Product market efficiency: The bright side of myopic, uninformed, and passive external finance

Thomas H. Noe
Saïd Business School and Balliol College
University of Oxford

Michael J. Rebello
School of Management
University of Texas at Dallas

Thomas A. Rietz
Henry B. Tippie College of Business
University of Iowa

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Abstract

Short-term financial claims held by uninformed outside investors impose a tax on insider opportunism by diluting the ownership stake of opportunistic owner-managers. By thus limiting managerial opportunism, short-term financing increases firm value and social welfare. When given a choice, owner-managers will prefer socially beneficial short-term external financing over internal financing. We show that these results are equilibrium outcomes of a model where firms can act opportunistically in product markets. Moreover, we document the same beneficial effect of short-term external finance in a laboratory experiment implementing this game.

JEL Classification Codes: C91, D82, G31, G32, L15
Keywords: adverse selection, financing, reputation

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Short-term financial claims held by uninformed outside investors impose a tax on insider opportunism by diluting the ownership stake of opportunistic owner-managers. By thus limiting managerial opportunism, short-term financing increases firm value and social welfare. When given a choice, owner-managers will prefer socially beneficial short-term external financing over internal financing. We show that these results are equilibrium outcomes of a model where firms can act opportunistically in product markets. Moreover, we document the same beneficial effect of short-term external finance in a laboratory experiment implementing this game.

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1. Introduction

When information is asymmetric, the dilution costs associated with external finance can deter investment in positive NPV projects. This is the well-known dark side of financing by uninformed external investors. We show that the dilution costs associated with uninformed external finance also have a bright side—they can mitigate hidden insider opportunism. Opportunism shortens the duration of the firm's expected future cash flows by producing a short-run inflow at the cost of long-run gains.[1] Thus, opportunism increases the value of short-run cash flows and the value of short-run claims issued to outsiders. As a result, short-term claims issued by the firm may be undervalued when insiders behave opportunistically. The dilution of insider claims resulting from this undervaluation acts as a tax, destroying insider incentives to behave opportunistically.

This effect is fairly robust to the specific type of short-term finance and the specific nature of the opportunism so long as, (a) the financial instrument issued by the firm is sensitive to the value of the firm's assets, and (b) opportunism accelerates the maturity structure of the firms assets. To demonstrate the internal consistency of this idea, we develop a formal model that implements conditions (a) and (b) in as simple a fashion as possible—we assume outside equity finance in a Myers and Majluf (1984) setting and assume that opportunism takes the form of the substitution of inferior goods in a Kreps and Wilson (1982), and Milgrom and Roberts (1982) product market reputation setting. In Appendix II we show that our results are robust to the use of outside debt finance instead of outside equity.[2]

Because, actual behavior in markets may vary from Bayes-Nash predictions, we assess the benefit associated with external finance through an experimental implementation of our model. As predicted, external finance reduces opportunism and increases production. External finance never significantly decreases total economic surplus and increases it significantly when full reputation formation is predicted only with external financing. While the overall outcomes reflect the benefits of external finance, subject behavior frequently does not conform to our model's predictions. Investors tax opportunism less than predicted and, in fact, tend to overvalue the claims of both

[1] This feature of opportunism is not specific to our model but rather is pervasive in the contracting and agency literature. 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. Diversion by insider owners is frequently modeled as in Myers (2000), where insiders divert investment funds, which would generate long-term gains if properly invested, to personal consumption. In the empirical literature, Roychowdhury (2006) provides evidence that real earnings manipulation, involving pushing sales and earnings forward to meet earning targets, is common.

[2] In our experiments, short-term finance takes the form of short-term-equity-project finance. At the start of a period, outsiders finance that period's production and receive a dividend liquidating their claim at the end of that period. We chose, an equity-like claim rather than a debt claim to simplify the explanation of the experiment to subjects. Informed insiders must have imperfect knowledge of future value for risky debt to be issued in equilibrium (see Noe, 1988). Thus, implementing the experiment with risky debt would have required endowing insiders with a value distribution rather than a single project value, complicating their decision problem. As Appendix II shows, risky short-term debt supports the same effects as short-term-equity-project finance. Thus, our theoretical results easily extend to short-term debt financing and, in fact, to any form of short-term financing subject to mispricing.

opportunistic and non-opportunistic producers. But this also has a bright side for consumers: it shifts surplus to them.

Our model melds together a classic capital markets model with a classic product market model. We model external financing under asymmetric information like Myers and Majluf (1984). Our product market is based on the Kreps and Wilson (1982) and Milgrom and Roberts (1982) models of reputation formation in markets with finitely lived agents. Thus, in our model, we have a single incentive problem resulting from the ability to substitute inferior goods, and we show that introducing a new market (in our case the capital market) remedies the incentive problems in the product market. This contrasts with a number of papers, for example (Mookherjee and Png, 1995) and (Noe and Rebello, 1996) which show that introducing a second incentive problem, as opposed to a new market in the context of a single incentive problem, can lower the adverse effects produced by the initial problem.

Maksimovic and Titman (1994) have also adapted the Kreps and Wilson (1982) and Milgrom and Roberts (1982) models to consider product market reputation in a finance context. Our results are quite different than Maksimovic and Titman's because the financial market problem we analyze is quite different. In their analysis, the firm's initial capital structure is exogenous and outside claims are long-lived. In our analysis there is no initial exogenous capital structure and outsider claims are short-lived. Moreover, dilution costs do not affect opportunism in their framework because insiders have perfect knowledge at the time they make their quality decision of the payment received by outsiders. Thus, Myers and Majluf-type dilution, which is only possible when payments to outsiders are risky conditioned on insider information, cannot affect opportunism.

Our results also explain why firms choose external finance over internal finance. Opportunistic gains wrung from consumers inflate the cash flows of opportunistic firms. To realize these gains, opportunistic firms have to shield their true identities from consumers. If non-opportunistic firms raise external capital by issuing short-term claims, to hide their identities, opportunistic firms will mimic and resort to external financing. This occurs despite the fact that their claims will be mispriced because investors will be unable to price in their opportunistic gains. Thus, firms will prefer short-term outside finance, though it is subject to misvaluation. In fact, they may well pay out financial slack and then raise short term finance. In this way, product market considerations can lead firms to dividend payouts and a reliance on outside suppliers of capital. This reliance on outside capital is consistent with the capital market bonding theory of Easterbrook (1984). However, our paper's rationale for external capital is quite different from Easterbrook's. In Easterbrook, external capital is valuable because it is informed and able to monitor management opportunism. In our analysis, external capital is valuable because it is uninformed and taxes opportunism through dilution losses. Thus, the pattern of financing modeled here corresponds more closely with the extensive use of short-term rollover finance by high-reputation producers like GE than the reputation bonding provided to a small start up by a venture capitalist.

To test the predictions of our model regarding the effect of external finance, we run experiments

that combine the two markets in a single, two-sided reputation game. We also run control experiments with only a product market. Thus, we compare directly games with external financing to those without to explicitly document the effects of external financing. This is important because it is difficult to test the effect of capital markets access in naturally occurring environments without numerous confounding factors.[3] Here, in a controlled environment holding all other factors constant, we isolate the effects of the external capital market alone.

The experimental outcomes support our prediction that capital markets boost economic welfare, raise output, and improve product quality. The channels for this improvement differ somewhat from theory: investors tax opportunistic behavior and subsidize production, and production of high quality goods in particular. In fact, this subsidizing behavior skews the division of economic surplus towards consumers. However, it costs investors. Some of our experimental results mirror previous work on one-sided reputation games. We find that the degree of reputation formation does not follow game theoretic predictions exactly, but is affected by parameters, experience and learning. In particular, our data supports the idea that subjects do not automatically backward induct nor arrive at the equilibrium via fictitious play. Instead, as suggested by Camerer and Ho (1989), direct experience is an important determinant of their actions.

The remainder of the paper proceeds as follows: In the next section, we describe the framework for our analysis and derive the predictions for our experimental study. Section 3. is devoted to a description of our experimental procedures. We describe and analyze the experimental outcomes in Sections 4. and 5. We conclude the paper with an overview of our results in Section 6. Proofs of all claims are presented in Appendix I. In Appendix II, we establish that single-period debt financing also supports equilibrium outcomes similar to those described below. Finally, Appendix III contains the experimental instructions.

2. Model

Consider an n-period world with several types of risk-neutral agents: investors, entrepreneurs, and consumers, who discount cash flows at a risk-free rate of zero. Each period, an entrepreneur can produce one unit of a good. The good can be either low (l) or high (h) quality, each with an associated production cost. The good is sold to consumers at a competitive, market determined price, p. In each period, production of the good requires an investment of $\$I$. Capital is obtained at the start of the period, either internally, or externally from investors operating in a competitive capital market. In exchange for capital, external investors obtain a claim entitling them to α percent of end-of-period cash flows. The investor claims resemble equity. However, unlike equity, they only dictate the distribution of cash flow during the current period and expire thereafter.[4]

[3] We note that there is some limited empirical research linking product and financial and financial markets. For example, Hellmann and Puri (2000) study the relationship between venture capital and the production process in technology firms, and Campello (2003), studies the effects of capital structure on markups and sales growth.

[4] As we demonstrate in Appendix II, our results are not an artifact of this security design. However, we base our analysis on this security design because it is simple and its cash flow implications are easily

Consumers observe quality only after purchasing a good. High quality goods increase utility by u_h, while low quality goods increase utility by $u_l < u_h$. The cost of producing a low quality product is normalized to zero, while the cost of producing a high quality product is $c < u_h - u_l$. This ensures that the increase in a consumer's utility from improved product quality exceeds the incremental cost of producing high quality. Further, we assume that $u_l \leq I$, ensuring that production is not a positive NPV endeavor so long as the goods command the price u_l. The incremental cost of improved quality is paid at the end of the period, when the good is sold to the consumer. If internally financed, the entrepreneur keeps the net end-of-period cash flows. If externally financed, end-of-period cash flows are shared between the entrepreneur and investor based on the claim issued at the beginning of the period.

There are two types of entrepreneurs: flexible (F) and high quality (H). High quality entrepreneurs always produce high quality goods, while, in each period, each flexible entrepreneur chooses between high and low quality to maximize his expected wealth. The entrepreneur's type is private information. However, both consumers and investors have a prior distribution on the entrepreneur's type; At time zero, they assess a probability of π to the entrepreneur being type H.

We employ the Bayesian Nash equilibrium concept. This requires that entrepreneurs maximize payoffs in each sub-game given consumer and investor responses. Investors and consumers base their financing and product pricing decisions on a system of beliefs which are conditioned on the past actions of the entrepreneur. These beliefs, whenever possible, must be consistent with Bayes' rule. An important condition of the Bayesian Nash equilibria is that both consumers and investors correctly conjecture entrepreneur behavior. This implies that, in equilibrium, both consumers and investors have to maintain the same beliefs regarding the entrepreneur's type and actions.

