Portfolio Size and Information Disclosure: An Analysis of Startup Accelerators

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Abstract

We study the information-gathering role of a startup accelerator and consider the accelerator's incentives to choose a portfolio size of participating ventures, taking into account entrepreneurs' rational expectations. We find that the accelerator suffers from a time-inconsistency problem, whereby the accelerator chooses a portfolio size that is larger than the commitment solution but smaller than the social optimum. The theoretical model can explain a set of real-world observations on startup accelerators: Both portfolio success and failure rates decrease in portfolio size; the accelerator may choose to only reveal favorable information about ventures; and the accelerator may choose a shorter time horizon and partial information disclosure for its program.

Keywords: Startup accelerators, early-stage financing, portfolio size, information disclosure.

JEL Classifications: D82, G24, G32

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1 Introduction

Early-stage financing in the entrepreneurial lifecycle has gone through considerable changes in the last decade. Traditionally, new startups were nurtured in so-called 'business incubators,' typically referring to a facility established by a university, a local government, or a non-profit organization with the aim of providing some basic support for entrepreneurs. The primary source of funding for successful startups had been venture capital (VC) firms. Over the years, however, VC firms have largely moved to larger and later stage financing and tend not to invest in deals that seek less than a certain dollar threshold of, in some cases, \$2 to \$4 million (Ibrahim, 2008). Meanwhile, a new hybrid form of entrepreneurial nurturing and equity financing, known as 'startup accelerators,' has become a popular way to jumpstart nascent ventures.

Although antecedents to startup accelerators date back to the early 2000s (e.g., CMGI purchased equity stakes in a large number of startup companies), the most well-known accelerator model was pioneered by Y Combinator (founded in 2005) and Techstars (founded in 2006).[1] In contrast to both traditional incubators and VC firms, accelerators make a small equity investment in a group of startups and require a relatively early exit. For instance, Y Combinator runs its program twice a year, where it invests in the neighborhood of \$11,000 (plus \$3000 per founder) in each participating venture and takes on average a 6% equity stake in the startup. Its program runs for 12 weeks and concludes with 'Demo Day,' which is well attended by potential investors interested in the accelerator's portfolio. That is, graduating from a top-rated accelerator program seems to yield a considerable advantage in securing major funding.

Despite its significant presence in early-stage entrepreneurial financing, the accelerator model has received little attention in the literature (see, e.g., Denis, 2004). The role of accel-

[1] Top accelerator programs are highly competitive with an acceptance rate lower than one percent. According to Y Combinator, the number of accelerators grew from four in 2007 to nearly 100 in 2011. Seedcamp (founded in 2007) and Startupbootcamp (founded in 2010) are some of the most well-known accelerators in Europe.

erators warrants a careful examination because they can influence the supply and valuation of startups as an intermediary between entrepreneurs and investors. In particular, when studying the dot-com bubble, researchers have mostly focused on the demand side rather than the supply of high-valuation startups. However, it is interesting to note that the dot-com bubble was preceded by a proliferation of what was then called 'network incubators' (Hansen et al. 2000). As *Forbes* magazine put it at the time, "no incubator has experienced a more dramatic fall from grace than CMGI" (DiCarlo, 2001). Some pundits say "90% of incubators and accelerators will fail" (Relan, 2012).

The objective of this paper is to study the incentives of startup accelerators, revealing some sources of potential inefficiencies that can render ventures more susceptible to 'valuation bubbles.' Specifically, we focus on the certifying role of accelerators for early-stage startups. In our model, entrepreneurs can apply to participate in the accelerator's program prior to seeking major funding, or they can approach investors directly. The accelerator is then able to obtain and credibly reveal signals about the viability of participating startups; and after signals are revealed, entrepreneurs raise funding from investors. Thus, our theoretical model is different from those in the VC financing literature because the accelerator itself does not provide major funding — rather, it stands to gain from its relatively small equity stakes in portfolio firms when they attract subsequent investments.

We focus on the time-inconsistency problem faced by an accelerator. The issue here is that entrepreneurs have certain expectations regarding the benefits that they can derive from participating in the accelerator's program, and these expectations are (rationally) realized in equilibrium. This is an important consideration because the accelerator's and entrepreneurs' incentives may be misaligned. That is, if entrepreneurs were naïve, then the accelerator may attempt to provide value that is lower than what entrepreneurs had initially expected when they agreed to participate in its program. We show how the accelerator's incentives towards time-inconsistent behavior can help explain its relatively large portfolio size. On the other hand, we show that the accelerator's time-inconsistent behavior is beneficial from the standpoint of social welfare.[2]

To our knowledge, the insight that the accelerator has the incentive to mislead entrepreneurs has not been thoroughly investigated in the VC literature (e.g., Gompers, 1995; Lerner, 1995; Hellmann and Puri, 2000), where the focus is often on the tradeoffs between portfolio size and the quality of VC advising due to limited human resources (e.g., Kanniainen and Keuschnigg, 2003, 2004; Cumming, 2006; Bernile et al., 2007; Inderst et al., 2007; Fulghieri and Sevilir, 2009).[3] We believe that the general concept and implications of time inconsistency in early-stage financing are important considerations, and thus the underlying technical issues warrant a careful treatment. For instance, our model can help explain why a larger portfolio size may be associated with less informative outcomes and relatively early exits.

Our baseline model shows that the accelerator tends to have a larger portfolio size than the profit-maximizing level. The reason is that the accelerator faces a commitment problem: If the accelerator were to offer its profit-maximizing terms to entrepreneurs, it would have an incentive to admit additional participants. In equilibrium, entrepreneurs recognize this, which results in a lower equity fee and too large a portfolio for the accelerator. We then show that there is another potential source of inefficiency in the accelerator's certification process: The accelerator may selectively disclose signals to investors in order to maximize its profits. More specifically, we consider an informational environment where there is a positive probability that the accelerator receives no signal. Here, we identify conditions under which the accelerator chooses to withhold negative information and share only positive information with investors. These conditions are relatively mild: they are satisfied if the prior probability of lower-quality startups being successful is above a certain threshold.

[2]In the macroeconomics literature, the well-known inflationary bias in monetary policy tends to lower consumer welfare (e.g., Barro and Gordon, 1983). However, time inconsistency is an integral component of explanations for many economic phenomena; for instance, in the context of R&D investments, Waldman (1996) showed that time inconsistent behavior can increase social welfare.

[3]For instance, Inderst et al. (2007) consider a model where the VC firm can raise enough capital to refinance two portfolio firms at the interim stage or deliberately limit the amount of capital to fund only one of them. However, unlike in this paper the venture's interim type is non-verifiable information, so it does not make outside investors update their beliefs.

This partial information disclosure is consistent with findings in the accounting literature (e.g., Verrecchia, 1983; Dye, 1985; Jung and Kwon, 1988), where managers may only reveal favorable information and withhold unfavorable news. This occurs when investors cannot discern whether the managers have received information but chosen not to reveal it or whether they have not received any information. The main differences are that in our model the accelerator faces an additional time-inconsistency problem, and has the incentive to increase the probability of uninformative signals; that is, to encourage early exits. In contrast, in the above-mentioned papers, managers either do not take actions beyond the acts of disclosure or are not subject to a time-inconsistency problem.

Our paper is related to a couple of other literatures. At a broader level, the accelerator is a financial intermediary for early-stage startups and we focus on its role in providing credible information to potential investors (e.g., Leland and Pyle, 1977; Allen, 1990). This literature has shown that an informed individual faces a reliability problem when he tries to sell his private information, but an intermediary can credibly signal its informed status by investing in assets. The accelerator program in our model is similar in that it invests into and earns profits from startups when buyers of information (investors) invest in program participants. Campbell and Kracaw (1980) and Chan (1983) showed that intermediaries can in fact produce information and provide services valued by investors, which bears a relationship to the mentoring services provided by accelerators.[4] We contribute to this literature by analyzing the accelerator's time-inconsistent behavior in the certification process.

