$= \theta\, (1 - \bar{\alpha})(\theta\, \bar{p} + (1 - \theta)\, u_l) - (1 - \alpha^+)c$$

$$+ (1 - \pi) \left[\theta\, (u_h - u_l) - c\, \bar{\alpha} \frac{u_l}{u_l + \theta\, (u_h - u_l) - c} \right] > 0. \tag{ec-74}$$

This follows because (ec-69) is satisfied and the last set of terms is positive as $\theta\,(u_h - u_l) - c > 0$ by assumption (ec-57) and $\bar{\alpha} < 1$ by assumption (ec-58). Thus, (ec-72) is satisfied for all periods when (ec-69) is satisfied.

Now we establish uniqueness. For a mixed strategy equilibrium, let α_t^* represent the equilibrium level of α in period t; let ρ_t^* represent the period t posterior probability that the entrepreneur is type H; let p_t^* represent the equilibrium price in period t. Note that, so long as type H earns a profit in every period, in any equilibrium in which type F randomizes before period n it must be the case that $\rho_n^* > \pi$ and $p_n^* > \bar{p}$. Because, in equilibrium, α is decreasing in the probability of high quality production, it must be the case that in period n,

$$\alpha_n^* < \bar{\alpha}, \tag{ec-75}$$

and in any mixed strategy equilibrium

$$\alpha_{n-1}^* > \alpha^+. \tag{ec-76}$$

Thus, (ec-75) and $p_n^* > \bar{p}$ imply that

$$(1 - \alpha_n^*)\,(\theta\, p_n^* + (1 - \theta)\, u_l) > (1 - \bar{\alpha})\,(\theta\, \bar{p} + (1 - \theta)\, u_l), \tag{ec-77}$$

and (ec-76) implies that

$$(1 - \alpha_{n-1}^*)\, c < (1 - \alpha^+)\, c. \tag{ec-78}$$

Randomization in period $n - 1$ requires that

$$\theta\, (1 - \alpha_n^*)\,(\theta\, p_n^* + (1 - \theta)\, u_l) - (1 - \alpha_{n-1}^*)\, c \leq 0. \tag{ec-79}$$

However, as (ec-77) and (ec-78) show, (ec-79) cannot be satisfied if (ec-69) is satisfied. Thus, type F will not randomize in period $n - 1$. This implies that in period $n - 1$, type F must follow the pure strategy of producing high quality.

Now consider period $n - 2$. Randomization in period $n - 2$ requires that

$$\theta\, (1 - \alpha^+)\,(\theta\, p^+ + (1 - \theta)\, u_l - c) + \theta^2\, (1 - \alpha_n^*)\,(\theta\, p_n^* + (1 - \theta)\, u_l) - (1 - \alpha_{n-2}^*)\, c \leq 0. \tag{ec-80}$$

However, because, in equilibrium, α is decreasing in the probability of high quality production $(1 - \alpha^*_{n-2})\, c < (1 - \alpha^+)\, c$. Further, because $p^*_n > \bar{p}$ and $\alpha^*_n < \bar{\alpha}$

$$\theta\,(1 - \alpha^+)\,(\theta\, p^+ + (1 - \theta)\, u_l - c) + \theta^2\,(1 - \alpha^*_n)\,(\theta\, p^*_n + (1 - \theta)\, u_l)$$
$$> \theta\,(1 - \alpha^+)\,(\theta\, p^+ + (1 - \theta)\, u_l - c) + \theta^2\,(1 - \bar{\alpha})\,(\theta\, \bar{p} + (1 - \theta)\, u_l), \tag{ec-81}$$

and because, as we have just demonstrated, when (ec-69) is satisfied

$$\theta\,(1 - \alpha^+)\,(\theta\, p^+ + (1 - \theta)\, u_l - c) + \theta^2\,(1 - \bar{\alpha})\,(\theta\, \bar{p} + (1 - \theta)\, u_l)$$
$$> \theta\,(1 - \bar{\alpha})\,(\theta\, \bar{p} + (1 - \theta)\, u_l). \tag{ec-82}$$

Thus (ec-80) cannot be satisfied when (ec-69) is satisfied. This establishes that F will not randomize in period $n - 2$. The case for $t < n - 2$ follows by induction. Thus, when (ec-69) holds, there will not exist an equilibrium where type F defects to low quality in any period $t < n$.