The price of the good sold by the entrepreneur depends on consumers' beliefs regarding its quality. If ρ represents the probability they assess to a good being high quality, consumers will be willing to pay $p(\rho)$, where

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

To help with exposition, let $\bar{p}$ denote the price consumers pay when they assess probability π to good being high quality, and let $p^+ = p(1)$ represent the price consumers pay when they assess probability 1 to the good being high quality. Quality depends on the entrepreneur's type and his quality choice contingent on being type F. Thus, if consumers believe that the entrepreneur is type H with probability ρ and, contingent on being type F, the entrepreneur will produce low quality, they will be willing to pay $p(\rho)$.

External investors' demands when approached for financing will be determined by their beliefs regarding the payoff from their investment. If investors assess probability ρ to a profit of $u_h - c$

understood. These features make it ideal for use in experiments.

and probability of $1-\rho$ to a profit of u_l, they will demand $\alpha(\rho)$ of the profit, where

$$\alpha(\rho) = \frac{I}{\rho\,(u_h - c) + (1-\rho)\,u_l}. \tag{2}$$

To ease exposition, let $\bar{\alpha} = \alpha(\pi)$ and $\alpha^+ = \alpha(1)$. In equilibrium, investors and consumers have to share the same beliefs regarding the entrepreneur's type and quality choice. Thus, if both investors and consumers believe that the entrepreneur is type H with probability ρ and will produce low quality contingent on being type F, in exchange for financing him, investors will demand $\alpha(\rho)$.

Now consider the entrepreneur's choice in the final period. Fixing consumer beliefs (because the consumer cannot observe quality until after the purchase), a type-F entrepreneur can switch quality without affecting prices. Further, in the final period, the entrepreneur's decision has no effect on cash flows in future periods. Because low quality goods cost 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, type F produces low quality in period n. Further, in any equilibrium in which type F ceases production after period $t < n$, he will produce low quality in period t.*

While type F will always choose low quality in his final period of production, there exists an equilibrium in which he produces high quality goods in all prior periods. Switching to low quality before the final period reveals the entrepreneur's type (F) to consumers and investors. This ensures that he 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 a one time immediate saving of the cost of producing high quality. The cost is identification as type F and, thus, the future loss of the quality premium earned by pooling with type Hs. As the next proposition shows, the future gains from a reputation exceed the short term profit from opportunism whenever production by type H is sustainable.

Proposition 2 *Suppose that the entrepreneur employs internal finance. Then a* reputation *equilibrium exists in which only high quality is produced until period n if and only if the following condition is satisfied:*

$$\bar{p} - c - I > 0. \tag{3}$$

This equilibrium has the following properties: The product is priced at p^+ until period n and at $\bar{p}$ in period n. If the entrepreneur produces low quality prior to period n, in all subsequent periods consumers pay u_l for his product.

If (3) *is satisfied, then there does not exist an equilibrium in which type F produces low quality in any period prior to n.*

The reputation equilibrium described in Proposition 2 is sustained by the profitability of high quality production in period n. This period n profitability ensures that, if the entrepreneur is of type F, he can earn a large profit if he maintains his reputation until period n and then switches to low quality. The underlying logic 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 profits dissipated by the destruction of the entrepreneur's reputation. Thus, the incentive to deviate to low quality diminishes with distance from period n.

A reputation equilibrium similar to the one described in Proposition 2 is also feasible when the entrepreneur uses outside capital. The underlying logic behind the existence and uniqueness of this reputation equilibrium is identical to that sustaining the reputation equilibrium with internal financing—the short-term benefit from producing low quality is smaller than the reputation gain from sustaining high quality production until period n. Access to external finance, however, affects the ability of type H to sustain production. When consumers expect type F to produce low quality, goods will command a lower price, reducing the profitability to type H. However, because consumers and investors share the same beliefs regarding the entrepreneur's type, investors will overprice the securities sold by type H. This overpricing gain partially offsets the profits lost because of lower product prices.

Proposition 3 *Suppose that the entrepreneur employs internal finance. Then a* reputation *equilibrium exists in which only high quality is produced until period n if and only if the following condition is satisfied:*

$$(1-\bar{\alpha})\,\bar{p} - (1-\alpha^{+})\,c > 0. \tag{4}$$

This equilibrium has the following properties: In period n, type F switches to producing low quality. The product is priced at p^{+} until period n and at $\bar{p}$ in period n. Capitalists demand α^{+} until period n and $\bar{\alpha}$ in period n. If the entrepreneur produces low quality prior to period n, in all subsequent periods consumers pay u_l for his product and capitalists demand $\frac{I}{u_l}$.

If (4) *is satisfied and the entrepreneur employs external capital, there does not exist an equilibrium in which type F produces low quality in any period prior to n.*

These results demonstrate that reputation equilibria are feasible whether or not the entrepreneur relies on external or internal financing. However, the entrepreneur's financing choice can determine the feasibility of these reputation equilibria. The impact of the entrepreneur's financing decision on the feasibility of reputation equilibria is readily ascertained by comparing (4) and (3). Note that

(4) can be rewritten as follows:

$$(1-\bar{\alpha})(\bar{p}-\pi\,c+\pi c)-c+\alpha^{+}\,c$$
$$=\bar{p}-c-I+c\,I\left(\frac{1}{u_h-c}-\frac{\pi}{\pi\,(u_h-c)+(1-\pi)\,u_l}\right) \tag{5}$$

Because the last term in parentheses is positive, it follows that the condition for the existence and uniqueness of reputation equilibria when entrepreneurs raise capital from outside investors, (4), is less restrictive than the corresponding condition when they finance production internally, (3). This result relies on the countervailing effect of capital market mispricing on the product market losses incurred by a type-H entrepreneur. As our numerical parameterizations of the model in the subsequent section demonstrate, there exist parameters of the model under which only external finance supports reputation formation. Given this fact and the fact the more restrictive constraints for reputation formation with internal capital we can record the following proposition:

Proposition 4 *Condition* (4) *is satisfied whenever* (3) *is satisfied. Thus, there exist parameters where reputation formation will occur if and only if financing is external.*

From (5) it is clear that, even when a reputation equilibrium is not feasible with internal financing, a reputation equilibrium with external financing may exist if the production cost (c) and the required investment (I) are relatively high or π is relatively small. The differential effect of the production cost is the most transparent–the larger the production cost, the larger the gain to external investors from entrepreneur opportunism. This tax on opportunism is the primary force underpinning the superiority of external finance. The investment level determines the amount of funding required from external investors and, thus, their share of any gains from entrepreneur opportunism, i.e., the investment level in effect determines the tax rate on opportunism. Finally, a lower prior probability raises the mispricing loss incurred by an opportunistic entrepreneur, discouraging defection to low quality production.

Because, opportunism in the last period is a dominant strategy for type F, a lower bound on opportunism is reached by the reputation equilibrium in which no opportunism occurs until the last date. Welfare is maximized 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. Thus, there exist parameterization of our model where external finance maximizes welfare over all possible financing mechanisms and internal finance does not maximize welfare.

Further, as we demonstrate in the following proposition, there exist equilibria where entrepreneurs prefer outside financing even when (3) is satisfied. These equilibria are supported by the belief that internal financing signals entrepreneur flexibility. While there may also exist equilibria where external finance signals entrepreneur flexibility, these equilibria succumb to standard refinements. The robustness of equilibria where internal financing signals entrepreneur flexibility is driven by the

fact that the entrepreneur, if he is of type H, will always receive a higher payoff in these equilibria than in equilibria in which internal finance is used. This follows because type H always captures a mispricing gain from external finance.

Proposition 5 *When* (4) *is satisfied, there exist equilibria where entrepreneurs strictly prefer financing production with capital raised from outside investors.*

Now that we have established the superiority of short-term external finance provided by uninformed investors, we provide further insight into the relation between production and financing decisions by examining outcomes when conditions (3) and (4) are not satisfied. We develop these results using the three parameterizations of our model presented in the following section. Our experiments are calibrated using these parameterizations, and thus, the equilibrium outcomes they support provide benchmarks against which we can gauge subject behavior and outcomes in our experiments.

2.1. Parameterizations used in experiments

Table 1 shows the three parameter sets used in our experiments. For each set of parameters, the number of periods, n=3.[5] Under Parameterization 1, both the conditions for the existence of reputation equilibria, (3) and (4), are satisfied. This ensures that whether an entrepreneur uses internal or external financing he will produce in every period in equilibrium. Further, regardless of the financing source, type F will eschew low quality production until the final period. Under Parameterization 2, only (4) is satisfied. Thus, entrepreneur opportunism is higher than under Parameterization 1. In equilibrium, an internally financed entrepreneurs may produce low quality prior to period 3. Under Parameterization 3, neither (4) nor (3) is satisfied ensuring entrepreneur opportunism is so acute that production is never undertaken without outside financing. Below, we describe the equilibria supported by each parameterization under both internal and external financing.

Table 1: *Parameterizations*

Parameterization	π	I	u_h	u_l	c
1	0.5	400	1000	400	200
2	0.75	500	1000	400	400
3	0.25	500	1000	400	400

2.1.1. Parameterization 1

Because Parameterization 1 satisfies (4) and (3), it only supports pure strategy equilibria where type F produces high quality until the final period, when he switches to low quality. Thus, entrepreneur actions and product market prices are not dependent on the manner in which production

[5]To test the robustness of our results, we also ran experimental sessions with n ranging from 1 to 4.

is financed. Product prices remain at $1,000$ for the first two periods, and drop to 700 in the final period. Similarly, investors will demand $\frac{1}{2}$ of the profits in the first two period. In the final period, they will demand $\frac{2}{3}$ of the profit.

Corollary 1 *In all equilibria supported by Parameterization 1, type F produces high quality until period n. In period n, type F produces low quality. The product is priced at* $p^+ = 1000$ *until period n and at* $\bar{p} = 700$ *in period n. Investors demand* $\alpha^+ = \frac{1}{2}$ *of the profits until period n and* $\bar{\alpha} = \frac{2}{3}$ *of profits in period n. If the entrepreneur produces low quality prior to period n, in all subsequent periods consumers pay* $u_l = 400$ *for his product and investors demand* $\frac{I}{u_l} = 100\%$ *of the profits.*

2.1.2. Parameterization 2

Parameterization 2 differs from Parameterization 1 in three dimensions: (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. With these changes, high quality production until period $n-1$ can only be consistently sustained if entrepreneurs finance investment using external capital. Overall, these changes encourage entrepreneur opportunism and highlight the role of the capital market in limiting this opportunism.