From a modeling perspective, this paper is related to a strand of literature where some investors possess superior screening technologies for distinguishing between good and bad projects (e.g., Admati and Pfleiderer, 1994; Manove et al., 2001; Casamatta, 2003; Hellmann, 2007; Strausz, 2009). The main difference is that in these articles investors use staged financing to control agency problems, whereas in our paper accelerators do not make follow-

[4]While much attention has been given to the professional services that VC firms provide, we note that traditional VC firms also frequently act as certification intermediaries in helping their portfolio companies raise new capital (Gorman and Sahlman, 1989; Sahlman, 1990; Megginson and Weiss, 1991; Brav and Gompers, 1997).

on investments but instead make small-scale investments in a set of participating ventures. The certification role of accelerators and an accelerator's incentives to disclose information may be relevant to broader financial markets as well. For instance, our findings may shed some light on issues in private equity, where portfolio investments tend to change hands more often than in the VC industry; and issues surrounding credit-rating agencies, where potential conflicts of interests exist between an agency and investors (e.g., Bolton et al., 2012).

The remainder of the paper is organized as follows. Section 2 describes the model and presents the main results on portfolio sizes. Section 3 explains the model's empirical implications and considers an entrepreneur's effort in a variant of the model. Section 4 extends our analysis to examine the accelerator's incentives to disclose information and exit early. Section 5 contains concluding remarks. All formal proofs are relegated to the Appendix.

2 Portfolio Size

2.1 Model

Consider a large number of penniless entrepreneurs, an accelerator program that selects a group of startups, and market investors (such as angels and VC firms). The players are symmetric and risk neutral. Each entrepreneur is endowed with an idea and starts a venture. A successful venture generates revenues v_S and an unsuccessful one v_F, where $v_S > v_F \geq 0$. An entrepreneur i's venture idea is either good ($\theta_i = H$) or bad ($\theta_i = L$). It is commonly known that a type L venture succeeds with probability λ_L and a type H with probability λ_H, where $0 < \lambda_L < \lambda_H < 1$. Entrepreneurs are *ex ante* identical and uninformed; the prior probability that a venture's type is H is given by $\gamma > 0$. We abstract from entrepreneurs' private information because given our focus on early-stage startups, an accelerator may be better able to discern a venture's type than entrepreneurs themselves.[5]

[5] Given that accelerators typically allow participants to change their venture ideas during the program and accept entrepreneurs who do not even yet have an idea (see `http://ycombinator.com/noidea.html`), it seems plausible to assume that accelerators have a superior screening ability than entrepreneurs do in the

Entrepreneurs need to finance an amount $F > 0$ to scale up their ventures. An entrepreneur can choose to obtain this funding directly by approaching investors, or participate in the accelerator program and then approach investors. The accelerator acquires information about its portfolio ventures and reveals verifiable information to investors before the next round of funding.[6] We assume that experienced and successful 'micro-venture capitalists,' who run the accelerator programs, can generate more accurate information about early-stage startup participants than market investors. Given a limited supply of experienced mentors and the large excess demand for accelerator programs, we examine a single monopolist accelerator.[7] The investment market, on the other hand, is assumed competitive, whereby investors earn zero expected profits.

Upon receiving applications, the accelerator chooses how many new ventures to support in its program, and subsequently acquires information about each participating venture through monitoring. The marginal cost of supporting a venture is $c > 0$, where c is a payment to the early-stage entrepreneurs in exchange for an ownership stake in the venture. As previously mentioned, the accelerator does not typically provide a major (seed or series A) funding, and instead entrepreneurs would have to raise required capital from angels or VC firms. That is, the accelerator's business model is to invest in a set of ventures with a relatively small amount of money rather than continue to support the ventures in multiple rounds. That the accelerator does not provide F in our model is an exogenous assumption; however, we believe that it is not unreasonable given real world practices.

Following the literature (e.g., Fulghieri and Sevilir, 2009), we assume that the accelerator's information-acquisition technology is limited by the available human resources. Specifically, a larger portfolio entails a noisier (less informative) signal regarding an individual

early stages.

[6]This is a standard assumption in the disclosure literature (e.g., Grossman, 1981; Milgrom, 1981): Firms cannot misrepresent information due to potentially severe legal penalties for false reporting. Additionally, we believe that there are significant reputational concerns in the VC community that strongly discourage accelerators from lying.

[7]In an interview, the president of Y Combinator admitted that programs like Y Combinator have monopoly power over early-stage startups. See, e.g., http://techcrunch.com/2014/05/05/sam-altman-kinda-sorta-monopoly/.

venture's type: The signal the accelerator generates for each venture i is either good ($\sigma_i = g$) or bad ($\sigma_i = b$), according to $Pr(\sigma_i = g|\theta_i = H) = 1$ and $Pr(\sigma_i = g|\theta_i = L) = \alpha(n) < 1$, where n denotes the number of portfolio companies. Thus, $\alpha(n)$ denotes the probability of a 'false positive' signal and captures the level of noise in the certification process. We make some mild technical assumptions: $\alpha'(n) > 0$ and $2\alpha'(n) + n\alpha''(n) > 0$, which means that the rate of decrease in signal precision is either increasing or decreasing moderately in n.[8] In this section, we assume that the signals are public information.

After observing the signals, investors update their beliefs in a Bayesian fashion. For simplicity, we assume that investors do not acquire additional information about portfolio companies given positive signals revealed by the accelerator. This assumption can be satisfied by an appropriate range of investors' screening costs, whereby an investor's additional screening does not pay off. On the other hand, if an entrepreneur approaches investors directly without participating in the accelerator program, then investors obtain a signal about the venture according to the same type of screening technology, except now with a higher level of noise $\alpha(k)$.[9] That is, k is some constant larger than the maximum feasible value for n. Notice that this is necessary for the accelerator to profitably operate because otherwise there is no reason for entrepreneurs to pay to participate in the accelerator program.

Throughout the paper, we focus on the parameterization where ventures receiving a negative signal (hence type L) are not worth financing. (We consider in Section 4 the case in which some ventures that receive negative private signals may end up being funded.) Thus, if a positive signal is obtained for a venture, then investors make competitive financing offers, which entrepreneurs accept or reject (and some type L ventures that received positive signals will be financed). Further, we only consider a simple equity contract between entrepreneurs

[8]These technical assumptions are necessary to guarantee interior solutions and thus a meaningful role for the accelerator. The assumptions are satisfied by common functional forms such as $\alpha(n) \propto \sqrt{n}$ and $\alpha(n) \propto ln(n)$, and also by any convex function of n (since precision is then reduced at an increasing rate, that is, $\alpha''(n) > 0$).

[9]To be more precise, we assume that an entrepreneur approaches multiple investors and at least two of them receive the same signal about the entrepreneur's venture according to $\alpha(k)$, so that investors engage in price competition. Such correlated information can be motivated by investors' close networks and information sharing (e.g., Kerr et al., 2011).

and the accelerator (as well as investors). Although convertible securities may be optimal in some environments (see, e.g., Cornelli and Yosha, 2003; Schmidt, 2003), these are often equity-equivalent (Admati and Pfleiderer, 1994) in simplified models and most accelerators use standardized equity financing. We thus believe that our results are not sensitive to cash flow changes if convertible securities were used instead.

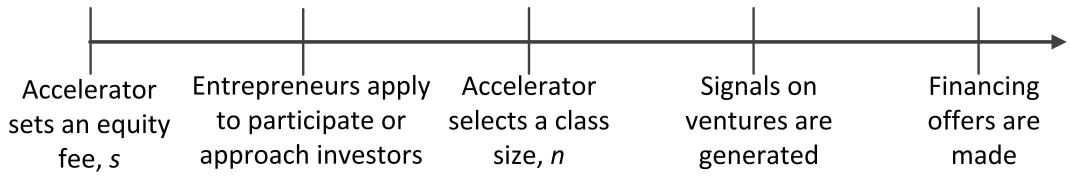

Figure 1: Timeline

The timing of the game is depicted in Figure 1 and runs as follows. First, the accelerator announces the term sheet for the program, which specifies an equity fee for program participation. Second, entrepreneurs decide whether to apply for the accelerator program or to approach investors directly. Third, the accelerator decides how many ventures to accept, which determines its portfolio size n. (Importantly, in line with real world practices, the accelerator cannot credibly commit to a portfolio size in its term sheet.) Fourth, the accelerator reveals a public signal about portfolio firms to the market. If investors were approached directly by entrepreneurs, then they obtain signals about the ventures using their own technology. Finally, investors make financing offers to ventures that received a positive signal (either from investors themselves or through the accelerator program), which entrepreneurs accept or reject.