Debt financing Let $X^+ = \theta\,(p^+ - c - D^+)$ and $\bar{X} = \theta\,(\bar{p} - \bar{D})$. Suppose that the entrepreneur has only produced high quality until period $n - k - 1$. Then, in period $n - k$, by producing high quality until the final period the entrepreneur's expected payoff equals

$$\sum_{j=0}^{k-1} \theta^j\, X^+ + \theta^k\, \bar{X}. \tag{ec-83}$$

In contrast, if he switches to producing low quality in period $n - k$, the entrepreneur will be identified as F. Thus, because revenue can only equal $u_l \leq I$, investors will either refuse to finance the project or demand 100% of the project's cash flow. In either case the entrepreneur's expected future payoff is 0. Consequently, the present value of his payoffs through period n equals $X^+ + \theta\, c$. Thus, producing high quality for all periods before n is a best response if and only if

$$\min_{1 \leq k < n} \left[\sum_{j=1}^{k-1} \theta^j\, X^+ + \theta^k\, \bar{X} \right] > \theta\, c. \tag{ec-84}$$

First note that (ec-84) must be satisfied for period $n - 1$. However, in this case (ec-84) reduces to (ec-70), establishing that (ec-70) is a necessary condition. Next note that the left hand side of (ec-84) is increasing in k if and only if

$$X^+ - (1 - \theta)\, \bar{X} > 0. \tag{ec-85}$$

However this condition is always satisfied because

$$X^+ - (1 - \theta)\, \bar{X} = \theta\,(p^+ - c - D^+) - (1 - \theta)\,\theta\,(\bar{p} - \bar{D})$$
$$= \theta\,[\theta\,(\bar{p} - \bar{D}) - c] + (1 - \pi)\,[\theta\,(u_h - u_l) - (1 - \theta)\, c]$$
$$> \theta\,[\theta\,(\bar{p} - \bar{D}) - c] + (1 - \pi)\,[\theta\,(u_h - u_l) - c] > 0, \tag{ec-86}$$

where the last inequality follows because (ec-70) is satisfied and assumption (ec-57) ensures that the last term is positive.

Now we establish, uniqueness. For a mixed strategy equilibrium, let D_t^* represent the equilibrium level of D in period t; let ρ_t^* represent the equilibrium period t probability assessed to the entrepreneur being type H. Let p_n^* represent the equilibrium price in period n. Note that, so long as type H earns a profit in every period, in any equilibrium in which type F randomizes starting in period k it must be the case that $\rho_t^* > \pi$ for all $t > k$. Thus, $\rho_n^* > \pi$. Because, in equilibrium, $p(\rho, 0) - D(\rho, 0)$ is increasing in ρ, it must be the case that in period n,

$$\theta\left(p_n^* - D_n^*\right) > \theta\left(\bar{p} - \bar{D}\right). \tag{ec-87}$$

Randomization in period $n-1$ requires that

$$\theta\left(p_n^* - D_n^*\right) - c \leq 0. \tag{ec-88}$$

However, as (ec-87) shows, (ec-88) cannot be satisfied if (ec-70) is satisfied. Thus, no equilibrium exists in which type F randomizes in period $n-1$. This implies that type F must follow the pure strategy of producing high quality in period $n-1$.

Now consider period $n-2$. Randomization in period $n-2$ requires that

$$\theta(p^+ - c - D^+) + \theta^2\left(p_n^* - D_n^*\right) - c \leq 0. \tag{ec-89}$$

However, because, in equilibrium, $\theta\left(p_n^* - D_n^*\right) > \theta\left(\bar{p} - \bar{D}\right)$,

$$\theta(p^+ - c - D^+) + \theta^2\left(p_n^* - D_n^*\right) > \theta(p^+ - c - D^+) + \theta^2\left(\bar{p} - \bar{D}\right), \tag{ec-90}$$

and because, as we have just demonstrated, when (ec-70) is satisfied,

$$\theta(p^+ - c - D^+) + \theta^2\left(\bar{p} - \bar{D}\right) > \theta\left(\bar{p} - \bar{D}\right). \tag{ec-91}$$

Thus (ec-89) cannot be satisfied when (ec-70) is satisfied. This establishes that F will not randomize in period $n-2$. The case for $t < n-2$ follows by induction. Thus, when (ec-69) holds, there will not exist an equilibrium where type F defects to low quality in any period $t < n$. $\square$

PROPOSITION EC.3. *(i) The parameter set that supports reputation equilibria when the entrepreneur employs internal finance is a subset of the set of parameters that supports reputation equilibria when the entrepreneur employs external equity finance. (ii) The parameter set that supports reputation equilibria when the entrepreneur employs internal finance is a subset of the set of parameters that supports reputation equilibria when the entrepreneur employs external debt finance.*