First note that, with the increased capital investment, production is no longer economically viable if consumers price the product as if it were low quality because

$$u_l = 400 < 500 = I. \tag{6}$$

Consequently type F will only operate if consumers cannot detect the entrepreneur's type. The increased capital investment may also make production uneconomic for type H if he cannot access the capital market. Such a situation occurs if consumers assume that the likelihood that type F equals the prior probability and that type F will produce low quality. Given these consumer beliefs, the product price will fall short of the cost of producing high quality, i.e.,

$$\bar{p} = 0.75 \times 1000 + 0.25 \times 400 = 850 < 500 + 400 = I + c. \tag{7}$$

Because type H cannot profit from high quality production 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 subsequent period he randomizes between high and low quality. In the final period, he produces only low quality goods. Early defection to low quality is induced by product prices that decline over time in response to the decline in the average quality of goods. Early defection forces production to shut down in future periods, 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 6 *Under Parameterization 2, 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:*

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

b. *In period 2, if high quality was produced in period 1 produce high quality with probability* $\frac{3}{5}$ *and low quality with probability* $\frac{2}{5}$*; if high quality was not produced in period 1, shut down.*

c. *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* $p^+ = 1000$*; in period 2, offer* 940 *and in period 3, offer* 900*.*

Under Parameterization 2, type F has more to gain from opportunistic behavior than under Parameterization 1. When an entrepreneur accesses capital markets, however, he must share the gains from opportunism with the investor. This dilutes the entrepreneur's incentive to act opportunistically. In fact, this dilution is sufficient to ensure that (4) is satisfied. Thus, external financing dilutes the incentives for opportunistic behavior enough to ensure that type F will eschew low quality production until the final period.

Corollary 2 *Under Parameterization 2, when the entrepreneur uses external finance, only high quality is produced until period 3. In period 3, type F switches to low quality. The product is priced at* $p^+ = 1000$ *in periods 1 and 2, and at* $\bar{p} = 850$ *in period 3. Investors demand* $\alpha^+ = \frac{5}{6}$ *of the profits until period 3 and* $\bar{\alpha} = \frac{10}{11}$ *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* $\frac{I}{u_l} = \frac{5}{4}$ *of the profits, i.e., they refuse to finance the entrepreneur.*

One interesting aspect of Corollary 2 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, an externally financed type-H entrepreneur 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 $\frac{10}{11}(850 - 400) - 500 = -90.91$ conditional on financing type H. However, they are willing to finance entrepreneurs because, in expectation, they break even as their profits from financing type F exactly offset the losses from funding type H.

2.1.3. Parameterization 3

The only difference between Parameterizations 2 and 3 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 entrepreneurs use internal financing.

Proposition 7 *Under Parameterization 3, there exists no equilibrium in which internally financed entrepreneurs produce.*

Even when entrepreneurs raise external financing, they resort to low quality production prior to the final period. As we have demonstrated above, capital market access dampens the incentive for type F to act opportunistically. However, here, this effect is not strong enough to ensure that type F produces 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 8 *Under Parameterization 3, when entrepreneurs access the capital market, there exists a mixed strategy equilibrium in which type F uses the following strategy:*

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

b. *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.*

c. *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.*

Overall our results show that financing by uninformed investors can alter entrepreneur incentives. More specifically, because entrepreneurs have to share gains from opportunistic actions with investors, they have less incentive to act opportunistically when they receive external financing. Thus, they tend to produce higher quality goods even though consumers are uninformed about the quality of goods at the time of purchase. Because capital market 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

In experimental sessions, paid subjects play the roles of investors, entrepreneurs and consumers. We employ a 2×3 design, running a one internal and one with external financing session for each parameterization presented in Table 1. Sessions labels are presented in Table 2. With the exception of session E2, where one subject left for unknown reasons, each session resulted in 48, 3-period-group observations. Details of the procedures can be found in the subject instructions that are reproduced in Appendix III. We summarize them here.

Table 2: *Experimental Design*

	Internal Financing		External Financing	
Parameterization	Treatment	Observations	Treatment	Observations
1	I1	48	E1	48
2	I2	48	E2	40
3	I3	48	E3	48

3.1. Common Design Features

The subjects were recruited from a volunteer subject pool of undergraduate and MBA students taking business classes at the University of Iowa. Subjects were asked to come to a session that would last up to three hours and were paid \$5 for showing up on time. During the session, payments were denominated in "francs," the experimental medium of exchange. At the end of the session, francs were converted into dollars at the known exchange rate of \$0.002 per franc. Sessions typically lasted less than three hours. Payments to subjects (including the \$5 show up fee) averaged \$28.52. The high was \$37.02 and the low was \$21.90.

Upon arrival, subjects were seated at separate computer terminals and given instruction sets, experimental forms and receipts that would be filled in during the session. The sessions themselves were not computerized, but each subject had a "trial" spreadsheet available on the computer that would 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

Upon arrival, subjects were randomly assigned a role, "Green" players (consumers) or "Blue" players (entrepreneurs), and were randomly assigned to six groups consisting of one consumer and one entrepreneur.[6] Groups ran simultaneously, each remaining constant for three periods to allow a common history and reputation formation. Though they kept their roles throughout a session, subjects were randomly reassigned to six new groups after each 3-period game. This

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

mixing procedure is similar to that employed in DeJong, Forsythe and Lundholm (1984), Camerer and Weigelt (1988), and King (1996).

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

3.2.1. Consumer Choices and the Product Market

The goal of the product market was to elicit a competitive price for the item that the consumer would be willing to pay before knowing the quality of the product.[7] We implemented this by adapting a Becker, DeGroot and Marschak (1964) procedure (hereafter "BDM procedure"). Recent research shows that, on average, the BDM procedure elicits risk neutral valuations (Berg, Dickhaut and McCabe, 2005) which, in our case, correspond to competitive prices. By implementing this procedure, we were able to elicit a competitive price from a single subject. Further, it was fast to implement, it allowed us to avoid complications from auction procedures (e.g., overbidding as in Kagel and Levin, 1993), and did not require pre-specifying a limited set of allowable prices (e.g., Forsythe, Lundholm and Rietz, 1999). To facilitate the use of the BDM procedure and to equalize expected net profits across player types, each player was given a fixed endowment of francs each period that depended on his or her type.

Specifically, each consumer was asked to submit the highest price he or she would be willing to pay for the item (with the restriction that the price be between 400 and 1000 inclusive). This number determined the "established price" for the item that the entrepreneur would receive for the product. After all consumers had submitted their established prices, the experimenter drew a ticket from a box containing 601 tickets numbered 400 to 1000 each representing the corresponding price between 400 and 1000 francs. If the ticket drawn was less than or equal to the established price submitted by the consumer, the consumer bought the item from the experimenter at a price equal to the random draw. This was called a "discounted price." If not, the consumer did not purchase the item. In either case, the consumer received a report showing the quality (value) of the item.

To this point, this was an ordinary BDM procedure and should have, on average, elicited risk neutral (i.e., competitive) valuations from the consumers. Our adaptation allowed the game to continue whether the consumer bought the item or not. The experimenter gave the entrepreneur the established price of the item regardless of whether the consumer purchased it. In turn, the consumer bought the item from the experimenter if the discounted price was lower than the established price

[7]Bidding on an item before its quality is known is common (e.g., Miller and Plott, 1985) and the quality choice is sometimes endogenous (e.g., DeJong, Forsythe and Lundholm, 1984, and King, 1996). Our implementation differs somewhat from those employed in prior research and the combination of capital and product markets here is unique.

and the experimenter made up the difference. This created an incentive compatible mechanism to elicit the maximum price the consumer was willing to pay and the entrepreneur always received this price. When we report results below, they will be in terms of the consumer established prices.

When a consumer purchased the item, he received a payoff at the end of the period equal to the initial endowment plus the value of the item minus the discounted price. When a consumer "sat out" because of the BDM procedure or production was halted by the investor (see below), he received a payoff equal to the initial endowment. Thus, a consumer's payoff was

$$e_C + D_C \times (u(q) - p_C), \tag{8}$$

where e_C is the consumer's endowment, D_C is an indicator variable that equals 1 if the consumer established price was higher than the discounted price and production was allowed, $u(q)$ is the consumer's value given the quality, and p_C is the discounted price.

3.2.2. Entrepreneur Choices and Internal Finance

The entrepreneur effectively made two choices in this treatment: (1) the quality type to produce and (2) whether to invest the capital necessary for production.

The entrepreneur chose quality by committing to produce a "round" item (high quality) or a "square" item (low quality).[8] Restricted entrepreneurs were restricted to choosing the high quality item. Flexible entrepreneurs could choose either quality type.

The experimenter implemented the capital investment policy by subtracting the capital cost from the entrepreneur's profit on the sale of the item if the profits were sufficient to cover these costs. If not, production was not allowed. This made the experimenter and "Blue" player together act like an entrepreneur who (i) knew the capital cost of production and contributed it, (ii) determined the quality type of produced each period, and (iii) given the good's price in a given period and his quality commitment, chose to halt production if profits are insufficient to cover capital costs.[9] Whether or not production was halted, the entrepreneur received a report of the outcomes.

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 item minus the capital investment. When production was not allowed, the entrepreneur received his endowment. Thus, an entrepreneur's payoff was

$$e_E + D_E \times (p_E - c(q) - I), \tag{9}$$

where e_E is the entrepreneur's endowment, D_E is an indicator variable that equals 1 if production was allowed, p_E is the established price, $c(q)$ is the (marginal) cost of the quality type produced,

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

[9]While 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. 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.

and I is the capital investment.

3.3. External Finance Games

The external finance experiments were different in two respects: (1) entrepreneurs only made a quality choice and (2) the capital investment/financing rate choice was made in an external capital market by an investor. To accommodate the introduction of a capital market, the groupings added a "Red" player (investor) to each group. In addition, we also ran one, two and four period, external finance games as robustness checks as discussed below.

3.3.1. Investor Choices and the External Capital Market

The goal of the external capital market was to elicit a competitive share of the profits that, before knowing profitability, an investor would demand in exchange for supplying the capital needed to support production.[10] As with the product market, this was implemented by adapting a BDM procedure as detailed in the instructions. This procedure resulted in an "established percentage" of profits that the entrepreneur paid to the experimenter and a "marked-up" percentage that the investor received from the experimenter (with the experimenter making up the difference as in the product market). By setting an established percentage greater than or equal to 100%, the investor could halt production for the period.[11] The established percentage was communicated to the entrepreneur before he made his quality choice.

