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Satisficing Contracts

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We propose a model of equilibrium contracting between two agents who are "boundedly rational" in the sense that they face time costs of deliberating current and future transactions. We show that equilibrium contracts may be incomplete and assign control rights: they may leave some enforceable future transactions unspecified and instead specify which agent has the right to decide these transactions. Control rights allow the controlling agent to defer time-consuming deliberations on those transactions to a later date, making her less inclined to prolong negotiations over an initial incomplete contract. Still, agents tend to resolve conflicts up-front by writing more complete initial contracts. A more complete contract can take the form of either a finer adaptation to future contingencies, or greater coarseness. Either way, conflicts among contracting agents tend to result in excessively complete contracts in the sense that the maximization of joint payoffs would result in less complete contracts.

1. INTRODUCTION

This paper analyses a contracting model with two agents, each facing thinking costs, in which equilibrium incomplete contracts arise endogenously. The basic situation we model is an investment in a partnership or an ongoing new venture. The contract the agents write specifies in a more or less complete manner what action plan they agree to undertake initially, and how the proceeds from the venture are to be shared. In any given state of nature, both agents face costs in thinking through optimal decisions in that state. Therefore an optimal contract that maximizes gains from trade net of thinking costs is generally incomplete in the sense that it is not based on all the information potentially available to agents in all states of nature. By introducing positive thinking or deliberation costs into an otherwise standard contracting framework, it is thus possible to formulate a theory of endogenously incomplete contracts.

We build on a model of decision making with *time-costs* in deliberating decisions developed in Bolton and Faure-Grimaud (2008). In this model the decision maker has a prior estimate of her best course of action in every state of nature. However, the decision maker also knows that her prior estimate may not be based on much information and that she can improve her decisions by thinking further about her choices in any given state of nature. Thinking is modelled as a thought-experimentation process which allows the decision maker to obtain a more accurate estimate of her payoffs from different choices. At any moment the decision maker faces the problem of whether to think further or make a decision based on what she has learnt. As thinking takes time, the decision maker optimally decides to not think about all future decisions at once, and to postpone thinking about decisions that she is unlikely to ever face or that may arise in the distant future.[1] In this paper we consider a contracting problem between two agents that face such time-costs of deliberating future transactions under a contract. As will become clear in the formal analysis below, even such a minimal departure to an otherwise standard bilateral contracting problem introduces major new conceptual issues. Yet in spite of these complications our quasi-rational contracting model captures several important features of incomplete contracting observed in practice.

One first basic result is that boundedly rational agents write what we call *satisficing contracts,* which do not fully exploit all gains from trade that would be available to agents who face no deliberation costs.[2] In equilibrium, agents do not waste time resolving all future transactions and instead leave many decisions to be determined later. Agents will tend to settle on more incomplete action plans when they have broadly aligned interests, and when they all expect to benefit substantially from the deal. Note, in particular, that boundedly rational agents choose to leave transactions unresolved in perfectly foreseeable, describable and enforceable contingencies, if these contingencies are sufficiently unlikely or distant, or if they do not affect expected payoffs much. In addition, contracts become more and more detailed over time, as agents complete the contract in light of new information.

We refer to such contracts as *incomplete contracts* to the extent that they do not involve complete *ex ante* information acquisition on payoffs of all transactions in all states, and they do not just specify state-contingent transactions based only on the information agents have acquired *ex ante*. Contracts can always be made contingent on all the information available to the contracting parties and in that sense contracts can always be complete. That said, when agents choose to defer information acquisition on certain transactions to when a given state of nature arises, they may as well write what is more commonly referred to as an incomplete contract, namely a contract where the ultimate transaction to be undertaken in that state is left unspecified and where a controlling agent has the right to determine the transaction should that state of nature arise (see Grossman and Hart, 1986; Hart and Moore, 1988; Hart, 1995). Such an incomplete contract would often yield the same expected payoff as an optimal contract that is based on all the information agents choose to acquire in a particular state, and would be a lot simpler to write.

The main results from our analysis are as follows. First, incomplete contracts specifying *control rights* may emerge in equilibrium (when such contracts are not strictly dominated by a complete contract with the same equilibrium information acquisition). The rationale for control rights in our model—defined as rights to decide between different transactions in contingencies left out of the initial contract—is that the holder of these rights benefits by having *the option to defer thinking* about future decisions. Second, control rights tend to be allocated to the more cautious party. Indeed, the more cautious party is then more willing to close the deal quickly, even though it has not had the time to think through all contingencies, in the knowledge that thanks to its control rights it can impose its most favoured decision in the unexplored contingencies.

Third, the sharp distinction between a first contract negotiation phase followed by a phase of execution of the contract usually made in the contract theory literature is no longer justified in

1. Our model builds on earlier work on decision making with deliberation costs by Simon (1955) and Conlisk (1980, 1988, 1996) among others, and on the literature on multi-armed bandits by Gittins and Jones (1974), Rothschild (1974), Gittins (1979), Berry and Frystedt (1985) and Whittle (1980, 1982).

2. We borrow Simon's notion of *satisficing* for decision problems of boundedly rational agents to describe a contracting problem between such agents (see Simon, 1955; Radner, 1975; Radner and Rothschild, 1975). Interestingly, although satisficing behaviour has been explored extensively in decision problems it has not, to our knowledge, been extended to a contracting problem.

our setup. Contracts are completed over time and negotiations about aspects that have been left out initially can be ongoing. In particular, the contracting agents may choose to begin negotiations by writing a *preliminary contract* specifying the broad outlines of a deal and committing the agents to the deal. The agents then continue with a further exploration phase (which may be thought of as a form of *due diligence*) before deciding whether to go ahead with the venture and agreeing to a detailed contract. Interestingly, a party with all the bargaining power may choose to leave rents to the other party, so as to meet its *prior aspiration level*—that is, the level before it has had time to think through all contingencies—and thus persuade it to sign on more quickly.

Fourth, when agents' objectives conflict more, equilibrium contracts are more complete. The main reason is that each agent may be concerned about the detrimental exercise of control by the other agent. In such situations, the exercise of control may have to be circumscribed contractually by writing more complete contracts. Another reason is that when agents have conflicting goals they are less willing to truthfully share their thoughts, so that the net benefit of leaving transactions to be fine-tuned later is reduced.

This analysis thus provides new foundations for incomplete contracts and the role of control rights. In our model equilibrium contracts may be incomplete even though more complete contracts (relying on more information acquisition) are enforceable. Similarly, contractual completeness increases over time even though enforceability remains unchanged. This is in our view a critical difference with first-generation models of incomplete contracts. Two important implications immediately follow. First, our framework allows for contractual innovation by the contracting agents independently of any changes in legal enforcement. Second, changes in legal enforcement may have no effect on equilibrium contracts if enforcement constraints were not binding in the first place.

There can be substantial contractual innovation unprompted by changes in legal enforcement as, Kaplan, Martel and Stromberg (2007) have strikingly documented. In their study they track the evolution of venture capital (VC) contracts in over 20 countries outside the United States and compare them to US VC contracts. A key finding is that although contracts differ across jurisdictions, and thus seem at first sight to be constrained by local legal enforcement, the more experienced VCs end up writing the same US-style contracts independently of the local legal environment. Bienz and Walz (2008) provide other empirical support and find that exit rights for VCs are generally only written into the contract at later financing rounds, consistent with our hypothesis that VCs focus on exit rights only once exit issues become more pressing. They also find that older, hence more experienced, VCs write more complete contracts by including more control rights clauses into contracts. Another common VC contracting practice they highlight is the use of "term sheets", a form of preliminary contract containing general clauses of the form "other terms and conditions customary to VC financing will apply".

In the first-generation models of incomplete contracting theories à la Grossman and Hart (1986) and Hart and Moore (1988), agents are fully rational but unable to contractually specify transactions in some states of nature due to *exogenous* verifiability or describability constraints. Being fully rational, agents will always write the most complete contract they can, and contractual efficiency is always constrained by enforcement effectiveness. Moreover, since contract incompleteness is entirely driven by exogenous enforcement constraints, the contracting agents are unable to limit discretion contractually and are reduced to only determining optimal control allocations over decisions that cannot be written into the contract. Except that, as Maskin and Tirole (1999) have observed, rational agents may actually be able to write complete contracts by circumventing enforcement constraints through sophisticated Maskin (revelation) schemes.

Our analysis of incomplete contracts is related to the early work of Dye (1985), and a second generation of incomplete contracting theories, which includes Anderlini and Felli (1994, 1999, 2001), Al Najjar, Anderlini and Felli (2006), MacLeod (2000), Battigalli and Maggi (2002), Bajari and Tadelis (2001) and Hart and Moore (2008). These studies also provide theories of endogenous contractual incompleteness, but based on transaction costs such as the costs of writing detailed contracts or limits on language in describing certain transactions or contingencies.

In closely related independent work, Tirole (2009) also considers contracting between two boundedly rational agents. Contracts in his setup always specify a given action to be taken, but they are less likely to be renegotiated (more complete) when contracting agents have incurred larger cognitive costs. Although the basic setup he considers is quite different from ours, similar themes and results emerge, such as the endogenous incompleteness of contracts and the excessive completeness of equilibrium contracts. Unlike in our model, Tirole only allows for "effort costs of cognition" and does not explore the dynamics of contractual completion when agents face time-costs of deliberating transactions. He focuses on a hold-up problem and the value of exerting cognition effort in his model comes from the greater likelihood of solving a hold-up problem contractually up-front. Incurring cognition effort is valuable primarily to the agent making sunk investments and is otherwise of no social value. This is the main reason why contracts tend to be excessively complete in his setup. Some of our results on excessive completeness, however, differ conceptually from Tirole (2009) in that the excessive completeness is due to equilibrium underinvestment (rather than an over investment) in cognition. That is, in our setup the contracting parties may devote insufficient time learning about future payoffs because the potential conflicts they may have about future decisions reduce the value of information for each party.

Finally, our model and the second-generation theories can be seen as attempts to formalize different aspects of Williamson's (1979, 1985) transactions costs theory. As Williamson has forcefully argued, contracts in reality are likely to be incomplete primarily due to the costs of specifying transactions on paper and due to the bounded rationality of contracting agents. Interestingly, a major theme in Williamson's theory is that a key role of organizations is to move enforcement away from courts and inside firms, thereby dampening potential conflicts between agents and thus increasing the efficiency of incomplete contracts.

The paper proceeds as follows. Section 2 presents our model of contracting between two boundedly rational agents. Section 3 characterizes satisficing contracts when the parties have congruent underlying payoffs, and under the assumptions of (i) non-transferable utility and (ii) communication of hard information. Section 4 considers satisficing contracts when the parties have conflicting objectives, under the same assumptions of non-transferable utility, and communication of hard information. Section 5 considers extensions to communication of soft information and transferable utility. Section 6 concludes and an appendix contains the more involved proofs.

2. THE MODEL

Two infinitely lived agents, A and B, can join forces to undertake a new venture at time $t = 0$. The venture requires initial funding $I > 0$ from each agent. If investments are sunk at date $t \geq 0$, then at date $t + 1$ the venture ends up in one of two equally likely states: $\theta \in \{\theta_1, \theta_2\}$. In state θ_1 the two agents get the same known payoff $\pi \geq 0$. In state θ_2, the two agents face the collective decision of choosing between a *safe* and a *risky* action. The *safe* action yields known payoffs S_A and S_B, while the *risky* action yields either $(\underline{R}_A, \underline{R}_B)$ or $(\overline{R}_A, \overline{R}_B)$. To make the problem non-trivial, we assume

$$\overline{R} \equiv \overline{R}_A + \overline{R}_B > S \equiv S_A + S_B > \underline{R} \equiv \underline{R}_A + \underline{R}_B.$$

Thus the only uncertainty in the model is which state of nature will occur and the payoff of the risky action in state θ_2.

At $t = 0$, the beginning of the game, neither agent $k = A, B$ knows the true value of R_k and each agent starts out with prior belief $\nu = \Pr(R = \overline{R})$, which can be revised by engaging in *thought experimentation* over time as follows. If agent k experiments in a given period, he privately observes R_k with probability λ_k and nothing otherwise.

As long as neither agent has found out the true payoff of the risky action, either agent can and may want to continue to engage in thought experimentation. The agents can engage in thought experimentation before or after signing a contract, and before or after the state of nature θ is realized.

Both agents discount future returns by the same factor $\delta \leq 1$. Thought experimentation thus involves a time-cost when $\delta < 1$. This is the only cost of thinking in our model and, unlike in Tirole (2009), there is no other cognitive effort involved in thinking.

2.1. *Timing of the game*

We shall make the following timing assumptions:

1. Technological timing

At date 0, the agents can invest I right away or postpone investment. They can also engage in one round of thought experimentation. Investment can be undertaken only if both agents have agreed to invest.

