Contractual Execution, Strategic Incompleteness and Venture Capital

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Abstract

Contractual execution generates hard information, available to the contracting parties, even when contracts are secretly executed. Building on this simple observation, the paper shows that incomplete contracts can be preferred to complete contracts. This is because (i) execution of incomplete contracts reveals less information to outside parties, giving rise to strategic gains; (ii) secretly executed complete contracts could not do better, given the possible strategic uses of the hard information generated by execution of the contract. The key effects at work are explored in the case of financial contracts for innovative start-up companies, providing a rationale for the observed differences in the extent to which *venture capital* contracts include a variety of *contingencies*, and for how this varies across industries and geographically.

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1. Introduction

The notion that real-world contracts are often too "incomplete"[1], and the reasons, as well as the consequences, of such incompleteness, have intrigued and fascinated economists for some time.[2] When it comes to *explaining* contractual incompleteness, a number of approaches have been proposed in the literature, including those based on some form of bounded rationality, transactions costs, and signaling. Most of these have focused on possible *costs of complete contracts* arising at the *ex ante* stage when the contract is agreed[3]. This paper identifies instead a potential cost of complete contracts arising at the *ex post*, execution stage. It then explores its implications in the context of financial contracts for innovative start-up companies, providing a rationale for the observed differences in the extent to which *venture capital* contracts include a variety of *contingencies*, and for how this varies across industries and geographically.

The main idea is the following. The *execution* of a complete contingent contract typically generates *hard* information, which is informative about the realized state of nature. For example, the contract may specify state-contingent trades and/or transfers; ex post, hard evidence of the trade and/or transfer that has actually occurred will be informative about the realized state. In a variety of circumstances, it may be in the interest of the contracting parties ex ante to commit not to reveal this information to other parties ex post. Thus if the production of hard information about realized contingencies can be reduced by specifying fewer contractual contingencies, incomplete contracts may be preferred to complete con-

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[1]Incompleteness has been defined in different ways. Ex post, it can be argued that contracts that are renegotiated must have been "incomplete". Ex ante, contracts are often viewed as incomplete through a comparison with (theoretically) optimal contracts. Thus a sufficiently broad definition of optimality (i.e. contracts that are optimal given all possibly relevant constraints, including those due to the cognitive costs of trying to foresee future contingencies) would make the distinction between complete and incomplete contracts largely redundant. In this paper, I will follow most of the literature and use a less broad definition of optimality, and hence incompleteness.

[2]Incomplete contracts were central to the property rights approach developed by Grossman and Hart (1986) and Hart and Moore (1990), building on the insights of Williamson (1975, 1985) and Klein, Crawford and Alchian (1978). Since then, they have been at the heart of numerous theories attempting to shed light on a variety of economic outcomes.

[3]These include cognitive/delay costs incurred in thinking about future contingencies (see especially Bolton and Faure-Grimaud (2005, 2007), and Tirole (2008)), and the costs of writing appropriate contracts (as in, for example, Anderlini and Felli (1994, 1999), Battigalli and Maggi (2002), Dye (1985), Hart and Moore (1999), and Segal (1999)).

tracts, even when the latter would be more efficient in reducing agency costs, or hold-up problems, in the relationship between the two contracting parties.

There are two natural potential objections to this line of argument. First, suppose that an incomplete contract is agreed between A and B, which will benefit one of the two, say B, ex post, by not revealing information about the realized state of nature to a third party C. Suppose however that A can, privately and independently, generate hard evidence about the realized state of nature, and sell it to C ex post. This may, in some cases, "undo" the benefits of an incomplete contract. In very many cases, though, each individual contracting party will have some scope for discretion and manipulation in the production of hard evidence (e.g. omitting some "unfavorable" detail; engaging in some form of "window-dressing")[4]. This will undermine the credibility of such evidence in the eyes of third parties. In contrast, if A and B sign a complete contingent contract specifying, say, a (unique) transfer $t(\gamma)$ to be paid by B to A in state γ, then evidence of the transfer actually paid ex post is *credible* evidence about γ, since it requires *agreement* between the two informed parties[5]. It is this difference in credibility that gives an advantage to incomplete contracts.

The second natural potential objection to the main argument in this paper is that the trade-off I identify between complete and incomplete contracts will not arise if the parties can commit to *secret execution* of complete contracts. In practice, confidentiality clauses are often included in contracts, and courts are typically willing to enforce them[6]. Does this solve the problem? In the circumstances I consider, it does not. The reason is that court enforcement of confidentiality clauses requires legally acceptable proof to be produced when the contract is breached. However, as will become clearer below, when information can be credibly transmitted simply by showing, privately, evidence to another party, without handing it over, it becomes very difficult to prove that breach occurred, hampering attempts to enforce confidentiality clauses. Thus in a variety of circumstances, the fact that *hard* information has been generated by execution of a complete contract may enable outside parties to extract the information at no cost (in the spirit of Grossman (1981), Grossman and Hart (1980) and Milgrom (1981)), even

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[4]See Tirole (2006), pp.299-300, for a discussion and examples of firms' earnings manipulations and balance-sheet window dressing.

[5]Thus any attempt by A to manipulate the evidence in his favor would be challenged by B. The one caveat is the case where the ex post gains that B could make by inducing C to believe the true state is γ exceed the cost of paying the transfer $t(\gamma)$ even when the true state is not γ. I rule out this less interesting case to focus on the key trade-offs at the heart of the paper.

[6]See Daughety and Reinganum (2005).

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in the presence of confidentiality clauses. Complete contracts with confidentiality clauses will not, in this case, provide a more efficient solution to the parties' original contracting problem, and the trade-off identified above between complete and incomplete contracts will continue to apply.

To fix ideas, consider the following example. Suppose a capital-constrained entrepreneur with a novel idea (project) obtains funding from a venture capitalist to enter a new industry; call them "the incumbent" and "investor 1", respectively. Turning the idea into commercial success requires entrepreneurial effort. Assume that, following the incumbent's effort choice but before realization of the project's returns, an intermediate performance signal γ is realized, observable only by the entrepreneur and the venture capitalist. At this stage, another entrepreneur ("the entrant") seeks funding for a rival project, whose expected profitability depends on how successful the incumbent has been in building up a competitive advantage. Let the intermediate performance signal be informative about the incumbent's effort and also about the potential entrant's expected profitability. In this case, leaving aside entry considerations, the efficient complete contract between the incumbent and investor 1 may entail a reward for the incumbent contingent on a good performance signal. However, execution of the contract may reveal to other parties the realization of the signal, and hence also information about the potential entrant's expected profitability.

Intuitively, in some circumstances it may be advantageous for the original contracting parties (incumbent and investor 1) to commit not to reveal the realization of the signal to other interested parties (potential entrant, other possible investors), by choosing an incomplete contract that is not contingent on the signal. As I will show, this can generate informational rents for the contracting parties that may be greater than any losses associated with less efficient effort incentives. Moreover, as suggested earlier, secretly-executed complete contracts would not improve on such incomplete contracts: this is because the execution of a complete contract, even when it is not observable by others, generates hard information available to the contracting parties (in our example, transfers and receipts). Other parties may then be able to view such evidence, secretly, or to make appropriate inferences if denied viewing.

Delaying execution of complete contracts (in our example, waiting until the project's returns are realized and only then establishing the realized value of the intermediate signal, and any reward that might be due) would avoid generating hard information at the intermediate stage. This might help in some circumstances, but in general it will be problematic, not least because, as noted earlier,

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the process of determining reliably the realized state depends crucially on the ability of each contracting party to challenge possible omissions and manipulations of the evidence by the other party. To challenge successfully often requires obtaining and presenting relevant additional evidence, which will be much more difficult after a long delay, as circumstances change, and past information is forgotten by potential witnesses[7].

The key trade-off remains therefore the one between complete and incomplete contracts identified earlier. To explore these ideas, and study their implications for venture capital and innovation, I develop in section 2 a model of sequential entry into a new industry by innovative, capital-constrained entrepreneurs, of the kind often financed by venture capitalists (see Sahlman and Stevenson (1985) for a detailed account of such venture-funded sequential entry in the disk-drive industry). I examine two cases, corresponding to different assumptions about the nature of competition among venture capitalists. To begin with, I study the case of *imperfect competition*. In particular, in line with the evidence on venture capital discussed below, I assume that there are a number of venture capitalists who behave cooperatively, thereby earning an expected rate of return equal to $1 + \alpha$; i.e. they do not undercut each other (but do compete if one of them is observed deviating by trying to obtain an expected rate of return greater than $1 + \alpha$). As will become clear, in the setting under consideration this is equivalent to assuming that there is a single investor, *and* that entrepreneurs have all the bargaining power in negotiating with this investor, subject to guaranteeing him an expected rate of return equal to $1 + \alpha$. On the other hand, the fact that this is not a monopoly investor means that there is nothing to be gained by using exclusive contracts with liquidated damages as in Aghion and Bolton (1987), or equivalently, sophisticated contracts contingent on subsequent entry[8]. A trade-off between complete and incomplete contracts emerges in this case when the potential entrant is of sufficiently *high quality*, because the investor can then obtain *informational rents* from the entrant if the latter is uninformed about the realization of γ. The expected value of these rents has to be set against two potential costs. First, the incomplete contract requires that the entrepreneur's reward be more sensitive to

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[7]The problem of witnesses forgetting information is well-known: this has been shown to happen over periods as short as five months (see, for example, Flin et al. (1992)). As for documentary evidence, the legal literature makes clear the importance of obtaining this at the time when the relevant "state of nature" is realized (see, for example, Rosenstock (2007), pp. 530-531). See also footnote 11.

[8]I discuss this point in more detail on page 15.

final returns, implying that the entrepreneur's *loss from entry* (for which, unlike the investor, he is not compensated) will be greater. Second, there is the cost of providing *effort incentives* less efficiently. Interestingly though, in some cases this second cost may be more than offset by the beneficial impact on effort incentives due to the fact that informational rents help to relax the investor's participation constraint.

I then investigate how the results are affected when we assume a much more competitive environment among venture capitalists. Specifically, I consider the polar case of *perfect competition*, in which investors behave competitively and entrepreneurs have all the bargaining power. I find that a trade-off between complete and incomplete contracts can emerge in this case too, albeit of a different nature. When potential entrants are of *intermediate quality*, investor 1's informational advantage under incomplete contracting[9] enables him to *reduce the losses* associated with entry. This advantage has to be set against the cost of providing effort incentives less efficiently - with no offsetting benefit due to informational rents though. Indeed, if potential informational rents are sufficiently important, the benefits of incomplete contracts will be greater in the presence of imperfectly competitive, cooperative venture capitalists than in the presence of perfectly competitive investors.

In line with the intuition discussed earlier, allowing for the possibility of *secretly-executed* complete contracts does not undermine the basic trade-offs just described. Executing such contracts would generate hard information about transfers, available to each of the contracting parties. In the imperfectly competitive case, this would enable the entrant to extract the information from the investor and use it to reduce his informational rents to zero. With perfectly competitive investors, on the other hand, the information could be obtained from the incumbent at the expense of investor 1. In both cases, the incumbent and his financier do not gain ex ante from choosing a complete contract with a commitment to secret execution.

The trade-off I obtain between complete and incomplete contracts is consistent with evidence on venture capital contracts analyzed by Kaplan and Strömberg (2003). In their sample, approximately 37% of contracts provided some form of reward for the entrepreneur contingent on intermediate performance signals[10], as

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[9]Being the one who funds the incumbent, investor 1 is the only one able to observe the realization of γ.

[10]Rewards included giving equity, options or additional funding to the entrepreneur, or suspending dividend payments to venture capitalists.

in our complete contracts. The remainder did not, as in our incomplete contracts. The performance measures used included financial targets, based on revenues and operating profits, and product targets, such as reaching a threshold number of customers who have purchased the product and given positive feedback, acquiring a technology, or developing a facility. As assumed in our model, it seems likely that in the event of disagreement between the entrepreneur and the venture capitalist, the "honest" party could have successfully challenged the other's (dishonest) claim; for example, the venture capitalist could have challenged "creative accounting", as well as "embellished" claims of customer satisfaction, technology acquisition or facility development[11]. The evidence analyzed by Kaplan and Strömberg therefore seems relevant to our model, and the fact that a significant proportion of contracts in their sample included rewards based on intermediate performance signals, while the majority did not, is consistent with an underlying cost-benefit trade-off of the kind explored in this paper.

One important implication of my analysis is that the nature of the trade-off between complete and incomplete contracts will be sensitive to the degree of competition among investors[12]. The venture capital industry is often viewed as being characterized by imperfect competition, owing to the specialized knowledge required to evaluate, monitor and advise innovative entrepreneurial start-ups[13]. The evidence on venture capitalists' behavior is consistent with this view: they often lend in syndicates, which encourages cooperative behavior through the prospect of repeated interaction, and do not compete strongly in "cold" periods[14]. Indeed, "There is a great deal of cronyism among venture capital firms",[15] and "if two venture capitalists are approached by an entrepreneur, they will likely participate

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[11]These examples illustrate the potential difficulties associated with delaying contractual execution. For instance, it is much easier to prove today that a facility or technology has not been adequately developed, than to do so retrospectively in a few years' time, when development may have progressed substantially. Moreover, it would be very costly for each of the contracting parties to obtain privately all the evidence that could potentially be useful in the event of a dispute at the enforcement stage later on.

[12]In this respect, my paper is related to Caillaud, Jullien and Picard (1995), albeit very different: in their work, the nature of competition affects contractual choices through its impact on the payoffs from precommitment. There is no trade-off between complete and incomplete contracts.

[13]See Gompers and Lerner (1999), Kaplan and Strömberg (2003, 2004), Gorman and Sahlman (1989), and Sahlman (1990).

[14]See Gompers and Lerner (1999, 2000), Kaplan and Strömberg (2003).