When production occurred, an investor received a payoff at the end of the period equal to the marked up percentage of the entrepreneur's profits on the production and sale of the item. His endowment was used as to cover the capital cost. When an investor "sat out" because of the BDM procedure or halted production, he received his endowment. In either case, he received a report showing the quality of the item and firm profitability. Thus, an investor's payoff was

$$e_I + D_I \times [(p_E - c(q)) \times \alpha_I - e_I], \tag{10}$$

where e_I is the investor's endowment, D_I is an indicator variable that equals 1 if production was allowed and the marked-up percentage exceeds the established percentage, p_E is the established price, $c(q)$ is the (marginal) cost of the quality type produced, and α_I is the marked up percentage of the profits.

[10]This portion of the design is similar to that employed in Cadsby, Frank and Maksimovic (1990 and 1998), but differs in implementation. Other researchers study the financing decision in contexts that differ considerably from ours. These include Goswami, Grace, and Rebello (2007), Asparouhova (2006), and Camerer and Weigelt (1988).

[11]This is explicitly stated and given as an option in treatments E2 and E3. Because it is not an optimal equilibrium response in treatment E1, halting production was not discussed explicitly. However, if the investor did not feel that profits would be sufficient to cover costs, he or 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.

3.3.2. Product Markets and Entrepreneur Choices

The procedure followed for the remainder of the external finance experiments was identical to the procedures for the internal finance treatment. Product markets were implemented in exactly the same manner as with internal finance. Knowing the terms of financing in advance, entrepreneurs made the same quality choice as with internal finance. However, entrepreneur payoffs reflect the cost of external finance instead of internal. Specifically, an entrepreneur's payoff was

$$e_E + D_E \times (p_E - c(q)) \times (1 - \alpha_E), \tag{11}$$

where e_E is the entrepreneur's endowment, D_E is an indicator variable that equals 1 if production is allowed, p_E is the established price, $c(q)$ is the (marginal) cost of the quality type produced, and α_E is the percentage of the profits on the sale of the item established by the investor in exchange for financing production.

4. Experimental outcomes

In this section, we describe the experimental outcomes. We begin by examining the influence of external capital markets on economic surplus. Then we examine, in turn, how external capital markets affect the determinants of economic surplus and its division between agents—the level of output, product quality, and prices (which drive the division of surplus).

4.1. Surplus

One way of capturing the influence of external capital markets is to estimate their effect on economic surplus. In our context, economic surplus is a good's value minus its (total) production cost. Under Parameterization 1, high quality production results in an economic surplus of 400 and low quality production or no production results in 0 surplus. The reputation formation equilibrium results in a predicted surplus of 400 per entrepreneur in the first two periods, dropping to an average of 200 per entrepreneur in period 3, when all flexible firms defect.

Under Parameterizations 2 and 3, high quality production increases economic surplus while low quality production reduces it. However, in equilibrium, low quality production occurs infrequently. In treatment E2 (external finance, Parameterization 2), the reputation equilibrium predicts average surpluses of 100, 100 and 50 per entrepreneur in periods 1, 2 and 3, respectively. In treatment I2, early defection by flexible entrepreneurs should result in surpluses of 100, 80 and 60 in periods 1, 2, and 3, respectively. Similarly, early defections in treatment E3 result in expected surpluses of 45.5, 16.5 and 5.4. Finally, because production should not occur, predicted economic surplus is zero for treatment I3 in all periods.

In Table 3, we report the average economic surplus per period across all six treatments. To facilitate comparisons across the three parameterizations, the surplus figures presented in the table are normalized by the surplus produced under the (Pareto) optimal outcome of 100% high quality production. Normalized surplus averaged 57.6 in treatment I1. In treatment E1 the average surplus was 60.4. Generally, external financing lead to higher average surpluses than internal. Sometimes

this effect was large and significant. For example, the average surplus of 53.3 in treatment E2 is statistically significantly higher than the surplus of 22.9 generated in treatment I2. Thus, access to capital markets increased economic surplus.

Overall, average surpluses declined monotonically from Parameterization 1 to Parameterization 3. A similar pattern holds on a period-by-period basis. These patterns are consistent with our predictions for internal financing, but the difference between the surplus in treatments E1 and E2 is inconsistent with our predictions. Further, in contrast to our predictions, the surplus produced did not decline monotonically over time.

While some broad patterns of surplus generation conform with our predictions, comparing actual to predicted surplus for each treatment paints a different picture. With the exception of the surplus in period 3 of the six treatments (when flexible entrepreneurs have a dominant strategy), both overall and periodic average realized surpluses were significantly lower than predicted. This difference arose because, in periods 1 and 2, a significant fraction of flexible entrepreneurs either did not produce or produced low quality goods. Nevertheless, when external financing had a significant impact on surplus, it was in the predicted direction. In particular, under Parameterization 2, it increased surplus significantly by reducing the (negative) deviation in surplus from the prediction.

4.2. Production

Under Parameterization 1, we predict entrepreneurs will produce in every period regardless of the financing means, resulting in 100% production rates. Under Parameterizations 2 and 3, predicted production levels vary with financing. In both cases, external financing should sustain higher levels of production. Under Parameterization 2, we predict full production with external financing. With internal financing, period 2 defections should shut down 10% of production in period 3. Under Parameterization 3, external financing should fund production for firms who have not defected, resulting in expected production rates of 100%, 72.4% and 44.6% in periods 1, 2 and 3. In contrast, internal financing should result in no production at all.

Table 4 documents production rates across all six treatments. The average production rate was approximately 88.9% in treatment I1. In treatment E1, the production rate was 97.9%. This pattern of higher average production under external financing was repeated for Parameterizations 2 and 3. These production differences are statistically significant for all three parameterizations, and in the case of Parameterizations 2 and 3 the outcomes are consistent with our predictions.

As predicted, production occurred most frequently under Parameterization 1. However, contrary to our predictions, more production occurred under Parameterization 3 than under Parameterization 2. In fact, with external financing, production in every period was higher under Parameterization 3 than under Parameterization 2. Consistent with our predictions, we also find that, with the exception of treatments I1 and I2, production declined monotonically over time.

Again, while some broad patterns conform with predictions, specific rates often diverge significantly from predictions. The only exception is treatment E1. In treatments I1, I2, and E2, production tended to be significantly lower than predicted. In contrast, in treatments E3 and I3,

production was generally higher than predicted. This pattern is reversed when we examine the effect of external capital market access on the difference between the incidence of production and predictions. For Parameterization 1 and 2 capital market access boosted production by significantly more than the amount predicted by our model. This effect was strongest for Parameterization 2. However, under Parameterization 3, the production boost from capital market access was significantly lower than expected. As a result, external financing increased production, as predicted by theory, but not exactly in the manner or extent predicted.

4.3. Quality of output

Now we turn to the frequency of high quality production. In treatments E1, I1 and E2, the reputation equilibrium predicts high quality production from all entrepreneurs in periods 1 and 2. In period 3, all flexible firms should defect, resulting in 50% high quality production in treatments E1 and I1 and and 75% high quality production in treatment E2. In treatment I2, high quality production rates are predicted to be 100%, 90% and 75% in periods 1, 2 and 3. Treatment E3 is predicted to result in high quality production rates of 72.7%, 44.6% and 25%. Internal financing should drive out all production in treatment I3.

Table 5 shows the frequency of high quality production in each of our six treatments. Consistent with our predictions, we find that external capital market access promotes the production of high quality goods. This effect is significant when it is predicted (under Parameterizations 2 and 3). Average rates of high quality production declined monotonically from treatments I1, to I2, and from I2 to I3. With external financing, quality production rates were highest under Parameterization 2 followed by 1 then 3. Both of these patterns are consistent with our predictions. Further, access to external capital markets drove quality down monotonically over time as predicted. This was not the case under internal financing.

Once again, while some broad patterns emerged as predicted, high quality production rates consistently fell below predicted levels. In one instance, the first period in treatment I2, this shortfall was as high as 91.7%. Further, while external capital market access promoted quality more than we anticipated under Parameterization 2, external capital market access had a significantly weaker influence on quality than predicted under Parameterization 3.

4.4. The division of surplus

Now we turn from examining the influence of external capital markets on aggregate economic activity to their influence on the division of surplus between agents. Given that the established percentage demanded by the investor is determined competitively, we expect that the investor should be unable to capture a share of the economic surplus. Similarly, competitive pricing should prevent consumers from capturing any surplus.[12] Thus, the entire economic surplus should be appropriated by the entrepreneurs. As a result, while external capital markets may affect overall

[12]We compute the surpluses based on the established percentages and prices from the experiment determined by investors and consumers, not the random-draw-determined "marked-up percentages" and "discounted prices."

surplus, they should have no effect on its division.

Table 6 shows the division of surplus in all six treatments. To allow for comparisons across treatments, we have normalized the surplus shares by the surplus under the Pareto optimal decision, production of high quality goods. As expected, with the exception of treatment E2, producers captured the largest share of the surplus. While consumer shares are not statistically different from zero in treatments E1, I1, and E3, they captured a large share of the surplus in treatment E2 and ended up with negative surplus in treatments I2 and I3. On average, product prices were too high in treatments I2 and I3, and too low in treatment E2. Investors also earned negative surpluses in treatments E2 and E3. They overpriced the securities they received in exchange for capital. In fact, in both treatments, investor losses exceeded the predicted surplus in these treatments, indicating that they subsidized production quite heavily.

The source of financing affected consumer surplus; It was higher in the presence of capital markets. For Parameterizations 2 and 3, where investors incurred significantly large losses, consumer gains were significantly higher with capital markets. Capital markets had a more muted effect on the surplus earned by entrepreneurs, generally resulting in no significant change in entrepreneur surplus. However, for Parameterization 1, capital market access actually significantly reduced entrepreneur surplus.

4.5. Entrepreneur actions

In Table 7, we summarize the actions of flexible entrepreneurs in our experiment. We observed all entrepreneur decisions, including decisions regarding product quality when production was suspended. Because we observed these "off-equilibrium-path-actions" and because entrepreneur's equilibrium strategies also call for specific actions off-equilibrium, the table presents entrepreneur actions whether they actually produced or not.

First note that, in equilibrium, flexible entrepreneurs should always produce low quality goods in period 3. In treatments E1, E2, and I1, flexible entrepreneurs should produce high quality goods until period 3. In treatment, I2, the mixed strategy equilibrium results in flexible entrepreneurs producing high quality output 60% of the time until period 3. The remaining flexible entrepreneurs should produce high quality in period 1 and low quality in period 2. While these entrepreneurs should not produce in period 3, their (off) equilibrium strategies call for low quality goods in period 3. Similarly, in treatment E3, we should observe high quality production until period 3 by flexible entrepreneurs 26.2% of the time. Flexible entrepreneurs should produce high quality goods in period 1 and low quality goods 37.5% of the time in period 2. Finally, 36.4% of flexible entrepreneurs should produce low quality goods in period 1. After entrepreneurs produce low quality, their off equilibrium actions should also result in low quality output thereafter. In treatment I3, flexible entrepreneurs should always play the off-equilibrium strategy of producing low quality goods.