Subsequent periods are essentially identical to date 0 until investment takes place. The only difference is that the agents may have been able to update their beliefs about the payoff of the risky action in state θ_2. Once investment has been completed, either state of nature θ_1 or θ_2 is realized one period later. When state θ_2 occurs, the agents either engage in more thinking or choose an action. Once an action has been chosen, payoffs are realized and the game ends.

2. Timing of the negotiation game

For expositional convenience we divide each period into two stages: a first stage when a contract (or renegotiation) offer is made and possibly accepted, and a second stage where agents can make investment decisions and engage in a round of thought experimentation, as described in the technological timing above.

We make the extreme simplifying assumption that at the beginning of date 0 nature randomly gives one of the two agents (*the proposer*) all the bargaining power and the exclusive right to make all contract offers. In each period until the contract is signed the proposer can choose to wait or offer a contract to the other party (*the receiver*), who can either accept or reject the offer. If no offer is made or if the offer is rejected, the game moves to the next period and starts over again. If the offer is accepted, the agents move on with the venture. If the contract is complete, post-contractual play is fully specified. If the contract is incomplete, the agents play a post-contractual game, which we describe in detail below (Figure 1).

2.2. *Information and contracts*

We assume that coming into date 0 neither agent has any private information about R_k and that agents' prior belief ν is common knowledge. Subsequently, however, each agent obtains private information about their payoffs through thought experimentation. Each agent can elect to disclose some of that information to the other agent. We shall distinguish between the cases of *hard information*, in which information can be credibly disclosed, and *soft information*, where communication is *cheap talk*.

We also distinguish between two polar contracting environments: one where the agents' utility is perfectly transferable (*the TU case*) and the other where utility is non-transferable (*the NTU case*).

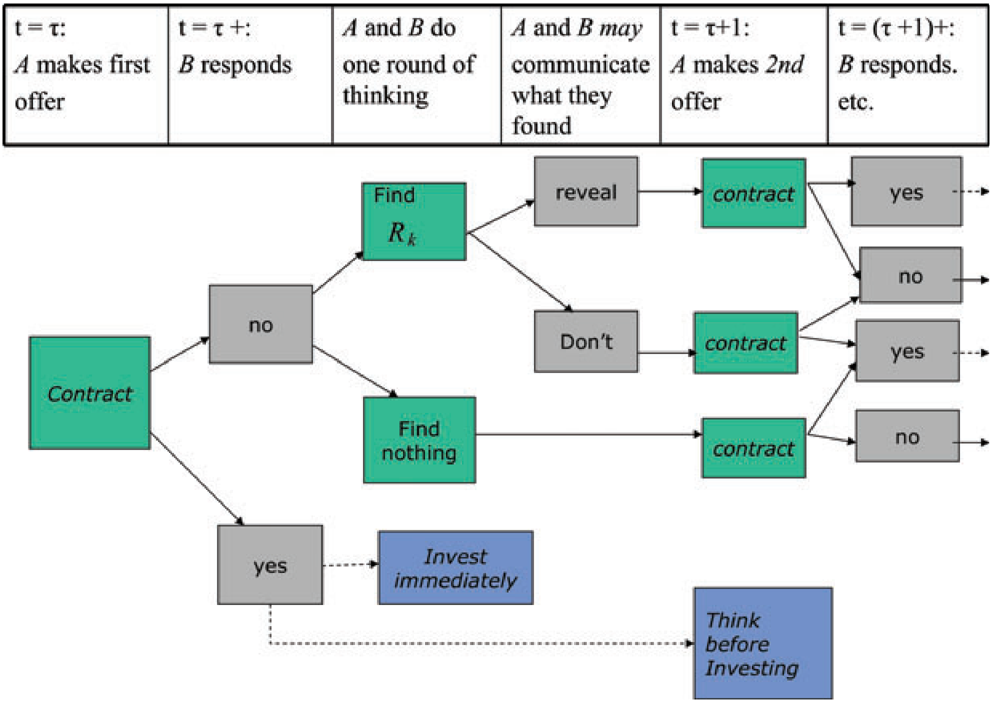

FIGURE 1

Time line

Throughout most of our analysis we focus on the case where utility is non-transferable and where private information can be credibly disclosed. We consider the cases of perfectly and partially transferable utility, as well as cheap talk communication in three extensions.

2.3. *Assumptions on payoffs*

We denote by

$$\rho_k^* \equiv \nu \max\{\overline{R}_k, S_k\} + (1-\nu)\max\{\underline{R}_k, S_k\}$$

each party's expected payoff under their preferred *ex post* action choice and by

$$\rho_k \equiv \nu\overline{R}_k + (1-\nu)\underline{R}_k$$

the expected payoff of the risky action. We make the following assumptions on payoffs throughout the analysis:

Assumption A1. $\frac{\delta(\pi+S_k)}{2} > I$ and $\rho_k > S_k$.

Assumption A1 guarantees that the project is valuable for both agents when the safe action is chosen in state θ_2. Moreover, both agents prefer the risky over the safe action given their prior beliefs. As will become clear below, this assumption is not essential and our analysis can be extended to the case where agents prefer the safe over the risky action when they are uninformed.

We consider in turn the situations where the agents have *congruent underlying objectives* over which action to choose, and where they have *conflicting objectives* on the preferred action plan. In the first situation, the two agents can only disagree on how quickly to act, or, in other words, on how far ahead to plan.

2.4. *Discussion of the model and assumptions*

Our model imposes several restrictive assumptions, some of which are mostly for analytical convenience but others importantly limit the scope of our analysis and should be relaxed in future research. First, we have imposed a number of symmetry assumptions on payoffs, such as equal investments I for the two agents, equal payoffs π in state θ_1, common priors ν and common discount factors δ. The role of these assumptions is mainly to reduce the number of cases to analyse. Our analysis could be straightforwardly extended by allowing for differences between the two agents in each of these parameters. In fact, we consider an example with different investments and different payoffs in state θ_1 for the two agents in Section 4. Allowing for different discount factors would not affect our analysis significantly to the extent that we already have different underlying payoffs R_k and S_k. Differences in discounted values can already be captured by allowing for different underlying payoffs. Perhaps the most important limitation is the assumption of common priors combined with Assumption A1. These assumptions exclude interesting contracting situations where the two agents have *ex ante* conflicting objectives, but congruent underlying payoffs R_k.

The two polar cases of non-transferable and perfectly transferable utility are clearly extreme and unrealistic. Most contracting situations in reality involve partially transferable utility, as contracting parties often have limited wealth, which imposes constraints on the size of transfers they can agree to. In addition, incentive and information considerations also limit the extent to which future returns from ventures can be pledged, as Holmstrom and Tirole (1998) have argued. A general analysis of equilibrium contracting with partially transferable utility is substantially more involved and is beyond the scope of this article. However, we provide a brief analysis of a start-up financing example with limited transferability of utility in Section 5.

Our bargaining game is also overly simple and extreme. In reality all contracting agents can make offers and counter-offers even if they do not all have the same bargaining power. However, allowing for a general alternating-offer bargaining game à la Rubinstein (1982) would substantially complicate the analysis. Interestingly, some of our results, such as Propositions 1, 2 and 4, are robust to different ways of modelling the bargaining process, including allowing for offers and counter-offers as in Rubinstein (1982), but the other results are sensitive to how we model bargaining. Still, the main qualitative insights of our analysis concerning contractual incompleteness and the excessive completeness of equilibrium contracts when agents have conflicting objectives are likely to be robust to changes in the bargaining game.

Finally, an important restrictive assumption of our setup is that agents only incur time costs of deliberating decisions and do not otherwise incur any cognitive effort costs. Adding such cognition costs is likely to fundamentally alter our analysis. It would imply that (i) agents need to be rewarded for thinking; (ii) agents may free-ride on the costly thinking of others; and (iii) once an agent has incurred cognition costs he may be held up by the other agent, as in Anderlini and Felli (2001). The analysis of the TU case is most likely to be changed fundamentally by this addition, since it will not generally be possible to simultaneously align agents' objectives through transfers and provide all agents with adequate incentives to think.

2.5. *A real-world example*

There are many examples of contracting on new ventures in reality that fit the broad description of our model. One recent example that may help put the formal analysis in context is that of a large Canadian software company, Cognos Inc., that has launched a new search tool in partnership with IBM and Google to facilitate the search for information within large companies.[3] The contracting problem between the three partners to set up the joint venture can be analysed in terms of our model. First, each company is providing resources in terms of funding, staffing, human capital and know-how to the venture. Second, the new software to be marketed may either work out as initially foreseen and no further major new planning or decision is required (this is analogous to our state of nature θ_1), or the new software product may have bugs, may require new security patches, may be incompatible with some clients' operating systems, etc., in which case a major review of the venture may be required (this is analogous to our state of nature θ_2). In highly simplified terms, the business decision faced by the venture in state θ_2 is to either limit the product offer to a more basic well-functioning software program, or to pursue a more ambitious and risky course, which requires resolving the glitches encountered in the first development phase. Which of these two actions to take may be unclear, may involve conflicts among the partners and may require further thinking.

Thinking ahead about all possible software glitches is time consuming and the opportunity cost of delaying the launch of a beta version, say, could be very high, as the joint venture might lose its first mover advantage. On the other hand, if the partners expect that it is very likely that state of nature θ_2 might arise, then they may prefer to delay launching the product, prepare ahead for possible future upgrades and thus reduce the competitive threat from followers entering the market with a slightly improved software.

The partners to this joint venture may approach the contracting problem they face as in our formal analysis. For example, they may choose to write a *preliminary agreement* to begin with, which establishes a general commitment to the joint venture without tying down the partners to a specific action plan. Subsequently, the parties may spend potentially considerable time to work out a long-term contract which narrows down a more specific action plan, allocation of (state-contingent) control rights and the time of the initiation of the venture. Finally, after the product development phase, the partners learn which state of nature they find themselves in. Should they end up in state θ_2, then depending on what the initial long-term contract has specified, the partnership will pursue an already predetermined plan of action, or if the initial contract left open what course to pursue in this event, the partnership will have to make a decision on what actions to take, according to the procedures specified in the initial contract. In sum, the three partners to the joint venture will have to determine the optimal incompleteness and coarseness of the initial long-term contract governing the joint venture.[4]

3. SATISFICING CONTRACTS UNDER CONGRUENT OBJECTIVES

In this section we consider the contracting game when the two agents' objectives are congruent. We define the agents' underlying preferences to be congruent when the following assumption holds:

Assumption A2. $\overline{R}_A > S_A > \underline{R}_A$ and $\overline{R}_B > S_B > \underline{R}_B$.

3. See, *Cognos to launch new search tool with IBM, Google,* 19 April 2006, CMP TechWeb, and *Tech firm to offer search tool with IBM, Google*, 20 April 2006, The Toronto Star.

4. See Gilson, Sabel and Scott (2008) for several examples of such incomplete contracts for innovation.

Under Assumption A2 both agents agree on the action choice once they know their true payoffs.

The contracting game begins at date 0 with nature selecting the contract *proposer*. We shall take it that agent A is the proposer and B the *receiver*. If B accepts A's offer, the continuation game is dictated by the terms of the contract. If A does not make an offer or if B rejects the contract, then each agent engages in one round of thought experimentation and communication before moving on to the next period. In the next period again A gets to make a contract offer, and so on, until an offer is accepted by B.

The set of relevant contract offers for A under our assumption that utility is not transferable can be reduced to essentially six contracts, $\mathbb{C} = \{C_R, C_S, C_A, C_B, C_{AB}, C_\alpha\}$, and any probability distribution over $\mathbb{C}$, where:

1. C_R requires the immediate choice of the risky action r in state θ_2 following investment;
2. C_S requires the immediate choice of the safe action s in state θ_2 following investment;
3. C_A allocates all control rights to agent A following investment. The controlling party can decide which action to take in state θ_2 at any time she wants;
4. C_B is identical to C_A except that it allocates all control rights to agent B;
5. C_{AB} is identical to C_A except that it requires unanimous agreement to select an action;
6. C_α is what we refer to as a *preliminary contract*. Under this contract the parties agree to first find out what the payoffs of the risky action are and to invest only once they have agreed on a final contract $C \in \{C_R, C_S\}$.[5]

There are only six contracts to consider, as there are in effect only two decisions to determine in a contract: whether to commit to the safe or risky action ahead of the realization of state θ_2, and whether to leave the choice of action open. When the latter course of action is chosen, the parties must also determine who gets to choose the action in state θ_2 and under what circumstances. There are then effectively only four options: control to A, control to B, joint control or a pre-specified rule on how future information about payoffs maps into a choice of action.