[15]Bygrave and Timmons (1992), citing sociologist Everett Rogers.

in a syndicate rather than compete away fees by undercutting".[16] In such circumstances, my results suggest that incomplete contracts are more likely to emerge when the expected value of the informational rents that can be extracted from new entrants is higher, implying that the incumbent's intermediate performance can be very good (high γ) or very poor (low γ). To my knowledge, this implication has not been tested directly so far. However, Kaplan and Strömberg (2003, 2004) do find that incomplete venture capital contracts are more common for firms in industries with a high R&D/sales ratio. Their finding seems consistent with this paper's analysis, since highly innovative projects tend to be more risky (γ can be very high or very low), and the expected profitability of new entrants in high R&D industries is likely to be particularly sensitive to the progress made (or not) by the incumbent.

Kaplan and Strömberg (2003) also find that venture capital contracts tend to be more incomplete in California. This "California effect" is confirmed by Bengtsson and Ravid (2009) with a larger dataset. The finding is interesting in the light of our model because of the importance of networks in the venture capital industry, and the fact that the top firms in the high-tech venture capital network are located in California (Bygrave and Timmons (1992)). We would therefore expect the California venture capital industry to be particularly close to the cooperative, imperfectly competitive case analyzed in this paper. The widespread use of incomplete contracts in California would then be predicted by our model in the presence of significant rents for venture capitalists, notably from high quality entrants. Highly suggestive evidence in support of this prediction has been provided in recent work by Hochberg, Ljungqvist and Lu (2009). They compare valuations of venture-funded companies in different venture capital markets, and find that valuations are significantly lower, after controlling for other value drivers, in more densely networked venture capital markets, such as Silicon Valley.

The paper is organized as follows. The remainder of this section discusses the relationship with the existing literature. Section 2 introduces the model. Section 3 briefly presents the benchmark case where entry is ruled out exogenously. Subsequent sections develop the analysis allowing for the possibility of entry: section 4 examines the case of imperfect competition, while section 5 studies the implications of perfect competition between investors. Section 6 concludes.

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[16]Anand and Galetovic (2000).

1.1. Relationship to the literature

This paper is related to several important literatures. First, obviously, the large literature on incomplete contracts. Here the closest links are with contributions that have explored strategic and informational explanations for contractual incompleteness. Bernheim and Whinston (1998) show that when contracts cannot condition on some aspects of performance, because they are not verifiable, they may optimally leave other, verifiable, aspects unspecified, generating strategic ambiguity. The key to their results is the effect that explicit contractual provisions have on the set of feasible self-enforcing implicit agreements between the parties. The present paper is also concerned with strategic incompleteness, but for a very different reason: incompleteness makes contractual execution less informative, and through this channel affects subsequent strategic interactions with other parties.[17] Other papers that have explored the informational implications of incomplete contracts have tended to focus on the informational content of a contractual offer, as in Allen and Gale (1992) and Spier (1992).[18] Allen and Gale consider an environment in which different agents have different abilities to manipulate information about contingencies. Non-contingent contracts emerge in equilibrium because they do not create incentives to engage in such manipulation. Spier shows how, in the presence of (exogenous) transactions costs, an informed principal may prefer an incomplete contract to signal that his "type" is "good". My paper is, to my knowledge, the first to focus instead on the (hard) information generated by contractual execution, and the ways in which outside parties, as well as the contracting parties, may use strategically this information.

Second, my work builds on the insights from the "unraveling result" of Grossman (1981), Grossman and Hart (1980) and Milgrom (1981), leading to full disclosure of hard information. This result applies in my model since hard evidence is generated by the execution of complete contracts. Moreover, this hard evidence can be transmitted privately (secretly) to another party by simply being shown to that party: in this respect, it acts essentially as an "eye-opener", rather like the enunciation of information in Tirole (2008). At the same time, this effectively rules out reliance on private "contracts of silence", as in Daughety and Reinganum (2005), since breach of contract would be very difficult to prove in court.

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[17]Ellison (2005) and Martimort and Piccolo (2007) also study the potential strategic benefits of incomplete contracts, again due to very different reasons: in both papers, incompleteness helps to "soften" competition.

[18]See also Aghion and Hermalin (1990), who study the desirability of legal restrictions on contracting to prevent inefficient signaling.

Another important related literature is the one on entry prevention. Here the closest links are with Aghion and Bolton (1987), and Cestone and White (2003). Aghion and Bolton analyze a setting where a buyer and a seller negotiate a contract under a threat of entry by another seller. They show that an exclusive contract with appropriately designed liquidated damages can be used optimally to extract some of the entrant's surplus: the damages act as an entry fee. In the present paper, such an exclusive contract between the incumbent and investor 1 would not have the same effect because of the presence of other investors. Nevertheless, the insight of Aghion and Bolton can be extended to our setting in the following sense: in the presence of imperfectly competitive investors, informational rents may act as an endogenous entry fee, making it possible to extract some surplus from the entrant.

Cestone and White study instead how entry can be deterred through financial contracts. They find that imperfect competition (monopoly) in financial markets can lead to entry deterrence in product markets, which vanishes as financial markets approach perfect competition. In the present paper this need not be the case: imperfect competition in financial markets can lead to entry accommodation (and surplus extraction) when incomplete contracts are chosen, while perfectly competitive investors may use incomplete contracts to achieve entry deterrence. The difference with Cestone and White arises because they examine a very different model, where there is no intermediate performance signal for the incumbent, and hence no trade-off between complete and incomplete contracts. My work therefore highlights the importance of taking into account the nature of contracts used in examining the link between financial and product market competition.

Finally, my paper builds on the insights of the literature on financial intermediaries and their ex post informational advantage, starting with the key contributions by Rajan (1992) and Sharpe (1990).[19] A key difference is that this literature has studied primarily financial contracts between a single borrower (entrepreneur) and his lender(s), whereas potential competitors (entrants) play a crucial role in my model.

2. The model

The model has two periods and three dates, $t = 0, 1, 2$. At the beginning of the first period ($t = 0$), an entrepreneur may enter a new industry and invest

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[19]See also Admati and Pfleiderer (1994), Casamatta and Haritchabalet (2006), Dessí (2005), Garmaise (2006), Inderst and Mueller (2006), Schmidt (2003) and Von Thadden (2004).

in a project, call it project F (F for "first"). At the end of the first period ($t = 1$), the state γ is realized (see below). At this stage another entrepreneur may enter the industry and invest in a competing project, call it project E (E for "entrant"). The probability of success of project F at the end of the second period ($t = 2$) will depend on the state γ and on whether entry occurs. The state γ will also affect the probability of success of the competing project E. Entrepreneurs possess no capital and need to raise finance from investors (venture capitalists). For simplicity, there is no discounting. All agents in the model are assumed to be risk neutral and protected by limited liability.

2.1. The incumbent

Project F requires an initial outlay of value K_F. The first entrepreneur (henceforth also called the incumbent) faces considerable uncertainty about his project's returns when he invests at $t = 0$: some of the uncertainty is resolved at $t = 1$, when the state γ is realized. For simplicity, γ is assumed to take one of two values: γ_G ("good" state) or γ_B ("bad" state), with $\gamma_G > \gamma_B > 0$. If there is no entry, project F yields verifiable returns R^H at $t = 2$ with probability γ, and R^L otherwise, where $R^H > K_F > R^L > 0$. Thus γ represents the probability of "success" (high returns) in the second period in the absence of competition. The impact of competition is considered below.

If project F is undertaken at $t = 0$, the incumbent chooses his effort level $e \in (0, e_H)$, where $0 < e_H < 1$. The cost of effort is given by $c(e) \equiv \dfrac{1}{2}e^2$. Entrepreneurial effort increases the probability of the good state: specifically, the good state occurs with probability e. I shall make the following assumption:

$$\gamma_B R^H + (1 - \gamma_B)R^L < K_F \quad (A1) \tag{2.1}$$

implying that, leaving aside entry considerations, the project is not worth undertaking with zero effort. In what follows, I denote by $\Delta\gamma = \gamma_G - \gamma_B > 0$ the difference in the probability of success between the good state and the bad state.

2.2. The entrant

At $t = 1$, a second entrepreneur (henceforth also called the entrant or rival) may enter the industry and invest in a competing project. This project requires an initial outlay of value K_E. It succeeds with probability ρ, which is defined as

follows[20]:

$$\rho \equiv \frac{\theta}{\gamma} \tag{2.2}$$

Here θ represents the quality of the entrant, and may take any value between θ_L and θ_H (where $\theta_H > \theta_L > 0$). For simplicity, I will assume that θ is known when the incumbent contracts to obtain funding for his project at $t = 0$. This is in fact plausible in high-technology sectors, where competitors are mostly drawn from a pool of potential entrants of known quality; e.g. other actual or potential entrepreneurs working on related projects, or on a similar project but at a less advanced stage. The specification in (2.2) captures in a simple way the idea that the entrant's probability of success is reduced when the incumbent has been very successful in the first period (for example, in developing and testing new products and processes, forming valuable strategic alliances, developing ties with suppliers and customers, and building up a reputation that gives him a competitive advantage): ρ therefore decreases with γ.

If the project succeeds, it yields verifiable returns Y^H; if it fails, it yields Y^L ($Y^H > K_E > Y^L > 0$). If the entrepreneur decides to enter, he obviously has an impact on the profitability of the incumbent. I model this by assuming that entry reduces the incumbent's success probability to $\gamma - \mu$, where $\gamma_B > \mu > 0$.

2.3. Investors

Entrepreneurs seek financing from investors such as venture capitalists, who possess enough expertise and sector-specific knowledge to be able to evaluate entrepreneurs. Section 4 focuses on the case of imperfectly competitive, cooperative venture capitalists. Perfect competition between investors is examined in section 5. The investors' cost of funds is normalized to one. Investors require an expected rate of return on their capital contributions equal to $1 + \alpha$, where $\alpha > 0$ implies that they earn some rents ($\alpha = 0$ under perfect competition). The investor who finances the incumbent will be denoted as "investor 1", or simply "the investor", throughout the paper. For expositional convenience, define $I_F \equiv K_F(1 + \alpha)$ and $I_E \equiv K_E(1 + \alpha)$.
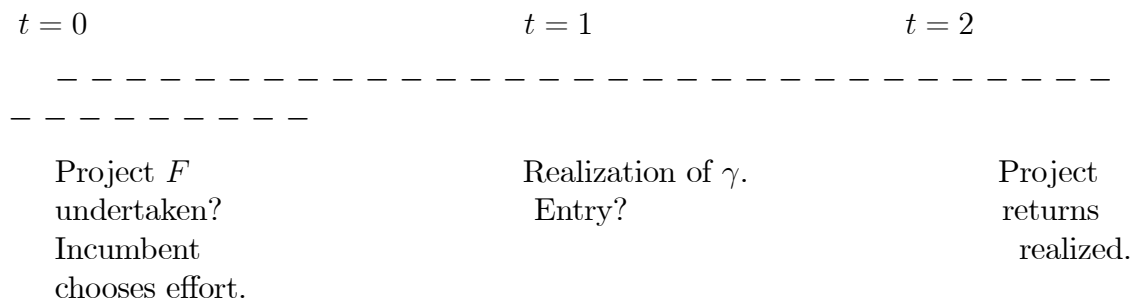
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[20]For simplicity I do not allow the entrant's probability of success to depend also on his effort. The main qualitative insights of the analysis would continue to hold in this case.

2.4. Information

I assume that γ is only observed by the incumbent and investor 1 at $t = 1$. The notion that firm "insiders" possess an informational advantage concerning the firm's progress and prospects seems a very reasonable assumption in the context of young, entrepreneurial firms (see, for example, Admati and Pfleiderer (1994), Dessí (2005) and Schmidt (2003)). On the other hand, as discussed in the Introduction, γ is contractable, in the following sense. In the event of a legal dispute at $t = 1$ between the incumbent and his investor, the courts would be able to establish who was telling the truth concerning the realization of γ, by examining the information provided by the two informed parties and obtaining additional evidence where necessary.

By assuming that γ is contractable, and that it is a sufficient statistic for effort, I am deliberately stacking up the odds in favour of "complete contracts", meaning contracts contingent on γ. This will help to isolate clearly the possible strategic benefits of incomplete contracts.

2.5. Time line

$t = 0$	$t = 1$	$t = 2$
Project F undertaken? Incumbent chooses effort.	Realization of γ. Entry?	Project returns realized.

3. No entry

This section presents the benchmark case where entry is ruled out *a priori*: optimal financial contracts for this case will provide a useful benchmark for comparison. In subsequent sections, I shall allow for the possibility of entry.

Suppose that no entry can occur at $t = 1$. In this case the only financial contract to be examined is the one agreed at $t = 0$ between the incumbent and investor 1. For expositional convenience, I shall refer to investor 1 simply as "the investor" in what follows. To make this benchmark case as general as possible

(for later comparisons), I assume that the investor requires an expected rate of return equal to $1 + \alpha$ ($\alpha \geqslant 0$) on his capital contribution.

Given that γ is a sufficient statistic for effort, the most efficient way to elicit effort from the entrepreneur is to offer him a reward, $R_e > 0$, contingent on the realization of the "good" state at $t = 1$ (i.e., when $\gamma = \gamma_G$), and zero otherwise (because of limited liability). The investor provides the initial capital K_F at $t = 0$ and receives the project's returns at $t = 2$. The entrepreneur's contractual offer to the investor at $t = 0$, denoted by $C1$, solves the following problem, $P1$:

$$Max \qquad eR_e - \frac{1}{2}e^2 \tag{3.1}$$

$$e = R_e \quad (IC) \tag{3.2}$$

$$e[\gamma_G R^H + (1 - \gamma_G)R^L] + (1 - e)[\gamma_B R^H + (1 - \gamma_B)R^L] - eR_e \geqslant I_F \quad (IR) \tag{3.3}$$

where (IC) is the entrepreneur's incentive constraint and (IR) the investor's participation constraint (using the notation of section 2, i.e. $I_F \equiv K_F(1 + \alpha)$). It can be easily checked that the first-best effort level, which maximizes the project's expected returns net of effort costs, is given by $e_1^{FB} \equiv \Delta\gamma(R^H - R^L)$. To implement this would require setting $R_e = \Delta\gamma(R^H - R^L)$ (from (IC)). This would imply that the maximum income that could be pledged to the investor would be equal to $R^L + \gamma_B(R^H - R^L)$. By assumption $(A1)$, this will not be sufficient to satisfy (IR). Thus effort e^N will be determined by the binding (IR) constraint as follows:

$$(e^N\Delta\gamma + \gamma_B)(R^H - R^L) + R^L - (e^N)^2 = I_F \tag{3.4}$$

and will be lower than the first-best level.