The solution concept we employ is a rational-expectations equilibrium (REE) that is subgame perfect. REE is an appropriate solution concept in our model because we consider a large number of entrepreneurs striking a deal with the accelerator in a bilateral negotiation. That is, while entrepreneurs are fully rational about what they can expect, they are likely to take the mapping from all entrepreneurs' strategy into the contract space as given because the number of entrepreneurs is large. If a portfolio consisted of only a couple of ventures (e.g., Inderst et al., 2007; Fulghieri and Sevilir, 2009), then it is reasonable to expect a Bayes-Nash equilibrium (BNE), where one entrepreneur takes into account the effects of his action on others.[10] However, we want to consider a wider range of portfolio sizes without limiting attention to a small number of portfolio firms.[11]

2.2 Analysis

The model is solved by using backward induction. We start with the final stage where investors make financing offers. Given that only the ventures for which positive signals were obtained are worth financing, an investor's problem is straightforward: Following a positive signal for venture i, the posterior probability that the venture is of type H is given by

$$\tilde{\gamma}_n = \frac{\gamma}{\gamma + (1-\gamma)\alpha(n)}.$$

Thus, the expected revenue of venture i conditional on a positive signal is

$$E_n[v|\sigma_i = g] = \tilde{\gamma}_n(\lambda_H v_S + (1-\lambda_H)v_F) + (1-\tilde{\gamma}_n)(\lambda_L v_S + (1-\lambda_L)v_F).$$

Substituting yields

$$E_n[v|\sigma_i = g] = v_F + \lambda_L(v_S - v_F) + \frac{\gamma(\lambda_H - \lambda_L)(v_S - v_F)}{\gamma + (1-\gamma)\alpha(n)}. \quad (1)$$

Because investors are risk neutral and the market is competitive, it follows that an investor would require an ownership share of $F/E_n[v|\sigma_i = g]$ in exchange for investing F in the venture. This means that an entrepreneur's share is diluted both from raising capital F as well as from participating in the accelerator program. To be precise, let s denote

[10] REE and BNE also differ in their epistemic assumptions. That is, BNE requires common knowledge of the game and rationality of players. In contrast, REE makes no assumptions about what each player knows about the other players' cognitive capabilities.

[11] Kanniainen and Keuschnigg (2003, 2004) consider a continuous portfolio size; however, the VC contract terms in their model are not endogenous to the expected portfolio size (as it is in our model). Hence, the REE concept need not be invoked in their model.

the equity fee charged by the accelerator. Then the entrepreneur's expected payoff after participating in an accelerator program that has n portfolio firms is given by

$$(\gamma + (1-\gamma)\alpha(n))(1-s)(1-\frac{F}{E_n[v|\sigma_i = g]})E_n[v|\sigma_i = g], \tag{2}$$

where $\gamma + (1-\gamma)\alpha(n)$ is the probability of receiving a positive signal.

Notice that the above derivation is exactly the same if entrepreneurs approached investors directly, with two exceptions: n is replaced by k, and $s = 0$. That is, an entrepreneur's expected payoff from approaching investors directly is given by

$$(\gamma + (1-\gamma)\alpha(k))(1-\frac{F}{E_k[v|\sigma_i = g]})E_k[v|\sigma_i = g]. \tag{3}$$

Breaking ties in favor of the accelerator, an entrepreneur would be better off by participating in the accelerator program than approaching investors directly if and only if the accelerator's equity fee, s, is less than or equal to

$$\hat{s}(n) = 1 - \frac{(\gamma + (1-\gamma)\alpha(k))(E_k[v|\sigma_i = g] - F)}{(\gamma + (1-\gamma)\alpha(n))(E_n[v|\sigma_i = g] - F)}. \tag{4}$$

Notice that this threshold value, $\hat{s}(n) \in (0, 1)$, is a function of the accelerator's portfolio size n. In our proofs, we show that $\hat{s}(n)$ is a decreasing function of n, that is, $\hat{s}'(n) < 0$. The intuitive reason is that a larger portfolio means a less precise signal, which diminishes the accelerator's certification benefit to entrepreneurs.

After entrepreneurs apply for the program, the accelerator's problem is to choose a portfolio size n to maximize its expected profits,

$$\sum_{i=1}^{n} \left\{ (\gamma + (1-\gamma)\alpha(n))s\left(1 - \frac{F}{E_n[v|\sigma_i = g]}\right) E_n[v|\sigma_i = g] - c \right\}. \tag{5}$$

It is convenient to denote the expected value of a venture (net of financing F) as $V(n) = (\gamma + (1-\gamma)\alpha(n))(E_n[v|\sigma_i = g] - F)$, so that the accelerator's problem at this stage can be re-written as

$$\max_{n} nsV(n) - nc. \tag{6}$$

To characterize the rational-expectations equilibrium, we now introduce entrepreneurs' beliefs. Let n^e denote an entrepreneurs' expectation of the portfolio size when they decide whether to apply for the accelerator program. Because entrepreneurs are better off only if the accelerator's equity fee, s, does not exceed the threshold $\hat{s}(n)$, they would apply for the program if they believe that the program is worth its cost, that is, if $s \leq \hat{s}(n^e)$. (Of course, entrepreneurs' expectation of the portfolio size, n^e, would be determined in equilibrium.)

Given this decision rule by entrepreneurs, the accelerator would optimally set the maximum equity fee $s = \hat{s}(n^e)$ in its term sheet to maximize its profit given an arbitrary expectation n^e. Hence, the accelerator chooses its portfolio size taking into account entrepreneurs' expectation n^e as well as the equilibrium of the ensuing subgame. On equilibrium path, $s = \hat{s}(n^e)$ can be substituted into (6) to yield

$$\max_{n} n\hat{s}(n^e)V(n) - nc. \tag{7}$$

The profit-maximizing portfolio size, n^*, is then specified by the first-order condition:

$$\hat{s}(n^e)(V(n^*) + n^*V'(n^*)) = c. \tag{8}$$

Equation (8) characterizes the accelerator's best response to entrepreneurs' expectation, n^e. We show in the Appendix that this equation implies a negative relationship between n^* and n^e; that is, the smaller the entrepreneurs' expectation of the portfolio size, the larger is the portfolio size the accelerator would choose. This is because when entrepreneurs expect n^e to be smaller, they expect the signal precision to be higher, whereby they are willing to pay a larger equity fee. This, however, induces the accelerator to accept a larger than expected portfolio.

The rational-expectations equilibrium is characterized by the requirement that the expectation of entrepreneurs matches the portfolio size chosen by the accelerator; that is, $n^* = n^e$, which is the intersection of the best response curve and the 45 degree line (see Figure 2). The condition that characterizes the equilibrium portfolio size, n^*, is thus given by

$$\hat{s}(n^*)(V(n^*) + n^* V'(n^*)) = c. \tag{9}$$

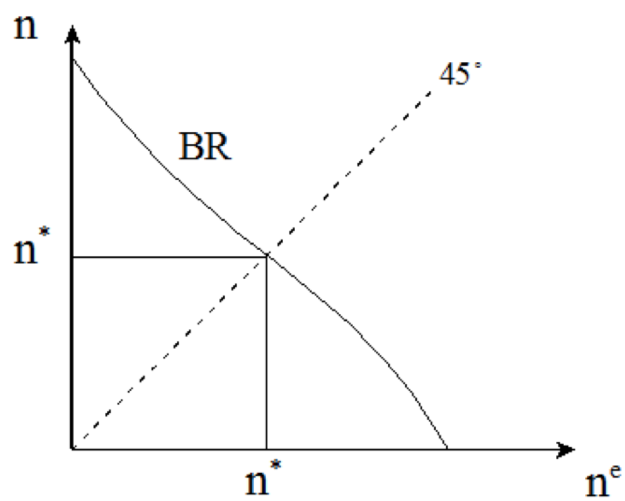

Figure 2: Rational-Expectations Equilibrium

2.3 Results

To highlight the time-inconsistency problem faced by the accelerator, suppose that the accelerator were able to commit to a portfolio size in its term sheet (that is, before entrepreneurs apply). If the accelerator can credibly promise not to exercise its discretion in choosing its portfolio size (i.e., choose one that is different from what it announces before entrepreneurs apply), then the accelerator's problem would be given by

$$\max_n \, n\hat{s}(n)V(n) - nc.$$

Let n° denote the first-best portfolio size under commitment. Then the first-order condition that characterizes n° is the following:

$$\hat{s}(n^\circ)(V(n^\circ) + n^\circ V'(n^\circ)) + n^\circ \hat{s}'(n^\circ)V(n^\circ) = c. \tag{10}$$

The following proposition provides a comparison between the equilibrium and the first-best.