There are three striking results in Table 7. First, entrepreneur actions tended not to resemble those predicted by the equilibria. In fact, the predicted frequency of action sequences was seldom approached by actual play. Generally, when we predict a pure strategy will be followed, the actual

percentage of entrepreneurs following that strategy is closer to Selten's (1991) measure of area for that strategy than 1. This means the observation is closer to the frequency predicted by random behavior than our model. The one exception to this rule is in treatment I3, where we predict that all flexible entrepreneurs will produce low quality and they actually do 63.9% of the time. The model fares no better when it makes mixed strategy predictions. Again, with one exception, the actual frequencies of strategies are closer to random behavior than the predicted frequencies. The exception is treatment E3, strategy LLL, where random behavior would account for 12.5% of the observations, our model predicts 36.4% and the actual frequency was 72.2%.

Second, the most frequently observed strategies were ones where flexible entrepreneurs produced low quality goods in all three periods. In fact, in treatments E2, E3, I2, and I3, the majority of flexible entrepreneurs adopted this strategy. Further, in treatments E2, E3, and I2 the realized frequencies of this particular action sequence significantly exceeded the frequency of these actions predicted by random play, which is higher than the frequency with which this action sequence should be observed in equilibrium, 0.

Third, flexible entrepreneurs opted to produce high quality goods in period 3 under Parameterization 1, even though this is strongly dominated. These frequencies sometimes rose to surprisingly high levels under Parameterizations 2 and 3. However, in several instance these entrepreneurs were not financed.

Overall, entrepreneur behavior is not well predicted by the sequential equilibrium. This accords with the findings of experimental work on one-sided reputation games (e.g., Brandts and Figueras, 2003) that reputation formation in short games is difficult to achieve even when it is the sequential equilibrium. However, as we will show in the next section, investors and consumers did not price according to equilibrium predictions and, as a result, observed entrepreneur behavior was not necessarily sub-optimal. Entrepreneurs may have been responding to the out-of-equilibrium behavior of the consumers and investors. We turn to explaining actual behavior after discussing the robustness of these outcomes.

4.6. Assessment and Robustness Checks

We ran several sessions based on Parameterization 1 to serve as checks on our procedures and to assess the robustness of our results. We describe these briefly here.

To assess the results of 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 reality, flexible entrepreneurs produced high quality 15% of the time.[13] Risk neutral consumers should price at 700 in theory. If their prices correctly reflected the actual

[13]This level remained fairly steady. It was 17% in the first half of the session and 13% in the second half.

production strategies adopted by subjects, 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 subject behavior.

Investors should demand 67% of the proceeds in theory. Since 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 0. 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 losses incurred by investors in other treatments are not an artifact of the stage game or the BDM procedure.

While three periods per group are sufficient to study reputation formation and early versus late defection, we also run two periods-per-group and four-periods-per group games. Results mirrored the three-periods-per group treatments reported here. With two periods per group, 20% of flexible entrepreneurs followed a reputation strategy, 13% followed a dominated strategy and the rest (67%) followed the defection strategy. Average values (750) were not significantly different from average prices (707). Average investor returns (418) did not differ significantly from the contribution of 400. These two results mirror the results in the one-period-per group treatment. With four periods per group, 20% of flexible entrepreneurs followed the reputation strategy, none followed dominated strategies, 33% followed the defection strategy throughout the four periods and the rest follow various other strategies (all ending with a low quality). Average prices (709) fell significantly below average values (790). Average investor returns (336) fell significantly below their contribution of 400. These two results mirror the typical three-periods-per-group results.

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. With experience, 19% of the flexible entrepreneurs followed the reputation strategy, 10% followed dominated strategies, 52% followed the defection strategy and 19% followed various other strategies. Average prices (764) did not differ significantly from average values (774). Average investor returns (463) significantly exceeded their contribution of 400. Thus, the only real difference with experience is that investors may have learned to ask for higher percentages.

5. Explaining subject behavior

While our model predicted the direction of the impact of external capital markets on aggregate measures of production and efficiency, individual subject behavior diverged considerably from predictions. To gain a better understanding of subject behavior, we now focus on identifying the forces that influenced subjects. First, we examine consumer behavior, then entrepreneur, and finally, investor behavior. Our results indicate that the subjects responded to the factors we predict,

but often not to the degree predicted.

For each subject type, a regression given in Table 8 analyzes how they react to various factors. All variables are defined in the table. Many of them are obviously defined. A set of dummy variables indicates the period in the group interaction and whether the entrepreneur was previously revealed as flexible. A set of variables corresponds to the parameterizations and financing treatments. A single variable proxies for experience by using the round in the experimental session (as opposed to the specific group interaction).

Two variables for each subject type are not obvious, but are particularly interesting in explaining behavior. For consumers, we summarize their experience with observed quality types by defining a (within group) historical average quality, where prior qualities are coded with +1 for high and -1 for low. We also define an experience-weighted version of this variable where we weight by 1 if the consumer actually purchased the item according to the BDM procedure and 0 if not. Both historical quality variables are set at 0 in period 1 of a group interaction.

For investors, we summarize their experience with observed profitability by defining a (within group) historical average profitability defined as the ratio of the profits on the sale to the capital expense. We also define an experience-weighted version of this variable where we weight by 1 if the investor actually participated in the profits according to the BDM procedure and 0 if not. Again, both variables are set to 0 in the first period.

Finally, for entrepreneurs, we measure the costs and benefits of high quality production. The short-run cost of high quality is the realized profit on the sale times the percentage of profits kept by the entrepreneur. We define the long-run benefit as the (within session) average maximum payoff to a continuing strategy after high quality production minus the maximum payoff to a continuing strategy after low quality production.

5.1. Consumer behavior

To understand consumer behavior, we focus on pricing decisions. More specifically, we examine whether these pricing decisions were influenced by the history of play, information set and experience of the consumer, and the parameterization. We employ these variables to estimate the censored regression presented in Panel A of Table 8.

The regression estimates show that a consumer's experience with an entrepreneur mattered. Prices rose over time as long as the entrepreneur was not revealed to be flexible, with period 3 prices for the output from an unrevealed entrepreneur being significantly higher than the period 1 price. However, if an entrepreneur was revealed as flexible, consumers reduced the price they were willing to pay. This reduction was significant in period 3. The coefficients estimated for the historical quality variables provide additional evidence that a history of high (low) quality products lead to higher (lower) prices, with the changes being more marked when the consumer actually acquired goods rather than found out about product quality from the experimenter. The negative and significant sign for the cost of high quality shows that consumers were sensitive to the strength of entrepreneur's incentive to produce low quality goods. However, it appears that

consumers behavior was not affected by the presence of capital markets or the prior probability that an entrepreneur was flexible.

Overall, consumer behavior was consistent with an anchor and adjust model where initial expectations were that most (or all) flexible entrepreneurs would produce low quality. Conditional expectations adjusted upward as high qualities were observed and downward as low qualities were observed. However, these adjustments, especially the downward adjustments, are not as rapid as predicted by theory. Consistent with Camerer and Ho (1996), consumers responded more when they actually experienced the quality types through purchasing the good rather than merely observing them.

5.2. Entrepreneur behavior

To understand entrepreneur behavior, we focus on quality decisions. More specifically, we examine whether these quality decisions were influenced by the history of play, and tradeoffs faced by the entrepreneur. We employ these variables to estimate the logistic regression presented in Panel B of Table 8. The dependent variable in this regression is a dummy variable that indicates whether the entrepreneur chose high quality.

The regression estimates suggest that, in line with our model predictions, entrepreneurs were significantly more likely to produce high quality goods in the initial rounds of a group. In addition, once entrepreneurs revealed themselves as flexible, they were more likely to produce low quality goods. A higher production cost for high quality goods encouraged entrepreneurs to opt for low quality as did a higher short run-net cost of producing high quality. Entrepreneur's quality choices do not appear to have been significantly influenced by long-run considerations.

Overall, entrepreneurs responded to market incentives, but more to short-run incentives than long. This explains both the high degree of opportunism relative to predictions and the large impact of the attenuation in incentives for opportunism driven by external financing.

5.3. Investor behavior

To understand investor behavior, we focus on security pricing decisions. More specifically, we examine whether the demanded percentage of profits was influenced by the history of play, information set and experience of the investor, and the parameterization. We employ these variables to estimate the censored regression presented in Panel C of Table 8.

The estimated coefficients indicate that investors demanded higher profit shares over time whether the entrepreneur was revealed as flexible or not. Further, the negative coefficients on the historical profitability variables indicate that a history of higher profits induced investors to reduce their demanded profit shares, with the reduction being more marked if they actually capitalized the entrepreneur in the past. Investors also appear to have been sensitive to both the prior distribution of entrepreneurs and the amount of capital needed by entrepreneurs, demanding more of the profits as the percentage of flexible entrepreneurs in the population and their capital needs rose. Finally, investors appear to have demanded larger profit shares as they become more

experienced. This seems reasonable given that, on average, their profit shares were too low to compensate them for their investment expense.

Overall, investor behavior appears myopic initially, but adjusted with specific and general experience. Again, consistent with Camerer and Ho (1996), investors responded more when they actually experienced the results of financing a firm rather than merely observing them.

6. Concluding comments

We highlight an unrecognized benefit of capital market access by examining the effect of introducing capital markets into a production-market-reputation model. We demonstrate that external finance dilutes entrepreneurs' incentives to enjoy short-term gains by selling low quality goods to uninformed consumers. Effectively, short term external finance taxes opportunistic behavior. By inducing entrepreneurs to produce higher quality goods, capital markets support higher product prices. These higher prices, in turn, raises economic welfare by increasing both entrepreneur (i.e., firm) profitability and production.

We also describe the outcomes of experiments designed to investigate the benevolent effects of external finance. These outcomes support our prediction that capital markets boost economic welfare, raise output, and improve product quality. The channels for this improvement differ somewhat from theory: investors tax opportunistic behavior and subsidize production and production of high quality goods in particular. In fact, this subsidizing behavior skews the division of economic surplus towards consumers. However, it costs investors. While more sophisticated investors (who learn not to subsidize production) may eliminate the redistribution of toward consumers, the other beneficial effects should remain.

Our results show that investors, entrepreneurs, and consumers all respond to incentives and the tradeoffs they face. However, instead of arriving at the equilibrium as anticipated by theory, they appear to anchor their initial decisions at a focal point and adjust through experience. The effects of actual experience have a larger effect than reading reports of outcomes without participating. While interesting on the product market side, we think this has especially interesting potential implications for differences in behavior between investors who actually have an ownership stake in a company relative to those who read reports on the company.