4. Entry: imperfectly competitive investors

I now allow for the possibility of entry at $t = 1$. In this section, I focus on the case of imperfectly competitive, cooperative investors, which seems particularly relevant to venture capitalists, as discussed in the Introduction. I assume that by cooperating, these investors may be able to earn some rents; i.e. $\alpha > 0$. Investors who are observed deviating by trying to earn even higher rents will

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trigger competitive behavior by the others; otherwise, investors do not undercut each other, nor try to profit by inflicting losses on another.

I begin by analyzing the case where the incumbent and investor 1 at $t = 0$ sign a contract contingent on the realization of γ, and execution of the contract at $t = 1$ reveals γ to outside parties ("*complete contracts*"). I will then study the case where the contract is not contingent on the realization of γ, so as to avoid revealing information to outside parties ("*incomplete contracts*"). The end of the section will examine what can be achieved with *secretly-executed* complete contracts.

Given our assumptions we can, without loss of generality, focus attention on non-exclusive contracts, as will become clear below. In particular, the incumbent could not extract additional surplus from the entrant, relative to the contracts examined in the remainder of this section, by offering investor 1 an exclusive contract with liquidated damages (as in Aghion and Bolton (1987)). The reason is that in the presence of sufficiently high damages intended to extract such a surplus, the entrant would be able to obtain funding from other investors. The same reason rules out any gains from using more sophisticated contracts between the incumbent and investor 1, contingent on subsequent entry.[21]

The financial contracts that will emerge optimally in the presence of imperfectly competitive, cooperative investors are equivalent to those that would be agreed between entrepreneurs and a monopoly investor if the entrepreneurs had all the bargaining power, subject to guaranteeing the investor an expected rate of return equal to $1 + \alpha$. For ease of exposition, therefore, I shall analyze the latter case, and refer to investor 1 simply as "the investor" in what follows.

The timing of the game is the following. The incumbent offers a contract to the investor at $t = 0$. The investor accepts or rejects. If he accepts, project F is undertaken, and the entrepreneur chooses his effort level. At $t = 1$, the state γ is realized and is observed by the incumbent and the investor. A second entrepreneur seeks financing for a competing project, project E. He makes a take-it-or-leave-it offer to the investor. The investor decides whether to accept or reject the rival's offer. If he accepts, project E is undertaken. Both projects' returns are realized at $t = 2$.

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[21]For example, contracts in which investor 1 is required to only accept the entrant's offer if it yields a sufficiently high return. This is essentially equivalent to the Aghion and Bolton scheme, and again would trigger a competitive response by other investors in our setting.

4.1. Complete contracts

The optimal complete contract agreed at $t = 0$ between the incumbent and the investor takes the form studied above for the no-entry case: the entrepreneur receives a reward R_e if, and only if, $\gamma = \gamma_G$, while the investor receives the project's final returns. This type of contract is optimal because it elicits effort efficiently from the incumbent, and at the same time makes the investor the residual claimant at $t = 1$. The investor therefore fully internalizes the costs of entry for project F when he decides whether to fund project E. Given this form of contract between the incumbent and the investor, the game between the entrant and the investor at $t = 1$ is also very simple.

4.1.1. The entrant's offer

The second entrepreneur learns the value of γ at $t = 1$, when the incumbent is rewarded (or not). He can therefore condition his take-it-or-leave-it offer to the investor on γ. To characterize this offer, note first of all that the investor's expected loss on project F if he finances project E is given by $L^C \equiv \mu(R^H - R^L)$. The rival entrepreneur can only obtain funding for his project if he can pledge enough income to the investor to compensate for this loss, as well as guaranteeing him the required expected rate of return on the initial outlay K_E. The circumstances in which entry will occur are therefore described by the following result.

Lemma 1. (i) Entry always occurs when $\theta \geqslant \theta_G$, where θ_G is defined by:

$$\theta_G \equiv \frac{\gamma_G}{Y^H - Y^L}(I_E + L^C - Y^L) \tag{4.1}$$

(ii) Entry occurs if, and only if, $\gamma = \gamma_B$, when θ is in the range $\theta_E \leqslant \theta < \theta_G$, where θ_E is equal to:

$$\theta_E \equiv \frac{\gamma_B}{Y^H - Y^L}(I_E + L^C - Y^L) \tag{4.2}$$

(iii) When $\theta < \theta_E$, the rival entrepreneur cannot enter.

Proof: see Appendix.

Thus for high values of θ, the rival's pledgeable income will be sufficient for him to secure funding irrespective of the realization of γ. For intermediate values of θ, on the other hand, the rival will only be able to obtain financing when the incumbent has not been successful in the first period, which makes entry profitable. Finally, entry will never occur for sufficiently low values of θ. When

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entry is feasible, the entrant offers a contract that maximizes his expected utility subject to the constraint that the investor be willing to fund the project, given the value of γ. Formally, denote by $CMR = \{Y_I^H, Y_R^H, Y_I^L, Y_R^L\}$ the entrant's take-it-or-leave-it offer to the investor at $t = 1$, where Y_M^J ($M = I, R$) denotes M's payoff at $t = 2$ if project E yields returns Y^J ($J = H, L$). Here I denotes the investor and R the entrant. For a given realization of γ, the entrepreneur solves the following problem, $P2$:

$$Max \qquad (\frac{\theta}{\gamma})Y_R^H + (1 - \frac{\theta}{\gamma})Y_R^L \qquad (4.3)$$

$$(\frac{\theta}{\gamma})Y_I^H + (1 - \frac{\theta}{\gamma})Y_I^L - \mu(R^H - R^L) \geqslant I_E \quad (IR) \qquad (4.4)$$

$$Y_I^H + Y_R^H = Y^H \qquad (4.5)$$

$$Y_I^L + Y_R^L = Y^L \qquad (4.6)$$

$$Y_I^H \geqslant 0, Y_R^H \geqslant 0, Y_I^L \geqslant 0, Y_R^L \geqslant 0 \quad (LL) \qquad (4.7)$$

The investor's participation constraint is given by (IR); we then have the feasibility and limited liability constraints. Clearly the investor's participation constraint will hold as an equality. The solution to $P2$ will therefore be a contract that just compensates the investor for his expected loss on project F while yielding the required expected rate of return, $1 + \alpha$, on his capital contribution to project E (K_E)[22].

4.1.2. The incumbent's offer

Given that the investor will earn no informational rents in his interaction with the entrant, while fully internalizing the costs of entry for project F (implying

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[22]Clearly for $\theta \geqslant \theta_G$, the investor would like, if he could, to induce the entrant to believe that $\gamma = \gamma_G$ when in fact $\gamma = \gamma_B$, since this would enable him to earn some informational rents - denote these by Q^N. To the extent that the entrant's beliefs about γ are determined by observing whether the incumbent is rewarded or not, this would generate incentives for strategic manipulation of rewards if $R_e < Q^N$. In order to isolate the potential benefits of incomplete contracts even in the absence of such considerations, I will focus on the more interesting case where $R_e \geqslant Q^N$.

that he will fund the rival if, and only if, he is compensated for these costs), the incumbent's offer will be the same as in the no-entry case analyzed in section 3, denoted by $C1$. The incumbent's expected payoff from this contract is simply the NPV of project F, given effort e^N, which is equal to:

$$NPV = e^N \Delta \gamma (R^H - R^L) - \frac{1}{2}(e^N)^2 + R^L + \gamma_B (R^H - R^L) - I_F \qquad (4.8)$$

4.2. Incomplete contracts

We now examine what happens if the incumbent and the investor at $t = 0$ agree a contract that is *not* contingent on γ. In this case, the entrant will not be able to learn the realization of γ at $t = 1$. As we shall see below, this may entail some benefits for the incumbent. However, there is also a potential cost, to the extent that effort incentives cannot be provided as efficiently as when the entrepreneur's reward is contingent on γ. Moreover, the incumbent will incur a loss when entry occurs. To study the interplay of these effects and their implications, note first of all that the contract between the incumbent and the investor now can only condition on the realization of final project returns. It will therefore take the general form $CMI = \{R_I^H, R_E^H, R_I^L, R_E^L\}$, where R_M^J denotes the payoff for M ($M = I, E$) at $t = 2$ when realized returns are equal to R^J ($J = H, L$). I denotes the investor, as before, and E the entrepreneur (incumbent).

The timing of the game is the same as in the case of complete contracts studied above; the difference is in the information structure. In particular, the entrant will make his offer to the investor without knowing the realized value of γ.

4.2.1. The entrant's offer

The game is solved by backward induction. We begin with the second entrepreneur's take-it-or-leave-it offer to the investor at $t = 1$. As before, there will be a threshold value of θ, call it θ_E^I, such that for all $\theta < \theta_E^I$, project E would not yield enough pledgeable income to induce the investor to provide the required capital K_E (taking into account his expected loss on project F if he decides to fund the rival project E), even when $\gamma = \gamma_B$. Clearly this threshold value will depend on the contract agreed at $t = 0$ between the investor and the incumbent, which will be derived below: the terms of this contract determine the investor's expected loss on project F if he decides to fund project E, denoted by $L \equiv \mu(R_I^H - R_I^L)$. Similarly, there will be a second threshold value, θ_G^I, such that for all $\theta < \theta_G^I$,

the income that can be pledged to the investor will be insufficient to induce the investor to fund project E when $\gamma = \gamma_G$.

For a given contract CMI, the threshold values are given by the following lemma.

Lemma 2. There is a threshold value θ_E^I such that for all $\theta < \theta_E^I$, the investor will not be willing to fund project E at $t = 1$, irrespective of the realization of γ. This threshold value is equal to:

$$\theta_E^I \equiv \frac{\gamma_B}{Y^H - Y^L}(I_E + L - Y^L) \tag{4.9}$$

There is a second threshold value θ_G^I such that for all $\theta < \theta_G^I$, the investor will not be willing to fund project E when $\gamma = \gamma_G$. This threshold value is equal to:

$$\theta_G^I \equiv \frac{\gamma_G}{Y^H - Y^L}(I_E + L - Y^L) \tag{4.10}$$

Proof: follows from the proof of Lemma 1.

The two thresholds, θ_E^I and θ_G^I, are both increasing in L, the magnitude of the investor's expected loss on project F when he funds project E.

We can now characterize the second entrepreneur's take-it-or-leave-it offer to the investor at $t = 1$, given the terms of the existing contract between the investor and the incumbent. We begin by deriving the optimal contract when θ is in the range $\theta_E^I \leqslant \theta < \theta_G^I$; we shall then derive the optimal contract for $\theta \geqslant \theta_G^I$.

In the range $\theta_E^I \leqslant \theta < \theta_G^I$, the entrant knows that he can only induce the investor to fund his project if the incumbent has not been successful in the first period; i.e. if $\gamma = \gamma_B$. He therefore offers a contract that maximizes his expected utility subject to the constraint that the investor be willing to fund the project when $\gamma = \gamma_B$. This contract is obtained by solving problem $P2$ (equations (4.3) to (4.7)), for $\gamma = \gamma_B$. For ease of exposition, define $Z \equiv I_E + L$. The solution is then described by the following result.

Proposition 1. Assume $\theta_E^I \leqslant \theta < \theta_G^I$. The rival's take-it-or-leave-it offer to the investor, CMR^I, has the following properties: (a) the investor is just compensated for his expected loss on project F when $\gamma = \gamma_B$, and earns no informational rents; (b) the investor will accept the offer when $\gamma = \gamma_B$, and reject it otherwise; (c) the rival's expected utility when the offer is accepted is equal to:

$$U^S = \frac{\theta}{\gamma_B}(Y^H - Y^L) + Y^L - Z \tag{4.11}$$

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Proof: see Appendix.

Now consider the optimal contract for $\theta \geqslant \theta_G^I$. The rival knows that in this case his project is worth funding irrespective of the value of γ. In principle, he could either offer CMR^I, described above, which leaves no informational rents to the investor but is only accepted when $\gamma = \gamma_B$, or he could offer a contract that induces the investor to finance the project in both states. This second contract, denoted by $CMG = \{Y_I^{GH}, Y_R^{GH}, Y_I^{GL}, Y_R^{GL}\}$, solves the following problem, $P3$:

$$Max \qquad U^P = p_G W_G + (1 - p_G) W_B \qquad (4.12)$$

$$where \qquad W_J = (\frac{\theta}{\gamma_J})(Y_R^{GH} - Y_R^{GL}) + Y_R^{GL}; \quad J = G, B \qquad (4.13)$$

$$(\frac{\theta}{\gamma_G})(Y_I^{GH} - Y_I^{GL}) + Y_I^{GL} \geqslant Z \quad (IRG) \qquad (4.14)$$

$$(\frac{\theta}{\gamma_B})(Y_I^{GH} - Y_I^{GL}) + Y_I^{GL} \geqslant Z \quad (IRB) \qquad (4.15)$$

$$Y_I^{GH} + Y_R^{GH} = Y^H \qquad (4.16)$$

$$Y_I^{GL} + Y_R^{GL} = Y^L \qquad (4.17)$$

$$Y_I^{GH} \geqslant 0, Y_R^{GH} \geqslant 0, Y_I^{GL} \geqslant 0, Y_R^{GL} \geqslant 0 \quad (LL) \qquad (4.18)$$

where (IRG) and (IRB) are the investor's participation constraints, one for each state (realization of γ). The entrepreneur's beliefs about γ are given by his perceived probability that $\gamma = \gamma_G$, denoted by p_G. Clearly only one participation constraint binds, (IRG). The following result describes the solution to $P3$ and the circumstances in which the entrepreneur will choose contract CMG or contract CMR^I.