Proposition 1 *In REE, the accelerator chooses a larger portfolio size than in the commitment solution (i.e., $n^* > n^\circ$).*

Let us further examine how the welfare-maximizing solution compares with the equilibrium outcome. Specifically, we assume that a social planner can specify how many entrepreneurs participate in the accelerator program, but the planner cannot dictate any other aspects of the accelerator's behavior as well as those of investors. Since the equity fees charged by the accelerator and investors are transfers, the division of surplus does not affect social welfare. Thus, the socially optimal portfolio size is the unique solution to the following problem:

$$\max_n nV(n) - nc.$$

Let $\hat{n}$ denote the socially optimal portfolio size. The first-order condition that characterizes $\hat{n}$ is given by

$$V(\hat{n}) + \hat{n}V'(\hat{n}) = c. \tag{11}$$

A comparison of the two first-order conditions, (9) and (11), shows that the left-hand side (LHS) of equation (11) is strictly greater than that of equation (9) because $\hat{s}(n) < 1$. Similarly, the second term on the LHS of equation (10) is negative because $\hat{s}'(n) < 0$. In the following proposition, $SW(n)$ denotes the level of social welfare when the portfolio size is n.

Proposition 2 *Let n°, n^*, and $\hat{n}$ denote the first-best, equilibrium, and socially optimal portfolio sizes, respectively. Then the following is true: (i) $n^\circ < n^* < \hat{n}$; (ii) $SW(n^\circ) < SW(n^*) < SW(\hat{n})$.*

3 Discussion

3.1 Empirical Relevance

The basic insight from the time-inconsistency problem (Proposition 1) is that the accelerator has the incentive to renege on a promise to keep its portfolio size small. Unless the accelerator can credibly commit to a portfolio size *ex ante*, the resultant portfolio size tends to be larger, and subsequently the accelerator's expected profit would be lower. As will become clearer in the next section, the accelerator's time-inconsistent behavior arises because, once its portfolio is formed, the accelerator only gains from those ventures that are subsequently funded. Having a larger portfolio helps in that it leads to a greater chance to draw false-positive signals in the certification process, but doing so in turn reduces the participation benefit to entrepreneurs.

One might wonder whether, in practice, accelerators really behave as predicted by time inconsistency. The main empirical implications of our model thus far are that with a larger portfolio size, there would be less venture failures because bad ideas are more likely to receive false-positive signals; similarly, due to a reduction in signal precision, the *ex-post* value of a venture would decrease in portfolio size conditional on surviving (i.e., drawing a positive signal). We argue below that the existing (limited) evidence is consistent with these predictions; however, even if one postulates that the time-inconsistent incentive towards larger portfolios appears weaker than what the model suggests, its implications shed light on some normative aspects of early-stage financing.

Our empirical observations are based on available data from the two leading accelerator programs in the U.S., namely, Y Combinator and Techstars. We collected these two pro-

	Y Combinator			Techstars		
Year	Portfolio size	Failure rate	Exit rate*	Portfolio size	Failure rate	Exit rate*
2005	8	0.25	0.83	-	-	-
2006	17	0.53	0.25	-	-	-
2007	32	0.28	0.39	10	0.3	0.86
2008	43	0.37	0.26	10	0.3	0.43
2009	39	0.10	0.20	19	0.32	0.38
2010	61	0.07	0.21	31	0.23	0.21
2011	89	0.02	0.08	60	0.13	0.17
2012	115	0	0.02	73	0.04	0.06

*Exit rate is conditional on surviving (not failing)

Table 1: Descriptive Statistics

grams' portfolio sizes each year since their founding, including the number of failures and exits. We then calculated each cohort's failure rate (to date) and exit rate conditional on not failing (to date). These statistics are presented in Table 1. The evidence generally supports our hypotheses. That is, both rates tend to decrease with the cohort's portfolio size, indicating that the accelerator's signal precision decreased over time, and a participant's valuation (conditional on surviving) is likely to be lower, as suggested by lower probabilities of exits.

There are a couple of caveats to this conclusion: One is that there may be a truncation bias because the more recent cohort's outcomes (failures/successes) have yet to be realized. However, from the Crunchbase database,[12] we observe that most of these events tend to occur within a couple of years' time of participation in the accelerator program. We are certainly likely to see more outcomes for more recent cohorts in the future, but we believe that the decreasing trends for failure and conditional exit rates are not likely to be reversed with more complete information. Another caveat is that there may be some irregular observations that are at odds with our predictions. For instance, Techstars' 2007 and 2008 cohorts have vastly different exit rates despite their portfolio sizes being the same. We believe that this in part reflects heterogeneity across ventures; in particular, the overall trends still support our

[12]See `www.crunchbase.com`.

predictions. Moreover, because both of these accelerator programs focus on high-tech, their portfolio companies should be generally comparable to one another.

Another empirical prediction follows from Proposition 2: the equilibrium portfolio size is larger than the (accelerator's) first best, but it is smaller than the socially-efficient level. Setting aside the question of whether it is feasible to measure social welfare, one approach we can take to test the second prediction is to assume that government-sponsored VC funds would yield outcomes that correlate with the socially-efficient outcome. Cumming (2006) examined Canadian VC funds' portfolios sizes during 1991–2000 and found that the portfolio sizes of private limited partnerships tend to be much smaller than those of government-sponsored (as well as labor-sponsored) VC funds. Specifically, the number of portfolio firms in a private VC fund is, on average, 8, while it is 32 for government-sponsored funds. Even after adjusting for the number of VC fund managers, the average number of portfolio ventures per manager is 2.5 for private funds while it is 7.4 for government funds. While we are not aware of other systematic evidence on portfolio sizes, this seems to support our prediction.

Finally, we note that our theoretical results contain an unambiguous policy implication. The first-best, equilibrium, and socially optimal outcomes can be ranked in terms of social welfare. Proposition 2 implies that the profit-maximizing accelerator's portfolio size would be too small relative to the social optimum even though the accelerator's time-inconsistent behavior can help reduce this gap. That is, given that the accelerator has a superior technology for acquiring information about startups, it is socially efficient to have more entrepreneurs go through this certification process; however, as its portfolio grows, the equity fee the accelerator can charge decreases, disincentivizing the accelerator from growing its portfolio beyond a certain size. This suggests that a policy that subsidizes accelerators to induce larger portfolios of startups can increase welfare. For instance, a policy may assign the accelerator a fixed subsidy per participating startup, which would reduce the accelerator's operating cost, c, and lead to a larger equilibrium portfolio size by shifting its best response curve outward.

3.2 Entrepreneur's Effort

In the previous section, we abstracted from a number of real world considerations in order to highlight the accelerator's time-inconsistency problem. In this subsection, we consider a simple variant of the baseline model, where entrepreneurs make effort decisions. To be more specific, suppose everything is the same as in the base model, except that, after the accelerator program chooses its portfolio size (but before the signals are revealed to investors), entrepreneurs exert unidimensional effort $e > 0$ at a cost $\phi(e)$, where $\phi(e)$ satisfies the standard convexity properties. The entrepreneur's effort choice complements the expected value of the entrepreneur's venture — which so far has only been a function of the accelerator's portfolio size. Instead, with effort choice, this value is represented by $V(e, n)$.

There are numerous ways for how entrepreneurial effort may interact with the base model in Section 2, and thus our approach here may appear somewhat ad hoc. With this caveat in mind, our focus is to illustrate a case in which entrepreneurial effort is neutral to time inconsistency under simple and reasonable assumptions. First, for tractability, we assume that effort choice is not contractable. This means that the entrepreneur chooses his effort after the portfolio size n is determined. Second, and more importantly, we assume that the function $V(e, n)$ is separable into multiplicative terms, $U(e)V(n)$, where $U(e)$ is increasing and concave. Roughly speaking, this means that the entrepreneur's effort has a proportional impact on the value of the venture, in which case effort may represent activities related to the scaling of the venture's underlying product.