Even if agents have congruent underlying preferences, they may still have disagreements under incomplete information. In particular, they may have different preferences on how quickly to invest due to differences in how patient they are. To see this, note first that when the agents engage in thought experimentation in a given period, and share their thoughts, they uncover the true payoff of the risky action in a given period of time with probability

$$\Lambda \equiv 1 - (1 - \lambda_A)(1 - \lambda_B).$$

Now, suppose that the agents find themselves in state θ_2 and are uninformed. If the two agents delay any action choice and engage in thought experimentation until they learn the true payoff R_k, they can each expect to get

$$\Lambda\rho_k^* + \Lambda(1-\Lambda)\delta\rho_k^* + \Lambda(1-\Lambda)^2\delta^2\rho_k^* + \cdots = \widehat{\Lambda}\rho_k^*$$

where

$$\widehat{\Lambda} = \frac{\Lambda}{1 - (1-\Lambda)\delta}$$

can be interpreted as an *effective discount factor*.

5. We consider this contract in Section 4.2.

Clearly, it is possible that

$$\widehat{\Lambda}\rho_A^* < \rho_A \text{ and } \widehat{\Lambda}\rho_B^* > \rho_B$$

even under Assumption A2.[6] In this case, the two agents disagree on the best course of action in state θ_2: A prefers to take the risky action immediately, while B prefers to learn R_k first before deciding on an action.

It is helpful to begin our analysis by studying first the contracting outcome when both agents have "unbounded rationality". This corresponds to the situation in our model where there is nothing to be learned ($\nu = 0$ or $\nu = 1$).

3.1. *An "unbounded rationality" benchmark*

When either $\nu = 1$ or $\nu = 0$, the equilibrium outcome of the contracting game is to sign a contract requiring immediate investment. If $\nu = 1$, the contract specifies the risky action and if $\nu = 0$, it specifies the safe action in state θ_2. Indeed, in this case payoffs are known and when $\nu = 1$ agents agree that the best action choice in state θ_2 is the risky action (as $\overline{R}_k > S_k$ by Assumption A1) and when $\nu = 0$ they agree that the safe action is best (as $\underline{R}_k < S_k$). Another optimal contract is to give discretion to one or both of the agents over the action choice in state θ_2. The agents' respective payoffs are

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}\overline{R}_k,$$

when the risky action is optimal, and

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}S_k,$$

when the safe action is optimal.

To see that this is an equilibrium outcome, note that since A and B's preferred action plan is the same, when A offers a contract requiring investment at date 0 and specifying his preferred action plan, B is strictly better off accepting the offer. Importantly, there is no (strict) role for control rights in this case and the initial contract fully specifies the entire action plan.[7] This is not surprising given that the two agents can write fully enforceable complete contracts.[8]

6. To see this, suppose that Assumption A2 holds, and note that $\widehat{\Lambda}\rho_A^* < \rho_A$ and $\widehat{\Lambda}\rho_B^* > \rho_B$ are equivalent to, respectively,

$$\widehat{\Lambda}(\nu\overline{R}_A + (1-\nu)S_A) < \nu\overline{R}_A + (1-\nu)\underline{R}_A \tag{1}$$

and

$$\widehat{\Lambda}(\nu\overline{R}_B + (1-\nu)S_B) > \nu\overline{R}_B + (1-\nu)\underline{R}_B. \tag{2}$$

Now, since $\widehat{\Lambda} < 1$, inequality (1) holds in the limit when $\underline{R}_A \longrightarrow S_A$. As for inequality (2), it holds for all $\widehat{\Lambda} \in \left(\frac{\nu\overline{R}_B+(1-\nu)\underline{R}_B}{\nu\overline{R}_B+(1-\nu)S_B}, 1\right]$. Note that by Assumption A2 we have

$$\frac{\nu\overline{R}_B + (1-\nu)\underline{R}_B}{\nu\overline{R}_B + (1-\nu)S_B} < 1.$$

7. A contract giving full control to the proposer or the receiver may also be an equilibrium contract. However, this contract can never be strictly preferred to the optimal complete contract.

8. As is well known, when rational agents can write complete, state-contingent, fully enforceable contracts under symmetric information, there is no role for control (see, e.g. Hart, 1995; Bolton and Dewatripont, 2005).

In contrast, as we shall show below, *boundedly rational agents* may *agree on an incomplete contract*, which leaves open the action choice in state θ_2 and gives control to one or both agents.

3.2. *Full disclosure*

The typical contracting game considered in the literature boils down to a contract offer by the proposer followed by an accept/reject decision by the receiver.[9] The central new difficulty in our game is that both agents can learn something (privately) about their payoffs between two rounds of offers, so that the negotiation game can evolve into a game of incomplete information even though it starts out as a game of symmetric information. This is, we believe, an inevitable feature of any game of contracting between boundedly rational agents, who can each learn over time about their payoffs in the contracting relation. It turns out, however, that the negotiation game reduces to a game of complete information under our twin assumptions that (i) any information learned can be credibly disclosed, and (ii) the two agents have congruent underlying preferences.

Lemma 1. *Under Assumptions A1 and A2, a strategy of revealing all new information to the other party is a subgame-perfect equilibrium strategy of the contracting game for each agent.*

Proof. This observation follows immediately from the observations that (i) once the information is shared, agents have fully congruent objectives under the stated assumptions; and (ii) not revealing what a party has learned can only delay the time at which payoffs are received and cannot result in higher payoffs. As each party gets strictly positive payoffs (under Assumption A1), it follows that immediate truthful disclosure is a weakly dominant strategy. ||

3.3. *Complete satisficing contracts*

We refer to equilibrium contracts as *satisficing contracts* to convey the idea that when contracting agents face positive deliberation costs they may agree on contracts in equilibrium that are satisfactory but not optimal from the perspective of rational agents who do not incur any deliberation costs. We begin by observing that, when the value of thinking is positive and the opportunity cost of delaying investment is negative, then satisficing contracts will be complete. Formally, a situation with a positive value of information and negative costs of delay is characterized by the following assumption on payoffs.

Assumption A3. $\widehat{\Lambda}\rho_k^* > \rho_k$ and $I > \frac{\delta\pi}{2}$.

The first inequality implies that both agents prefer to find out first which action is optimal before taking an action. Under full disclosure (Lemma 1), agent k expects to get $\widehat{\Lambda}\rho_k^*$ when both agents set out to think ahead about which action is optimal, while if they immediately choose the preferred action given their prior belief, agent k only gets ρ_k. The second inequality implies that thinking ahead involves no opportunity cost.

When there is a positive value of information and a negative cost of delay, it is intuitive that the two agents will want to delay investment and first determine the optimal action in state θ_2.

9. If the contract is rejected, the game ends and each party gets their reservation utility and, if the contract is accepted, the game proceeds to the implementation phase of the contract.

Proposition 1 (Complete Satisficing Contracts). *Under Assumptions A1, A2 and A3, the equilibrium of the contracting game involves thinking ahead of investing followed by the offer of either contracts C_R or C_S.*

Proof. First, when $I > \frac{\delta\pi}{2}$ the strategy of immediately investing and waiting for the realization of θ before thinking about which action is optimal is dominated for each agent k by the strategy of thinking about the optimal action before investing and ahead of the realization of θ. Under the latter strategy, agent k obtains:

$$\widehat{\Lambda}\left(-I + \frac{\delta\pi}{2} + \frac{\delta\rho_k^*}{2}\right) \tag{3}$$

while, under the strategy of investing immediately and thinking about the optimal action after the realization of θ_2 agent k gets:

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}\widehat{\Lambda}\rho_k^*. \tag{4}$$

The former is preferred to the latter strategy if and only if:

$$\widehat{\Lambda}\left(-I + \frac{\delta\pi}{2} + \frac{\delta\rho_k^*}{2}\right) > -I + \frac{\delta\pi}{2} + \frac{\delta}{2}\widehat{\Lambda}\rho_k^*$$

or, rearranging, if

$$(1 - \widehat{\Lambda})\left(-I + \frac{\delta\pi}{2}\right) < 0. \tag{5}$$

Under Assumption A3 this inequality always holds, since $\widehat{\Lambda} < 1$.

Second, when $\widehat{\Lambda}\rho_k^* > \rho_k$, both agents prefer to think before acting in state θ_2. This implies that an offer by A of either C_A, C_B or C_{AB} at date 0 would be dominated by a strategy of waiting and thinking before investing. Similarly, offering to invest immediately at date 0 under contract C_R is also dominated.

Given Lemma 1, the uniquely optimal strategy for agent A (the proposer) is then to wait and think until the two agents have learned and communicated the optimal action. At that point, agent A offers C_R if the risky action yields a higher payoff, or C_S if the safe action is preferred. Given A's strategy, B's best response is to think until she learns the optimal action, to disclose it to A if she learns it first, and to accept agent A's subsequent offer. ||

3.4. *Incomplete satisficing contracts*

In contrast, when there is a cost of delaying investment, one should expect satisficing contracts to sometimes be incomplete. Such situations arise under the following assumption.

Assumption A4. $\widehat{\Lambda}\rho_k^* > \rho_k$ *and* $I < \frac{\delta\pi}{2}$.

Indeed, delaying investment involves an opportunity cost when $I < \frac{\delta\pi}{2}$. In light of our discussion above, it is easy to see that under this assumption the two agents are better off investing immediately and postponing thinking about the optimal action until after the realization of state θ_2.

Proposition 2. *Under Assumptions A1, A2 and A4 the equilibrium of the contracting game involves an immediate offer of either contracts C_A, C_B or C_{AB}. Either of these contracts is* *accepted by agent B. Following the realization of state θ_2, agents think about the optimal action and the controlling party selects the optimal action once it is identified.*

Proof. Under Assumption A4, condition (5) is violated and therefore both agents prefer to invest at date 0 and think about the optimal action after the realization of θ_2. Thus, an equilibrium strategy for A is to offer at date 0 either contracts C_A, C_B or C_{AB}, and to do the same in future periods should B reject the offer and should the agents remain uninformed. Otherwise, if the agents learn the optimal action, offer either contracts C_R or C_S. Party B's best response to A's strategy is to accept A's offer at date 0. ||

Under Assumption A4, the venture is so profitable that the agents agree to a contract involving immediate investment so as to bring forward the time when they realize the returns from their investment. As they have congruent underlying preferences, they do not care who has control, so that either control allocation C_A, C_B or C_{AB} can be an equilibrium outcome. However, we next show that, even when the two agents have congruent underlying preferences, the indeterminacy over control allocations disappears when the two agents have different preferences over how much thinking to undertake before investing.

3.5. *Conflicts over cautiousness and the allocation of control rights*

We now consider situations in which the two agents disagree on how quickly to act and how much planning to undertake before investing. This is the case when Assumption A5 holds.

Assumption A5. $\widehat{\Lambda}\rho_A^* < \rho_A$, $\widehat{\Lambda}\rho_B^* \geq \rho_B$ *and* $I < \frac{\delta\pi}{2}$.

Under this assumption, A is *impatient* and prefers to invest immediately and to choose the risky action in state θ_2. Agent B, on the other hand, is more *cautious* and prefers to take her time to think through what is the best action in state θ_2.[10]

We shall show that the equilibrium outcome of the contracting game between the two agents under these circumstances may be for the more *impatient* party to relinquish control to the more *patient* party, paradoxically as a way of accelerating the implementation of the project. The intuition is that the more patient party may agree to an earlier implementation of the project if she has control, as control gives her the right to block hasty future decisions and thus allows her to *defer thinking* about future decisions to the time when they arise. As a result, she is prepared to commit to the project sooner.

Proposition 3. *When agent A is the proposer, and under Assumptions A1, A2, A5 and condition*

$$-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B}{2} < \widehat{\Lambda}\left(-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B^*}{2}\right) \tag{6}$$

10. Note that in a more general model the impatience of agent A and patience of B may be due more directly to different discount factors, with say, $\delta_A < \delta_B$, so that $\widehat{\Lambda}_A < \widehat{\Lambda}_B$. In such a model, we may have conflicts over cautiousness even if underlying payoffs are the same, $R_A = R_B$ and $S_A = S_B$. That is, we may have:

$$\widehat{\Lambda}_A\rho^* < \rho \text{ and } \widehat{\Lambda}_B\rho^* \geq \rho.$$

the equilibrium play is for agent A to offer immediately contract C_B with probability y^* and C_R with probability $(1-y^*)$, where y^* is given by:

$$-I+\frac{\delta\pi}{2}+y^*\widehat{\Lambda}\left(\frac{\delta\rho_B^*}{2}\right)+(1-y^*)\frac{\delta\rho_B}{2}=\widehat{\Lambda}\left[-I+\frac{\delta\pi}{2}+\frac{\delta\rho_B^*}{2}\right].$$

When the reverse condition holds, agent A immediately offers contract C_R.