Proof of Proposition EC.3: First note that, if the entrepreneur is restricted to internal finance, producing high quality for all periods before n is a best response if and only if (ec-64) is satisfied. Similarly, if the entrepreneur is restricted to external equity finance, producing high quality for all periods before n is a best response if and only if (ec-72) is satisfied. Thus, to show that the set of parameters that supports reputation equilibria with external equity finance contains the set of parameters that supports reputation equilibria with internal finance, we have to demonstrate that (ec-72) is satisfied whenever (ec-64) is satisfied, i.e.,

$$\theta^k (1 - \bar{\alpha})(\bar{Y} + I) - (1 - \alpha^+) c > \theta^k \bar{Y} - c, \tag{ec-92}$$

for all $k < n$. For this condition to hold we need to show that

$$\alpha^+ c > \theta (\bar{\alpha}(\bar{Y} + I) - I). \tag{ec-93}$$

Now note that

$$\frac{\alpha^+ c}{I} = \frac{c}{u_l(1 - \theta) + u_h \theta - c} \tag{ec-94}$$

$$\frac{\bar{\alpha}(\bar{Y} + I) - I)}{I} = \frac{c\pi}{u_l(1 - \theta\pi) + u_h \theta\pi - c\pi}. \tag{ec-95}$$

Because

$$\pi\Big(u_l(1 - \theta) + u_h \theta - c\Big) - \Big(u_l(1 - \theta\pi) + u_h \theta\pi - c\pi\Big) = -u_l(1 - \pi) \tag{ec-96}$$

we see that

$$\alpha^+ c > (\bar{\alpha}(\bar{Y} + I) - I) \tag{ec-97}$$

must hold which implies, *a fortiori* that (ec-93) holds.

Now note that, if the entrepreneur is restricted to external short-term debt finance, producing high quality for all periods before n is a best response if and only if (ec-84) is satisfied. Thus, to show that the set of parameters that supports reputation equilibria with external debt finance contains the set of parameters that supports reputation equilibria with internal finance, we have to demonstrate that (ec-84) is satisfied whenever (ec-64) is satisfied, i.e.,

$$\theta^k \bar{X} - \theta c > \theta^k \bar{Y} - c, \tag{ec-98}$$

or equivalently,

$$(1 - \theta) c > \theta^k (\bar{Y} - \bar{X}). \tag{ec-99}$$

Note that

$$\bar{Y} - \bar{X} = (1 - \theta) \pi c. \tag{ec-100}$$

Thus (ec-99) always holds. $\square$

PROPOSITION EC.4. *When* (ec-69) *is satisfied, there exist equilibria where entrepreneurs strictly prefer financing production with capital raised from outside investors.*

Proof of Proposition EC.4: The beliefs that support this equilibrium are as follows: If an entrepreneur ever fails to choose external finance, he must be type F. Given this belief, the price received by the entrepreneur for his product in all periods subsequent to using internal finance will be u_l. At this price, production is not profitable. Thus, as soon as an entrepreneur finances production himself, his continuation payoff falls to 0. Hence, always selecting external finance is the best response for the entrepreneur regardless of his type. Thus, an equilibrium exists in which external finance is used. □

EC.3. Experimental Instructions

Here, we present instructions for the internal and external financing treatments. Specific language for the internal treatments is set off in bold faced square brackets (i.e., [text]). Specific language for the external treatments is set off in bold face braces (i.e., {text}). The instructions here contain the specific numbers and percentages used in parameterization one. Numbers and percentages were changed as needed for parameterizations two and three.

<div align="center">INSTRUCTIONS</div>

<div align="center">General</div>

You are about to participate in an experiment in the economics of decision making. If you follow these instructions carefully and make good decisions, you might earn a considerable amount of money that will be paid to you in cash at the end of the experiment.

The experiment will consist of a series of separate decision making periods. Each period will consist of [two] {three} stages. During these stages, [two] {three} participants will be assigned to a group and engage in a series of decisions. The [two] {three} participants will be labeled {"Red,"} "Blue" and "Green." In the following sections, we will discuss this process and show how each player's payoff is determined. Then, we will discuss how you are assigned to groups.

The type of currency used in these games is francs. All trading and earnings will be in terms of francs. At the end of each period, you will receive franc payoffs that are yours to keep. At the end of the experiment, each franc will be worth $ ____ to you. Do not reveal this number to anyone. At the end of the experiment, your francs will be converted to dollars at this rate, and you will be paid in dollars. Notice that the more francs you earn, the more dollars you will earn.

<div align="center">Stages of the Game</div>

During each of the [two] {three} stages of the game, one of the players will make a decision regarding the item that may be sold. These decisions will determine whether an item is available for sale and a sales price. We will explain what happens in the [two] {three} stages of this game in reverse order because it will make it easier for everyone to see what happens.

Stage [II] {III} Instructions

The Decision

In Stage [II] {III} the Green Player will make a decision that establishes a price for an item (which will be called the "Established Price") and may buy the item. If he or she does buy the item, it will be from the experimenter at a "Discounted Price" that is less than or equal to the Established Price.