Suppose that the accelerator determined its portfolio size n. Then participating entrepreneurs solve the following problem:

$$\max_{e} \, (1 - s)U(e)V(n) - \phi(e),$$

where s is the accelerator's equity fee. Similarly, non-participating entrepreneurs solve

$$\max_{e} \, U(e)V(k) - \phi(e).$$

Notice that s, n, and k are all fixed at this stage, so the above problems are well defined and in fact have unique solutions (which we denote as $e^*(n,s)$ and $e^*(k)$, respectively). As in the preceding analysis, the threshold equity fee, $\hat{s}(n)$, can be determined by setting equal the two value functions, that is, $(1-s)U(e^*(n,s))V(n)-\phi(e^*(n,s))$ and $U(e^*(k))V(k)-\phi(e^*(k))$. Here, $\hat{s}(n)$ is only implicitly determined because a venture's valuation is endogenous to effort, $e^*(n,s)$, in the former case. We will make the mild technical assumption that the value function, $(1-s)U(e^*(n,s))V(n)-\phi(e^*(n,s))$, crosses the constant, $U(e^*(k))V(k)-\phi(e^*(k))$, only once, so that the threshold $\hat{s}(n)$ is unique for any given n and k. Under this assumption, the optimal solution entails, rather surprisingly, the same effort regardless of portfolio sizes.

This can be easily shown by verifying that the same level of effort, regardless of portfolio sizes, is indeed the unique solution to the above maximization problems. To see this, suppose that $e^*(n,s) = e^*(k) = e^*$. From $(1-s)U(e^*)V(n) - \phi(e^*) = U(e^*)V(k) - \phi(e^*)$, it follows that, as in equation (4), $\hat{s}(n)$ is independent of e^*. Further, this equation implies $(1 - \hat{s}(n))V(n) = V(k)$ on the equilibrium path, which are the two terms post-multiplied by $U(e)$. Because this holds for arbitrary n and k, the optimal solution induces the same level of entrepreneurial effort no matter what the portfolio size n is and whether the entrepreneur participates in the accelerator program or not. The multiplicative form, $U(e)V(n)$, is partly responsible for this sharp conclusion; however, we think this is a reasonable approximation to some real world cases.

Given that entrepreneurs exert the same level of effort independent of portfolio sizes, the fact that entrepreneurial effort is neutral to the accelerator's portfolio choice is straightforward. Because the effort cost $\phi(e)$ is born entirely by the entrepreneur, the only change to the set of first-order conditions in equations (9), (10), and (11) is that on the right-hand side, the marginal cost c is divided by a common value, $U(e^*)$, which merely redefines the marginal cost. Intuitively, since the accelerator captures any additional rents via its equity fee, entrepreneurs' valuations for their equity stakes, whether participating in the accelerator program or approaching investors directly, are equal. Therefore, our main results in the previous section remain qualitatively unchanged when we introduce this form of entrepreneurial effort choice into our model. This contrasts with basic intuition from a moral hazard angle, where larger portfolios may reduce entrepreneurial incentives through weaker monitoring. Our model shows that this does not necessarily hold for startup accelerators.

4 Information Disclosure

4.1 Extended Model

In the previous two sections, we assumed that the information learned by the accelerator is a public signal, where time inconsistency tends to reduce the value of information revelation. In this section, we explain another, related phenomenon whereby accelerators seem to reveal only positive signals about their portfolio ventures. This is an important question because if some startups with negative signals obtain funding as a result of incomplete information revelation, then this practice can directly reduce social welfare. Before presenting an extension of our model, we remind the reader that in Section 2's model the assumption of a public signal was without loss of generality. This is because even if the signals were private, the accelerator can only choose to disclose both types of signals or none at all. That is, if the accelerator were to disclose only positive (or negative) signals, then the absence of such signals would be correctly interpreted by investors as revealing the opposite kind of signal about the venture. In the literature, this result is known as the 'unraveling theorem' (e.g., Milgrom, 1981; Milgrom and Roberts, 1986), whereby merely assuming that the signals are private cannot explain partial information disclosure in equilibrium.

However, one mechanism by which partial disclosure may occur was identified by a set of articles that deals with corporate disclosure of nonproprietary (accounting) information (e.g., Verrecchia, 1983; Dye, 1985; Jung and Kwon, 1988). In that literature, unlike in the full disclosure models, with some positive probability the manager may have received no private information, whereby the manager cannot credibly announce that he has not received any. On the other hand, the manager is assumed to refrain from misreporting his private information because investors can verify the manager's claims and impose (legal and reputational) penalties for lying. We show that partial disclosure may occur in our model and relate it to the accelerator's preference for early exit.

We extend our baseline model (abstracting from entrepreneurial effort) by making the following changes. First, we assume that the accelerator learns no new information about a portfolio company with some positive probability $\rho \in (0, 1)$. With probability $1 - \rho$, the accelerator receives a signal according to the same information-gathering technology as in Section 2. The signals obtained constitute private information, which the accelerator may withhold from investors but cannot misrepresent. Second, as in the base model, the signal arrives through close monitoring after the accelerator program begins (i.e., after the portfolio size is determined). For each portfolio venture, there are three disclosure possibilities for the accelerator; namely, the accelerator may reveal only a positive signal (which we denote by $\mu_i = g$), a negative signal ($\mu_i = b$), or no signal ($\mu_i = \phi$). After seeing any disclosed signals, investors update their beliefs and may also screen before making financing offers.

We continue to assume the parametrization where ventures that received a negative signal (hence revealed to be of a type L) are not worth financing. In Section 2, we also assumed that investors do not further screen ventures that received a positive signal, but do screen the entrepreneurs who approach them directly without participating in the accelerator program. In this section, we make analogous assumptions regarding investors' screening behavior. Specifically, investors do not screen the pooled group of ventures for which either a positive or no signal were obtained, but they do screen the pool of ventures for which either a negative or no signal were obtained. Notice that investors continue to screen ventures that did not participate in the accelerator program or the group of ventures that in fact received no signal from the accelerator. Investors' screening behavior can be similarly rationalized by assuming suitable screening costs which are not worth incurring if investors' posteriors are sufficiently accurate or if additional signals are insufficiently informative given the posteriors.

4.2 Analysis

There are three interim types of entrepreneurs who participated in the accelerator program: those who (i) received a positive signal; (ii) received a negative signal; and (iii) received no signal. If positive signals are withheld by the accelerator, then ventures for which no signals were obtained would be pooled with those with positive signals. Similarly, if negative signals are withheld, then ventures with no signals would be pooled with those with negative signals. In this subsection, we establish results that hold for any portfolio size n while holding constant the probability $\rho > 0$.

Let us denote the accelerator's disclosure policy by $d \in \{A, N, P\}$, where A refers to disclosing both negative as well as positive signals, N disclosing only negative signals, and P disclosing only positive signals. Notice that if the accelerator were to withhold both types of signals, then it provides no new information to investors, which means that the accelerator would be unable to appropriate any positive equity fee from entrepreneurs. In the following, we start by showing that the accelerator never has an incentive to withhold a positive signal.

Consider policy A, in which case the accelerator's expected profit is given by

$$ns\left[(1-\rho)V(n) + \rho V(k)\right] - nc.$$

As in our previous analysis, conditional on being informed, $V(n) = (\gamma + (1-\gamma)\alpha(n))(E[v|\mu_i = g] - F)$ is the expected value of the venture, where γ is the prior probability that a venture's type is H. That is, if all signals are revealed, then with probability $1-\rho$ only ventures with a positive signal will be funded. With probability ρ, a venture will be funded if it is successfully screened by investors. Substituting in for $V(n)$ and $V(k)$ yields expected payoffs under policy A:

$$\Pi^A_{\rho>0} = ns\big[(1-\rho)\{(\gamma + (1-\gamma)\alpha(n))(v_F + \lambda_L(v_S - v_F) - F) + \gamma(\lambda_H - \lambda_L)(v_S - v_F)\}$$

$$+\rho\{(\gamma + (1-\gamma)\alpha(k))(v_F + \lambda_L(v_S - v_F) - F) + \gamma(\lambda_H - \lambda_L)(v_S - v_F)\}\big] - nc.$$

Next, consider policy N, whereby the accelerator only discloses negative signals (and withholds positive signals) conditional on being informed. Under the model's assumptions, ventures with a negative signal will not be funded, while those with a positive or no signal will be pooled together from the standpoint of investors. Investors will update their beliefs given this pool of ventures. Specifically, type H ventures would all fall into this pool regardless of receiving a signal or not, and type L ventures for which no signal or false-positive signals were received would also remain in this pool.