Proof. See the Appendix. ||

Corollary 1. *If the more patient party (agent B) is the proposer then this party optimally retains full control.*

Under condition (6), B prefers to reject contract offers C_R, C_S and C_A, and to keep thinking ahead until she determines the optimal action in state θ_2. But A would prefer to get B to agree to invest immediately. He can only do so if B has some guarantees not to be forced into a hasty decision in state θ_2. Therefore, he grants B some control rights by offering either contracts C_B or C_{AB} with positive probability.

There is a cost for A in giving up control to B, as B would exercise control in state θ_2 by taking time to think through which of the safe or risky actions is the preferable choice. Agent A, however, would prefer not to waste time deliberating about the action choice in state θ_2 and to immediately take the risky action upon realization of the state of nature. Hence, agent A will not give up more control than y^*, the minimum probability of control transfer required to get B to sign on to the venture at date 0.

Proposition 3 thus establishes that the *impatient* proposer may prefer to leave the action choice in state θ_2 open and give up some control, to get the *patient* receiver to commit to the project sooner and refrain from spending too much time fine-tuning the details of the deal. By giving up control A gives B the option to fine-tune details later if needed, and thus avoids the opportunity cost of delaying investment.[11]

Propositions 2 and 3 are among our main results. Each proposition establishes first that in a world where complete contracts are fully enforceable, "boundedly rational" agents optimally choose to write incomplete contracts with control rights over future decisions left unspecified in the contract. As in other models of incomplete contracts, Proposition 3 also establishes that the way control is allocated is in part driven by the agents' relative bargaining strengths. Thus, the proposer tends to appropriate more control, other things equal. But, remarkably, Proposition 3 further establishes that an impatient proposer may choose to give some control rights to the other more patient party, as a way of accelerating the closure of contract negotiations.[12]

Interestingly, in situations where the transfer of control rights may not be legally enforceable, party B can still impose her preferred action. However, the equilibrium of the contracting

11. Note that when Assumption A1 is not satisfied we may have situations where:

$$\nu\overline{R}_A+(1-\nu)\underline{R}_A>S_A \text{ but } \nu\overline{R}_B+(1-\nu)\underline{R}_B<S_B.$$

That is, the two agents have non-congruent objectives *ex ante*, even though their underlying preferences are congruent. In such situations the logic of Proposition 3 still applies.

12. This transfer of control would come at the cost of an efficiency loss in the exercise of control by the patient party if the parties can only engage in *cheap talk*. As we explain in Section 4.2, agent A might then always claim that the risky action is optimal no matter what he learns about the true underlying payoffs. There would then be imperfect communication between the parties and therefore learning about payoffs would be slower. Our assumption that the parties can communicate hard information thus plays an important role here.

game would then involve party B waiting until she has determined the preferred complete action plan before agreeing to participate in the venture. Thus, our analysis suggests, paradoxically, that a condition for the emergence of equilibrium incomplete contracts could be that the legal infrastructure is sufficiently developed that the enforcement of control rights is possible.

Note finally that the situation where A has no choice but to wait until B has determined a complete action plan can also arise when control rights are fully enforceable. Indeed, we describe a contracting situation below where party A is keen to close a deal immediately but B prefers to think ahead, and where equilibrium play is such that A completely caves in on B's demands and ends up writing an excessively complete contract (from A's perspective). This situation differs from the one we have considered in the following way.

Assumption A6. (i) $\widehat{\Lambda}\left(-I+\frac{\delta\pi}{2}+\frac{\delta\rho_A^*}{2}\right)<-I+\frac{\delta\pi}{2}+\frac{\delta\rho_A}{2}$,
(ii) $\widehat{\Lambda}\rho_B^* \geq \rho_B$, and
(iii) $I>\frac{\delta\pi}{2}$.

As before, Assumptions A6.(ii) and A6.(iii) ensure that there is no opportunity cost in thinking ahead and delaying investment for B. At the same time, under Assumption A6.(i), A's preferred course of action remains investing immediately. However, although A makes contract proposals, the bargaining power is effectively with B, who can credibly reject all offers until after underlying payoffs are known. In this situation, the preferred outcome for A is to invest immediately and choose action r without thinking, while the worst outcome is to invest immediately and think after the realization of θ_2. As for B, she prefers to think ahead to any other alternative. Remarkably, B in this situation fully gets her way even though she has no bargaining power.

Proposition 4. *Under Assumptions A1, A2 and A6 agent A has no choice but to follow B's preferred path of action, which is to invest only after payoffs in state θ_2 have been uncovered. When this is the case, the equilibrium contract is either C_R when $R_k=\overline{R}_k$ or C_S when $R_k=\underline{R}_k$.*

Proof. See the Appendix. ||

Interestingly, the equilibrium outcome of the contracting game may in some sense be inefficient, as the agents' joint welfare may be lower than under A's most preferred course of action. The reason is that B does not internalize A's opportunity cost of delayed investment and A is unable to compensate B to get her to accept A's preferred action.

4. CONFLICTING UNDERLYING OBJECTIVES

How do conflicts over action choice affect equilibrium contracting? In first generation models of incomplete contracting—in which contractual incompleteness is exogenously fixed—allocating control to the right agent is more important the more agents disagree on the choice of action (Aghion and Bolton, 1992). In our setting instead, greater conflicts between agents are resolved through more complete contracts that generally give less discretion to the party in control. In other words, control is less relevant when there are greater conflicts between the parties. There are three related reasons why equilibrium contracts leave less room for discretion.

First, note that control rights may be as much a form of protection to the holder of the rights as a threat to the non-controlling party. Each party is concerned about potential abusive exercise of control by the other party and therefore may prefer to negotiate specific contractual guarantees rather than give up control.

Second, when the agents have conflicting goals, they are likely to *miscommunicate*. That is, each party will have incentives to suppress information detrimental to itself but beneficial to the other party. As a result, the agents will learn more slowly as a group and the value of information is reduced. The lower value of information in turn induces the contracting parties to do less *fine-tuning* and to write *coarser* but more complete satisficing contracts.

Third, because the holder of control rights may have to accept limits on the exercise of control (to get the other party to participate), the value of control is reduced. Therefore, again, agents may prefer to sign a coarse and more complete contract rather than leaving the choice of actions in some states of nature open to be determined later.

Note finally that the agents are less likely to miscommunicate as long as they have not signed any contract and are free to walk away from the deal. The reason is simply that they are then less concerned about disclosing information that might be used against them. For these reasons, anticipated future conflicts introduce a bias towards thinking ahead or not thinking at all, which leads to more complete satisficing contracts.

To focus on the consequences of non-congruent underlying objectives, we assume that the agents always *disagree* on which action is best under complete information:

Assumption A7. $\overline{R}_A < S_A < \underline{R}_A$ and $\overline{R}_B > S_B > \underline{R}_B$.

Although the agents disagree on what to do under complete information, we shall for the most part continue to assume that their *ex ante* expected payoffs remain aligned. That is, we shall maintain Assumption A1, which states that *both agents* prefer the risky action over the safe action under their common prior beliefs ν.[13]

4.1. *Miscommunication and the lower value of control*

Consider first the situation where the conflict is so severe that each party is better off liquidating the venture *ex post* than have its least preferred action chosen. Moreover, one party's least preferred action is the other party's most preferred action. Such a situation arises whenever the following assumption holds:

Assumption A8. $\overline{R}_A < 0$ and $\underline{R}_B < 0$.

We shall refer to this situation as one where the exercise of control is *abusive*. The reason is that Assumptions A7 and A8 together imply that any party in control in state θ_2 takes an action that produces a negative payoff for the non-controlling party, a worse outcome than inaction which yields a zero payoff.

Recall that when both agents have congruent underlying objectives, the net value for agent k of determining the optimal action choice in state θ_2 (when this choice is left to be determined after state θ_2 arises) is given by

$$\widehat{\Lambda}\rho_k^* - \rho_k.$$

This value can be obtained through the parallel thinking efforts of the two agents combined with full communication of any information obtained by the two agents.

13. Note that Assumptions A1 and A7 can only be consistent for interior values of prior beliefs ν.

When there are underlying conflicts among the two agents, the value of thinking before acting in state θ_2 is generally lower, as the agents no longer "share all their thoughts" when they have conflicting goals and stop fully communicating what they have learned. The next subsection illustrates the complexities of the dynamics of learning and disclosure in this situation.

4.1.1. The dynamics of communication and learning. The non-controlling party is understandably reluctant to disclose information to the controlling party that could be used against her. Thus, consider the situation the agents face under contract C_A when they are uninformed in state θ_2.

Suppose first that B learns $R_k = \underline{R}_k$. She then prefers to postpone the time when the risky action is chosen by A (as she then gets a *discounted* negative payoff $\underline{R}_B$). She therefore suppresses this information and reports that she did not learn anything. Hence, A can only discover this payoff on his own with probability λ_A. Note, however, that if A learns nothing after one round of thought experimentation (with probability $1 - \lambda_A$) and B reports nothing, A updates his estimate of $\Pr(R_k = \underline{R}_k)$ from his prior $(1 - \nu)$ to

$$1 - \nu_1 \equiv \frac{(1-\nu)}{\nu(1-\lambda_B) + (1-\nu)}.$$

Similarly, after τ rounds of experimentation in which A has learned nothing and B has reported nothing, A's posterior belief that $R_k = \underline{R}_k$ becomes

$$1 - \nu_\tau \equiv \frac{(1-\nu)}{\nu(1-\lambda_B)^\tau + (1-\nu)},$$

which converges to 1. After a sufficiently long run of unsuccessful trials, it is then optimal for A to stop experimenting and to choose the risky action.

Agent A's optimal stopping time τ_A and posterior ν_{τ_A} are such that A is indifferent between taking the risky action immediately or continuing thinking for one more round:

$$\begin{aligned} \nu_{\tau_A}\overline{R}_A + (1-\nu_{\tau_A})\underline{R}_A = \delta[&\nu_{\tau_A} S_A \Lambda + (1-\nu_{\tau_A})\lambda_A \underline{R}_A \\ &+ ((\nu_{\tau_A}(1-\Lambda) + (1-\nu_{\tau_A})(1-\lambda_A))(\nu_{\tau_A+1}\overline{R}_A + (1-\nu_{\tau_A+1})\underline{R}_A)] \end{aligned} \tag{7}$$

(ignoring integer constraints).[14]

Although B does not disclose anything, A still learns something from B's silence. Even if A cannot tell for sure what the true payoff of the risky action is, when his beliefs have been updated to the point where he estimates that the risky action yields a payoff $\overline{R}_A$ with probability ν_{τ_A}, agent A is better off stopping to think further and choosing the risky action.

Suppose next that B learns $R_k = \overline{R}_k$. Although B is less reluctant to disclose this information—for then A responds by choosing the safe action with a positive payoff S_B for B—she may still choose to withhold that $R_k = \overline{R}_k$. The reason is that by withholding this information she may be able to induce A to choose the risky action (a preferred choice as $\overline{R}_B > S_B$ under Assumption A7). More precisely, when A's beliefs are near ν_{τ_A} (so that A prefers to stop if he remains uninformed about the optimal action) B is better off withholding the information that $R_k = \overline{R}_k$. But when A's belief ν is low, then A prefers to continue thinking when uninformed, in which case B's best response is to disclose $\overline{R}_k$, so as to bring forward the time when A chooses the safe action.

14. If the optimal stopping time τ_A that solves equation (7) is not an integer, then agent A stops thinking at the earliest time when he strictly prefers to stop thinking.

Thus, the strategic difficulty in this situation is that B's best response varies with A's belief ν. Moreover, A's best response also depends on B's disclosure policy. When A's belief is near ν_{τ_A}, A prefers to stop thinking if he expects B to disclose $R_k = \overline{R}_k$, but to continue thinking if he expects B to withhold $R_k = \overline{R}_k$.

In short, a pure strategy equilibrium in stopping times and disclosure strategies cannot exist in this situation. However, as the next lemma establishes, a mixed strategy equilibrium always exists.

We denote by $\widehat{\tau}$ the first time at which A's beliefs $\nu_{\widehat{\tau}}$ are such that A prefers to continue thinking if B is expected to stop withholding $\overline{R}_k$ at time $\widehat{\tau} - 1$, but to stop if B is expected to only stop withholding $\overline{R}_k$ at time $\widehat{\tau}$.

Lemma 2. *Under Assumptions A7 and A8, when the agents are uninformed in state θ_2, the only equilibrium under contract C_A that exists is a mixed strategy equilibrium, where both A randomizes between stopping and continuing to think and B randomizes between disclosing and stopping to disclose $\overline{R}_k$ at any time $\tau \geq \widehat{\tau} + 1$.*

Proof. See the Appendix. ||

4.2. *Coarse contracts*

As the value of thinking before acting in state θ_2 is lower when there are underlying conflicts among the two agents, the *ex ante* value of leaving decisions to be fine-tuned when the state of nature arises is also lower. The implication, as we show here, is that the two agents may then prefer not to fine-tune their action choice and to write a complete contract with a coarse action plan. We refer to such contracts as *coarse contracts*.