Proposition 2. Assume $\theta \geqslant \theta_G^I$. Denote by p_G the rival's perceived probability that $\gamma = \gamma_G$. Then: there is a threshold value p_G^* such that at $t = 1$ (i) for $p_G > p_G^*$, the rival offers contract CMG to the investor, who accepts; (ii) for $p_G < p_G^*$, the rival offers contract CMR^I to the investor, who accepts iff $\gamma = \gamma_B$. Contract CMG has the following properties: (a) $Y_I^{GL} = Y^L$, $Y_R^{GL} = 0$; (b) $Y_I^{GH} = (\gamma_G/\theta)(Z - Y^L) + Y^L$, $Y_R^{GH} = Y^H - Y_I^{GH}$.

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The threshold value p_G^* is defined by the following condition:

$$p_G^* \{ \frac{\theta}{\gamma_G}(Y^H - Y^L) + (\frac{\gamma_G}{\gamma_B} - 2)(Z - Y^L) \} = (\frac{\gamma_G}{\gamma_B} - 1)(Z - Y^L) \qquad (4.19)$$

Proof: see Appendix.

Thus when the rival believes that the probability of the good state is low, he offers a contract that will induce the investor to finance his project if and only if the state is bad. This contract has the advantage that it leaves no informational rents to the investor. On the other hand, when the rival believes that the probability of the good state is sufficiently high, he prefers to offer a contract that will always induce the investor to finance his project. This contract enables the investor to earn some informational rents when $\gamma = \gamma_B$. The following result determines the expected value of these rents, which will prove useful below.

Corollary 1. When contract CMG is agreed between the investor and the rival, the investor earns no informational rents if $\gamma = \gamma_G$, whereas he earns positive informational rents when $\gamma = \gamma_B$. The magnitude of these rents, denoted by Q, is given by:

$$Q = (\frac{1}{\gamma_B} - \frac{1}{\gamma_G})\gamma_G(Z - Y^L) \qquad (4.20)$$

We can now examine the optimal contract proposed by the incumbent at $t = 0$, taking into account the possibility of entry at $t = 1$.

4.2.2. The incumbent's offer

The incumbent at $t = 0$ can choose between three types of contract in principle: one ensuring that the rival will not enter at $t = 1$ ("entry deterrence"); one that will accommodate entry if and only if $\gamma = \gamma_B$ ("partial entry deterrence"); and one that will accommodate entry in both states ("entry accommodation"). However, it is straightforward to verify that the optimal complete contract $C1$ described earlier offers a strictly higher payoff to the incumbent than an incomplete contract designed to achieve either entry deterrence or partial entry deterrence. In the case of entry deterrence, this is due to the fact that effort incentives are provided less efficiently than with complete contracting. Moreover, there are no offsetting benefits associated with the entry deterrence contract (relative to $C1$). Partial entry deterrence, on the other hand, entails an expected loss for the incumbent

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when entry occurs, since, unlike the investor, he receives no compensation from the rival. Contract $C1$ avoids this problem because the investor is the residual claimant; moreover, $C1$ elicits effort more efficiently. It therefore strictly dominates the partial entry deterrence contract from the perspective of the incumbent.

Thus to see whether and when incomplete contracts might be preferred to complete contracts, we can focus attention on the entry-accommodation contract.

Entry accommodation

Note first of all that this is only relevant for sufficiently large values of θ: if θ is too low, the rival will not be able to obtain funding when $\gamma = \gamma_G$, because his project cannot generate enough pledgeable income. When θ is not too low, entry accommodation becomes feasible. The optimal contract in this case, denoted by $CME = \{R_I^H, R_E^H, R_I^L, R_E^L\}$, is the solution to the following problem, $P4$: maximize U, given by

$$U \equiv -\frac{1}{2}e^2 + e[(\gamma_G - \mu)R_E^H + (1 - \gamma_G + \mu)R_E^L] + (1 - e)[(\gamma_B - \mu)R_E^H + (1 - \gamma_B + \mu)R_E^L]$$

(4.21)

subject to the constraints:

$$e = \arg\max(U) \quad (IC) \tag{4.22}$$

$$e[\gamma_G R_I^H + (1 - \gamma_G)R_I^L] + (1 - e)[\gamma_B R_I^H + (1 - \gamma_B)R_I^L + Q] \geqslant I_F \quad (IR) \tag{4.23}$$

$$\theta_G^I < \theta \quad and \ p_G > p_G^* \quad (EA) \tag{4.24}$$

$$R_I^H + R_E^H = R^H \tag{4.25}$$

$$R_I^L + R_E^L = R^L \tag{4.26}$$

$$R_I^H \geqslant 0, R_E^H \geqslant 0, R_I^L \geqslant 0, R_E^L \geqslant 0 \quad (LL) \tag{4.27}$$

In this problem, Q represents the expected value of the informational rents the investor will earn at $t = 1$ if $\gamma = \gamma_B$, and was given by Corollary 1. (EA) is the entry-accommodation constraint: it requires the rival to have sufficient pledgeable

income to obtain funding even when $\gamma = \gamma_G$ (otherwise entry accommodation is not feasible, as noted above). Moreover, the rival's expectations must be such that he prefers to offer the investor contract CMG (defined by Proposition 2) and enter, irrespective of the realization of γ, rather than offer contract CMR^I and enter only when $\gamma = \gamma_B$. The solution to $P4$ is described in detail in the Appendix, and summarized by the following result.

Proposition 3 (Entry accommodation) When entry is accommodated, second-best efficiency would require setting $R_E^H - R_E^L$ so as to maximize the following expression:

$$W = -\frac{1}{2}[\Delta\gamma(R_E^H - R_E^L)]^2 + (\Delta\gamma)^2(R^H - R^L)(R_E^H - R_E^L) - \mu(R_E^H - R_E^L)$$

$$+\gamma_B(R^H - R^L) + [1 - \Delta\gamma(R_E^H - R_E^L)]Q + R^L - I_F \qquad (4.28)$$

Let R^S denote the value of $R_E^H - R_E^L$ that maximizes W. The optimal contract that accommodates entry, CME, has the following properties:

(i) Suppose the following condition holds:

$$R^L + (R^H - R^L - R^S)[(\Delta\gamma)^2 R^S + \gamma_B] + (1 - \Delta\gamma R^S)Q(R^S) \geqslant I_F \quad (M1) \ (4.29)$$

Then: (a) if $\theta > \theta_G^I$ $\ and \ $ $p_G > p_G^*$, (EA) does not bind. In this case, $R_E^H - R_E^L = R^S$, $e = \Delta\gamma R^S$ and R_I^L is given by the following expression:

$$R_I^L + (R^H - R^L - R^S)[(\Delta\gamma)^2 R^S + \gamma_B] + (1 - \Delta\gamma R^S)Q(R^S) = I_F \qquad (4.30)$$

(b) otherwise, (EA) binds and determines $R_E^H - R_E^L$. As long as entry accommodation is feasible, R_E^L is then determined by (binding) (IR).

(ii) Suppose condition $(M1)$ does not hold. Then: (a) if (EA) does not bind, $R_E^H - R_E^L < R^S$, $R_I^L = R^L$ and R_I^H is determined by (IR); (b) if (EA) does bind, entry accommodation is not feasible.

Proof: see Appendix.

The intuition for this result is the following. The first best, obtained by maximizing the project's expected value net of effort and entry costs, and inclusive of the investor's informational rents, would require setting effort equal to $e^{FB} = \Delta\gamma(R^H - R^L) - Q$, and $R_E^H - R_E^L$ as small as possible. First-best effort

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is lower than in the no-entry case because the investor now earns informational rents in the bad state, whose probability decreases with effort. Making $R_E^H - R_E^L$ (i.e. the power of the entrepreneur's incentives) as small as possible minimizes the expected loss from entry, since only the entrepreneur loses in the event of entry, and his loss increases with the sensitivity of his claim to final returns. At the same time, the expected value of the investor's informational rents is maximized in this way, because the magnitude of the rents (i.e. Q) increases with the sensitivity of the investor's claim to final returns. In general, the first best is not feasible because of the entrepreneur's incentive-compatibility constraint; there is then a trade-off between the gains from making $R_E^H - R_E^L$ small, just described, and the gains from making $R_E^H - R_E^L$ large, which elicits higher effort from the entrepreneur. This trade-off is captured by the expression for W: maximizing this determines the second-best value for $R_E^H - R_E^L$, denoted by R^S. As discussed in the Appendix, second-best efficiency will entail one of two possibilities, depending on parameter values: setting $R_E^H - R_E^L$ small enough to maximize rent extraction from the rival; or an interior solution with an intermediate value of $R_E^H - R_E^L$.

It is possible to achieve second-best efficiency if condition $(M1)$ is satisfied and (EA) does not bind: $(M1)$ simply requires that the project's maximum pledgeable income when $R_E^H - R_E^L = R^S$ be sufficient to compensate the investor for his capital contribution. If (EA) binds, second-best efficiency is no longer feasible; $R_E^H - R_E^L$ has to be increased to satisfy (EA), implying that effort will be *higher*, and informational rents lower. When $(M1)$ is not satisfied, on the other hand, the investor has to be offered a more high-powered claim (if feasible), implying a less high-powered claim for the entrepreneur, and hence *lower* effort. Clearly, this is only possible if (EA) does not bind; otherwise, entry accommodation is not feasible.

4.3. Complete contracts or incomplete contracts?

Denoting by e^* the effort level implemented by the optimal incomplete contract that accommodates entry, described by Proposition 3, we can now examine the trade-off between complete and incomplete contracts. The incumbent's expected payoff from the incomplete contract described by Proposition 3, is equal to the NPV of project F, taking into account the effect of entry, plus the expected value of the investor's informational rents. It is therefore given by:

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$$NPV^* = e^*\Delta\gamma(R^H - R^L) - \frac{1}{2}(e^*)^2 + R^L + \gamma_B(R^H - R^L) - I_F - \frac{\mu e^*}{\Delta\gamma} + (1 - e^*)Q^*$$

$$(4.31)$$

where the last term represents the expected value of the investor's informational rents, while the previous term represents the expected value of the incumbent's loss from entry, for which he is not compensated. If the incomplete contract implemented the same effort level as under complete contracting, i.e. $e^* = e^N$, we would have:

$$NPV^* - NPV = (1 - e^*)Q^* - \frac{\mu e^*}{\Delta\gamma}$$

In this case, incomplete contracts would be preferred to complete contracts if, and only if, the expected value of the investor's informational rents exceeded the expected value of the incumbent's loss from entry. This would be the case, for example, if μ were sufficiently small. Since the optimal incomplete contract typically implements a different effort level, there will be an additional term in the above expression for $NPV^* - NPV$, equal to:

$$EC = e^N\Delta\gamma(R^H - R^L) - \frac{1}{2}(e^N)^2 - [e^*\Delta\gamma(R^H - R^L) - \frac{1}{2}(e^*)^2]$$

Intuition suggests that this term should be positive, reflecting the fact that complete contracts can reward entrepreneurial effort more efficiently than incomplete contracts. This need not be the case, however, for the following reason: effort under complete contracting may be reduced significantly below its first-best level by the need to generate sufficient pledgeable income to satisfy the investor's participation constraint. With incomplete contracts, on the other hand, the expected value of the investor's informational rents becomes part of pledgeable income, making it easier to satisfy (IR). If this effect is sufficiently important, EC may become negative.

Taking into account the implications for effort, we see that *incomplete contracts will be chosen* if, and only if, the following condition holds:

$$NPV^* - NPV = (1 - e^*)Q - \frac{\mu e^*}{\Delta\gamma} - EC > 0$$

This condition clarifies and elaborates the general intuition that incomplete contracts will be preferred when the cost of using less efficient incentive schemes

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between the principal and the agent (here, the investor and the entrepreneur) is outweighed by the benefits of revealing less information to third parties (here, the rival) and thereby obtaining a "better deal" from them. The efficiency cost here is represented by the term EC, while the net expected benefit (the expected value of informational rents, net of the cost of entry borne by the incumbent) is represented by the first two terms. Interestingly, as noted above, it may even be the case that EC is negative, because of the effect of informational rents on pledgeable income. This highlights an additional potential benefit of incomplete contracts.

4.4. Secretly-executed complete contracts?

Intuition might suggest that complete contracts with secret execution could do better than any of the contracts considered so far, by combining the benefits of more efficient reward schemes for entrepreneurial effort with the benefits of not revealing information about γ to outside parties (the rival). To see this, consider how the incumbent's problem would be modified, when entry accommodation is feasible, if both kinds of benefit could be combined:

$$Max \qquad eR_e - \frac{1}{2}e^2 \tag{4.32}$$

$$e = R_e \quad (IC) \tag{4.33}$$

$$e[\gamma_G R^H + (1-\gamma_G)R^L] + (1-e)[\gamma_B R^H + (1-\gamma_B)R^L + Q'] - eR_e \geqslant I_F \quad (IR) \tag{4.34}$$

$$(\theta_G^I)' < \theta \quad and \ p_G > (p_G^*)' \quad (EA) \tag{4.35}$$

In this problem, as in the complete contracting case examined earlier, the incumbent is rewarded if, and only if, $\gamma = \gamma_G$. The investor receives the project's final returns, implying that his expected loss if he funds the rival is equal to L^C, for which he is fully compensated. The difference with complete contracting is that the rival cannot condition his offer on the realization of γ. This makes it possible for the investor to earn informational rents as in the incomplete contracting case studied above. If (EA) does not bind, the solution to this problem gives the incumbent a higher expected payoff than that from the corresponding complete contract where execution is not secret (because of the presence of informational

rents Q'), as well as a higher expected payoff than under incomplete contracting (since the incumbent bears no loss from entry, his effort is rewarded more efficiently, and $Q' > Q$).