If the Green Player buys the item, he or she will receive a "Redemption Value" from the experimenter for the item. There are two types of items: "Round" and "Square." The Redemption Value for the item depends on its type. Round items will be redeemed for 1000 francs. Square items will be redeemed for 400 francs. That is, Round items are worth 1000 francs to the Green Player while Square items are worth 400 francs. The type of the item will be determined by the Blue Player in Stage [I] {II} but the type will not be known by the Green player until after he or she establishes the price in Stage [II] {III}. We will discuss how the item type is determined later in the instructions.

Procedures

The Established Price and the Discounted Price for the item will be determined as follows. The Green Player will be asked to indicate the *highest* price he or she is willing to pay for the item. This will determine the Established Price. The Established Price must be greater than or equal to 400 and less than or equal to 1000. The Green Player indicates the Established Price, by filling out a green "Price Form" from his or her packet.

Below is a sample green Price Form:

```
                           Price Form

    Period:  _____      Player:  _____      Group:  _____

    1.    Highest price that I would be willing to
          pay for the item (Established Price, this
          number must be >= 400 and <=1000):        _____

    2.    Random draw (Discounted Price):           _____

    3.    Will I be buying the item if it is available for sale?
          ("Yes" if line 2 <= line 1 or
          "No" if line 2 > line 1)
```

The period, player and group will be filled in for you. Using the Price Form for the current period, place the highest price that you would be willing to pay for the item in line 1. This will become the Established Price of the item. We will discuss the rest of the form next.

The Discounted Price is determined as follows. After all Green Players have filled in line 1 on their Price Forms for the current period, the experimenter will draw a ticket from a box containing 601 tickets numbered 400-1000 that represent possible prices. If you are a Green Player, fill this number in on line 2 of your Price Form.

If the random draw is less than or equal to the price indicated by the Green Player, then the random draw will determine the Discounted Price. In this case, the Green Player will buy the item if it is available for sale at the price *indicated by the random draw* (the Discounted Price) from the experimenter and receive the redemption value. Thus, the price indicated by the Green Player defines the highest price that he or she will pay in exchange for the item.

If the random draw is greater than the price indicated by the Green Player OR the item is not made available for sale, then the Green Player will not buy the item. In this case, there is no Discounted Price, but the Established Price will remain the value indicated by the Green Player on line 1 of his or her Price Form. Thus, the Established Price will always be the *price indicated by the Green Player.*

If you are a Green Player mark whether you will be buying the item if it is available for sale or not on line 3 and turn the form into the experimenter. The information from the form will be used to help determine the payoffs for the players in the game.

<div align="center">Notes on this Procedure</div>

Notice that it is in the best interest of the Green Player to be accurate; that is, the best thing he or she can do is be honest and state truthfully the highest price he or she is willing to pay for the item. If the price stated is too high or too low, then the Green Player is passing up opportunities that he or she would prefer.

For example, suppose you are a Green Player and you would be willing to pay up to 750 francs for the item, but instead you say that the most you would pay is 850 francs. (That is, you place 850 on line 1 instead of 750. As a result, the Established Price becomes 850.) If the ticket drawn at random is between the two prices (for example 800) you would have to pay 800 francs to buy the item if it is available for sale even though you would have preferred not to have purchased the item at that price. In this case, you would put 800 on line 2 and you would buy the item (because line 2 is less than line 1) at a Discounted Price of 800 francs, which is more than you wanted to pay for the item.

On the other hand, suppose that you would pay up to 750 francs, but instead you state your price as 650 francs. (That is, you place 650 on line 1 instead of 750. As a result, the Established

Price becomes 650.) If the ticket drawn at random is between the two prices (for example 700) you would not be allowed to buy the item if it is available for sale even though you would have preferred to purchase the item at the 700 franc price. In this case, you would put 700 on line 2 and you would not buy the item (because line 2 is greater than line 1).

In either case, it is in the Green Player's best interest to establish a price that equals the most he or she is actually willing to pay for the item.

<div align="center">Payoff Determination</div>

The Green Player starts each period with 450 francs. The Green Player's payoffs are determined by (1) the initial endowment of 450 francs, (2) whether or not he or she bought the item, (3) the price of the item if he or she did buy it and (4) the redemption value for the item if he or she did buy it. Specifically, the Green Player's payoff will be:

Payoff = 450

+ Redemption Value (if Discounted Price <= Established Price and available for sale)

– Discounted Price (if Discounted Price <= Established Price and available for sale)

There are three possible outcomes:

(1) If the item is Round AND the Green Player buys it, he or she will receive 450 francs plus the 1000 franc redemption value minus the Discounted Price.

(2) If the item is Square AND the Green Player buys it, he or she will receive 450 francs plus the 400 franc redemption value minus the Discounted Price.