Given that the agents do not cooperate in thinking through the best plan of action in state θ_2, the value of control for A under contract C_A is now no more than

$$V^A \equiv \sum_{\tau=1}^{\widehat{\tau}} [\nu S_A \Lambda (1 + (1-\Lambda)^\tau \delta^\tau) + (1-\nu)\lambda_A \overline{R}_A (1 + (1-\lambda_A)^\tau \delta^\tau)] \\ + \delta^{\widehat{\tau}} (\nu_{\widehat{\tau}} \overline{R}_A + (1-\nu_{\widehat{\tau}}) \underline{R}_A).$$

(Note that since A is indifferent between stopping or continuing thinking at $\widehat{\tau}$ his payoff at $\widehat{\tau}$ is given by $\nu_{\widehat{\tau}} \overline{R}_A + (1-\nu_{\widehat{\tau}}) \underline{R}_A$.)

The main difficulty in our analysis here is the characterization of the first stopping time $\widehat{\tau}$. However, for some parameter values we can establish that A prefers to stop thinking right away—so that $\widehat{\tau} = 0$—even if thinking is optimal if the agents cooperate. This is so if:

$$\rho_A \geq (\nu S_A \Lambda + (1-\nu)\underline{R}_A \lambda_A) + \delta[\nu(1-\Lambda) + (1-\nu)(1-\lambda_A)]\rho_A,$$

which can be rewritten as:

$$\rho_A \geq \frac{\nu S_A \Lambda + (1-\nu)\underline{R}_A \lambda_A}{1 - \delta(1 - (\nu\Lambda + (1-\nu)\lambda_A))}. \tag{8}$$

To side-step the difficulty of characterizing the optimal first stopping time $\widehat{\tau}$ in general, we restrict attention to parameter values for which $\widehat{\tau} = 0$. Thus, we assume henceforth,

Assumption A9. $\rho_A \geq \frac{\nu S_A \Lambda + (1-\nu)\underline{R}_A \lambda_A}{1-\delta(1-(\nu\Lambda+(1-\nu)\lambda_A))}$.[15]

Recall that when Assumption A4 holds (that is $\widehat{\Lambda}\rho_k^* > \rho_k$ and $I < \frac{\delta\pi}{2}$) and when the agents have congruent underlying preferences, then satisficing contracts are incomplete and assign control to one or both agents (Proposition 2). In contrast, as we show below, when the agents have non-congruent preferences, they will sign a complete but *coarse* contract under the same circumstances.

We have already established that under Assumption A9, A cannot do better under contract C_A than under contract C_R. Similarly, when the agents sign contract C_{AB} in this situation, the best they can do is not to think and instead immediately choose the risky action in state θ_2. The value of thinking is even lower than under contract C_A, as a *complete stalemate* arises once the agents know the true payoff R_k and learn that they fundamentally disagree on the action choice. Therefore an additional reason why the risky action is chosen before the agents know the true payoff R_k is that each party knows that by engaging in thought experimentation they run the risk of a stalemate.

Proposition 5. *Under Assumptions A1, A4, A7, A8 and A9, agent A (weakly) prefers the coarse contract C_R at date 0 to contracts C_A, C_B or C_{AB}, and therefore there is no equilibrium in which an incomplete contract is proposed and accepted.*

Proof. See the Appendix. ||

Under the assumptions of Proposition 5, incomplete contracts cannot be equilibrium contracts. This is entirely due to the agents' extremely non-congruent objectives. As we have shown in the previous section, if the agents had congruent preferences, then under Assumption A4 they would prefer to sign an incomplete contract. Here, the agents prefer to commit to a coarse action plan rather than leave things to be fine-tuned later, as they anticipate that they will face *ex post* miscommunication inefficiencies. Miscommunication, in turn, reduces the value of thinking and fine-tuning *ex post* to the point that the agents prefer not to think and instead to stick to a coarse action plan.

Note that, although incomplete contracts are (weakly) dominated here, it is not obvious whether a complete *coarse* contract or a complete state-contingent contract is optimal. More precisely, it is not clear whether the agents will immediately sign contract C_R or whether they will think first and then sign a complete state-contingent contract. Indeed, despite their non-congruent objectives the agents may prefer to put their differences aside and collaborate in working out a state-contingent action plan *before committing to invest*.

Agent B prefers the coarse contract C_R, since under a state-contingent action plan A imposes the risky action when it is detrimental to B and the safe action when B stands to benefit from the risky action:

$$-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B}{2} > \widehat{\Lambda}\left[\nu\left(-I + \frac{\delta\pi}{2} + \frac{\delta S_B}{2}\right) + (1-\nu)\max\left\{0, -I + \frac{\delta\pi}{2} + \frac{\delta\underline{R}_B}{2}\right\}\right].$$

15. Note that, since

$$(\nu S_A\Lambda + (1-\nu)\underline{R}_A\lambda_A) + \delta[\nu(1-\Lambda) + (1-\nu)(1-\lambda_A)]\rho_A$$
$$< \Lambda(\nu S_A + (1-\nu)\underline{R}_A) + \delta(1-\Lambda)\rho_A,$$

there are situations under Assumption A8 where both $\widehat{\Lambda}\rho_A^* > \rho_A$ and condition (8) hold.

Agent A also prefers the coarse contract C_R if the opportunity cost of delaying investment $(\frac{\delta\pi}{2} - I)$ is high, and otherwise prefers to think before investing.

Suppose that B's participation constraint does not bind:

Assumption A10. $-I + \frac{\delta\pi}{2} + \frac{\delta R_B}{2} > 0.$

As we have established in the previous section, under Assumptions A4 and A10, agents with congruent preferences agree on the incomplete contract C_A. In contrast, here, with extreme non-congruent preferences such that Assumption A8 holds, either the coarse contract C_R is signed at date 0, or both agents think ahead before signing a contract.

Proposition 6. *Under Assumptions A1, A4, A7, A8, A9 and A10, a cutoff $\overline{I} < \frac{\delta\pi}{2}$ exists such that in equilibrium agents think ahead before committing to invest in the venture if $I \geq \overline{I}$. Otherwise, A and B sign the coarse contract C_R at date* 0.

Proof. See the Appendix. ||

The agents prefer to agree on a complete contract because their conflicting objectives undermine future cooperation and, thus, reduce the benefits of postponing some decisions.

4.3. *The need to compromise reduces the value of planning ahead*

In this section, we consider a situation where the agents are best off thinking ahead of investing. We show that there will be no miscommunication in equilibrium as long as the agents are not committed to the venture. Nevertheless, the need to compromise to make the venture acceptable to both agents may reduce the value of information sufficiently that the agents end up preferring a coarse complete contract to a complete state-contingent contract. Similarly, the need to reduce discretion of the controlling party may reduce the value of control sufficiently that the agents prefer a coarse complete contract.

Under Assumption A3 ($\widehat{\Lambda}\rho_k^* > \rho_k$ and $I > \frac{\delta\pi}{2}$) each agent would prefer to think before choosing an action, provided it could choose its preferred action and agents share their thoughts. In addition, since $I > \frac{\delta\pi}{2}$, each agent would prefer this thinking to take place ahead of investing. Under conflicting preferences, however, agents cannot both implement their preferred action. Only the controlling party may be able to do so. Even though Assumption A3 holds, the non-controlling party may well prefer not to engage in any planning. To get the non-controlling party to accept a contract where it has no control, the controlling party may then need to constrain its own discretion. But as we show below, while limiting its discretion, the controlling party may in turn prefer not to engage in any planning and instead sign a complete but coarse contract.

To illustrate this observation, we assume that the conflict among the agents is so severe that, if the agents think ahead of investing and learn that $R_k = \underline{R}_k$, B prefers to stay out of the venture rather than agreeing to A's preferred action:

Assumption A11. $-I + \frac{\delta\pi}{2} + \frac{\delta}{2}\underline{R}_B < 0.$

Here, to get B to participate A must commit not to implement the risky action in state θ_2 with a probability exceeding x^* given by:

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}(x^*\underline{R}_B + (1 - x^*)S_B) = 0. \tag{9}$$

Note that, unlike in the situation when the parties have already made their investments and are uninformed in state θ_2, there will be no miscommunication when the agents think before they commit to the venture. The reason is that the worst outcome for either party before investment takes place is to obtain a payoff of zero by walking away from the venture. Therefore, a (weak) best response for B is to always disclose $\underline{R}_k$. And given that B always discloses $\underline{R}_k$, it is also a best response to always disclose $\overline{R}_k$. The reason is that if B does not disclose $\overline{R}_k$, A only stops learning when his beliefs ν_τ are sufficiently close to 1, in which case he chooses the safe action. But then B is only delaying the time when she obtains S_B by not disclosing $\overline{R}_k$.

Still, even though agents share their thoughts, the value of information may be sufficiently reduced for A (when he needs to compromise), that he prefers to immediately settle on the risky action without thinking. If A ends up choosing the safe action most of the time—whenever $R_k = \overline{R}_k$, and with probability $(1 - x^*)$ when $R_k = \underline{R}_k$—what is the point of engaging in time-consuming thinking?

Another difficulty here is that after one period of thinking the agents bargain under incomplete information. Thus, if A makes an offer C_R in any period $t \geq 1$, B may suspect that A actually knows that $R_k = \underline{R}_k$.

Proposition 7. *Under Assumptions A1, A3, A7, A8, A9 and A11, an offer C_R from A at $t = 0$ is an equilibrium of the contracting game when*

$$x^* = \frac{1}{\underline{R}_B - S_B}\left(\frac{2I}{\delta} - \pi - S_B\right)$$

is close enough to zero.

Proof. See the Appendix. ||

When agents attempt to write down a detailed plan of action, they also learn that they have fundamental differences. The need to compromise then reduces the value of information and will result in less fine-tuned contracts. A coarse contract is also a compromise but one where the cost of thinking is avoided. Here a deal is quickly concluded because this is an efficient resolution of the agents conflicting objectives, avoiding lengthy and ultimately sterile negotiations.

4.4. *Preliminary contracts*

So far we have restricted attention to five main contracts. But there is also a sixth contract, which we refer to as a *preliminary contract*, which can be an equilibrium contract. Under this contract, which we denote by C_α, the agents agree to first think ahead of investing and are committed to an action contingent on R_k.

This contract may be preferred to the coarse contract C_R because it yields higher expected payoffs by committing the agents to participate even when an agent's *ex post* participation constraint does not hold. More precisely, the preliminary contract can secure B's participation *ex ante*, and thus relax the *ex post* participation constraint,

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}\left(x\underline{R}_B + (1 - x)S_B\right) \geq 0.$$

A preliminary contract can then raise A's value from thinking ahead while guaranteeing B's participation. However, to be acceptable to B, the preliminary contract must guarantee B

a sufficiently high expected payoff in state θ_2 even though A gets to choose the risky action with a higher probability than x^*.

To illustrate this possibility while keeping the analysis simple, we shall consider the special situation where B is unable to think, so that $\lambda_B = 0$.[16]

Consider the following preliminary contract C_α offered by A to B at $t = 0$:

(a) the agents commit to invest once they have discovered the value of R_k;
(b) if $R_k = \underline{R}_k$, action r is chosen in state θ_2;
(c) if $R_k = \overline{R}_k$, action s is chosen with probability χ and action r with probability $(1 - \chi)$ in state θ_2, where χ solves agent B's participation constraint at date 0.

We shall show that this contract may be strictly preferred by A to C_R and that B accepts this offer under the assumptions of Proposition 7, when

$$x^* = \frac{1}{\underline{R}_B - S_B}\left(\frac{2I}{\delta} - \pi - S_B\right)$$

is close to 1. Indeed, when x^* is close to 1, the agents prefer to think ahead and settle on either contract C_S or C_{x^*} rather than immediately agree on C_R. But we shall show that in this case the agents can do even better by signing a preliminary contract under two additional assumptions.

This preliminary contract, offered before the agents have thought through their action in state θ_2, allows them to effectively transfer payoffs across states of nature and thus achieve a higher *ex ante* expected payoff, as with an insurance contract. Although they are both risk neutral, there are gains from such an agreement by letting the agents trade commitments to choosing the risky action in situations when it is not their most preferred action. In this way, the agents can make *ex post* non-transferable utilities partially transferable *ex ante*.