Let us denote the expected firm value conditional on not receiving a negative signal under policy N by $E_n[v|\mu_i = \phi]$. That is, unless a negative signal is obtained by the accelerator, all ventures in the pool are presented to investors with no signals revealed. In this case, the investors would demand an equity share of $F/E_n[v|\mu_i = \phi]$ in exchange for investing F. On the other hand, the accelerator can privately distinguish the ventures having received positive signals ($\sigma_i = g$) and those having in fact received no signal ($\sigma_i = \phi$). Thus, the accelerator's expected profit under policy N is given by

$$\Pi^N_{\rho>0} = ns\left(1 - \frac{F}{E_n[v|\mu_i = \phi]}\right)((1-\rho)(\gamma + (1-\gamma)\alpha(n))E_n[v|\sigma_i = g] + \rho E[v|\sigma_i = \phi]) - nc$$

where $E_n[v|\sigma_i = g]$ is the expected venture value conditional on the accelerator's private knowledge that the venture has received a positive signal ($\sigma_i = g$), and, similarly, $E[v|\sigma_i = \phi]$ is the expected value when the accelerator has indeed received no signal. Notice that the terms do not collapse because the accelerator's information set (σ_i) is different from investors' information set (μ_i) under the disclosure policy N. We summarize our results as follows:

Proposition 3 *Given a positive probability $\rho > 0$ of drawing an uninformative signal, the partial disclosure policy N is never optimal for the accelerator.*

Finally, under policy P, the accelerator only discloses positive signals, in which case venture receiving those signals will be funded. Ventures that have received negative or no signals would be pooled together, and investors would need to screen them further prior to investing. Thus, investors update their beliefs conditional on observing a positive signal, and also conditional on observing that no signal is disclosed by the accelerator. For the latter case, notice that a type H venture for which the accelerator received no signal would remain in the pool, as would type L ventures that received negative or no signals.

To come up with the accelerator's expected profit, we need to consider three cases. First, with probability ρ, the accelerator does not learn anything about a venture which subsequently goes into the pool. Let $\hat{\gamma}$ denote the posterior probability that a venture is of type H conditional on being in the pool. Then with probability $(1-\hat{\gamma})(1-\alpha(k))$, investors receive a negative signal, and the venture is not funded. With probability $\hat{\gamma}+(1-\hat{\gamma})\alpha(k)$, investors receive a positive signal for ventures in the pool, and invest F. The expected firm value has the same expression as $V(n)$, except that the posterior $\hat{\gamma}$ is used:

$$V(k|\hat{\gamma}) = (\hat{\gamma} + (1-\hat{\gamma})\alpha(k))(E_k[v|\kappa_i = g, \mu_i = \phi] - F), \tag{12}$$

where $\kappa_i = g$ indicates that investors screened and received a positive signal.

Second, with probability $1-\rho$, the accelerator privately observes whether a venture receives a positive or a negative signal. If it receives a positive signal, then the expected venture value would be $V(n) = (\gamma + (1-\gamma)\alpha(n))(E[v|\mu_i = g] - F)$.

Third, if the accelerator receives a negative signal, however, such signals will not be disclosed under policy P. That is, the accelerator privately knows that a venture is of type L, and the venture may subsequently be screened as a false-positive by investors with probability $\alpha(k)$ conditional on being placed in the pool. Thus, the accelerator's expected value for such ventures is

$$V(k|\gamma) = (1-\gamma)(1-\alpha(n))\alpha(k)(1 - \frac{F}{E_k[v|\kappa_i = g, \mu_i = \phi]})(v_F + \lambda_L(v_S - v_F)). \qquad (13)$$

Collecting the terms, the accelerator's overall expected profit under policy P is given by

$$\Pi^P_{\rho>0} = ns[\rho V(k|\hat{\gamma}) + (1-\rho)(V(n) + V(k|\gamma))] - nc.$$

The following proposition comes from comparing $\Pi^A_{\rho>0}$ and $\Pi^P_{\rho>0}$ combined with the result from Proposition 3 that $\Pi^N_{\rho>0} < \Pi^A_{\rho>0}$.

Proposition 4 *There exists values $\rho^* > 0$ and $\lambda^* > 0$, such that for all $\rho < \rho^*$ and $\lambda_L > \lambda^*$, the partial disclosure policy P is optimal for the accelerator.*

4.3 Early Exits

The results above imply that investors may end up investing in some portfolio companies even if investors do not receive a positive signal about particular startups from the accelerator. The accelerator creates a 'no signal' pool and leaves it for investors to decide whether to invest after their own due diligence process. The accelerator may choose to do so because it will benefit from its ownership stakes in type L ventures that end up being financed by investors (i.e., L ventures that are subsequently identified as false positives). The accelerator has a superior information-gathering technology than investors do, and by concealing negative signals the accelerator reduces social welfare. Therefore, the accelerator tends to produce a potentially overvalued portfolio of ventures under the conditions of Proposition 4; that is, when the probability, ρ, of an uninformative signal is sufficiently small, and the probability that a type L venture would succeed in generating revenue v_S is sufficiently large.

In the previous subsection, we analyzed the accelerator's incentives to choose a disclosure policy, $d \in \{A, N, P\}$, given an arbitrary number of portfolio firms n as well as an exogenously given probability of an uninformative signal $\rho > 0$. We now discuss how the accelerator's preferred disclosure policy may help explain the observation that, according to some critics, accelerators tend to exit their investments too early (e.g., Vascellaro, 2011). That is, in order to increase the chance of uninformative signals, accelerators may encourage program participants to seek investments relatively early by setting a short duration for their programs. For simplicity, suppose that the accelerator can choose to exit at no cost at any time before a maximum period, T (i.e., T is the maximum viable program length). Suppose that the accelerator will be perfectly informed ($\rho = 0$) if it exits at T, while if it exits earlier than T, then the probability of drawing an uninformative signal is positive ($\rho > 0$), and it decreases as the exit time is extended.

The proceeding logic comes from the proof of Proposition 4, where it is shown that (i) $\Pi^A_{\rho>0} < \Pi_{\rho=0}$ holds, and (ii) $\Pi^P_{\rho>0} > \Pi_{\rho=0}$ holds if and only if the inequality $\rho V(n) < (1-\rho)V(k|\gamma) + \rho V(k|\hat{\gamma})$ is satisfied. Here, $\Pi_{\rho=0}$ denotes the accelerator's expected profits in the base model (i.e., when $\rho = 0$), $\Pi^A_{\rho>0}$ denotes the accelerator's profit when disclosing all signals given $\rho > 0$, and $\Pi^P_{\rho>0}$ denotes the accelerator's profit under policy P given $\rho > 0$.

Together, these inequalities imply that if the conditions of Proposition 4 are satisfied in equilibrium, then the accelerator would choose disclosure policy P and indeed prefer to exit early ($\rho > 0$) rather than at T. If the conditions of Proposition 4 do not hold for a given $\rho > 0$, then it is possible that the accelerator finds it optimal to disclose all signals, because the comparison between $\Pi^A_{\rho>0}$ and $\Pi^P_{\rho>0}$ is ambiguous. In such cases, both $\Pi^A_{\rho>0}$ and $\Pi^P_{\rho>0}$ are dominated by $\Pi_{\rho=0}$, so the accelerator would seem to prefer to exit at T. However, if ρ is endogenous along the lines described above, and decreases as the program length is extended, there may exist a more profitable strategy for the accelerator. Namely, the accelerator can decrease the uncertainty ρ by exiting later but still before T. Because the above inequality, $\rho V(n) < (1-\rho)V(k|\gamma) + \rho V(k|\hat{\gamma})$, is necessarily satisfied at some point before T (i.e., as $\rho \to 0$), exiting earlier than T would indeed increase the accelerator's expected profits. Therefore, our model gives rise to the predictions that (i) accelerators may choose to introduce noise into the startup screening process, and (ii) early exits would be prevalent among accelerators programs.

5 Conclusion

This paper examined the role of startup accelerators in certifying the value of portfolio ventures to outside investors. We focused on the time-inconsistency problem, whereby entrepreneurs rationally take into account the value of the accelerator program when agreeing to the terms of participation. This problem constrains the accelerator's ability to maximize its expected profits, leading to a larger portfolio size and less precise signals generated by the program. We showed that the accelerator's time-inconsistency problem is beneficial from the standpoint of social welfare, and that a policy that subsidizes the accelerator's marginal cost could increase social welfare. We also showed that the accelerator may prefer partial information disclosure, whereby only favorable signals about portfolio firms are revealed. This is because only when its portfolio firms raise subsequent funding does the accelerator stand to gain from its ownership stakes. Consequently, the accelerator may choose to exit its investments early, prior to fully screening program participants.