Our novel results arise by combining the problem faced by uninformed investors who finance a firm, and uninformed consumers who purchase the output of the firm that has the ability to develop a reputation for producing high-quality goods. Each of these problems has been extensively studied in isolation and the implications of these studies for capital and product markets are well known. However, our analysis demonstrates that combining these two well understood problems generates unanticipated results. Our results arise because the financing takes the form of short-term claims sold to uninformed investors. In effect, we show the beneficial effects of having to repeatedly raise financing in capital markets, whether the financing takes the form of equity-like claims (as in our main analysis and experiments), short-term debt (addressed in the appendix) or other arrangements where firms disgorge cash after projects and must seek new financing.

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Table 3: *Economic surplus.* This table presents the average per-round economic surplus in each of our treatments. The economic surplus generated equals the value of the good produced less the production cost. All surplus figures are normalized by the Pareto optimal surplus. The table presents the period-by-period predicted value of surplus as well as the realized surplus by period in our experiments. The table presents statistical tests for the difference between the predicted surplus and the realized surplus. An * in the deviation row indicates the predicted surplus differs from the mean actual surplus according to a t-test with a 95% confidence level. For each parameterization, the table also presents the effect of introducing external capital markets on economic surplus as well as the difference between the deviations from the predicted surplus across the two treatments employing that parameterization. An * in either treatment effect row indicates a significant effect according to a t-statistic at the 95% confidence level.

		Panel A: Parameter set 1				Panel B: Parameter set 2				Panel C: Parameter set 3			
Financing			Period				Period				Period		
Treatment	Item	Overall	1	2	3	Overall	1	2	3	Overall	1	2	3
	Prediction	83.3	100.0	100.0	50.0	80.0	100.0	80.0	60.0	0.0	0.0	0.0	0.0
Internal	Actual	57.6	54.2	66.7	52.1	22.9	0.0	31.3	37.5	-29.9	-52.1	-27.1	-10.4
	Deviation	-25.7*	-45.8*	-33.3*	2.1	-57.1*	-100.0*	-48.8*	-22.5*	-29.9*	-52.1*	-27.1*	-10.4
	Prediction	83.3	100.0	100.0	50.0	85.0	100.0	100.0	55.0	22.4	45.5	16.5	5.4
External	Actual	60.4	66.7	62.5	52.1	53.3	60.0	47.5	52.5	-34.0	-27.1	-37.5	-37.5
	Deviation	-22.9*	-33.3*	-37.5*	2.1	-31.7*	-40.0*	-52.5*	-2.5	-56.5*	-72.5*	-54.0*	-42.9*
Treatment Effect	Difference	2.8	12.5	-4.2	0.0	30.4*	60.0*	16.3	15.0	-4.2	25.0	-10.4	-27.1
on Levels	p-value	0.63	0.22	0.67	1.0	0.00	0.00	0.28	0.23	0.65	0.11	0.51	0.08
Treatment Effect	Difference	2.8	12.5	-4.2	0.0	25.4*	60.0*	-3.8	20.0	-26.6*	-20.5	-26.9*	-32.5*
on Deviations	p-value	0.61	0.22	0.67	1.0	0.00	0.00	0.78	0.08	0.00	0.12	0.04	0.01

Table 4: *Production levels.* This table presents the frequency with which entrepreneurs produce in each of our treatments. The table presents the period-by-period predicted frequency of production as well as realized production by period in our experiments. The table presents statistical tests for the difference between predicted production and the realized production. An * in the deviation row indicates a deviation from production that differs significantly from zero according to a t-test at the 95% level of confidence. For each parameterization, the table also presents the effect of introducing external capital markets on production as well as the difference between the deviations from the predicted production across the two treatments employing that parameterization. An * in either treatment effect row indicates a significant effect at the 95% level of confidence.

		Panel A: Parameter set 1				Panel B: Parameter set 2				Panel C: Parameter set 3			
Financing			Period				Period				Period		
Treatment	Item	Overall	1	2	3	Overall	1	2	3	Overall	1	2	3
	Prediction	100	100	100	100	96.7	100	100	90	0	0	0	0
Internal	Actual	88.9	79.2	93.8	93.8	35.4	16.7	52.1	37.5	47.9	52.1	47.9	43.8
	Deviation	-11.1*	-20.8*	-6.3	-6.3	-61.2*	-83.3*	-47.9*	-52.5*	47.9*	52.1*	47.9*	43.8*
	Prediction	100	100	100	100	100	100	100	100	72.4	100	72.4	44.6
External	Actual	97.9	100.0	97.9	95.8	80.0	90.0	77.5	72.5	91.0	97.9	91.7	83.3
	Deviation	-2.1	0.0	-2.1	-4.2	-20.0*	-10.0*	-22.5*	-27.5*	18.5*	-2.1	18.9*	38.7*
Treatment Effect	Difference	9.0*	20.8*	4.2	2.1	44.6*	73.3*	25.4*	35.0*	43.1*	45.8*	43.8*	39.6*
on Levels	p-value	0.00	0.00	0.31	0.65	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Treatment Effect	Difference	9.0*	20.8*	4.2	2.1	41.2*	73.3*	25.4*	25.0*	-29.4*	-54.2*	-29.0*	-5.0
on Deviations	p-value	0.00	0.00	0.31	0.65	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.63

Table 5: *Quality produced.* This table presents the frequency with which entrepreneurs produce high quality goods in each of our treatments. The table presents the period-by-period predicted frequencies of high quality production as well as the realized frequencies in our experiments. The table presents statistical tests for the difference between the predicted frequencies of high quality production and the realized frequencies. An * in the deviation row indicates the predicted level differs from the mean actual level according to a t-test with a 95% confidence level. For each parameterization, the table also presents the effect of introducing external capital markets on the frequency of high quality production as well as the difference between the deviations from the predictions across the two treatments employing that parameterization. An * in either treatment effect row indicates a significant treatment effect according to a t-statistic at the 95% confidence level.

		Panel A: Parameter set 1				Panel B: Parameter set 2				Panel C: Parameter set 3			
Financing			Period				Period				Period		
Treatment	Item	Overall	1	2	3	Overall	1	2	3	Overall	1	2	3
	Prediction	83.3	100.0	100.0	50.0	88.3	100.0	90.0	75.0	0.0	0.0	0.0	0.0
Internal	Actual	57.6	54.2	66.7	52.1	29.2	8.3	41.7	37.5	9.0	0.0	10.4	16.7
	Deviation	-25.7*	-45.8*	-33.3*	2.1	-59.2*	-91.7*	-48.3*	-37.5*	9.0*	0.0	10.4*	16.7*
	Prediction	83.3	100.0	100.0	50.0	92.5	100.0	100.0	77.5	47.4	72.7	44.6	25.0
External	Actual	60.4	66.7	62.5	52.1	66.7	75.0	62.5	62.5	28.5	35.4	27.1	22.9
	Deviation	-22.9*	-33.3*	-37.5*	2.1	-25.8*	-25.0*	-37.5*	-15.0	-19.0*	-37.3*	-17.5*	-2.1
Treatment Effect	Difference	2.8	12.5	-4.2	0.0	37.5*	66.7*	20.8	25.0*	19.4*	35.4*	16.7*	6.3
on levels	p-value	0.63	0.21	0.67	1.00	0.00	0.00	0.05	0.02	0.00	0.00	0.04	0.45
Treatment Effect	Difference	2.8	12.5	-4.2	0.0	33.3*	66.7*	10.8	22.5*	-28.0*	-37.3*	-27.9*	-18.8*
on Deviations	p-value	0.63	0.21	0.67	1.00	0.00	0.00	0.31	0.03	0.00	0.00	0.00	0.02

Table 6: *Division of surplus.* This table presents the division of the average per-round surplus between the agents in the experiments. The surplus figures presented are normalized by the Pareto optimal surplus. The table presents the average levels of surplus received by each agent type and the predicted surplus for the entrepreneur. Predictions for consumers and investors are always zero. An * indicates when an agent's surplus is statistically different from the predicted surplus for that agent according to a t-test. For each parameterization, the table also presents the effect of introducing external capital markets on the consumer and entrepreneur surplus. An * in either treatment effect row indicates a significant effect according to a t-statistic at the 95% confidence level.

		Panel A: Parameter set 1				Panel B: Parameter set 2				Panel C: Parameter set 3			
Financing	Surplus		Period				Period				Period		
Treatment	Item	Overall	1	2	3	Overall	1	2	3	Overall	1	2	3
	Consumer	-2.8	2.5	4.9	-15.7	-22.4*	-26.8	-40.5*	0.1*	-124.4*	-178.7*	-125.0*	-69.5*
Internal	Entrepreneurs	60.4*	51.6*	61.8*	67.8*	45.3*	26.8*	71.7	37.4*	94.5*	126.6*	97.9*	59.1*
	Pred. Entrepreneurs	83.3	100.0	100.0	50.0	80.0	100.0	80.0	60.0	0.00	0.00	0.00	0.00
	Investor	0.7	-4.8	0.7	6.1	-137.3*	-188.9*	-107.1*	-116.0*	-121.2*	-155.4*	-104.7*	-103.5*
External	Consumer	10.5	26.6*	9.9	-5.0	132.8*	186.4*	101.4*	110.7*	-14.3	16.7	-39.8	-19.8
	Entrepreneurs	49.2*	44.8*	51.9*	51.0	57.8*	62.5*	53.2*	57.8	101.4*	111.6*	107.0*	85.8*
	Pred Entrepreneurs	83.3	100.0	100.0	50.0	85.0	100.0	100.0	55.0	22.4	45.5	16.5	5.4
Treatment	Consumers	13.3	24.1	5.0	10.7	38.8*	53.3*	35.5*	27.6*	27.5*	48.8*	21.3*	12.4
effect on	Entrepreneurs	-11.2*	-6.87	-10.0	-16.9*	3.1	8.9*	-4.6	5.1	1.7	-3.7	2.3	6.7

Table 7: *Firm actions.* This table presents the production strategies followed by flexible entrepreneurs. It gives the area of a strategy according to Selten's (1991) measure, the predicted frequency of each strategy under each treatment and the actual frequency. An * denotes a frequency that differs significantly from Selten's area according to a one-sided binomial test statistic at the 95% level of confidence.