However, this outcome cannot be achieved through an ex-ante ($t = 0$) agreement between the incumbent and the investor to keep contractual execution secret ex post (at $t = 1$). Why? Suppose the incumbent and the investor sign such an agreement. At $t = 1$, the contract needs to be executed: this requires establishing the realized value of γ and hence determining the value of the incumbent's reward (R_e or zero). If the reward is paid immediately, the transfer may well be observable by outside parties. This potential difficulty could be avoided through a deferred payment. But crucially, whether the transfer is immediate or deferred, both contracting parties will have some *hard* evidence concerning their current or deferred asset or liability, respectively[23]. The rival can use this to extract information about the realized value of γ. For example, he can make his take-it-or-leave-it offer to the investor contingent on the investor showing him evidence that $\gamma = \gamma_G$. If this is indeed the case, the investor will possess the required hard evidence concerning the entrepreneur's reward. Thus the rival will essentially offer a menu: the contract that maximizes his expected utility subject to the investor's participation constraint under the assumption that $\gamma = \gamma_G$, contingent on the investor showing him hard evidence about the incumbent's reward, and otherwise the contract that maximizes his expected utility subject to the investor's participation constraint under the assumption that $\gamma = \gamma_B$. Faced with this strategy by the rival, the investor would gain nothing by withholding the hard information he possesses when $\gamma = \gamma_G$. In such an equilibrium, the rival would indeed be able to learn the realized value of γ and obtain funding for his project without paying informational rents to the investor[24]. Thus secretly-executed contracts *would not* enable the incumbent to obtain a higher expected payoff than the payoff from the complete contract examined earlier.

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[23]To avoid this would require the process of contractual execution itself to be deferred; i.e. waiting until $t = 2$ to establish the realized value of γ and determine the value of the entrepreneur's reward. However, we have assumed that the process of establishing the realized value of γ at $t = 1$ depends crucially on each party's ability to challenge any attempted manipulation of information by the other party. As discussed in detail in the Introduction, this ability will decrease if execution is delayed, since the relevant information concerns *current* circumstances at $t = 1$, which will evolve over time.

[24]As discussed in the Introduction, the use of confidentiality clauses would not undermine this result since breach of contract would be very difficult to prove in court.

4.5. Renegotiation?

There are two situations where renegotiation might seem to be of interest, potentially. First, suppose the incumbent and the investor choose the complete contract $(C1)$ at $t = 0$. Then if $\theta \geqslant \theta_G$ and $\gamma = \gamma_B$ at $t = 1$, the investor would like the rival entrepreneur to believe that $\gamma = \gamma_G$ so as to get a better offer. This suggests the possibility of secret renegotiation between the investor and the incumbent, along the following lines: the investor commits to paying the entrepreneur the reward R_e, as if the realized state were $\gamma = \gamma_G$, but at the same time the incumbent commits to paying back a fraction φ of this reward (the fraction φ depending on the assumptions made about the renegotiation game). The investor could then use the hard evidence concerning the payment of the reward R_e to persuade the rival entrepreneur that indeed $\gamma = \gamma_G$. However, a similar difficulty would arise in this context as in the case of secretly-executed contracts discussed above. Specifically, the contracting parties would possess hard evidence concerning the outcome of any secret renegotiation: in particular, the incumbent would have evidence concerning his obligation to pay back the investor, implying that in fact $\gamma = \gamma_B$. He could therefore profit by (secretly) selling this evidence to the rival, which would destroy any possible gain the investor could obtain from renegotiation. Thus renegotiation will not occur in this case. A similar argument rules out secret renegotiation at $t = 0$ when the incumbent and the investor have chosen the incomplete contract.

Second, suppose the incumbent and the investor choose the incomplete contract at $t = 0$, and $\gamma = \gamma_G$ at $t = 1$. Then the incumbent would be willing to pay the investor to avoid entry, since he incurs a cost when the rival enters, while the investor gains nothing[25]. By assumption, the incumbent has no cash with which to pay the investor, but he can always offer the investor part of his claim to the project's final returns. However, this would imply additional rents for investor 1, clearly (and visibly) deviating from the cooperative agreement with other investors. The entrant would therefore obtain funding from other investors. Thus renegotiation will not occur in this case either.

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[25]Obviously this is not the case when $\gamma = \gamma_B$, because the investor obtains informational rents when he funds the rival.

5. Entry: perfectly competitive investors

We have seen that in the presence of imperfectly competitive, cooperative investors, incomplete contracts may be preferred to complete contracts because of the strategic gains from limiting disclosure of information to potential entrants. In this section, we study what happens when we allow for perfect competition among investors. Do the strategic benefits of incomplete contracts disappear in this case? To explore this question, we assume that there are two investors: investor 1, who finances the first entrepreneur (the incumbent) at $t = 0$, and investor 2. Both investors could finance the potential new entrant (rival) at $t = 1$. The difference between them of course is that at $t = 1$ investor 1 will observe the realized value of γ for project F, whereas investor 2, like the potential entrant, will not. The two investors are assumed to behave competitively, implying that $\alpha = 0$ (hence $I_F = K_F$ and $I_E = K_E$); thus the presence of investor 2 can be thought of as representing more generally the consequences of perfect competition in the financial sector. In particular, we assume that entrepreneurs have all the bargaining power and can make credible take-it-or-leave-it offers to investors.

The timing of the game is as in previous sections, except for $t = 1$ when the sequence of moves is the following:

(i) The entrant proposes a contract to investor 1. Investor 1 accepts or rejects. If he accepts, the contract is implemented. Investor 2 does not observe the negotiations between the entrant and investor 1 (in particular, he does not observe the entrant's offer to investor 1): he only observes the outcome, that is, the contract if it is implemented, or the fact that no contract has been agreed between the entrant and investor 1.

(ii) If investor 1 rejects the entrant's offer, the latter proposes a contract to investor 2, who accepts or rejects. If he accepts, the contract is implemented; if he rejects, the entrant cannot undertake his project. Both projects' returns are realized at $t = 2$.

The key assumption here is that each investor cannot observe the private negotiations between the entrant and the other investor, which seems reasonable in this setting[26].

The game is solved backward, starting with the rival's attempt to enter at $t = 1$.

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[26] Given this assumption, it can be verified that the assumed order of the sequential offers, i.e. first offer to investor 1, is optimal for the entrant under incomplete contracting, while it makes no difference under complete contracting.

5.1. The game between the entrant and investors at $t = 1$

As in the imperfectly competitive case studied earlier, the entrant's behavior will depend on his pledgeable income, and hence on the value of θ. Specifically, behavior will depend once again on whether θ is above or below each of two threshold values, denoted by θ_N and θ_B. These values differ from the ones derived earlier because they do not allow for the need to compensate investor 1 for his expected loss on project F if the rival enters. They are therefore given by the following lemma.

Lemma 3. There is a threshold value θ_N such that for all $\theta < \theta_N$, project E cannot generate enough pledgeable income to compensate for the required initial investment, K_E, irrespective of the realization of γ. This threshold value is equal to:

$$\theta_N \equiv \frac{\gamma_B}{Y^H - Y^L}(I_E - Y^L) \tag{5.1}$$

There is also a second threshold value θ_B such that for all $\theta < \theta_B$, project E cannot generate enough pledgeable income to compensate for the required initial investment, K_E, when $\gamma = \gamma_G$. This threshold value is equal to:

$$\theta_B \equiv \frac{\gamma_G}{Y^H - Y^L}(I_E - Y^L) \tag{5.2}$$

Proof: follows from the proof of Lemma 1.

Unlike the corresponding threshold values for the imperfectly competitive case, θ_N and θ_B do not depend on the form of the contract agreed between the incumbent and his investor: they are exogenous. The type of contract agreed at $t = 0$ will nevertheless influence the game between the entrant and investors at $t = 1$, through its impact on the information set of the different parties. We shall therefore begin by studying the game induced by the optimal complete contract. This will then be compared to the game induced by the optimal incomplete contract. In both cases, the analysis will focus on equilibria that do not rely on *ad hoc* out-of-equilibrium beliefs to sustain them, and are in this sense more robust[27].

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[27]For example, there are equilibria in which the rival and investor 1 believe that investor 2 will never be willing to fund the rival, i.e. he will refuse any contractual offer the rival might make to him other than the null contract, even if the offer satisfies his participation constraint. With these beliefs, it may be the case that the rival cannot induce investor 1 to finance him, and that he then offers the null contract to investor 2, thereby failing to obtain any funding for his project. Alternatively, the rival may make a more attractive offer to investor 1 (than the one that would have satisfied investor 2's participation constraint), which is accepted.

5.1.1. Complete contracts

The optimal complete contract agreed at $t = 0$ between the incumbent and investor 1 will, as in the previous sections, reward the incumbent if, and only if, $\gamma = \gamma_G$, while giving the investor the returns from project F. Execution of the contract will then reveal the realized value of γ to all parties at $t = 1$. The game that will follow between the entrant and investors can be summarized as follows.

Proposition 4. (Entrant's offers to investors under complete contracting) (1) Suppose $\theta \geqslant \theta_B$. Then for each realization of γ, the entrant offers investor 1 the contract, denoted by $CC(\gamma)$, that maximizes his (the entrant's) expected utility subject to the constraint that investor 1 be just compensated for providing the required investment outlay K_E. Investor 1 accepts and the project is undertaken.

(2) Suppose $\theta_N \leqslant \theta < \theta_B$. Then: (a) if $\gamma = \gamma_B$, the entrant behaves as in (1): specifically, he offers investor 1 $CC(\gamma_B)$. Investor 1 accepts and the project is undertaken. (b) if $\gamma = \gamma_G$, the entrant cannot obtain funding for his project.

(3) If $\theta < \theta_N$, the rival cannot enter.

Proof: (1) the entrant's pledgeable income would be sufficient to obtain funding from investor 2 for every realization of γ. Thus entry will occur irrespective of investor 1's behavior. Investor 1 will therefore accept the contractual offer that just compensates him for providing I_E.

(2) the entrant's pledgeable income would be sufficient to obtain funding from investor 2 if, and only if, $\gamma = \gamma_B$. For this case, the proof is as in (1). If $\gamma = \gamma_G$, pledgeable income is too low to compensate for the required initial outlay I_E, so that neither investor will be willing to fund the project.

(3) Irrespective of the realization of γ, pledgeable income is too low to compensate for the required initial outlay I_E, so that neither investor will be willing to fund the project.

□

The key difference between this result and the corresponding one in the presence of imperfectly competitive investors is that investor 1 *is not compensated* for the loss $L^C = \mu(R^H - R^L)$ he incurs when the rival enters. The reason is that the rival, if turned down by investor 1, could always obtain funding from investor 2, as long as his pledgeable income is at least equal to I_E. Moreover, and precisely for this reason, there will be *more entry* than with imperfectly competitive investors, in the sense that the entry thresholds will be lower; i.e. $\theta_N < \theta_E$ and $\theta_B < \theta_G$.

We can now turn to the game induced by incomplete contracting.

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5.1.2. Incomplete contracts

As in the previous section, incomplete contracts will not be contingent on the realization of γ; they will therefore take the form of a sharing rule for the project's returns. Let this be denoted by $CCI = \{R_I^H, R_E^H, R_I^L, R_E^L\}$, where R_M^J denotes, once again, the payoff for M ($M = I, E$) at $t = 2$ when realized returns are equal to R^J ($J = H, L$). I now denotes investor 1 and E the entrepreneur (incumbent). At $t = 1$, in contrast with complete contracting, the game between the rival and the investors will take place under asymmetric information; in particular, only investor 1 will be informed about the realized value of γ.

Before we analyze the game, it will be helpful to establish some definitions and preliminary results.

Definitions and preliminaries

Denote by $CP(\theta, p_G)$ the "pooling" contract between the rival and investor 2 which would maximize the entrepreneur's expected utility subject to the investor's participation constraint, given θ and uninformed beliefs p_G (where p_G represents the uninformed parties' perceived probability that $\gamma = \gamma_G$). The contract solves the following problem:

$$Max \qquad U \equiv p_G W_G^R + (1 - p_G) W_B^R \qquad (5.3)$$

$$where \qquad W_J^K = (\frac{\theta}{\gamma_J})(Y_K^H - Y_K^L) + Y_K^L; \quad J = G, B; \quad K = R, I \qquad (5.4)$$

$$p_G W_G^I + (1 - p_G) W_B^I \geqslant I_E \quad (IR) \qquad (5.5)$$

together with the feasibility and limited liability constraints (4.5) to (4.7). Clearly, the investor's participation constraint (IR) can only be satisfied if project E's maximum pledgeable income, given the parties' beliefs, is at least equal to I_E. In this case, (IR) will hold as an equality; investor 2 will make zero expected profits and the entrant will obtain the project's expected NPV. For expositional convenience, it is useful to define the project's maximum pledgeable income, given θ and uninformed beliefs p_G, as $MPI^P(\theta, p_G)$. This is given by the following expression:

$$MPI^P(\theta, p_G) = \lambda(Y^H - Y^L) + Y^L \qquad (5.6)$$

where

$$\lambda = \theta\left[\frac{p_G}{\gamma_G} + \frac{(1 - p_G)}{\gamma_B}\right] \tag{5.7}$$

As a final preliminary, it is also helpful to define the following: let $CPC(X)$ denote the contract between the rival and investor 1 that would maximize the rival's expected utility, subject to offering the investor an expected (gross) return equal to $I_E + X$, contingent on $\gamma = \gamma_B$. Thus $CPC(L)$ corresponds to contract CMR^I, described by Proposition 1, while $CPC(0)$ corresponds to contract $CC(\gamma_B)$, described by Proposition 4. Contract $CPC(X)$ solves a problem analogous to $P2$, with $\gamma = \gamma_B$ and L replaced by X: for ease of exposition, it will not be repeated here. The solution is obtained from Proposition 1 by simply replacing L with X (in the definition of Z). Corresponding to each value of X, there is a threshold value of θ, call it $\theta(X)$, such that contract $CPC(X)$ is feasible if, and only if, $\theta \geqslant \theta(X)$. It is easy to see from lemma 2 that this threshold value is equal to:

$$\theta(X) \equiv \frac{\gamma_B}{Y^H - Y^L}(I_E + X - Y^L) \tag{5.8}$$

and hence increasing in X. In particular, note that $\theta(0) = \theta_N$ and $\theta(L) = \theta_E^I$.

The entrant's offers to investors

We can now state the result and comment on its implications; details and the proof are in the Appendix.