(3) If the Green Player does not buy the item, he or she will receive 450 francs.

For example, if the Discounted Price is 600 AND the Green Player buys the item, the payoff will be 450+1000-600=850 francs if the item is Round and 450+400-600=250 francs if the item is Square. If the Green Player does not buy the item, the Green Player's payoff is 450 francs. The Green Player can only buy the item if it is actually available for sale.

We will discuss Stage [I] {II} next. Before doing that, are there any questions about the Green Player's action in Stage [II] {III} and the Green Player's payoffs?

<div align="center">Stage [I] {II}Instructions</div>

<div align="center">The Decision</div>

In Stage [I] {II}, the Blue Player will make a decision that establishes the type of the item, either Round or Square. If it is made available for sale, this item will be sold to the experimenter at the Established Price determined by the Green Player in Stage [II] {III} (as discussed above). In turn, the experimenter may sell this item to the Green Player at the Discounted Price. As discussed above, the type of the item determines the value of the item to the Green Player. In addition, the type of the item determines a cost which reduces the profits on the sale of the item. Selling Round items entails a cost of 400 francs. Selling Square items entails zero cost.

Procedures

The type of the item will be determined as follows. There are two types of items: Round and Square. To determine the type of the item, the Blue Player will fill out a Blue Item Form. Below is a sample blue Item Form:

```
+------------------------------------------------------+
|                      Item Form                       |
|                                                      |
|  Period: _____ Player: _____ Type: _____ Group:_____ |
|                                                      |
|  Since you are a Blue-F Player, you can choose either the  |
|  Round Item or the Square Item below. Please mark your     |
|  selection with a check.                             |
|                                                      |
|              (  Round  )      [ Square ]             |
|              (  Item   )      [  Item  ]             |
|                                                      |
+------------------------------------------------------+
```

The period, player and group will be filled in for you. In addition, the form may have two choices available (like the form above) OR the form may ONLY allow you to choose the Round Item. If you are restricted to choosing only the Round Item, you will be called a "Blue-R Player" (for "restricted"). If you can choose either item, you will be called a "Blue-F Player" (for "flexible"). Your player type and available choices will be filled in on the Item Form for you. We will discuss how restrictions are determined later.

To determine the item type, mark your choice with a check in the shape chosen and turn it in to the experimenter. The information from the form will be used to help determine the payoffs for the players in the game. Whether or not you were restricted will not be revealed to the other players by the experimenter.

Payoff Determination

The Blue Player starts each period with 450 francs. The Blue Player's payoffs are determined by (1) the initial endowment of 450 francs, (2) the Established Price of the item, (3) the type of the item sold, (4) an "Established Percentage" of the profits on the sale of the item that the Blue Player must pay to the experimenter and (5) whether the item will be made available for sale. The Established Price is determined by the Green Player in Stage [II] {III} as discussed above. The Established Percentage and whether the item is made available for sale is determined [as follows: (1) if the profits on the sale of the item are more then 500 francs, the percentage will be set so that the Blue Player gives 500 francs to the experimenter or (2) if the profits on the sale of the item are less than 500 francs, the item will not be made available for sale.] {by the Red Player in Stage I and will be discussed later.} Specifically, the Blue Player's payoff will be:

[Payoff = 450 + (Established Price – Cost)x(1-Established Percentage) if made available for

   sale (i.e., the profits on the sale are greater than or equal to 500) or

   = 450 + (Established Price – Cost) - 500 if made available for sale (i.e., the profits on the

   sale are greater than or equal to 500) or

Payoff = 450 if not made available for sale (i.e., the profits on the sale are less that 500).]

{ Payoff = 450 + (Established Price – Cost)x(1-Established Percentage) if made available for

   sale and

Payoff = 450 if not made available for sale**}**

The (Established Price – Cost) term determines the profits on the sale of the item. The Blue Player must give up the Established Percentage of these profits and, hence, keeps (1 – Established Percentage) of these profits. [If the item is made available for sale, the amount given up will equal 500 francs. If the profits on the sale of the item are less than 500 francs, the item will not be made available for sale.]

[For example, if the Established Price is 700 and the item is round, the profits on the sale of the item would be 700-400 = 300 francs and the item will not be made available for sale. This will leave the Blue Player with the initial 450 francs. If the item is square, the profits on the sale of the item will be 700-0 = 700 francs and the item will be made available for sale. The Established Percentage will be set at 500/700 = 72.43% of the profits. This will leave the Blue Player with a net payoff of 450 + 700x(1-0.7243) = 450 + 700 – 500 = 650 francs.]