The role of a preliminary contract is, thus, to overcome a form of *Hirshleifer effect*, whereby information acquisition eliminates insurance or trading opportunities and thus results in a decline in *ex ante* utility. Here, as the agents' information changes over time, so does the intensity of the conflicts that divide them. Absent a preliminary contract, B will be unwilling to invest when it expects to get $\underline{R}_B$ in state θ_2. Under the veil of ignorance concerning agents' true payoffs, they are able to find room for agreements they would not be able to reach once the information is revealed.

Suppose that in addition to Assumptions A1, A3, A7, A8 and A11, the following additional assumptions hold:

Assumption A12. $\frac{\underline{R}_A - S_A}{S_A - \overline{R}_A} > \frac{S_B - \underline{R}_B}{\overline{R}_B - S_B}$,

and

Assumption A13. $-I + \frac{\delta\pi}{2} + \frac{\delta}{2}\overline{R}_A > 0.$

Then we are then able to establish:

16. When $\lambda_B > 0$, agent B's thinking also contributes to the contracting parties' aggregate learning capacity. In this situation the analysis is more complex as B has incentives not to share her thoughts. The preliminary contract must then generally also specify a stopping time when the parties are committed to invest.

Proposition 8. *Under the same assumptions as in Proposition 7 and Assumptions A12 and A13, and provided that*

$$x^* = \frac{1}{\underline{R}_B - S_B}\left(\frac{2I}{\delta} - \pi - S_B\right)$$

is sufficiently close to 1*, the unique subgame-perfect equilibrium is such that* A *offers a preliminary contract to* B *at* $t = 0$ *with the following terms: (a) the agents commit to invest once they have identified* R_k*; (b) if* $R_k = \underline{R}_k$*, then action* r *is chosen in state* θ_2*; (c) if* $R_k = \overline{R}_k$*, then action* s *is chosen with probability* χ *and action* r *with probability* $(1 - \chi)$ *in state* θ_2*, where* χ *is given by:*

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}[\nu(\chi S_B + (1-\chi)\overline{R}_B) + (1-\nu)\underline{R}_B)] = 0. \tag{10}$$

Proof. See the Appendix. ||

Under Assumption A12, A strictly prefers the preliminary contract to thinking ahead and settling on either contracts C_S or C_{x^*}. Moreover, under Assumption A3 both agents prefer the preliminary contract to C_R given that x^* is close to 1.

5. EXTENSIONS

This section explores three extensions to our basic setup.

5.1. *Cheap talk*

We have assumed that agents' thoughts are hard information. This may be realistic in some situations (e.g. a mathematical proof) but less so in others. Here we examine the opposite case in which thoughts are soft information so that communication is pure cheap talk. Most of our qualitative results extend to this case.

With cheap talk there is inevitably more *miscommunication* than with disclosure of hard information. First, when agents have congruent preferences, but disagree about how cautiously to proceed, there is now some miscommunication. Second, under extreme non-congruent preferences over actions, miscommunication is now total while before it was only partial.

Under fully congruent objectives, however, agents trust each other's reports and communication is unimpaired. A result similar to Lemma 1, with the addition of Assumption A3, can be established, and Propositions 1 and 2 continue to hold.

Consider first the situation where agents may disagree on how cautiously to proceed. We show below that even though cheap talk gives rise to miscommunication, a result analogous to Proposition 3 and Corollary 1 is obtained under slightly different conditions.

The problem under *cheap talk* is that the more patient agent can no longer trust the more impatient one to tell the truth. Since the impatient agent prefers to choose the risky action without thinking further, he will always pretend that he has found that the risky action has a payoff $\overline{R}_k$ when he has not discovered anything. The impatient agent is thus credible only when reporting $R_k = \underline{R}_k$.

Suppose again that A is impatient and prefers the risky action in state θ_2 without thinking further, while B prefers to think before acting. Miscommunication then has two opposing effects. On the one hand, B's threat to reject all offers until she has thought through R_k is less credible, because miscommunication slows down the agents' joint thinking, thus reducing the value of thinking ahead. On the other hand, the value of control for B is reduced for the same reason. On net, although B is more likely to accept a contract without control rights, when she does require control to sign on, she demands more control than when thoughts are hard information.

More formally, assume that beginning at date $t = 0$, A makes repeated offers of C_R, which B rejects to gain time to think about R_k. Following each rejection both agents think and engage in cheap talk. As we have observed, A reports $\overline{R}_k$ both when this is the true payoff and when he learns nothing, and he truthfully reports $\underline{R}_k$. As for B, she truthfully shares her thoughts.

Therefore, when A reports $\underline{R}_k$, B believes this is true and accepts A's offer C_S. In contrast, when A reports $\overline{R}_k$, B only updates her belief ν_t. After t rounds of communication of $\overline{R}_k$, her posterior belief is:

$$\nu_t = \frac{\nu}{\nu + (1-\nu)(1-\lambda_A)^t}.$$

Thus, B's beliefs ν_t converge to 1. In other words, it dawns on B that A has learned that $R_k = \overline{R}_k$. Following a sufficiently long sequence of announcements of $\overline{R}_k$, B therefore finds it optimal to stop rejecting A's offers of C_R. At her optimal stopping time, denoted by t_B, B is indifferent between accepting C_R and thinking for one more period. That is, her posterior ν_{t_B} is such that:

$$\begin{aligned}\nu_{t_B}\overline{R}_B + (1-\nu_{t_B})\underline{R}_B = \delta[&\nu_{t_B}\lambda_B\overline{R}_B + (1-\nu_{t_B})S_B\Lambda \\ &+ ((\nu_{t_B}(1-\lambda_B) + (1-\nu_{t_B})(1-\Lambda))(\nu_{t_B+1}\overline{R}_B + (1-\nu_{t_B+1})\underline{R}_B)].\end{aligned}$$

Although conflicts over cautiousness may be reduced if miscommunication slows down thinking, they do not disappear. Formally, Assumption A5 must be replaced by Assumption A5b below to reflect the change in expected discounted payoffs resulting from miscommunication. Denoting agent k's payoff when both agents think before choosing the optimal action in state θ_2 by:

$$\begin{aligned}W^k \equiv &\sum_{t=1}^{t_B}[\nu\overline{R}_k\lambda_B(1+(1-\lambda_B)^t\delta^t) + (1-\nu)S_k\Lambda(1+(1-\Lambda)^t\delta^t)] \\ &+ \delta^{t_B}(\nu_{t_B}\overline{R}_k + (1-\nu_{t_B})\underline{R}_k),\end{aligned}$$

then Assumption A5b is as follows:

Assumption A5b. $W^A < \rho_A$, $W^B \geq \rho_B$ and $I < \frac{\delta\pi}{2}$.

Denoting by Y^B agent B's payoff when both agents *think ahead* of investing:

$$\begin{aligned}Y^B \equiv &\sum_{t=1}^{t_B}\left\{\nu\left[-I + \frac{\delta\pi}{2} + \frac{\delta\overline{R}_B}{2}\right]\lambda_B(1+(1-\lambda_B)^t\delta^t)\right. \\ &\left.+ (1-\nu)\left[-I + \frac{\delta\pi}{2} + \frac{\delta S_B}{2}\right]\Lambda(1+(1-\Lambda)^t\delta^t)\right\} \\ &+ \delta^{t_B}\left[-I + \frac{\delta\pi}{2} + \frac{\delta(\nu_{t_B}\overline{R}_B + (1-\nu_{t_B})\underline{R}_B)}{2}\right],\end{aligned}$$

then we are able to establish the following analogue of Proposition 3 for the contracting game with *cheap talk.*

Proposition 3b. *Under Assumptions A1, A2 and A5b and under condition*

$$-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B}{2} < Y^B,$$

in equilibrium A offers immediately C_B with probability y^* and C_R with probability $(1 - y^*)$, where y^* is given by:

$$-I + \frac{\delta\pi}{2} + y^* W^B + (1 - y^*)\frac{\delta\rho_B}{2} = Y^B.$$

When the reverse condition holds, A immediately offers contract C_R.

Proof. Omitted. ||

Similarly, a result analogous to Proposition 4, which we omit, can be established under modified conditions to reflect miscommunication.

Now consider situations where the two agents disagree about the choice of action (Assumption A7 holds). In this case, communication breaks down completely, as each agent has a strict incentive to mislead the other. As a result, the two agents think by themselves and duplicate their cognitive efforts. Results analogous to Propositions 5, 6 and 7 are obtained again under modified conditions to account for the slower thinking. The key difference with the previous analysis is that the parameter region for which equilibrium contracts are *coarse* is larger.

Lemma 3. *When the equilibrium contract under hard information is a coarse contract, it is also the equilibrium contract when information is soft.*

Proof. The agents' payoffs under a coarse contract are the same whether information is hard or soft. Indeed, no thinking is involved. Moreover, any other contract offer that involves some thinking cannot result in a higher payoff for A under soft information than under hard information. It therefore follows that if C_R is an equilibrium offer at $t = 0$ when information is hard, it must also be an equilibrium offer when information is soft. ||

Finally, another difference with the case with hard information is that negotiations may last forever even when A has identified R_k. Indeed, by repeating over and over again the same information, A is unable to *persuade* B that his information is reliable. Since B's beliefs do not change, A does not have a finite stopping time. This, in turn, reduces the value of a preliminary contract.

5.2. *Transferable utility*

We assume now that utility is fully transferable through (state-contingent) monetary payments. In this case, a preliminary contract has even greater benefits. Indeed, by first specifying the broad terms of the deal, such a contract aligns the agents' objectives, leading them to agree on how much thinking should precede investment. Hence, they will more readily accept to invest without having worked out a complete action plan.

Lemma 4 (The Congruence Principle). *Under fully transferable utility, it is weakly optimal for the agents to sign a preliminary contract establishing how the agents will share the profits.*

Proof. See the Appendix. ||

Once the agents have agreed on profit sharing, their objectives are fully congruent, and communication is perfect whether thoughts are hard or soft information. The contracting problem then reduces to determining the team's optimal plan of action. Any actions that the contracting agents determine by thinking ahead will be specified in the contract and any decisions to be determined at the time when they arise will be taken jointly by the two agents.

Strictly speaking, there is no need for contracts beyond the preliminary agreement. Note, however, that under even a very small risk of change in one of the agents' preferences resulting in a conflict *ex post*, the agents would strictly prefer to explicitly spell out what future action choices they have agreed to in a contract. For the same reason, the agents would strictly prefer to specify a governance structure that defines the process by which future decisions are taken.

With only one state of nature (θ_2) where some thinking is needed, the contracting problem with transferable utility collapses to a simple decision problem of the type studied in Bolton and Faure-Grimaud (2009). When thinking is required in more than one state of nature (e.g. in state θ_1), the team problem is of independent interest as it raises a number of organizational design questions. For instance, an interesting set of questions is who in the team should think about what problem? Is the team more efficient when both agents think about the same problem at the same time, or rather when they specialize and engage in parallel thinking? The analysis of these issues is beyond the scope of this paper and is left for future research.

5.3. *Partially transferable utility: a start-up financing example*

Most long-term contracting situations in reality—especially those involving substantial up-front investments—are likely to involve only partially transferable utility. There are at least two important limits in practice on the transferability of utility. First, some of the contracting parties may simply be wealth constrained, and therefore may not be able to "purchase" utility from the other parties. This is the case of most entrepreneurs involved in start-ups. Second, there may be limits on the pledgeability of future cash flows of a start-up to preserve the incentives of the entrepreneur, as Holmstrom and Tirole (1998) have emphasized. The analysis of contracting problems with partially transferable utility is generally quite involved, as it requires a detailed determination of when the limits on the transferability of utility are binding and when not. Accordingly, we shall only analyse a very special example of start-up financing in this section.

We shall take it that agent A is an entrepreneur with a limited wealth $w > 0$ that he can commit to the venture, and that agent B is a venture capital fund (VC) covering most upfront investment in the new venture $(2I - w)$. As above, the venture ends up in one of two equally likely states at date $t + 1$ after the investment has been made at an endogenous date $t \geq 0$. In state θ_1, the venture produces a total gross return of Π. In state θ_2, the two agents again face a decision of choosing the safe or the risky action. The *safe* action yields a known total gross return of S and the *risky* action yields either $\underline{R}$ or $\overline{R}$, where, as before, we have $\overline{R} > S > \underline{R}$. Also as before, the two agents start out with prior belief $\nu = \Pr(R = \overline{R})$ and we continue to assume that they have the same discount factor $\delta \leq 1$. To the limited wealth constraint of the entrepreneur we also add a limit on the pledgeability of future returns. The entrepreneur must receive a minimum fraction $\phi > 0$ of the venture's return in each state. Otherwise, he will not be sufficiently financially motivated to run the venture.

Now consider the situation where the following assumptions analogous to A1 and A4 hold:

Assumption A1c. $\delta(\Pi + S) > 2I$ and $\nu\overline{R} + (1 - \nu)\underline{R} > S$, and

Assumption A4c. $\widehat{\Lambda}(\nu\overline{R}+(1-\nu)S) > \nu\overline{R}+(1-\nu)\underline{R}$ and $2I < \frac{\delta}{2}\Pi$.