Panel A: Parameter set 1							
	Normal	Selten's	Internal Financing		External Financing		Treatment
Strategy	form	area	Predicted	Actual	Predicted	Actual	effect
Full Reputation	HHL	0.125	1.000	0.250	1.000	0.042	-0.208*
Partial Reputation	HLL	0.125	0.000	0.250	0.000	0.208	-0.042
Myopic Response	LLL	0.125	0.000	0.333*	0.000	0.417*	0.083
Other	LHL	0.125	0.000	0.083	0.000	0.208	0.125
Dominated Strategy	XXH	0.500	0.000	0.083*	0.000	0.125*	0.042
Panel B: Parameter set 2							
Full Reputation	HHL	0.125	0.600	0.000	1.000	0.222	0.222
Partial Reputation	HLL	0.125	0.400	0.167	0.000	0.000	-0.167
Myopic Response	LLL	0.125	0.000	0.583*	0.000	0.556*	-0.028
Other	LHL	0.125	0.000	0.000	0.000	0.000	0.000
Dominated Strategy	XXH	0.500	0.000	0.250	0.000	0.222	-0.028
Panel A: Parameter set 3							
Full Reputation	HHL	0.125	0.000	0.000*	0.262	0.028	0.028
Partial Reputation	HLL	0.125	0.000	0.056	0.375	0.111	0.056
Myopic Response	LLL	0.125	1.000	0.639*	0.364	0.722*	0.083
Other	LHL	0.125	0.000	0.111	0.000	0.056	-0.056
Dominated Strategy	XXH	0.500	0.000	0.194*	0.000	0.056*	-0.056

Table 8: *Subject behavior regressions.* Independent variables are product price, a quality dummy (1=high, 0=low) and the percentage of profits demanded by the investor (α). Period Dummies equal 1 in the corresponding group interaction period. Period, Revealed Flexible Dummies equal 1 if low quality had been observed earlier in the group. The SR Net Cost of High Quality is the high quality cost times one minus the profit share demanded by the investor. The LR Benefit of High Quality is the difference between the highest average (by session) payoff from continuation strategies after high quality and low quality choices. Historical quality is coded as -1 for low and +1 for high. Avg. Hist. Quality averages (by group) the prior coded qualities. Avg. Hist. Profitability averages (by group) the ratio of the profits on the sale of the good to the capital investment. Exp. Wtd. Avg. Hist. Quality weights the coded qualities by 1 if the buyer actually purchased the item and 0 if not, then averages. Weighting is similarly defined for the Exp. Wtd. Avg. Profitability. Parameterizations give the Additional Cost of High Quality (c), Percentage of Flexible Entrepreneurs (π) and Required Capital Investment (I). The External Financing Dummy equals 1 if financing was external. Rounds of Experience variables equal total number of periods to date in the experimental session. Significance at the 90, 95 and 99% level of confidence are indicated by *, **, and ***, respectively.

Panel A: Consumer behavior		Panel B: Entrepreneur behavior		Panel C: Investor behavior	
Dependent variable	Price	Dependent variable	Quality Dummy	Dependent variable	Equity percentage
Regression type	dual censored	Regression type	logistic	Regression type	dual censored
Censored at	400, 1000	Cluster by	session	Censored at	0, 1
Observations	840	Observations	423	Observations	408
constant	756.682***	constant	0.471	constant	0.215**
	(19.26)		(1.22)		(2.29)
Period 2 Dummy	58.421	Period 2 Dummy	1.509***	Period 2 Dummy	0.121***
	(1.22)		(2.66)		(4.05)
Period 2, Revealed	-40.491	Period 2, Revealed	-1.095**	Period 2, Revealed	0.053
Flexible Dummy	(-0.45)	Flexible Dummy	(-2.05)	Flexible Dummy	(1.61)
Period 3 Dummy	90.172*	Period 1 Dummy	0.927***	Period 3 Dummy	0.152***
	(1.84)		(2.92)		(4.49)
Period 3, Revealed	-146.920*	Short Net Run Cost	-0.019***	Period 3, Revealed	0.032
Flexible Dummy	(-1.89)	of High Quality	(-4.68)	Flexible Dummy	(1.10)
Avg Hist. Quality	113.586***	Long Run Benefit	0.002*	Avg. Hist.	-0.079***
(+1="H", -1="L")	(2.63)	of High Quality	(1.65)	Profitability	(-2.96)
Exp. Wtd. Avg.	48.330**			Exp. Wtd. Avg.-	-0.088***
Hist. Quality	(2.06)			Profitability	(-4.44)
External Financing	-16.151	External Financing	-0.048		
Dummy	(-1.05)	Dummy	(-0.31)		
Additional Cost	-0.235***	Additional Cost	-0.005***	Required Capital	0.001***
of High Quality	(-2.86)	of High Quality	(-4.08)	Investment	(6.46)
Percentage of Flexible	21.159	Percentage of Flexible	-0.125	Percentage of Flexible	-0.138***
Entrepreneurs	(0.52)	Entrepreneurs	(-0.19)	Entrepreneurs	(-3.32)
Rounds of	-1.926			Rounds of	0.003***
Buyer Experience	(-1.72)			Investor Experience	(2.82)

Appendix I: Proofs

Proof of Proposition 1: First consider equilibria where the entrepreneur raises capital from outside investors and produces until period n. Let α^* represent the equilibrium profit share of outsider investors and let p^* represent the price that consumers are willing to pay for the good produced by the entrepreneur. Now consider the entrepreneur's decision: If he accesses the capital market and produces low quality in period n, his payoff is $(1-\alpha^*)p^*$ but this is higher than $(1-\alpha^*)(p^*-c)$, the entrepreneur's payoff if he produces high quality. It follows that the entrepreneur's best response is to produce low quality.

Next consider equilibria where the entrepreneur finances production internally. The entrepreneur's period n payoff contingent on producing low quality is p^*-I which is greater than p^*-c-I, his payoff from producing high quality. Once again, it is clear that the entrepreneur's best response is to produce low quality.

Finally consider the entrepreneur's incentives in period $t<n$ if it is intended to be his last period of production. It is clear from the earlier arguments that, given that it is the entrepreneur's final period of production, he has nothing to gain by producing high quality and can save c by producing low quality. Thus, his best response is to always produce low quality. □

Proof of Proposition 2: First, we show that, in a candidate equilibrium in which consumers and investors conjecture that type F will produce high quality, producing high quality in all periods before n, is a best response for type F if and only if condition (3) is satisfied. 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 future earnings equals $(k-1)(p^+-c-I)+\bar{p}-I$. In contrast, if he switches to producing low quality in period $n-k$, the entrepreneur will be identified as F. Thus, because we assume that the project NPV in non positive, he will not be able to profitably undertake the project. Consequently, the present value of his payoffs through period n equals p^+-I. Producing high quality for all period before n is a best response if and only if

$$\min_{1<k<n}(k-1)(p^+-c-I)+\bar{p}-c-I\geq p^+-I \tag{A-1}$$

This condition is satisfied if and only if $\bar{p}-c-I>0$, i.e., if (3) 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, and also because 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, $p^*>\bar{p}$. 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., $c-(p^*-I)\geq 0$. Note however, that because $p^*>\bar{p}$, this contradicts our

maintained assumption (3). 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., $c-(p^+-c-I)-(p^*-I)\geq 0$. Once again, this condition contradicts (3). Thus, type F will not defect from high quality production in period $n-2$. Now note that while the gain from deviating from high quality production remains unchanged at c as we move backward in time, the cost of deviating increases. 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 not defect from high quality production prior to period n. □

Proof of Proposition 3: First, we show that, in a candidate equilibrium in which the consumers and investors conjecture that type F will produce high quality, producing high quality in all periods before n, is a best response for type F if and only if condition (4) is satisfied. 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 future earnings equals $(k-1)(1-\alpha^+)(p^+-c)+(1-\bar{\alpha})\bar{p}$. In contrast, if he switches to producing low quality in period $n-k$, the entrepreneur will be identified as F. Thus, because we assume that the project has a non positive NPV, he cannot profitably undertake the project, even if the capital market were to fund the entrepreneur. Consequently, the present value of his payoffs through period n equals $(1-\alpha^+)p^+$. Producing high quality for all period before n is a best response if and only if

$$\min_{1<k<n} k(1-\alpha^+)(p^+-c)+(1-\bar{\alpha})\bar{p}\geq(1-\alpha^+)p^+ \tag{A-2}$$

This condition is satisfied if and only if $(1-\bar{\alpha})\bar{p}-(1-\alpha^+)c\geq 0$, i.e., if (4) is satisfied.

Now we establish, uniqueness. For a mixed strategy equilibrium, let α_n^* represent the equilibrium level of α in period n; let α_{n-1}^* represent the equilibrium level of α in period $n-1$. 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 before period n it must be the case that that the posterior probability of H conditioned on high quality output in all remaining periods must be greater than π. For this reason, and also because 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 in mixed strategy equilibria must be more than π. Because, in equilibrium, α is decreasing in the probability of high quality production, it must be the case that in period n,

$$\alpha_n^*<\bar{\alpha}. \tag{A-3}$$

Now note that, in any mixed strategy equilibrium, Bayes rule requires, that

$$\alpha_{n-1}^*>\alpha^+. \tag{A-4}$$

Thus, $1-\alpha_{n-1}^{*}<1-\alpha^{+}$, and $(1-\alpha_{n-1}^{*})\,c<(1-\alpha^{+})\,c$. By the argument given above, in any equilibrium in which type F randomizes before period n, it must be the case that that the posterior probability of type F must be less than $1-\pi$. Since, in period n, type F produces low quality and H high quality, in any equilibirum featuring low quality production before period n it must be the case that

$$p_{n}^{*}>\bar{p}. \tag{A-5}$$

Next note that (A-3) and (A-5) imply that

$$(1-\alpha_{n}^{*})\,p_{n}^{*}>(1-\bar{\alpha})\,\bar{p}, \tag{A-6}$$

and (A-4) implies that

$$(1-\alpha_{n-1}^{*})\,c<(1-\alpha^{+})\,c. \tag{A-7}$$

Randomization in period $n-1$ requires that

$$(1-\alpha_{n}^{*})\,p_{n}^{*}-(1-\alpha_{n-1}^{*})\,c\leq 0. \tag{A-8}$$

However, as (A-6) and (A-7) show, (A-8) cannot be satisfied if (4) is satisfied.

Thus, we have shown that no equilibrium exists in which type F randomizes in period $n-1$. This implies that in period $n-1$, type F must follow the pure strategy of producing high quality. But if this is the case, the cost of deviating from high quality production in period $n-2$, must be at least

$$(1-\bar{\alpha})\,\bar{p}+(u_{h}-c-I) \tag{A-9}$$

The gain from deviating, by an argument identical to the one used to establish (A-7), must be no greater than $(1-\alpha^{+})\,c$. Thus, type F's payoff will be strictly higher from producing high quality, contradicting the use of a mixed strategy. It is clear that, while the upper bound on the gain from deviating from high quality production remains unchanged as we move backward in time, the cost of deviating increases. Thus, when defection from high quality production is not optimal in period $n-1$, it will not be optimal in any period earlier than $n-1$. Consequently, type F will not defect from high quality production prior to period n. □

Proof of Proposition 4: The desired result follows directly from the sign of the expresssion (5).□

Proof of Proposition 5: 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. □

Proof of Corollary 1: The existence and uniqueness of the equilibria follows directly from Propo-

sitions 2 and 3. The product and capital market prices follow directly from the equilibrium outcomes described in these propositons.□

Proof of Proposition 6: First we will establish that no equilibria in pure strategies exist. Then we will establish our claim regarding pooling equilibria.