{For example, if the Established Price is 700, the item is made available for sale and the Established Percentage is 75% of the profits, then the payoff will be 450 + (700-400)x(1-0.75) = 525 francs if the item sold is Round and 450 + 700x(1-0.75) = 600 if the item sold is Square.**}**

Notice that the Blue Player's earnings will not be affected in any way by whether the Green Player ends up buying the item from the experimenter and, if so, what the Discounted Price turns out to be. Only the Established Price and whether the item is made available for sale will determine earnings to the Blue Player. However, the Blue Player will not know what the Established Price is when he or she chooses the type of the item sold.

{We will discuss Stage I next. Before doing that, are there any questions about the Blue Player's actions in Stage II and the Blue Player's payoffs?

<u>Stage I Instructions</u>

The Decision

In Stage I, the Red Player will make a decision that (1) determines whether the item is made available for sale and, if so (2) establishes the percentage of profits on the sale of the item that the Blue Player must give up to the experimenter (which will be called the "Established Percentage") and may receive a different percentage of the profits on the sale. If he or she does receive a

percentage of the profits on the sale, it will be from the experimenter at a "Marked-up Percentage" that is greater than or equal to the Established Percentage.

In order to receive the Marked-up Percentage of the profits on the sale of the item, the Red Player must give up 500 francs in exchange for the Marked-up Percentage. The Red Player's decision determines whether he or she will give up the 500 francs and, if so, the minimum percentage of profits he or she will receive in exchange.

<div align="center">Procedures</div>

Whether the item is made available for sale, the Established Percentage and the Marked-up Percentage of profits on the sale of the item will be determined as follows. The Red Player starts the period with 500 francs. The Red Player will be asked to indicate the *lowest* percentage of profits he or she is willing to take in exchange for the 500 francs. This will determine the Established Percentage. The Red Player indicates the Established Percentage, by filling out a red "Percentage Form" from his or her packet.

Below is a sample red Percentage Form:

```
┌──────────────────────────────────────────────────────────┐
│                    Percentage Form                        │
│                                                            │
│  Period: _____      Player: _____      Group: _____        │
│                                                            │
│  1.   Smallest percentage of profits for which I          │
│       would give up the initial 500 francs                │
│       (Established Percentage):               _____%       │
│                                                            │
│  2.   Random draw (Marked-up Percentage):                 │
│                                               _____%       │
│                                                            │
│  3.   Will I be receiving the Marked-up Percentage?       │
│       ("Yes" if line 2 >= line 1                           │
│       or "No" if line 2 < line 1)             _____        │
├──────────────────────────────────────────────────────────┤
│                    Percentage Form                        │
│                               Period: _____                │
│                               Group: _____                 │
│                                                            │
│  The Established Percentage is:               _____%       │
│  (Fill in from line 1 above).                              │
└──────────────────────────────────────────────────────────┘
```

The period, player and group will be filled in for you. Using the Percentage Form for the current period, place the smallest percentage of profits for which you would give up the initial 500 francs in line 1 AND fill this number in on the bottom half of the form. If you would be unwilling to give

up the 500 francs for any percentage of the profits on the sale, mark this line >100%. In this case the item will not be made available for sale. We will discuss the rest of the form next.

After all Red Players have filled in line 1 and the bottom part of their Percentage Forms for the current period, the experimenter will draw a ticket from a box containing 100 tickets numbered 1-100 that represent possible percentages of profits. The ticket 100 represents 100%, 50 represents 50%, 1 represents 1%, etc. If you are a Red Player, fill this number in on line 2 of your Percentage Form.

If the Red Player has marked >100% on his or her Percentage Form, the Red Player will keep the 500 francs regardless of the draw and the item will not be made available for sale.

If the random draw is greater than or equal to the percentage indicated by the Red Player on line 1 and the percentage indicated is less than or equal to 100%, then the Red Player will give up his or her 500 francs and receive the percentage of Profits on the Sale of the Item *indicated by the ticket draw* (the Marked-up Percentage). Thus, the percentage indicated by the Red Player defines the lowest percentage of profits that he or she will receive in exchange for the 500 francs.

If the random draw is less than the percentage indicated by the Red Player and this percentage is less than or equal to 100%, then the Red Player will not receive a percentage of the Profits on the Sale of the Item. He or she will keep the initial 500 francs for the period. In this case, there is no Marked-up Percentage, but the Established Percentage will remain the percentage indicated by the Red Player on line 1 of his or her Percentage Form. The item will be made available for sale and the Blue Player will pay the Established Percentage to the experimenter. Thus, the Established Percentage will always be the *percentage indicated by the Red Player.*

If you are a Red Player, you will put the Established Percentage on the bottom half of the Percentage Form. Also mark whether you will be giving up your 500 francs in exchange for the Marked-up Percentage or not on line 3. Then, turn it in to the experimenter. The bottom half of the form will be given to the Blue player before Stage II of the game. The overall information from the form will be used to help determine the payoffs for the players in the game.