Under these assumptions, if the constraints on the transferability of utility are not binding, the two parties would enter into a preliminary contract at date 0 establishing a profit-sharing agreement (α_A, α_B) such that $\alpha_A \geq \phi$, $\alpha_B > 0$, $\alpha_A + \alpha_B = 1$, and such that both parties have congruent objectives under the contract:[17]

$$\delta\alpha_A(\Pi + S) \geq w \text{ and } \delta(1-\alpha_A)(\Pi + S) \geq (2I - w),$$

and also:

$$w \leq \frac{\delta}{2}\alpha_A\Pi \text{ and } 2I - w \leq \frac{\delta}{2}(1-\alpha_A)\Pi.$$

Under such a preliminary contract, both parties are happy to invest immediately at date 0 and to postpone deliberations on the decision whether to take the safe or risky action to when state θ_2 arises. In other words, both parties agree to write an incomplete satisficing contract.

But, suppose now that the following assumption holds:

Assumption A6c. $w < \frac{\delta}{2}\phi\Pi$ and $2I - w > \frac{\delta}{2}(1-\phi)\Pi$.

Under this Assumption, some of the constraints on the transferability of utility will be binding and will prevent a perfect alignment of objectives through a preliminary profit-sharing agreement. Such a situation can arise for start-ups, whenever the entrepreneur's minimum stake ϕ required to align his incentives to run the venture is disproportionately larger than his share of investment $w/2I$.

Under Assumption A6c, the VC (agent B) prefers to think ahead about which action to take in state θ_2, while the entrepreneur (agent A) prefers to invest immediately and deliberate later on what to do in state θ_2. A conflict over cautiousness arises as a result of the limited transferability of utility. An analogous result to Proposition 4 is then obtained, as agent B, the VC, prefers to think ahead to any other alternative and can get her way by simply refusing to invest in the venture until the optimal action in state θ_2 has been determined.

Proposition 4c. *Under Assumptions A1c and A6c, agent A has no choice but to follow B's preferred path of action, which is to invest only after the optimal action in state θ_2 has been determined. When this is the case, the equilibrium contract is either C_R when $R = \overline{R}$ or C_S when $R = \underline{R}$.*

Proof. See the proof of Proposition 4 in the Appendix. ||

The equilibrium outcome here involves an excessively complete contract, as the agents' joint welfare would be higher if they invested immediately in the venture and deliberated on the optimal action only once state θ_2 arises.

17. The profit-sharing agreement may also specify upfront transfers between the two contracting parties, which we are not modelling explicitly.

6. CONCLUSION

We have proposed and explored a first contracting model between two agents facing time-deliberation costs. In this model, equilibrium contracts may be endogenously incomplete. Control rights assigned to one of the parties allow the controlling agent to defer time-consuming deliberations to a later date without exposing her to too much uncertainty. As she will be in charge of the decisions most critical to her, she need not worry too much and unduly prolong negotiations at the initial contracting stage.

However, when agents face potentially major conflicts, they tend to resolve these upfront, by writing more complete initial contracts. This more complete contract may be either a more state-contingent or a coarser contract. Thus conflicts among contracting agents tend to result in excessively complete contracts from the perspective of joint payoff maximization.

Equilibrium contracts in our model are incomplete for two reasons: *first*, the costs of thinking about how to complete them may exceed the expected benefits; and *second*, the costs of thinking about how to outwit the other agent also exceed the expected benefits. In contrast to first-generation incomplete contracting models, contracts are not incomplete due to exogenously given enforcement constraints. Indeed, we have assumed that all state-contingent transactions are fully enforceable. Instead, contractual incompleteness is due to the limited cognition of the contracting agents.

APPENDIX A

Proof of Proposition 3. We first establish a series of preliminary results that simplify the argument.

Claim 1. *Let $U^{\mathrm{RFI}}_{\min}$ be the lowest guaranteed payoff of the receiver in any subgame under complete information. Then, either the proposer implements his most preferred contract or the receiver gets exactly $U^{\mathrm{RFI}}_{\min}$.*

Proof. Observe first that $U^{\mathrm{RFI}}_{\min} = 0$ in the absence of a pre-existing contractual agreement. Suppose now that the claim is not true and that there exists a subgame perfect Nash equilibrium where, under full information, the receiver gets some payoff $\widehat{U} > U^{\mathrm{RFI}}_{\min}$, and the proposer is not offering his most preferred plan of action. For this to be true, it must be that the receiver rejects any offer that gives her less than $\widehat{U}$. But, given that the proposer is not making his most preferred offer, it must then be the case that the receiver is just indifferent between accepting and rejecting the offer giving her $\widehat{U}$. Otherwise, the proposer could offer a lottery that would put some weight ε on his most preferred contract and $(1-\varepsilon)$ on the offer of $\widehat{U}$ to the receiver. Therefore it must be the case that along the equilibrium path in such an equilibrium, at any date t, $\widehat{U}_t = \delta\widehat{U}_{t+1}$. Iteration of this argument requires $\widehat{U}_{t+\tau}$ to go to infinity as τ goes to infinity, which is impossible. ||

Claim 2. *Denote by U^{RFI} the unique subgame perfect equilibrium payoff that the receiver obtains in any subgame under complete information. Then, in any subgame where the payoffs of the risky action are unknown, either the proposer offers her most preferred contract, or the receiver gets $U^{\mathrm{R}}_{\min} = \widehat{\Lambda} U^{\mathrm{RFI}}$.*

Proof. Suppose again this is not true. As in the proof of Claim 1, it then follows that the receiver must be indifferent at any date t between accepting or rejecting the offer that gives the receiver some utility level $\widetilde{U}^{\mathrm{R}}_t > U^{\mathrm{R}}_{\min}$. In particular, it then must be the case that

$$\widetilde{U}^{\mathrm{R}}_t = \Lambda U^{\mathrm{RFI}} + (1-\Lambda)\delta \widetilde{U}^{\mathrm{R}}_{t+1}.$$

And, if $\widetilde{U}^{\mathrm{R}}_t = \widetilde{U}^{\mathrm{R}}_{t+1}$, then $\widetilde{U}^{\mathrm{R}}_t = \frac{\Lambda}{1-(1-\Lambda)\delta} U^{\mathrm{RFI}} = \widehat{\Lambda} U^{\mathrm{RFI}}$, a contradiction. Alternatively, iterating the same argument, we would find that

$$\widetilde{U}^{\mathrm{R}}_{t+\tau} = \frac{\widetilde{U}^{\mathrm{R}}_t}{(1-\Lambda)^\tau \delta^\tau} - \widehat{\Lambda} U^{\mathrm{RFI}} \frac{1-(1-\Lambda)^\tau \delta^\tau}{(1-\Lambda)^\tau \delta^\tau}$$

which, when $\widetilde{U}_t^{\mathrm{R}} > U_{\min}^{\mathrm{R}}$, requires $\widetilde{U}_{t+\tau}^{\mathrm{R}}$ to go to infinity when τ goes to infinity. Again, this leads to a contradiction. ||

We now make use of these observations to establish Proposition 3.

Note first that under Assumptions A2 and A4 party B's minimum guaranteed payoff is

$$U_{\min}^{B} = \widehat{\Lambda}\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B^*}{2}\right].$$

If condition (6) in Proposition 3 does not hold, so that

$$-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B}{2} \geq \widehat{\Lambda}\left(-I + \frac{\delta}{2}\left(\pi + \rho_B^*\right)\right),$$

then the proposer's most preferred contract—C_R—gives a higher expected payoff to B than $U_{\min}^{B}$. Therefore B's best response is to accept this offer.

Now suppose that condition (6) holds. Then, from Claim 1, the receiver gets exactly $U_{\min}^{B}$ in equilibrium.

To complete the proof of Proposition 3, it remains to show that the stochastic contract offer that gives A the highest possible payoff while guaranteeing $U_{\min}^{B}$ to B takes the form described in the proposition, namely that both agents agree to invest immediately, party B gets control with probability y^* and the risky action is chosen in state θ_2 with probability $(1 - y^*)$.

There are several types of stochastic contracts that can implement $U_{\min}^{B}$. A first contract is to give full control to party B (contract C_B) with probability y and to take the risky action in state θ_2 with probability $(1 - y)$.[18] An alternative offer is to give B control in every period with some probability z and to take the risky action in state θ_2 with probability $(1 - z)$. As we show below, these two contracts are in fact equivalent. To see this, note that under the latter contract party k expects to receive:

$$\begin{aligned}
&(1-z)\rho_k + z\Lambda\rho_k^* + z(1-\Lambda)\delta\left[(1-z)\rho_k + z\Lambda\rho_k^* + z(1-\Lambda)\delta[\ldots]\right] \\
&= \frac{z\Lambda}{1 - z(1-\Lambda)\delta}\rho_k^* + \frac{1-z}{1-z(1-\Lambda)\delta}\rho_k.
\end{aligned}$$

Now setting

$$y = \frac{z\Lambda}{1 - z(1-\Lambda)\delta\widehat{\Lambda}}$$

this reduces to

$$y\widehat{\Lambda}\rho_k^* + (1-y)\,\rho_k.$$

(Note also that there is no loss of generality in considering only stationary strategies $z_t = z$ for all t.)

We now characterize the highest payoff available to A under the constraint that B gets $U_{\min}^{B}$. Agent A's control variables are the probability x of engaging in thinking ahead before investing and the probability y of engaging in thinking on the spot in state θ_2 before choosing an action. Therefore agent A is looking for the solution to the constrained maximization programme:

$$\begin{aligned}
MP_A \equiv \max_{x,y} x\widehat{\Lambda}&\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_A^*}{2}\right] \\
&+ (1-x)\left[-I + \frac{\delta\pi}{2} + y\widehat{\Lambda}\left(\frac{\delta\rho_A^*}{2}\right) + (1-y)\frac{\delta\rho_A}{2}\right]
\end{aligned}$$

subject to:

$$\begin{aligned}
\widehat{\Lambda}\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B^*}{2}\right] \leq x\widehat{\Lambda}&\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B^*}{2}\right] \\
&+ (1-x)\left[-I + \frac{\delta\pi}{2} + y\widehat{\Lambda}\left(\frac{\delta\rho_B^*}{2}\right) + (1-y)\frac{\delta\rho_B}{2}\right].
\end{aligned}$$

18. An equivalent contract is to offer contract C_α with probability y and to take the risky action in state θ_2 with probability $(1 - y)$.

Other contracts that involve, for instance, choosing the safe action before learning whether it is optimal, or choosing the sub-optimal action once agents have learned which action is best are dominated for both agents and cannot therefore maximize A's payoff under the constraint that B obtains at least $U^B_{\min}$.

Forming the Lagrangian, and taking its partial derivatives with respect to x and y we obtain:

$$\frac{\partial L}{\partial x}(1-x) = (1-y)\frac{\partial L}{\partial y} - (1-x)(1+\vartheta)(1-\widehat{\Lambda})\left(-I+\frac{\delta\pi}{2}\right)$$

where $\frac{\partial L}{\partial x}$ (resp. $\frac{\partial L}{\partial y}$) is the partial derivative of the Lagrange function with respect to x (resp. y) and ϑ is the Lagrange multiplier of the constraint.

From the last inequality it is apparent that the solution to this program is $x^* = 0$ and $y^* \in (0, 1)$ if and only if:

$$-I + \frac{\delta\pi}{2} + \widehat{\Lambda}\left(\frac{\delta\rho_B^*}{2}\right) > \widehat{\Lambda}\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B^*}{2}\right],$$

which is true under Assumptions A1, A2 and A5. This establishes that the most efficient way for A to deviate from his preferred course of action is to invest right away, to choose the risky action in state θ_2 with probability $(1 - y^*)$ and to think on the spot with probability y^*. This action plan is implemented by offering party B control with probability y^*, as party B would then want to think on the spot in state θ_2. Finally, the exact value of y^* is given by:

$$-I + \frac{\delta\pi}{2} + y^*\widehat{\Lambda}\left(\frac{\delta\rho_B^*}{2}\right) + (1-y^*)\frac{\delta\rho_B}{2} = \widehat{\Lambda}\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_B^*}{2}\right].$$

To summarize, the following strategies support this subgame-perfect equilibrium:

Equilibrium strategy for A: At date 0, offer a stochastic contract committing to immediate investment and that implements C_R with probability $1 - y^*$ and C_B with probability y^*. If the contract is accepted, invest at date 0 and if state θ_2 is realized and A has control, implement decision r. If B has control, think and credibly reveal any new information to B.