Proposition 5. (Entrant's offers to investors under incomplete contracting)

(1) Suppose $\theta \geqslant \theta_B$. Then: the entrant proposes contract $CC(\gamma_B)$ to investor 1, who accepts if, and only if, $\gamma = \gamma_B$. This contract just compensates the investor for the required outlay I_E when $\gamma = \gamma_B$; it provides no compensation for the expected loss on project F. If investor 1 rejects the offer, the entrant proposes contract $CC(\gamma_G)$ to investor 2, who accepts.

(2) Suppose $\theta_N \leqslant \theta < \theta_B$. There is a threshold value θ_P, with $\theta_N < \theta_P < \theta_B$, such that for all θ below this threshold, investor 2 is not willing to accept any offer. The game between the entrant and investor 1 is then the same as if investor 1 were a monopolist. For $\theta \geqslant \theta_P$, we have: (i) a pure strategy equilibrium when $\theta \geqslant \theta_E^I$, analogous to the corresponding one for the case of a monopoly investor. In this equilibrium, the entrant proposes contract CMR^I (described by Proposition 1) to investor 1, who accepts if, and only if, $\gamma = \gamma_B$. Investor 2 never accepts any offer. (ii) when $\theta < \theta_E^I$, a pure strategy equilibrium in which the rival chooses not to enter, and a mixed strategy equilibrium in which $\theta = \theta(X)$

$(0 < X < L)$. In the mixed strategy equilibrium, the entrant offers contract $CPC(X)$ to investor 1, who accepts with probability q $(0 < q < 1)$ if, and only if, $\gamma = \gamma_B$. If rejected, the entrant offers contract $CP(\theta, p_G(q))$ to investor 2, where $p_G(q) \equiv p_G / \{p_G + (1 - p_G)(1 - q)\}$. Investor 2 accepts with probability p $(0 < p < 1)$. The entrant's expected payoff in these mixed strategy equilibria is equal to zero. Investor 1 expects to make a loss, while investor 2 expects to make zero profits.

(3) If $\theta < \theta_N$, the entrant can never obtain funding for his project.

Proof: see Appendix.

Perfect competition among investors means that in the range $\theta \geqslant \theta_B$ the second entrepreneur will always be able to enter. Moreover, he will be able to do so without leaving any rents to the investors, and without compensating investor 1 for his expected loss on project F, just as in the symmetric information case described by Proposition 4. This is essentially because, once again, the entrant has enough pledgeable income to be able to obtain funding from investor 2 irrespective of the realization of γ; the fact that entry cannot be avoided (together with the entrepreneur's ability to make credible take-it-or-leave-it offers) prevents investor 1 from extracting any benefit from his informational advantage.

In the range $\theta_N \leqslant \theta < \theta_P$, on the other hand, investor 1's informational advantage means he can act effectively as a monopoly investor, since investor 2 will never be willing to fund the entrant. The reason is that, for any feasible uninformed beliefs, the entrant's pledgeable income would be too low to compensate investor 2 for the initial outlay I_E. Entry will therefore occur if, and only if, the entrepreneur can offer enough to investor 1 to compensate him not only for his initial investment in project E (I_E), but also for his expected loss on project F: that is, if $\theta \geqslant \theta_E^I$ and $\gamma = \gamma_B$.

In the range $\theta_P \leqslant \theta < \theta_B$, there are two possibilities. If $\theta \geqslant \theta_E^I$, the rival always enters when $\gamma = \gamma_B$, since he has enough pledgeable income to obtain funding from investor 1 with probability one. If $\theta < \theta_E^I$, however, the rival cannot pledge enough income to fully compensate investor 1 for his expected loss on project F, as well as for the required initial investment in project E. Thus a pure strategy equilibrium with entry is not feasible. A mixed strategy equilibrium is feasible, on the other hand, because it is possible to satisfy investor 2's participation constraint for sufficiently "favorable" uninformed beliefs, i.e. provided the winner's curse is not too strong. These equilibria are described in detail in the Appendix. A key feature of the mixed strategy equilibria is that they yield an expected payoff equal to zero for the entrant and investor 2, and an expected loss for investor 1. They

are therefore Pareto dominated by the pure strategy equilibrium in which the rival chooses not to enter, yielding an expected payoff of zero for the rival and both investors. It seems reasonable then to select the Pareto-dominant equilibrium.

5.2. The incumbent's offer: complete contract or incomplete contract?

We can now turn our attention to the incumbent's choice between complete and incomplete contracts at $t = 0$. Clearly, an incomplete contract could only be preferred if it induces a more "favorable" game between the entrant and investors at $t = 1$. Our analysis so far shows that this will not be the case for θ sufficiently high, or sufficiently low; we can therefore focus attention on intermediate values of θ, in the range $\theta_N \leqslant \theta < \theta_B$. Comparing Propositions 4 and 5, we see that complete contracting leads to entry when $\gamma = \gamma_B$, *without any compensation* for investor 1 for his expected loss on project F (and of course no compensation for the incumbent). Incomplete contracting, on the other hand, leads either to *entry deterrence* (hence no loss from entry for either investor 1 or the incumbent), or to entry when $\gamma = \gamma_B$ *with full compensation for investor 1*'s expected loss on project F (although again no compensation for the incumbent). This advantage has to be set against the possibly detrimental impact of incomplete contracting on *effort incentives* ex ante. We now examine this potential trade-off.

5.2.1. Complete contract

With complete contracting, the incumbent will once again be induced to provide effort through a reward contingent on the realization of γ, while investor 1 will receive all the final returns from project F. For $\theta_N \leqslant \theta < \theta_B$, entry will occur if, and only if, $\gamma = \gamma_B$. The incumbent's contractual offer to investor 1 therefore solves the following problem, $P5$:

$$Max \qquad eR_e - \frac{1}{2}e^2 \qquad\qquad (5.9)$$

$$e = R_e \quad (IC) \qquad\qquad (5.10)$$

$$e[\gamma_G R^H + (1-\gamma_G)R^L] + (1-e)[(\gamma_B - \mu)R^H + (1-\gamma_B+\mu)R^L] - eR_e \geqslant I_F \quad (IR)$$
$$(5.11)$$

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It is straightforward to verify that the first-best effort level is not feasible; the second-best effort will be determined by (IR) holding as an equality. It will therefore be given by the largest root of the following equation:

$$e(\Delta\gamma + \mu)(R^H - R^L) + (\gamma_B - \mu)(R^H - R^L) - e^2 = I_F - R^L \qquad (5.12)$$

Denote this by e^C. The incumbent's expected payoff from the complete contract, denoted by NPV^C, is then equal to:

$$NPV^C = [e^C\Delta\gamma + \gamma_B](R^H - R^L) - \frac{1}{2}(e^C)^2 + R^L - I_F - (1 - e^C)\mu(R^H - R^L) \quad (5.13)$$

5.2.2. Incomplete contract

Now consider the incumbent's problem if he opts for an incomplete contract. For $\theta_N \leqslant \theta < \theta_B$, there are two possibilities in principle: entry deterrence, or partial entry accommodation, which allows entry when $\gamma = \gamma_B$.

If entry deterrence is chosen, the optimal contract is the solution to the following problem, $P6$: maximize U, given by

$$U \equiv -\frac{1}{2}e^2 + e[\gamma_G R^H_E + (1 - \gamma_G)R^L_E] + (1 - e)[\gamma_B R^H_E + (1 - \gamma_B)R^L_E] \qquad (5.14)$$

subject to the constraints:

$$e = \arg\max(U) \quad (IC) \qquad (5.15)$$

$$e[\gamma_G R^H_I + (1 - \gamma_G)R^L_I] + (1 - e)[\gamma_B R^H_I + (1 - \gamma_B)R^L_I] \geqslant I_F \quad (IR) \qquad (5.16)$$

$$\theta^I_E > \theta \quad (ED) \qquad (5.17)$$

together with the feasibility and limited liability constraints (4.25) to (4.27). Here (ED) is the entry deterrence constraint, requiring that the endogeneous threshold for entry, θ^I_E, be higher than θ. From lemma 2, we know that this threshold is increasing in L, the magnitude of the investor's expected loss on project F when he funds project E. Thus if (ED) binds, entry deterrence can only

be achieved by giving the investor a more high-powered claim, thereby increasing L. However, this means giving a less high-powered claim to the entrepreneur, which reduces effort. If this is too costly, the incumbent will prefer a contract that results in entry being accommodated when $\gamma = \gamma_B$. In this case, problem $P6$ will be modified as follows. The incumbent will again maximize his expected utility, now equal to:

$$-\frac{1}{2}e^2 + e[\gamma_G R_E^H + (1 - \gamma_G)R_E^L] + (1 - e)[(\gamma_B - \mu)R_E^H + (1 - \gamma_B + \mu)R_E^L] \quad (5.18)$$

subject to the same constraints, except for (ED), which will be replaced by the entry accommodation constraint (EA), requiring that $\theta_E^I \leqslant \theta$.

The incumbent's optimal choice of incomplete contract is described by Proposition 6. Before stating the result, it is useful to define the following. Let e_1 be the largest root of the following equation for e,

$$[e\Delta\gamma + \gamma_B][R^H - R^L - \frac{e}{\Delta\gamma}] = I_F - R^L \quad (5.19)$$

and similarly e_2 the largest root of

$$[e\Delta\gamma + \gamma_B][R^H - R^L - \frac{e}{\Delta\gamma + \mu}] = I_F - R^L \quad (5.20)$$

Define also

$$e_0 \equiv \Delta\gamma(R^H - R^L) - \frac{\Delta\gamma}{\mu}[\frac{\theta(Y^H - Y^L)}{\gamma_B} - I_E + Y^L] \quad (5.21)$$

We can now state:

Proposition 6 (Incomplete contracts: choice between entry deterrence and partial entry accommodation) There is a threshold value $\theta^{IE} > \theta_N$ such that: (a) for $\theta < \theta^{IE}$, entry accommodation is not feasible; (b) for $\theta \geqslant \theta^{IE}$, the incumbent will prefer entry deterrence to partial entry accommodation if, and only if, $NPV^{ID} > NPV^{IE}$, where $NPV^{ID} = [e^{ID}\Delta\gamma + \gamma_B](R^H - R^L) - \frac{1}{2}(e^{ID})^2 + R^L - I_F$ and $NPV^{IE} = [e^{IE}\Delta\gamma + \gamma_B](R^H - R^L) - \frac{1}{2}(e^{IE})^2 + R^L - I_F - (1 - e^{IE})\mu e^{IE}/(\Delta\gamma + \mu)$. The effort levels $e^{ID} < e^{IE}$ are determined as follows. There is a second threshold value $\theta^{ID} > \theta^{IE}$, such that: (i) $e^{ID} = e_1$ if $\theta < \theta^{ID}$, and otherwise $e^{ID} = e_0 - \epsilon$ (for $\epsilon > 0$ arbitrarily small); (ii) $e^{IE} = e_2$.

Proof: see Appendix.

This result makes clear the trade-off in choosing between entry deterrence and partial entry accommodation. If the induced effort levels were the same, entry deterrence would always be chosen, since it avoids the expected loss borne by the incumbent when entry occurs. However, effort will be higher when entry is accommodated. The first reason for this is that entry, and hence the incumbent's expected loss, will occur if, and only if, $\gamma = \gamma_B$. Since effort reduces the probability of the bad state, the return to effort is correspondingly higher with the partial entry accommodation contract than with the entry deterrence contract. In addition, as noted above, if the entry deterrence constraint binds it will be necessary to give the incumbent a less high-powered claim, further reducing effort. If the effort induced by the partial entry accommodation contract is sufficiently greater, this contract may be preferred to the entry deterrence contract.

For ease of exposition, from now on I shall simply refer to the optimal incomplete contract, meaning the one optimally chosen according to Proposition 6. I shall denote its expected payoff for the incumbent as $NPV^I \equiv \max(NPV^{ID}, NPV^{IE})$.

5.2.3. Choosing between complete and incomplete contracts

Clearly the incumbent will prefer incomplete contracts to complete contracts if, and only if, $NPV^I > NPV^C$. Comparing expression (5.13) with Proposition 6, it is easy to check that this condition would always be satisfied for $e^C \leqslant e^{ID}$. This is because incomplete contracting provides more *effective protection against the losses associated with entry*. However, effort will in fact be higher under complete contracting, because incentives can be provided more efficiently in this case. Thus incomplete contracts will be preferred if, and only if, the benefits associated with reducing the losses from entry outweigh the *costs in terms of lower effort*.

What about *secretly-executed* complete contracts? Once again, execution would produce hard evidence about the realization of γ at $t = 1$, available to the contracting parties. It may be the case that hard evidence is only produced when $\gamma = \gamma_G$; i.e. when a transfer has occurred, or is due to occur if payment is delayed. This was the case considered in section 4. In this case, investor 2 could nevertheless learn the realized value of γ by offering (secretly) to pay the incumbent a price $P > 0$ for showing him hard evidence that $\gamma = \gamma_G$. The incumbent would have no reason to turn down a profitable side deal with investor 2, except of course when $\gamma = \gamma_B$. Thus investor 2 could obtain information about γ from the incumbent, and use it to make an offer to the entrant when $\gamma = \gamma_B$. The outcome would obviously depend on what we assume about bargaining power. The point,

though, is that the hard evidence generated by execution of the contract at $t = 1$ may well enable profitable side contracting, which will undermine the value, ex ante, of secretly-executed contracts.

6. Conclusions

Rather than summarize the paper's results, I will end with just two concluding remarks. The first concerns the main idea of the paper, namely, that incomplete contracts may be preferred in some circumstances because their execution reveals less information to outside parties. This seems potentially applicable in a variety of settings, beyond the one studied in the paper. Even in the canonical model with a buyer and a seller, a complete contract would generally specify the quality and quantity of the good to be traded, and the price, as a function of the state of nature, which would include the seller's cost and the buyer's valuation. It may be in the interest of the contracting parties ex ante to ensure that information about the realized state of nature does not become easily available to outside parties ex post.