Notice that, if the item is made available for sale, the Blue Player's earnings will not be affected in any way by whether the Red Player ends up giving up the initial 500 francs and, if so, what the Marked-up Percentage turns out to be. Only the Established Percentage will determine earnings to the Blue Player. The Blue Player will know what the Established Percentage is when he or she chooses the type of the item sold.

<div align="center">Notes on this Procedure</div>

Notice that it is in the best interest of the Red Player to be accurate; that is, the best thing he or she can do is be honest and state truthfully the lowest percentage for which he or she would

exchange the 500 francs. If the percentage stated is too high or too low, then the Red Player is passing up opportunities that he or she would prefer.

For example, suppose you are a Red Player and you would be willing to give up the 500 francs for 75% of the profit, but instead you say that the lowest amount for which you would give it up is 90%. (That is, you place 90% on line 1 instead of 75%. As a result, the Established Percentage becomes 90%.) If the ticket drawn at random is between the two (for example 85) you would keep the 500 francs even though you would have gladly given it up for 85% of the profit. In this case, you would put 85% on line 2 and you would keep the initial 500 francs (because line 2 is less than line 1).

On the other hand, suppose you are a Red Player and you would be willing to give up the 500 francs for 75% of the profit, but instead you say that the lowest amount for which you would give it up is 60%. (That is, you place 60% on line 1 instead of 75%. As a result, the Established Percentage becomes 60%.) If the ticket drawn at random is between the two (for example 65) you would be forced to give up the 500 francs for 65% of the profits even though, at this percentage, you would have preferred to keep the 500 francs. In this case, you would put 65% on line 2 and 65% would become the Marked-up Percentage. Thus, you would give up the 500 francs in exchange for 65% of the profit from the item sale (because line 1 is less than line 2), even though you would have preferred to keep the 500 francs.

In either case, it is in the Red Player's best interest to establish a percentage that equals the least he or she is actually willing to give up the 500 francs for.

<div align="center">Payoff Determination</div>

The Red Player starts each period with 500 francs. The Red Player's payoffs are determined by (1) the initial endowment of 500 francs, (2) whether or not he or she gives up the 500 francs in exchange for a Marked-up Percentage of the profits on the sale of the item, (3) the Marked-up Percentage if he or she did give up the initial 500 francs and (4) the profits on the sale of the item if he or she did give up the initial 500 francs. Specifically, the Red Player's payoff will be:

Payoff = 500

     - 500 (if Marked-up Percentage >= Established Percentage)

     + (Marked-up Percentage)x(Established Price-Cost) (if Marked-up Percentage >= Established Percentage)

There are three possible outcomes:

(1) If the item is Round AND the Red Player gives up the initial 500 francs, he or she will receive the Marked-up Percentage times (the Established Price minus 400).

(2) If the item is Square AND the Red Player gives up the initial 500 francs, he or she will receive the Marked-up Percentage times the Established Price.

(3) If the Red Player does not give up the initial 500 francs, he or she will receive 500 francs. For example, if the Established Price is 700, the Marked Up Percentage is 85% of the profits AND the Red Player gives up the initial 500 francs, then the payoff will be 0.85x(700-400) = 425 if the item sold is Round and 0.85x700 = 595 if the item sold is Square. If the Red Player keeps the initial 500 francs, then the Red Player simply receives 500 francs.

We will discuss how player types and groups are determined next. Before doing that, are there any questions about the Red Player's actions in Stage I and the Red Player's payoffs?**}**

[We will discuss how player types and groups are determined next. Before doing that, are there any questions about the Blue Player's actions in Stage I and the Blue Player's payoffs?]

<u>Group and Player Type Determination</u>

At the beginning of the experiment, you will be assigned a player type, **{**"Red,"**}** "Blue" or "Green." You will remain this type of player for the entire duration of the experiment. Every three periods, **{**one Red,**}** one Blue and one Green Player will be matched randomly to play the game and the players in each group will remain constant for three periods. Everyone will be re-assigned to new groups every third period. Thus, in periods 1 through 3, you will be with the same group. In period 4, you will be randomly re-assigned to new groups and these groups will remain constant in periods 4 through 6, etc. These groupings were determined randomly before the experiment began. For each group, Blue players are assigned a subtype: Blue-R or Blue-F. Subtype assignments remain constant for the duration of a group. Thus, Blue players keep their subtype throughout each group interaction (for three periods). Subtypes are re-assigned randomly each time groups are reassigned. On average, three quarters of the Blue Players will be Blue-R players and one quarter will be Blue-F players during each re-grouping and re-assignment. These types were assigned randomly before the experiment began.