References

[1] Admati, A., and P. Pfleiderer. (1994) "Robust Financial Contracting and the Role of Venture Capitalists." *Journal of Finance* 49: 371–402.

[2] Barro, R., and D. Gordon. (1983) "Rules, Discretion and Reputation in a Model of Monetary Policy." *Journal of Monetary Economics* 12: 101–121.

[3] Bernile, G., D. Cumming, and E. Lyandres. (2007) "The Size of Venture Capital and Private Equity Fund Portfolios." *Journal of Corporate Finance* 13: 564–590.

[4] Bolton, P., X. Freixas, and J. Shapiro. (2012) "The Credit Ratings Game." *Journal of Finance* 67: 85–111.

[5] Brav, A., and P. Gompers. (1997) "Myth or Reality? The Long-Run Underperformance of Initial Public Offerings: Evidence from Venture and Nonventure Capital-Backed Companies." *Journal of Finance* 52: 1791–1821.

[6] Casamatta, C. (2003) "Financing and Advising: Optimal Financial Contracts with Venture Capitalists." *Journal of Finance* 58: 2059–2085.

[7] Cornelli, F., and O. Yosha. (2003) "Stage Financing and the Role of Convertible Securities." *Review of Economic Studies* 70: 1–32.

[8] Cumming, D. (2006) "The Determinants of Venture Capital Portfolio Size: Empirical Evidence." *Journal of Business* 79: 1083–1126.

[9] Denis, D. (2004) "Entrepreneurial Finance: an Overview of the Issues and Evidence." *Journal of Corporate Finance* 10: 301–326.

[10] DiCarlo, L. (2001) "Incubators On Life Support: CMGI." *Forbes* Accessed December 2, 2013, `http://www.forbes.com/2001/01/22/0122cmgi.html`.

[11] Dye, R. (1985) "Disclosure of Nonproprietary Information." *Journal of Accounting Research* 23: 123–145.

[12] Fulghieri, P., and M. Sevilir. (2009). "Size and Focus of a Venture Capitalist's Portfolio." *Review of Financial Studies* 22: 4643–4680.

[13] Gompers, P. (1995) "Optimal Investment, Monitoring, and the Staging of Venture Capital." *Journal of Finance* 50: 1461–1489.

[14] Gorman, M., and W. Sahlman. (1989) "What Do Venture Capitalists Do?" *Journal of Business Venturing* 4: 231–248.

[15] Grossman, S. (1981) "The Informational Role of Warranties and Private Disclosure about Product Quality." *Journal of Law and Economics* 24: 461–483.

[16] Hansen, M., H. Chesbrough, N. Nohria, and D. Sull. (2000) "Networked Incubators: Hothouses of the New Economy," *Harvard Business Review* 78: 74–84.

[17] Hellmann, T. (2007) "Entrepreneurs and the Process of Obtaining Resources." *Journal of Economics & Management Strategy* 16: 81–109.

[18] Hellmann, T., and M. Puri. (2002) "Venture Capital and the Professionalization of Start-ups: Empirical Evidence." *Journal of Finance* 57: 169–197.

[19] Ibrahim, D. (2008) "The (Not So) Puzzling Behavior of Angel Investors." *Vanderbilt Law Review* 61: 1405–1452.

[20] Inderst, R., H. Mueller, and F. Munnich. (2007) "Financing a Portfolio of Projects." *Review of Financial Studies* 20: 1289–1325.

[21] Jung,W.-O., and Y. Kwon. (1988) "Disclosure When the Market Is Unsure of Information Endowment of Managers." *Journal of Accounting Research* 26: 146–153.

[22] Kanniainen, V., and C. Keuschnigg. (2004) "Start-up Investment with Scarce Venture Capital Support." *Journal of Banking & Finance* 28: 1935–1959.

[23] ———, and ——— (2003) "The Optimal Portfolio of Start-up Firms in Venture Capital Finance." *Journal of Corporate Finance* 9: 521– 534.

[24] Kerr, W., J. Lerner, and A. Schoar. (2011) "The Consequences of Entrepreneurial Finance: Evidence from Angel Financings." *Review of Financial Studies*. Advance Access. Published October 9, 2011, doi:10.1093/rfs/hhr098.

[25] Lerner, J. (1995) "Venture Capitalists and Oversight of Privately-Held Firms." *Journal of Finance* 50: 301–318.

[26] Manove, M., J. Padilla, and M. Pagano. (2001) "Collateral versus Project Screening: A Model of Lazy Banks." *RAND Journal of Economics* 32: 726–744.

[27] Megginson, W., and K. Weiss. (1991) "Venture Capitalist Certification in Initial Public Offerings." *Journal of Finance* 46: 879–903.

[28] Milgrom, P. (1981) "Good News and Bad News: Representation Theorems and Applications." *Bell Journal of Economics* 12: 380–391.

[29] Milgrom, P., and J. Roberts. (1986) "Relying on the Information of Interested Parties." *RAND Journal of Economics* 17: 18–32.

[30] Relan, P. (2012) "90% of Incubators and Accelerators Will Fail and That's Just Fine for America and the World." *TechCrunch*. Accessed December 2, 2013, `http://goo.gl/UCpAzh`.

[31] Sahlman, W. (1990) "The Structure and Governance of Venture-Capital Organizations." *Journal of Financial Economics* 27: 473–521.

[32] Schmidt, K. (2003) "Convertible Securities and Venture Capital Finance." *Journal of Finance* 58: 1139–1166.

[33] Strausz, R. (2009) "Entrepreneurial Financing, Advice, and Agency Costs." *Journal of Economics & Management Strategy* 18: 845–870.

[34] Vascellaro, J. (2011) "Some Fear a Glut in Tech 'Incubators'." *Wall Street Journal*. Accessed December 2, 2013, `http://goo.gl/GPzQDP`.

[35] Verrecchia, R. (1983) "Discretionary Disclosure." *Journal of Accounting and Economics* 5: 179–194.

[36] Waldman, M. (1996) "Planned Obsolescence and the R&D Decision." *RAND Journal of Economics* 27: 583–595.

Appendix

Proof of Proposition 1. By the model's assumptions, $E_n[v|\sigma_i = g] > F$, so that $V(n) = (\gamma + (1-\gamma)\alpha(n))(E_n[v|\sigma_i = g] - F) > 0$ for any n. Substituting in for $E_n[v|\sigma_i = g]$ from equation (1) yields

$$V(n) = (\gamma + (1-\gamma)\alpha(n))(v_F + \lambda_L(v_S - v_F) - F) + \gamma(\lambda_H - \lambda_L)(v_S - v_F).$$

Differentiating $V(n)$ with respect to n, we get $V'(n) = (1-\gamma)\alpha'(n)(v_F + \lambda_L(v_S - v_F) - F)$. By the model's assumptions, $\alpha'(n) > 0$ and $\lambda_L v_S + (1-\lambda_L)v_F < F$. The latter is true because we assumed that ventures for which a negative signal is obtained are not financed, and a negative signal means that the venture idea is bad ($\theta_i = L$) with probability 1. Given these, it follows that $V'(n) < 0$.

From equation (4), $\hat{s}(n) = 1 - (V(k)/V(n))$, and thus $\hat{s}'(n) = V(k)V'(n)/V(n)^2 < 0$ because $V(k) > 0$ and $V'(n) < 0$.

The first-order condition that characterizes the optimal choice n^* under rational expectations is given by equation (9):

$$\hat{s}(n)(V(n) + nV'(n)) = c.$$

The first-order condition that characterizes the profit-maximizing commitment solution n° is given by equation (10):

$$\hat{s}(n)(V(n) + nV'(n)) = c - n\hat{s}'(n)V(n).$$

Because the LHS of equations (9) and (10) has a positive sign when evaluated at $n = 0$, both $n^* > 0$ and $n^\circ > 0$ are at the interior. The RHS of equation (10) is greater than that of equation (9) because $\hat{s}'(n) < 0$ and $V(n) > 0$. On the other hand, the LHS of both equations (9) and (10) is decreasing in n: Differentiating $V(n) + nV'(n)$ yields $2V'(n) + nV''(n)$, where

$V''(n) = (1-\gamma)\alpha''(n)(v_F + \lambda_L(v_S - v_F) - F)$. Because $\lambda_L v_S + (1-\lambda_L)v_F < F$, it can be shown that $2V'(n) + nV''(n) < 0$ if and only if $2\alpha'(n) + n\alpha''(n) > 0$, which holds by assumption. Together with the fact that $\hat{s}'(n) < 0$, it follows that n° is smaller than n^*.