Note that, given (6), 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 (7), 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 (7) 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 (6) 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 asses the likelihood that an entrepreneur producing high quality in periods 1 and 2 is type F at

$$\frac{\frac{1}{4} \times \frac{3}{5}}{\frac{1}{4} \times \frac{3}{5} + \frac{3}{4}} = \frac{1}{6} \tag{A-10}$$

Thus, rational expectations requires that consumers offer

$$\frac{5}{6}u_h + \frac{1}{6}u_l = 900, \tag{A-11}$$

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 also equals $940 - 500 = 440$ Thus, producing high quality in period 1, as specified in the equilibrium is rational for type F. □

Proof of Corollary 2: 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 propositons.□

Proof of Proposition 7: 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:

$$\frac{3\sigma_1}{4} \leq \frac{1}{6} \tag{A-12}$$

$$\frac{3(1-\sigma_1)\sigma_2}{4\left(\frac{3(1-\sigma_1)}{4}+\frac{1}{4}\right)} \leq \frac{1}{6} \tag{A-13}$$

$$\frac{3(1-\sigma_1)(1-\sigma_2)}{4\left(\frac{3}{4}(1-\sigma_1)(1-\sigma_2)+\frac{1}{4}\right)} \leq \frac{1}{6} \tag{A-14}$$

$$\sigma_1 \in [0,1] \tag{A-15}$$

$$\sigma_2 \in [0,1]. \tag{A-16}$$

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:

$$\frac{3\sigma_1}{4} > \frac{1}{6} \tag{A-17}$$

$$\frac{3(1-\sigma_1)\sigma_2}{4\left(\frac{3(1-\sigma_1)}{4}+\frac{1}{4}\right)} > \frac{1}{6} \tag{A-18}$$

$$\frac{3(1-\sigma_1)(1-\sigma_2)}{4\left(\frac{3}{4}(1-\sigma_1)(1-\sigma_2)+\frac{1}{4}\right)} > \frac{1}{6} \tag{A-19}$$

$$\sigma_1 \in [0,1] \tag{A-20}$$

$$\sigma_2 \in [0,1]. \tag{A-21}$$

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. □

Proof of Proposition 8: Let p_t represent the equilbirum 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

$$p_t = p(q_t), \quad t = 1, 2, 3. \tag{A-22}$$

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

$$\alpha_t = \alpha(q_t) \quad t = 1, 2, 3. \tag{A-23}$$

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

$$q_1 = \frac{3}{4}\,\sigma_1, \tag{A-24}$$

$$q_2 = \frac{3\,(1-\sigma_1)\,\sigma_2}{4\left(\frac{3}{4}\,(1-\sigma_1)+\frac{1}{4}\right)}, \tag{A-25}$$

$$q_3 = \frac{3\,(1-\sigma_1)\,(1-\sigma_2)}{4\left(\frac{3}{4}\,(1-\sigma_1)\,(1-\sigma_2)+\frac{1}{4}\right)}. \tag{A-26}$$

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

$$((1-\alpha_t)\,(p_t - c) + (1-\alpha_{t+1})\,p_2) - (1-\alpha_t)\,p_t = 0, \quad t = 1, 2 \tag{A-27}$$

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

$$-42450 + 376491\,x - 1298865\,x^2 + 2377271\,x^3 - 2535761\,x^4 + 1591842\,x^5 - 547880\,x^6 + 80000\,x^7 = 0; \tag{A-28}$$

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

$$-3804480 + 21742776\,y - 57235260\,y^2 + 91050246\,y^3 - 91564373\,y^4 + 56230563\,y^5 - 18789162\,y^6 + 2753440\,y^7 = 0. \quad \text{(A-29)}$$

Define candidate actions at unrevealed histories as follows:

$$\begin{aligned}
&\sigma_1^* = \frac{4}{3}\,x^*, \quad \sigma_2^* = y^*, \quad \sigma_3^* = 1 \\
&q_1^* = \frac{3}{4}\,\sigma_1^*, \quad q_2^* = \frac{3\,(1-\sigma_1^*)\,\sigma_2^*}{4\left(\frac{3}{4}\,(1-\sigma_1^*)+\frac{1}{4}\right)}, \quad q_3^* = \frac{3\,(1-\sigma_1^*)\,(1-\sigma_2^*)}{4\left(\frac{3}{4}\,(1-\sigma_1^*)\,(1-\sigma_2^*)+\frac{1}{4}\right)} \\
&p_t^* = 400\,q_t^* + 1000\,(1-q_t^*) \quad t = 1,2,3 \\
&\alpha_t^* = \frac{5}{2(3-q_t^*)} \quad t = 1,2,3
\end{aligned} \quad \text{(A-30)}$$

A numerical approximation to this exact solution is given by

$$\begin{aligned}
&\sigma_1^* = 0.364, \sigma_2^* = 0.589, \sigma_3^* = 1.000, \\
&q_1^* = 0.273, q_2^* = 0.387, q_3^* = 0.440, \\
&p_1^* = 836.367, p_2^* = 768.055, p_3^* = 736.244, \\
&\alpha_1^* = 0.917, \alpha_2^* = 0.957, \alpha_3^* = 0.976.
\end{aligned} \quad \text{(A-31)}$$

The reader can verify that (A-30) satisfies the equilibrium conditions, (A-22), (A-23), (A-24), (A-25), (A-26), (A-27). Verification can be effected either by substituting the exact solution (A-30) into a symbolic algebra programming language, e.g., *Mathematica*, or by substituting the approximate solution, (A-31) into the same equations in which case the equalities will only be approximately satisfied. □

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Appendix II: Debt financing

In this appendix we demonstrate that even access to single-period debt financing supports equilibrium outcomes that result in higher production and higher quality than outcomes where the entrepreneur is restricted to financing himself internally. In order to keep the analysis tractable, we assume, as in the case of Parameterizations 2 and 3, $u_l = c < I$. We also modify the model slightly. After type a type-F entrepreneur has made his quality choice, a random act of nature can affect product quality. This act of nature occurs with probability $1-\theta$ and is observed by investors, entrepreneurs, and consumers. Once it occurs, the quality decision is irrelevant and current period output and all future output is low quality. If the act of nature does not occur, as is the case in our earlier analysis, the quality decision alone determines product quality.

This additional assumption considerably simplifies the analysis. It ensures that the entrepreneur can finance production with single-period debt whose payoffs are determined only by current period cash flows, because the entrepreneur is either able to pay off the entire debt in the current period or the firm itself ceases to exist. Note also that it is still the case that once the entrepreneur has been revealed as type F he will be unable to operate.

To ensure that the entrepreneur can always obtain financing so long as nature has not acted and he has not been revealed to be type F, we assume that θ is sufficiently high so that

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

Now note that when type F chooses high quality, the cash flow available to investors is $p-c$ while if he chooses low quality, the cash flow available to pay investors is p. Thus, when type F finances with single-period debt, rational pricing dictates that the promised repayment D satisfy

$$D\theta + (1-\theta)qu_l = I, \tag{B-2}$$

where q represents the probability than an unrevealed type-F entrepreneur chooses low quality. Thus, rational pricing dictates that the promised payment on single-period debt be given by

$$D = \frac{I - qu_l(1-\theta)}{\theta}. \tag{B-3}$$

We now demonstrate that any set of parameters that supports reputation building with internal finance will also support reputation building with single-period external debt. First, we establish that in period 2, if an unrevealed entrepreneur that is self financed chooses high quality so will a similar entrepreneur that is debt financed. To see this note that, in period 2, a self-financed

entrepreneur who chooses high quality can expect a payoff of

$$\theta[p_2 + (\theta p_3 + (1-\theta)u_l - I)] + (1-\theta)u_l - I - c, \tag{B-4}$$

where p_2 and p_3 represent period 2 and period 3 prices if the entrepreneur is not revealed to be type F. If the entrepreneur chooses low quality in period 2 he can expect,

$$\theta p_2 + (1-\theta)u_l - I. \tag{B-5}$$

It follows that the entrepreneur will only choose high quality so long as

$$\theta(\theta p_3 + (1-\theta)u_l - I) - c \geq 0. \tag{B-6}$$

Now consider the entrepreneur's period 2 quality choice when financed with single-period debt. If the entrepreneur chooses high quality, his expected payoff is

$$\theta[p_2 - c - D_2 + \theta(p_3 - D_3)], \tag{B-7}$$

where D_2 and D_3 represent period 2 and period 3, debt payments respectively. If the entrepreneur chooses low quality, however, his expected payoff is

$$\theta(p_2 - D_2). \tag{B-8}$$

The preceding two expressions, together, imply that the entrepreneur will choose to produce high quality in period 2 so long as

$$\theta\theta(p_3 - D_3) - c \geq 0. \tag{B-9}$$

Noting that $u_l = c$ and taking the difference between the left hand sides of (B-9) and (B-6), we obtain

$$\theta(I - \theta D_3) + c(\theta - 1)^2. \tag{B-10}$$

Because rational pricing implies that $I \geq \theta D_3$, this expression must be positive in any equilibrium. This establishes that, in period 2, any set of parameters that supports high quality production with self financing must also support high quality when the entrepreneur finances with debt. Note that the incentive to deviate from the reputation formation equilibrium is higher in period 2 than it is in period 1. Thus, if high quality production is optimal in period 2, it must also be optimal in period 1. Thus, any set of parameters that supports reputation formation with self financing also supports reputation formation with debt finance.

It is easy to verify that condition (B-9) is satisfied while (B-6) is violated when D_2 and D_3 are set under the assumption that type F will choose high quality in period 2 and low quality in period 3, $\pi = 0.082$, $\theta = 0.945$, and the remaining parameters equal their values under Parameterizations

2 and 3. Because incentives to deviation from reputation formation are lower in period 1, this establishes that there exist parameter values that support reputation formation with debt finance but not with self financing.

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Appendix III: Experimental Instructions

This appendix contains 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.

INSTRUCTIONS

General

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.

Stages of the Game

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.

Notes on this Procedure

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.

Payoff Determination

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?

Stage **[**I**] {**II**}** I Instructions

The Decision

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 Item

Square 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?

Stage I Instructions

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.

Procedures

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.

Notes on this Procedure

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.

Payoff Determination

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?**]**

Group and Player Type Determination

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 payers 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.

End of Period Results

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.

Summary of the Game

[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.

End of Experiment Rules

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?