The second remark concerns the interaction between the ex post cost of complete contracts studied in this paper and the ex ante costs associated with bounded rationality. The cognitive costs of complete contracts will presumably be greater if the parties need to foresee not only the contingencies themselves (for possible inclusion in the contract), but also the strategic use that may be made of the information generated by contractual execution ex post.

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8. Appendix

Proof of Lemma 1.

Let $CMR = \{Y_I^H, Y_R^H, Y_I^L, Y_R^L\}$ denote the contract agreed at $t = 1$ between the rival and the investor, where Y_M^J ($M = I, R$) denotes M's payoff at $t = 2$ if project E yields returns Y^J ($J = H, L$). Here I denotes the investor and R the entrepreneur (rival).

Denote by $PI(\theta, \gamma)$ the investor's expected income from project E at $t = 2$, given contract CMR. Thus:

$$PI(\theta, \gamma) = (\frac{\theta}{\gamma})Y_I^H + (1 - \frac{\theta}{\gamma})Y_I^L \tag{8.1}$$

Clearly the maximum pledgeable income, denoted by $MPI(\theta, \gamma)$, is simply equal to

$$MPI(\theta, \gamma) = Y^L + \frac{\theta}{\gamma}(Y^H - Y^L) \tag{8.2}$$

Let $f(\theta, \gamma) \equiv MPI(\theta, \gamma) - L^C$. To find the threshold value θ_E such that for all $\theta < \theta_E$ the investor will not be willing to fund project E irrespective of the value of γ, it is sufficient to find the value of θ for which $f(\theta, \gamma_B) = I_E$. The reason is that $MPI(\theta, \gamma_B)$ gives the highest possible income that could be pledged to the investor to induce him to fund project E: a higher value of γ (i.e. γ_G) would imply a lower pledgeable income. The threshold value θ_E is therefore defined by

$$Y^L + \frac{\theta_E}{\gamma_B}(Y^H - Y^L) - \mu(R^H - R^L) = I_E \tag{8.3}$$

The threshold value θ_G, below which the income that can be pledged to the investor would be insufficient to induce him to fund project E when $\gamma = \gamma_G$, is similarly given by the value of θ for which $f(\theta, \gamma_G) = I_E$, defined by

$$Y^L + \frac{\theta_G}{\gamma_G}(Y^H - Y^L) - \mu(R^H - R^L) = I_E \tag{8.4}$$

$\square$

Proof of Proposition 1

The contract $CMR^I = \{Y_I^H, Y_R^H, Y_I^L, Y_R^L\}$ solves the following problem:

$$Max \quad U^S = (\frac{\theta}{\gamma_B})Y_R^H + (1 - \frac{\theta}{\gamma_B})Y_R^L \tag{8.5}$$

$$(\frac{\theta}{\gamma_B})Y_I^H + (1 - \frac{\theta}{\gamma_B})Y_I^L \geqslant Z \quad (IR) \tag{8.6}$$

$$Y_I^H + Y_R^H = Y^H \tag{8.7}$$

$$Y_I^L + Y_R^L = Y^L \tag{8.8}$$

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$$Y_I^H \geqslant 0, Y_R^H \geqslant 0, Y_I^L \geqslant 0, Y_R^L \geqslant 0 \quad (LL) \tag{8.9}$$

Clearly (IR) will bind, implying that

$$U^S = \frac{\theta}{\gamma_B}(Y^H - Y^L) + Y^L - Z \tag{8.10}$$

□

Proof of Proposition 2

The contract $CMG = \{Y_I^{GH}, Y_R^{GH}, Y_I^{GL}, Y_R^{GL}\}$ solves the following problem, $P3$:

$$Max \quad U^P \equiv p_G W_G + (1 - p_G) W_B \tag{8.11}$$

$$where \quad W_J = (\frac{\theta}{\gamma_J})(Y_R^{GH} - Y_R^{GL}) + Y_R^{GL}; \quad J = G, B \tag{8.12}$$

$$(\frac{\theta}{\gamma_G})(Y_I^{GH} - Y_I^{GL}) + Y_I^{GL} \geqslant Z \quad (IRG) \tag{8.13}$$

$$(\frac{\theta}{\gamma_B})(Y_I^{GH} - Y_I^{GL}) + Y_I^{GL} \geqslant Z \quad (IRB) \tag{8.14}$$

$$Y_I^{GH} + Y_R^{GH} = Y^H \tag{8.15}$$

$$Y_I^{GL} + Y_R^{GL} = Y^L \tag{8.16}$$

$$Y_I^{GH} \geqslant 0, Y_R^{GH} \geqslant 0, Y_I^{GL} \geqslant 0, Y_R^{GL} \geqslant 0 \quad (LL) \tag{8.17}$$

Clearly (IRB) does not bind, while (IRG) does. Since (IRG) binds, we have:

$$W_G = \frac{\theta}{\gamma_G}[Y^H - Y^L - (Y_I^{GH} - Y_I^{GL})] + Y^L - Y_I^{GL} = \frac{\theta}{\gamma_G}(Y^H - Y^L) - (Z - Y^L) \tag{8.18}$$

$$W_B = \frac{\theta}{\gamma_B}[Y^H - Y^L - (Y_I^{GH} - Y_I^{GL})] + Y^L - Y_I^{GL} \tag{8.19}$$

$$W_B - W_G = (\frac{1}{\gamma_B} - \frac{1}{\gamma_G})\theta[Y^H - Y^L - (Y_I^{GH} - Y_I^{GL})] \tag{8.20}$$

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implying that the (rival) entrepreneur wants to set $Y_I^{GH} - Y_I^{GL}$ as small as possible. The optimal contract therefore sets $Y_I^{GL} = Y^L$, while Y_I^{GH} is determined by (IRG) and is equal to:

$$Y_I^{GH} = \frac{\gamma_G}{\theta}(Z - Y^L) + Y^L \tag{8.21}$$

Using this, we obtain

$$W_B = \frac{\theta}{\gamma_B}[Y^H - Y^L - \frac{\gamma_G}{\theta}(Z - Y^L)] = \frac{\theta}{\gamma_B}(Y^H - Y^L) - \frac{\gamma_G}{\gamma_B}(Z - Y^L) \tag{8.22}$$

The entrepreneur's expected utility from contract CMG is thus equal to:

$$U^P = p_G\{\frac{\theta}{\gamma_G}(Y^H - Y^L) - (Z - Y^L)\} + (1 - p_G)\{\frac{\theta}{\gamma_B}(Y^H - Y^L) - \frac{\gamma_G}{\gamma_B}(Z - Y^L)\} \tag{8.23}$$

We can now compare the entrepreneur's expected utility from offering contract CMG and contract CMR^I, described by Proposition 1.

The entrepreneur's expected utility from offering contract CMR^I is equal to $(1 - p_G)U^S$, since the contract will be accepted only when $\gamma = \gamma_B$. Denote by $\Delta U \equiv U^P - (1 - p_G)U^S$ the difference in expected utility between offering contract CMG and offering contract CMR^I. Thus:

$$\Delta U = p_G\{\frac{\theta}{\gamma_G}(Y^H - Y^L) + (\frac{\gamma_G}{\gamma_B} - 2)(Z - Y^L)\} - (\frac{\gamma_G}{\gamma_B} - 1)(Z - Y^L) \tag{8.24}$$

$$\frac{\partial \Delta U}{\partial p_G} = \frac{\theta}{\gamma_G}(Y^H - Y^L) + (\frac{\gamma_G}{\gamma_B} - 2)(Z - Y^L) \tag{8.25}$$

Since $\theta \geqslant \theta_G^I$, we know that

$$\theta \geqslant \frac{\gamma_G}{Y^H - Y^L}(Z - Y^L) \tag{8.26}$$

implying that

$$\frac{\partial \Delta U}{\partial p_G} > 0 \tag{8.27}$$

Moreover, when $p_G = 0$ we have

$$\Delta U = -(\frac{\gamma_G}{\gamma_B} - 1)(Z - Y^L) < 0 \tag{8.28}$$

while for $p_G = 1$ we have

$$\Delta U = \frac{\theta}{\gamma_G}(Y^H - Y^L) - (Z - Y^L) \geqslant 0 \tag{8.29}$$

with the inequality holding strictly for all $\theta > \theta_G^I$.

Thus there must be a unique value of p_G, call it p_G^*, such that contract CMR^I is preferred for all $p_G < p_G^*$, while contract CMG is preferred for all $p_G > p_G^*$. This value is defined by the condition $\Delta U = 0$.

□

Proof of Proposition 3

The contract $CME = \{R_I^H, R_E^H, R_I^L, R_E^L\}$ is the solution to the following problem, $P4$: maximize U, given by

$$U \equiv -\frac{1}{2}e^2 + e[(\gamma_G - \mu)R_E^H + (1 - \gamma_G + \mu)R_E^L] + (1-e)[(\gamma_B - \mu)R_E^H + (1 - \gamma_B + \mu)R_E^L] \tag{8.30}$$

subject to the constraints:

$$e = \arg\max(U) \quad (IC) \tag{8.31}$$

$$e[\gamma_G R_I^H + (1 - \gamma_G)R_I^L] + (1-e)[\gamma_B R_I^H + (1 - \gamma_B)R_I^L + Q] \geqslant I_F \quad (IR) \tag{8.32}$$

$$\theta_G^I < \theta \quad and \quad p_G > p_G^* \quad (EA) \tag{8.33}$$

$$R_I^H + R_E^H = R^H \tag{8.34}$$

$$R_I^L + R_E^L = R^L \tag{8.35}$$

$$R_I^H \geqslant 0, R_E^H \geqslant 0, R_I^L \geqslant 0, R_E^L \geqslant 0 \quad (LL) \tag{8.36}$$

The first best here would entail choosing e and $R_E^H - R_E^L$ to maximize:

$$e\Delta\gamma(R^H - R^L) - \frac{1}{2}e^2 + R^L + \gamma_B(R^H - R^L) - \mu(R_E^H - R_E^L) + (1-e)Q - I_F \quad (8.37)$$

which implies setting $e = \Delta\gamma(R^H - R^L) - Q$ and $R_E^H - R_E^L$ as low as possible. Given the assumptions made so far, the lower bound on $R_E^H - R_E^L$ would be given by setting $R_E^H = 0$ and $R_E^L = R^L$. However, this would mean that the incumbent has a strictly higher expected payoff in the bad state. In practice, this could easily generate perverse incentives; for example, if there are actions that the incumbent could choose that increase the probability of the bad state - a kind of negative effort. Since we have assumed effort to be non-negative, we will focus attention on the case where $R_E^H - R_E^L \geqslant 0$. In general, $e = \Delta\gamma(R^H - R^L) - Q$ and $R_E^H - R_E^L = 0$ is not consistent with the incumbent's incentive-compatibility constraint, given by:

$$e = \Delta\gamma(R_E^H - R_E^L) \quad (IC) \tag{8.38}$$

Thus the first best is not feasible[28]. The second best would entail choosing $R_E^H - R_E^L$ to maximize the project's NPV, taking into account (IC); i.e., maximizing the following expression:

$$W = -\frac{1}{2}[\Delta\gamma(R_E^H - R_E^L)]^2 + (\Delta\gamma)^2(R^H - R^L)(R_E^H - R_E^L) - \mu(R_E^H - R_E^L)$$

$$+\gamma_B(R^H - R^L) + [1 - \Delta\gamma(R_E^H - R_E^L)]Q + R^L - I_F \tag{8.39}$$

Differentiating W gives:

$$\phi \equiv \frac{\partial W}{\partial(R_E^H - R_E^L)} = -(\Delta\gamma)^2(R_E^H - R_E^L) + (\Delta\gamma)^2(R^H - R^L) - \mu$$

$$-\Delta\gamma Q + [1 - \Delta\gamma(R_E^H - R_E^L)]\frac{dQ}{d(R_E^H - R_E^L)} \tag{8.40}$$

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[28]Specifically, it is only feasible in the very special case where the following condition is satisfied:

$$(R^H - R^L)(1 - \frac{\mu}{\gamma_B}) = \frac{1}{\gamma_B}[I_E - Y^L]$$

where

$$\frac{dQ}{d(R_E^H - R_E^L)} = -\mu(\frac{1}{\gamma_B} - \frac{1}{\gamma_G})\gamma_G = -\mu(\frac{\Delta\gamma}{\gamma_B}) \qquad (8.41)$$

We are interested in the range $0 \leqslant R_E^H - R_E^L \leqslant R^{MAX} \equiv \max[0, R^H - R^L - (I_E - Y^L)/(\gamma_B - \mu)]$.[29]

Evaluating expression (8.40) when $R_E^H - R_E^L = 0$ and when $R_E^H - R_E^L = R^{MAX} = R^H - R^L - (I_E - Y^L)/(\gamma_B - \mu)$ yields:

$$\phi(0) = \frac{1}{\gamma_B}\{(\Delta\gamma)^2[(R^H - R^L)(\gamma_B - \mu) - (I_E - Y^L)] - \mu\gamma_G\}$$

$$\phi(R^{MAX}) = \frac{(\Delta\gamma)^2\mu}{\gamma_B}[R^H - R^L - (\frac{I_E - Y^L}{\gamma_B - \mu})] - \frac{\mu\gamma_G}{\gamma_B} < \frac{\Delta\gamma\mu}{\gamma_B} - \frac{\mu\gamma_G}{\gamma_B} < 0$$

The second derivative is given by:

$$\frac{\partial^2 W}{\partial(R_E^H - R_E^L)^2} = -(\Delta\gamma)^2 - 2\Delta\gamma\frac{dQ}{d(R_E^H - R_E^L)} = (\Delta\gamma)^2[\frac{2\mu}{\gamma_B} - 1] \qquad (8.42)$$

There are two cases to consider.

Case 1: $2\mu < \gamma_B$. Thus ϕ is decreasing. There are two possibilities, depending on parameter values: (i) if $\phi(0) > 0$, there is an interior solution; (ii) if $\phi(0) \leqslant 0$, there is a corner solution at $R_E^H - R_E^L = 0$.

Case 2: $2\mu \geqslant \gamma_B$. Thus ϕ is non-decreasing. The only possibility is a corner solution at $R_E^H - R_E^L = 0$.