<u>End of Period Results</u>

At the end of the period, you will receive an information and record sheet. The relevant actions taken by all payers in your group, the type of the item and your payoff will be given in this information and record sheet. You should record your payoff in the appropriate section of your profit sheet and receipt. Note that this sheet will NOT give the Blue Player type.

<u>Summary of the Game</u>

[Two] **{**Three**}** summary sheets are attached. Each shows actions in each of the [two] **{**three**}** stages of the game. One shows [how Blue Players payoffs are determined] **{**how Red Player payoffs are determined, one shows Blue Player payoffs**}** and one shows Green Player payoffs. The arrows show where the decisions of the Players and the random draws affect payoffs of each Player. The game proceeds as follows:

1. Players are randomly assigned to groups. All players start with and initial endowment of francs. The Blue Player's type (Blue-R or Blue-F) will be given on the Blue Player's Item Form.

[2. Stage I

a. The Blue Player must decide whether to sell a Round Item or a Square Item and check the choice on his or her blue Item Form. Type Blue-R Players must choose the Round Item. Type Blue-F Players can choose either the Round Item or the Square Item.

b. If a Blue Player sells the Round Item, the Profits on the sale of the Item would be the Established Price set by the Green Player minus 400.

c. If a Blue Player sells the Square Item, the Profits on the sale of the Item would be the Established Price set by the Green Player.

d. In either case, whether the item is made available for sale is determined by whether the Profits on the sale are greater than or equal to 500 francs.

   i. If the profits are greater than or equal to 500 francs, the item is made available for sale; the Blue Player gives up the Established Percentage of the profits equaling 500 francs and keeps the rest, along with his or her initial 450 francs.

   ii. If the profits are less than 500 francs, the item is not made available for sale; no costs are paid, no price is received and the Blue Player keeps his or her initial 450 francs.]

{2. Stage I

a. The Red Player decides the smallest percentage of profits for which he or she would give up the initial 500 francs. The Red Player will record this amount on his or her red Percentage Form. This determines the Established Percentage.

b. The experimenter draws a random number between 1% and 100% and the Red Player will record this amount on his or her red Percentage Form.

   i. If the random draw is greater than or equal to the percentage indicated by the Red Player, the random draw becomes the Marked-up Percentage and the Red Player gives up his or her 500 francs in exchange for the Marked-up Percentage of the Profits on the Sale of the Item in Stage III. The Profits on the Sale of the Item are determined by the Item choice of the Blue Player and the Established Price set by the Green Player (see the Red Player Payoff Summary Sheet).

   ii. If the random draw is less than the percentage indicated by the Red Player or if the Red Player indicates >100%, the Red Player will keep the initial 500 francs.

3. Stage II

a. The Blue Player will be given a portion of the Red percentage sheet that tells him or her the Established Percentage of Profits on the Sale of the Item that he or she must give up.

If it is >100%, then the item is not made available for sale. Otherwise, the Blue Player will keep the rest of the profits.

b. If the item is made available for sale (the Established Percentage $\leq$ 100%), the Blue Player must decide whether to sell a Round Item or a Square Item and check the choice on his or her blue Item Form. Type Blue-R Players must choose the Round Item. Type Blue-F Players can choose either the Round Item or the Square Item. If a Blue Player sells the Round Item, the Profits on the Sale of the Item are the Established Price set by the Green Player minus 400. If a Blue Player sells the Square Item, the Profits on the Sale of the Item are the Established Price set by the Green Player. In either case, the Blue Player gives up the Established Percentage of the profits determined by the Red Player in Stage I. (See the Blue Player Payoff Summary Sheet.)**}**

[3.] **{4.}** Stage [II] **{III}**

a. The Green Player decides the most he or she is willing to pay for the item if it is made available for sale. This determines the Established Price. The Green Player will record the Established Price on his or her green Price Form.

b. The experimenter draws a random number between 400 and 1000 and the Green Player will record this amount on his or her green Price Form.

i. If the random draw is less than or equal to the price indicated by the Green Player and the item is made available for sale, the Green Player will buy the item at the price determined by the random draw (the Discounted Price). If the item is Round and the Green Player buys it, he or she will receive a redemption value of 1000 francs. If the item is Square and the Green Player buys it, he or she will receive a redemption value of 400 francs. The item type is determined by the Blue Player in Stage [I] **{II}**. (See the Green Player Payoff Summary Sheet.)

ii. If the random draw is greater than the price indicated by the Green Player or it is not made available for sale, the Green Player will keep his or her initial 450 francs.

You are free to make as much money as you can according to these rules.

<u>End of Experiment Rules</u>

At the end of the experiment, add up your total earnings in francs and record this sum on your profit sheet. Multiply this amount by $ ___ to determine the amount of dollars you received. This is the amount of dollars you have earned in the experiment and will be paid to you in cash.

Are there any questions?