The second-order condition for n^* follows from $2V'(n) + nV''(n) < 0$. The second-order condition for n° is given by

$$\hat{s}'(n)(V(n)+nV'(n)) + \hat{s}(n)(2V'(n)+nV''(n)) + \hat{s}'(n)V(n) + n\hat{s}''(n)V(n) + n\hat{s}'(n)V'(n) < 0.$$

Substituting in for $\hat{s}'(n) = V(k)V'(n)/V(n)^2$ and for $\hat{s}''(n) = V(k)V(n)^{-2}V''(n) - 2V(k)V(n)^{-3}V'(n)^2$ yields

$$nV(k)V(n)^{-1}V''(n) + +2V(k)V(n)^{-1}V'(n) < 0,$$

or

$$V(k)V(n)^{-1}[2V'(n) + nV''(n)] < 0,$$

which holds by the assumption, $2\alpha'(n) + n\alpha''(n) > 0$.

That the accelerator's expected profit is lower in equilibrium is straightforward because the maximization problem under rational expectations is a constrained optimization problem of the commitment problem. Thus, as long as the solution under rational expectations is different from the commitment solution, the accelerator's profit is lower in equilibrium. ■

Proof of Proposition 2. Notice that as long as the accelerator optimally chooses an $n^* > 0$, the total surplus is also maximized at some strictly positive value of $\hat{n} > 0$. The first-order condition that characterizes the equilibrium is given by equation (9):

$$\hat{s}(n)(V(n) + nV'(n)) = c.$$

The first-order condition that characterizes the planner's solution is given by equation (11):

$$V(n) + nV'(n) = c,$$

where the second-order condition, $2V'(n) + nV''(n) < 0$, is satisfied.

Suppose $\hat{n} < n^*$. From the proof of Proposition 1, $V(n) + nV'(n)$ is a strictly decreasing function of n, which implies $V(\hat{n}) + \hat{n}V'(\hat{n}) > V(n^*) + n^*V'(n^*)$. Since $\hat{s}'(n) < 0$, it also follows that $\hat{s}(\hat{n}) > \hat{s}(n^*)$. Thus, $\hat{s}(\hat{n})(V(\hat{n}) + \hat{n}V'(\hat{n})) > \hat{s}(n^*)(V(n^*) + n^*V'(n^*))$, which is a contradiction to the fact that n^* is the constrained optimum. On the other hand, since $\hat{s}(n) \in (0, 1)$, $\hat{n} \neq n^*$. Therefore, $\hat{n} > n^*$.

Differentiating the planner's objective function twice yields $2V'(n) + nV''(n) < 0$, which holds under the same assumption as above: $2\alpha'(n) + n\alpha''(n) > 0$. That is, the objective function $SW(n)$ is a strictly increasing concave function, and given that $\hat{n}$ denotes the global maximum, $n^\circ < n^* < \hat{n}$ implies $SW(n^\circ) < SW(n^*) < SW(\hat{n})$. ■

Proof of Proposition 3. Under policy N, ventures for which a negative signal was revealed will not be funded. Ventures for which no signal was disclosed have two interim types: With prior probability γ, a venture is a type H, in which case it never receives a negative signal. With probability $1 - \gamma$, a venture is a type L, and the accelerator may be uninformed with probability ρ or it may receive a false-positive signal with probability $(1 - \rho)\alpha(n)$. Thus, conditional on receiving no signal under policy N, investors update their beliefs, so that the expected value of the venture is

$$E_n[v|\mu_i = \phi] = \frac{\gamma(\lambda_H v_S + (1 - \lambda_H)v_F) + (1 - \gamma)(\rho + (1 - \rho)\alpha(n))(\lambda_L v_S + (1 - \lambda_L)v_F)}{\gamma + (1 - \gamma)(\rho + (1 - \rho)\alpha(n))}.$$

When the accelerator privately observes that a venture has received a positive signal, $E_n[v|\sigma_i = g] = \tilde{\gamma}(\lambda_H v_S + (1 - \lambda_H)v_F) + (1 - \tilde{\gamma})(\lambda_L v_S + (1 - \lambda_L)v_F)$, where $\tilde{\gamma} = \frac{\gamma}{\gamma + (1-\gamma)\alpha(n)}$ is the posterior. If the accelerator has not received any signal, then $E[v|\sigma_i = \phi] = \gamma(\lambda_H v_S +$

$(1-\lambda_H)v_F) + (1-\gamma)(\lambda_L v_S + (1-\lambda_L)v_F)$, where prior beliefs γ is used instead.

It suffices to show that the disclosure policy N is dominated by policy A in terms of the accelerator's expected profit. Substituting $E_n[v|\mu_i = \phi]$, $E_n[v|\sigma_i = g]$, and $E[v|\sigma_i = \phi]$ in for $\Pi^N_{\rho>0}$ and simplifying further yields

$$\Pi^N_{\rho>0} - \Pi^A_{\rho>0} < 0 \text{ if and only if } \rho(1-\alpha(k))(1-\gamma)(\lambda_L v_S + (1-\lambda_L)v_F - F) < 0,$$

which holds because of the assumption that low-quality ventures are not worth financing, that is, $\lambda_L v_S + (1-\lambda_L)v_F - F < 0$. ■

Proof of Proposition 4. The posterior probability that a venture is of type H conditional on being in the pool under policy P is

$$\hat{\gamma} = \frac{\gamma\rho}{\gamma\rho + (1-\gamma)\rho + (1-\gamma)(1-\rho)(1-\alpha(n))},$$

where γ is the prior probability of being a type H, and ρ is the probability that the accelerator receives no signal. Notice that negative signals are not disclosed.

Thus, if a venture from the pool is successfully screened by investors, its expected value conditional on being from the pool is $E_k[v|\kappa_i = g, \mu_i = \phi] = v_F + \lambda_L(v_S - v_F) + \frac{\hat{\gamma}(\lambda_H - \lambda_L)(v_S - v_F)}{\hat{\gamma} + (1-\hat{\gamma})\alpha(k)}$. Substituting in $E_k[v|\kappa_i = g, \mu_i = \phi]$ for $V(k|\hat{\gamma})$ from equation (12), we obtain

$$V(k|\hat{\gamma}) = (\hat{\gamma} + (1-\hat{\gamma})\alpha(k))(v_F + \lambda_L(v_S - v_F) - F) + \hat{\gamma}(\lambda_H - \lambda_L)(v_S - v_F) \geq 0. \quad (14)$$

Notice that for ventures from the pool to be financed by investors, the above inequality must be satisfied. Since the only negative term in the inequality is $v_F + \lambda_L(v_S - v_F) - F$, it follows that there exists a value $\lambda^* \in (0, \frac{F - v_F}{v_S - v_F})$ such that (14) holds with a strict sign for all $\lambda_L > \lambda^*$. Moreover, when (14) is satisfied, it means that $E_k[v|\kappa_i = g, \mu_i = \phi] > F$; thus, from equation (13), it also follows that $V(k|\gamma)$ is positive.

We proceed in two steps. First, consider the accelerator's expected profit in the base model (i.e., when $\rho = 0$): $\Pi_{\rho=0} = nsV(n) - nc$. For any given n, it is easy to see that $\Pi_{\rho=0}$ is less than the accelerator's expected profit under disclosure policy P, $\Pi^P_{\rho>0}$, if and only if $\rho V(n) < (1-\rho)V(k|\gamma) + \rho V(k|\hat{\gamma})$. Since $V(k|\gamma)$ is positive on the range of λ_L, $\lambda_L > \lambda^*$, this inequality is satisfied as $\rho \to 0$.

Second, the accelerator's expected profit under disclosure policy A, $\Pi^A_{\rho>0}$, is lower than the profit $\Pi_{\rho=0}$ in the baseline model with $\rho = 0$. This is true because $\Pi^A_{\rho>0} - \Pi_{\rho=0} = \rho(\alpha(k) - \alpha(n))(1-\gamma)(\lambda_L v_S + (1-\lambda_L)v_F - F) < 0$, where the inequality follows from the model's assumption that low-quality ventures are not worth financing. Therefore, it follows that $\Pi^P_{\rho>0} > \Pi^A_{\rho>0}$. ■