Denote then by R^S the solution. To see whether the second best is feasible, we need to check whether (IR) and (EA) are satisfied.

(i) Suppose the following condition holds:

$$R^L + (R^H - R^L - R^S)[(\Delta\gamma)^2 R^S + \gamma_B] + (1 - \Delta\gamma R^S)Q(R^S) \geqslant I_F \quad (M1) \quad (8.43)$$

where $Q(R^S)$ is given by

$$Q(R^S) = \frac{\Delta\gamma}{\gamma_B}[I_E - Y^L + \mu(R^H - R^L - R^S)]$$

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[29]The upper bound is obtained by requiring that effort never exceed $\Delta\gamma(R^H - R^L) - Q$.

Then it is possible to set $R_E^H - R_E^L = R^S$ and to satisfy (IR). There are two possibilities: (a) if $\theta > \theta_G^I$ $\;and\;$ $p_G > p_G^*$, (EA) does not bind. In this case, $R_E^H - R_E^L = R^S$, $e = \Delta\gamma R^S$ and R_I^L is given by the following expression:

$$R_I^L + (R^H - R^L - R^S)[(\Delta\gamma)^2 R^S + \gamma_B] + (1 - \Delta\gamma R^S)Q(R^S) = I_F \qquad (8.44)$$

(b) otherwise, (EA) binds and determines $R_E^H - R_E^L$. As long as entry accommodation is feasible, R_E^L is then determined by (binding) (IR).

(ii) Suppose condition $(M1)$ does not hold. It is not possible to set $R_E^H - R_E^L = R^S$ and to satisfy (IR): even if we set R_E^L as low as possible (i.e. $R_E^L = 0$), setting $R_E^H - R_E^L = R^S$ (i.e. $R_E^H = R^S$) does not yield enough pledgeable income for the investor. It is therefore necessary to increase R_I^H in order to satisfy (IR) (note that this also increases Q). Then: (a) if (EA) does not bind, $R_E^H - R_E^L < R^S$, $R_I^L = R^L$ and R_I^H is determined by (IR); (b) if (EA) does bind, entry accommodation is not feasible, since satisfying (EA) would require reducing $R_I^H - R_I^L$, which would violate (IR)[30].

□

Proof of Proposition 5

(1) Suppose $\theta \geqslant \theta_B$. In this case, the rival's pledgeable income would be sufficient to obtain funding from investor 2 for every realization of γ. In particular, contract $CC(\gamma_G)$ would be feasible and would always satisfy investor 2's participation constraint. The following strategies therefore represent an equilibrium: the rival offers contract $CC(\gamma_B)$ to investor 1. Investor 1 accepts if, and only if, $\gamma = \gamma_B$. If investor 1 rejects the offer, the entrepreneur proposes contract $CC(\gamma_G)$ to investor 2, who accepts. Investor 1 has no incentive to deviate: given that the rival will be able to enter even if investor 1 rejects his offer, investor 1 cannot avoid losing L by rejecting the rival's offer. He will therefore accept the rival's offer as long as his expected return on project E is at least equal to the required investment outlay I_E. When the rival offers contract $CC(\gamma_B)$, this condition will be satisfied if, and only if, $\gamma = \gamma_B$. Investor 2 has no incentive to deviate either, since $CC(\gamma_G)$ satisfies his participation constraint (in equilibrium, he expects to make zero profits from this contract). Finally, the rival has no incentive to deviate, since in equilibrium he always succeeds in obtaining funding for his project, without leaving any rents to the investors.

(2) Suppose $\theta_N \leqslant \theta < \theta_B$. Let the threshold value θ_P be defined by the condition

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[30]It is straightforward to verify that θ_G^I and p_G^* are both decreasing in $R_E^H - R_E^L$.

$$MPI^P(\theta_P, p_G) = I_E \tag{8.45}$$

implying that for $0 < p_G < 1$,[31] $\theta_N < \theta_P < \theta_B$. Then:

(i) assume that $\theta < \theta_P$. In this case, suppose that the rival does not have the opportunity to make an offer to investor 1, so that his interaction with investor 2 occurs on the basis of common uninformed beliefs p_G, and this is common knowledge to both parties. Investor 2 will never be willing to fund the rival, because his pledgeable income is too low to compensate the investor for the required investment outlay I_E. Allowing for the rival's prior interaction with investor 1 can only reinforce this result, since the probability that $\gamma = \gamma_G$, conditional on the rival reaching the stage of making an offer to investor 2, may be higher but will never be lower than p_G. We can conclude that in equilibrium investor 2 will never fund the rival. Thus the game between the rival and investor 1 will be the same as if investor 1 were a monopolist. Specifically, for $\theta < \theta_E^I$ (where θ_E^I was defined by Lemma 2), the rival will not be able to obtain funding from investor 1, and will therefore be unable to enter. For $\theta \geqslant \theta_E^I$, the rival will offer investor 1 contract CMR^I, described by Proposition 1; the investor will accept if, and only if, $\gamma = \gamma_B$.

(ii) assume that $\theta \geqslant \theta_P$. In this case, if $\theta \geqslant \theta_E^I$, the pure strategy equilibrium in which the rival offers investor 1 contract CMR^I, described by Proposition 1, and the investor accepts if, and only if, $\gamma = \gamma_B$, while investor 2 never funds the rival (as in (i)), is still feasible. It is the only feasible pure strategy equilibrium, since if the rival could offer a contract that always induced investor 2 to fund him in equilibrium, he would first offer $CC(\gamma_B)$ to investor 1, as in (1) above, implying that he would only reach the stage of making an offer to investor 2 if $\gamma = \gamma_G$. But then investor 2 could only expect to make a loss by funding the rival, so this could not be an equilibrium. If $\theta < \theta_E^I$, there is no pure strategy equilibrium in which the rival obtains funding (when $\gamma = \gamma_B$), since he cannot pledge enough income to fully compensate investor 1 for his expected loss on project F, as well as for the required initial investment in project E. Thus if investor 1 believes investor 2 will never finance the rival, he will deny funding.

Suppose now that for $\theta \geqslant \theta(X)$ and $0 < X < L$, there is a mixed strategy equilibrium, in which the rival offers $CPC(X)$ to investor 1, who accepts with probability q ($0 < q < 1$) if, and only if, $\gamma = \gamma_B$. If rejected, the rival then offers

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[31] This condition will always hold in equilibrium, since in equilibrium we must have $p_G = e_1 \leqslant e_H < 1$, and by assumption $(A1)$ we must have strictly positive effort, hence $p_G = e_1 > 0$.

the "pooling" contract $CP(\theta, p_G(q))$ to investor 2, where $p_G(q) \equiv p_G/\{p_G + (1 - p_G)(1 - q)\}$. Investor 2 accepts with probability p ($0 < p < 1$). For this to be an equilibrium, investor 1 should have no incentive to deviate. Thus we require that, conditional on $\gamma = \gamma_B$, his expected loss from entry if he accepts the rival's offer, equal to $L - X$, be equal to his expected loss if he rejects the offer, equal to pL. This condition determines the probability p as follows:

$$p = \frac{L - X}{L} \tag{8.46}$$

It will then be the case that when $\gamma = \gamma_G$, the investor's expected loss from accepting the rival's offer will be strictly greater, while his expected loss from rejecting the offer will be the same, implying that rejection is his best response, as required.

Investor 2 will have no incentive to deviate, since his expected payoff from accepting contract $CP(\theta, p_G(q))$ is the same as his expected payoff from rejecting it (equal to zero). In equilibrium it must also be the case that the the entrepreneur could not gain by offering investor 2 a slightly different contract, which gives the investor a strictly positive albeit very small expected payoff (given beliefs $p_G(q)$), and thereby induces him to accept with probability one. This yields the following condition, which determines q:

$$MPI^P(\theta, p_G(q)) = I_E \tag{8.47}$$

Thus the entrepreneur's expected payoff when investor 2 accepts his offer is equal to zero in equilibrium. The same argument can therefore be applied to the entrepreneur's interaction with investor 1, implying the following further condition, which determines X:

$$MPI(\theta, \gamma_B) = I_E + X \tag{8.48}$$

Thus the entrepreneur's expected payoff when investor 1 accepts his offer must also be equal to zero. Note that the last condition is equivalent to the condition $\theta = \theta(X)$, implying that there is one and only one of the mixed strategy equilibria just described for each value of θ in the range $\theta_P \leqslant \theta < \theta_E^I$. It also follows that there are no such mixed strategy equilibria for $\theta \geqslant \theta_E^I$.

We have established that these mixed strategy equilibria would yield an expected payoff equal to zero for the entrant and investor 2, and an expected loss for investor 1, equal to $L - X = pL$. So far we have assumed, by convention, that when his expected payoffs from entry and no entry are the same, the rival

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will choose to enter. In this case, however, it seems reasonable to consider also the equilibrium in which the rival chooses not to enter (e.g. he offers the null contract). This equilibrium yields an expected payoff equal to zero for the rival and for both investors; it therefore Pareto dominates the mixed strategy equilibria just described.[32]

(3) If $\theta < \theta_N$, the entrepreneur's pledgeable income is insufficient to compensate for the cost of the required investment I_E, irrespective of the realization of γ. Thus neither investor will be willing to fund his project.

□

Proof of Proposition 6

Problem $P6$ entails maximizing

$$U \equiv -\frac{1}{2}e^2 + e[\gamma_G R_E^H + (1 - \gamma_G)R_E^L] + (1 - e)[\gamma_B R_E^H + (1 - \gamma_B)R_E^L] \quad (8.49)$$

subject to the constraints:

$$e = \Delta\gamma(R_E^H - R_E^L) \quad (IC) \quad\quad\quad (8.50)$$

$$e[\gamma_G R_I^H + (1 - \gamma_G)R_I^L] + (1 - e)[\gamma_B R_I^H + (1 - \gamma_B)R_I^L] \geqslant I_F \quad (IR) \quad\quad (8.51)$$

$$\theta_E^I > \theta \quad (ED) \quad\quad\quad (8.52)$$

$$R_I^H + R_E^H = R^H \quad\quad\quad (8.53)$$

$$R_I^L + R_E^L = R^L \quad\quad\quad (8.54)$$

$$R_I^H \geqslant 0, R_E^H \geqslant 0, R_I^L \geqslant 0, R_E^L \geqslant 0 \quad (LL) \quad\quad (8.55)$$

Implementing the first-best effort level $e = \Delta\gamma(R^H - R^L)$ would violate (IR); thus effort will be below its first-best level. There are two possibilities: if (ED)

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[32] For $\theta = \theta_P$, there are also mixed strategy equilibria with $q = 0$, X determined by (8.48), and p satisfying $pL \leqslant L - X$. These equilibria also have the property that the expected payoff for the rival and investor 2 are equal to zero, while investor 1's expected payoff is negative (zero for $p = 0$).

does not bind, maximizing second-best effort requires setting $R_E^L = 0$ ($R_I^L = R^L$) (from (IC)). R_I^H is then determined by (IR) holding as an equality. If (ED) does bind, it determines $R_I^H - R_I^L$ (using lemma 2). R_I^L is then determined by (IR) holding as an equality. Denote by e^{ID} the corresponding effort level. Thus, letting e_1 be the largest root of the following equation for e,

$$[e\Delta\gamma + \gamma_B][R^H - R^L - \frac{e}{\Delta\gamma}] = I_F - R^L \tag{8.56}$$

and defining

$$e_0 \equiv \Delta\gamma(R^H - R^L) - \frac{\Delta\gamma}{\mu}[\frac{\theta(Y^H - Y^L)}{\gamma_B} - I_E + Y^L] \tag{8.57}$$

$$R^{ID} \equiv R^H - \frac{e_1}{\Delta\gamma} \tag{8.58}$$

$$\theta^{ID} \equiv \frac{\gamma_B}{Y^H - Y^L}[I_E + \mu(R^{ID} - R^L) - Y^L] \tag{8.59}$$

we have: $e^{ID} = e_1$ if $\theta < \theta^{ID}$, and otherwise $e^{ID} = e_0 - \epsilon$ (for $\epsilon > 0$ arbitrarily small).

If the incumbent chooses instead to accommodate entry when $\gamma = \gamma_B$, problem $P6$ is modified as follows: expected utility is now equal to

$$-\frac{1}{2}e^2 + e[\gamma_G R_E^H + (1 - \gamma_G)R_E^L] + (1 - e)[(\gamma_B - \mu)R_E^H + (1 - \gamma_B + \mu)R_E^L] \tag{8.60}$$

implying that the incentive constraint becomes

$$e = (\Delta\gamma + \mu)(R_E^H - R_E^L) \quad (IC) \tag{8.61}$$

while (ED) is replaced by the entry-accommodation constraint (EA):

$$\theta_E^I \leqslant \theta \quad (EA) \tag{8.62}$$

First-best effort is correspondingly higher, and is given by $e = \Delta\gamma(R^H - R^L) + \mu(R_E^H - R_E^L)$. Again, this will not be feasible, and the solution will entail setting $R_E^L = 0$, with R_I^H determined by (IR) holding as an equality[33]. Denote by e^{IE}

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[33]Note that if this solution does not satisfy (EA), entry accommodation is not possible, since relaxing the (EA) constraint would require giving a more high-powered claim to the entrepreneur, which would violate (IR).

the corresponding effort level. Define the following: e_2 is the largest root of the equation

$$[e\Delta\gamma + \gamma_B][R^H - R^L - \frac{e}{\Delta\gamma + \mu}] = I_F - R^L \tag{8.63}$$

$$R^{IE} \equiv R^H - \frac{e_2}{\Delta\gamma + \mu} \tag{8.64}$$

$$\theta^{IE} \equiv \frac{\gamma_B}{Y^H - Y^L}[I_E + \mu(R^{IE} - R^L) - Y^L] \tag{8.65}$$

Then: $e^{IE} = e_2$ if $\theta \geqslant \theta^{IE}$; otherwise entry accommodation is not feasible. Clearly $e_2 > e_1$, $e^{IE} > e^{ID}$ and $\theta^{IE} < \theta^{ID}$.

□