If the offer is rejected, think and again credibly reveal any new information to B. If A uncovers the optimal decision in state θ_2, reveal it to B and offer the first-best optimal complete contract to B (either C_R or C_S depending on whether A uncovers that r or s is optimal). Similarly, if B reveals the optimal decision in state θ_2, offer the first-best complete contract to B.

If A learns nothing during that second sub-period of period 0 (from his own thinking or from B), repeat at date 1 the same strategy as at date 0 and continue doing so until investment takes place.[19]

Equilibrium strategy for B: At date 0, accept all contract offers with immediate investment that take support in $\mathbb{C}\backslash\{C_S\}$, provided that those offers put a weight of at least y^* on the choice of C_B. In state θ_2, when B has control, think on the spot and implement the optimal decision. Following a rejection at date 0, think in the second sub-period of date 0 and reveal any information to A. Then accept all first-best complete contract offers. Similarly, if A reveals that decision s (resp. r) is optimal in state θ_2, accept all first-best complete contract offers. If neither party learns anything, repeat at date 1 the same strategy as at date 0 and continue doing so until a contract is accepted. ||

Proof of Corollary 1. Immediate from previous results and noticing that now necessarily under A1, A2 and A5,

$$-I + \frac{\delta\pi}{2} + \frac{\delta\widehat{\Lambda}\rho_A^*}{2} > \widehat{\Lambda}\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_A^*}{2}\right] = U^A_{\min}.$$

Therefore, the proposer B must obtain her most preferred path of action, i.e. C_B.

Proof of Proposition 4. Note that under assumption A6.(ii) and A6.(iii), $U^B_{\min} = \widehat{\Lambda}U^{\text{RFI}}$ is the minimum guaranteed highest attainable payoff for B. From claim 2 above, this must be her equilibrium payoff. Also, under Assumption A6.(i), thinking ahead of investing is costly for A and is not his most preferred strategy. ||

Lemma 2. *Under Assumptions A7 and A8, when the agents are uninformed in state θ_2 under contract C_A, the only equilibrium that exists is a mixed strategy equilibrium where both A and B randomize between stopping and not stopping at any time $\tau \geq \widehat{\tau} + 1$.*

19. Note that nothing is changed if party A offers initially C_A instead of C_R, or C_α instead of C_B.

Proof of Lemma 2. We begin by showing that a pure strategy equilibrium cannot exist. To see this, note that withholding all information (whether $R_k = \underline{R}_k$ or $R_k = \overline{R}_k$) from time τ onwards is a best response for B whenever:

$$[\delta(1-\lambda_A)]^{(\tau_A-\tau)}\overline{R}_B \geq S_B(1 - \sum_{t=1}^{(\tau_A-\tau)} (\lambda_A(1+(1-\lambda_A)^t\delta^t)), \tag{11}$$

where we define A's stopping time τ_A under the assumption that B always discloses $\overline{R}_k$ up to time τ_A.

But if B stops disclosing $\overline{R}_k$ at some earlier time τ, A's optimal stopping time in turn may change, as A can then no longer update his beliefs after time τ. Let τ_B and ν_{τ_B}, respectively, denote the time when B stops disclosing $\overline{R}_k$ and A's belief at time τ_B. Also, let

$$\widehat{\lambda}_A = \frac{\lambda_A}{1-(1-\lambda_A)\delta},$$

then we have either:

$$\nu_{\tau_B}\overline{R}_A + (1-\nu_{\tau_B})\underline{R}_A \geq \widehat{\lambda}_A(\nu_{\tau_B}S_A + (1-\nu_{\tau_B})\underline{R}_A), \tag{12}$$

or

$$\nu_{\tau_B}\overline{R}_A + (1-\nu_{\tau_B})\underline{R}_A < \widehat{\lambda}_A(\nu_{\tau_B}S_A + (1-\nu_{\tau_B})\underline{R}_A). \tag{13}$$

That is, it is best for A to either stop thinking at time τ_B, or to continue thinking until he learns the optimal action.

In the latter situation we have $\tau_A \longmapsto \infty$ so that (11) no longer holds and B's best response is to disclose $\overline{R}_k$ at time τ_B. Similarly, in the former situation, we have $\tau_A = \tau_B$, but if this is anticipated, B's best response is to stop disclosing $\overline{R}_k$ even earlier. In sum, whether (13) holds or not, a pure strategy equilibrium in stopping times does not exist.

There exists a mixed strategy equilibrium, as we now establish, where both A and B randomize between stopping and not stopping at any time $\tau \geq \widehat{\tau}+1$. Time $\widehat{\tau}$ is the first time when $\nu_{\widehat{\tau}}$ is such that

$$\nu_{\widehat{\tau}-1}\overline{R}_A + (1-\nu_{\widehat{\tau}-1})\underline{R}_A < \widehat{\lambda}_A(\nu_{\widehat{\tau}-1}S_A + (1-\nu_{\widehat{\tau}-1})\underline{R}_A)$$

but

$$\nu_{\widehat{\tau}}\overline{R}_A + (1-\nu_{\widehat{\tau}})\underline{R}_A \geq \widehat{\lambda}_A(\nu_{\widehat{\tau}}S_A + (1-\nu_{\widehat{\tau}})\underline{R}_A).$$

If we denote by ϕ the probability that A stops thinking at any time $\tau \geq \widehat{\tau}$ and by $\varphi_{\tau-1}$ the probability that B stops disclosing $\overline{R}_k$ at $\tau-1$, then for any τ the following two equations must hold in equilibrium. For A we must have:

$$\begin{aligned}\rho^A(\nu_{\tau-1}) = \delta\{&\nu_{\tau-1}S_A(\varphi_{\tau-1}\lambda_A + (1-\varphi_{\tau-1})\Lambda) + (1-\nu_{\tau-1})\lambda_A\underline{R}_A \\ &+ [\nu_{\tau-1}((1-\varphi_{\tau-1})(1-\Lambda) + \varphi_{\tau-1}(1-\lambda_A)) + (1-\nu_{\tau-1})(1-\lambda_A)]\rho^A(\nu_\tau)\},\end{aligned}$$

where

$$\rho^A(\nu_\tau) = \nu_\tau\overline{R}_A + (1-\nu_\tau)\underline{R}_A,$$

and

$$1-\nu_\tau = \varphi_{\tau-1}(1-\nu_\tau) + \frac{(1-\varphi_{\tau-1})(1-\nu_{\tau-1})}{\nu_{\tau-1}(1-\lambda_B) + (1-\nu_{\tau-1})}.$$

Similarly, for party B we must have:

$$S_B = \lambda_A S_B + (1-\lambda_A)[\phi\overline{R}_B + (1-\phi)\delta S_B],$$

or,

$$\phi = \frac{S_B(1-\delta)}{\overline{R}_B - \delta S_B}.$$

In other words, for any τ, B must be indifferent between stopping disclosing $\overline{R}_k$ at $\tau+1$ or at τ. If B stops at $\tau+1$ (and therefore discloses $\overline{R}_k$ in period τ), she gets S_B at τ. If she does not disclose $\overline{R}_k$ at τ, then A discovers $\overline{R}_k$ at τ

with probability λ_A, in which case B gets again S_B. With probability $(1-\lambda_A)$, A does not discover $\overline{R}_k$ and stops with probability ϕ, in which case B gets $\overline{R}_B$; and finally with probability $(1-\phi)$ party A continues learning, in which case B's continuation value is δS_B (as B discloses $\overline{R}_k$ at $\tau+1$).

As can be readily checked, these equations admit a unique solution $\phi \in [0,1]$ and $\varphi_{\tau-1} \in [0,1]$ under Assumptions A7 and A8. ||

Proposition 5. *Under Assumptions A1, A4, A7, A8 and A9, agent A (weakly) prefers the coarse contract C_R at date* 0 *to contracts C_A, C_B or C_{AB}, and therefore there is an equilibrium in which no incomplete contract is proposed and accepted.*

Proof of Proposition 5. Under Assumptions A8 and A9, C_R is (weakly) preferred by both agents to C_A. In addition, under Assumptions A1 and A7, C_R is also preferred by A to C_S, which is again preferred by A to C_B as $S_A > V_B^A$, where V_B^A is A's payoff under contract C_B:

$$\begin{aligned} V_B^A \equiv & \sum_{\tau=1}^{\tau_B} [\nu \overline{R}_A \lambda_B (1+(1-\lambda_B)^\tau \delta^\tau) + (1-\nu) S_A \Lambda (1+(1-\Lambda)^\tau \delta^\tau)] \\ & + \delta^{\tau_B} (\nu_{\tau_B} \overline{R}_A + (1-\nu_{\tau_B}) \underline{R}_A), \end{aligned}$$

and where τ_B is similarly defined as $\widehat{\tau}$ but with A's and B's roles interchanged.

Also, C_R is (weakly) preferred by both agents to C_{AB}. Finally, by Claim 2 in the Appendix, C_B will not be offered in equilibrium even when B prefers C_B to C_R. ||

Proposition 6. *Under Assumptions A1, A4, A7, A8, A9 and A10, a cutoff $\overline{I} < \frac{\delta\pi}{2}$ exists such in equilibrium: agents think ahead before committing to invest in the venture if $I \geq \overline{I}$, otherwise, A and B sign the coarse contract C_R at date* 0.

Proof of Proposition 6. The cutoff $\overline{I}$ is defined by equating A's expected payoffs under the two contracting strategies. By offering the coarse contract C_R at date 0, party A gets:

$$-I + \frac{\delta\pi}{2} + \frac{\delta\rho_A}{2}.$$

And by first thinking ahead and offering a complete contingent contract, A gets:

$$\widehat{\Lambda}\left[-I + \frac{\delta\pi}{2} + \frac{\delta\rho_A^*}{2}\right],$$

given that Assumption A9 holds. The cutoff $\overline{I}$ is then defined by:

$$\overline{I} = \frac{\delta\pi}{2} - \frac{\delta}{2}\left(\frac{\widehat{\Lambda}\rho_A^* - \rho_A}{1-\widehat{\Lambda}}\right) < \frac{\delta\pi}{2}.$$

To see that an offer of C_R at date 0—which is accepted by B—is an equilibrium when $I < \overline{I}$, note first that under Assumptions A7, A8 and A9, an offer of C_R at date 0 provides a higher payoff than C_A, C_B or C_{AB} to both A and B (as established in Proposition 5). Moreover, when $I \leq \overline{I}$, both agents are also better off signing C_R at date 0 than thinking ahead. Therefore, B will accept an offer of C_R at date 0 and A will indeed offer C_R.

Finally, when $I \in [\overline{I}, \frac{\delta\pi}{2})$, A is better off delaying a contract offer and thinking ahead if B also thinks and shares her thoughts. Similarly, B's best response to A thinking ahead is to also think ahead and share her thoughts. ||

Proposition 7. *Under Assumptions A1, A3, A7, A8, A9 and A11, an offer C_R from A at $t=0$ is an equilibrium of the contracting game when*

$$x^* = \frac{1}{\underline{R}_B - S_B}\left(\frac{2I}{\delta} - \pi - S_B\right)$$

is close enough to zero.

Proof of Proposition 7. Given their prior beliefs, both agents prefer the risky to the safe action under Assumption A1. Agent A can make an offer C_R at $t = 0$ and have B accept it when it is common knowledge that none of the players is informed.

We shall assume that B has *pessimistic* out-of-equilibrium beliefs and that if a contract is not immediately accepted at time $t = 0$, B believes that A knows that $R_k = \underline{R}_k$ when he makes an offer C_R and therefore B rejects any offer C_R past period 0 given Assumption A11.

Thus after $t = 0$, A can no longer get an offer C_R accepted by B. Under Assumption A11, the only offers B will accept after time $t = 0$ are C_S and contract C_{x^*}, where r is chosen with probability x^* defined in equation (9) and s is chosen with probability $(1 - x^*)$ when $R_k = \underline{R}_k$. Therefore, A's payoff when thinking ahead of investing is at most

$$\widehat{\Lambda}[-I + \frac{\delta\pi}{2} + \frac{\delta}{2}(\nu S_A + (1-\nu)(x^*\underline{R}_A + (1-x^*)S_A))]$$

which is dominated by A's payoff under contract offer C_R at time $t = 0$:

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}(\nu\overline{R}_A + (1-\nu)\underline{R}_A),$$

when x^* is low enough, by Assumption A1.

Moreover, under Assumptions A8 and A9, A weakly prefers contract C_R to C_A. ||

Proposition 8. *Under the same assumptions as in Proposition 7 and Assumptions A12 and A13, and provided that*

$$x^* = \frac{1}{\underline{R}_B - S_B}\left(\frac{2I}{\delta} - \pi - S_B\right)$$

is sufficiently close to 1*, the unique subgame-perfect equilibrium is such that A offers a preliminary contract to B at* $t = 0$ *with the following terms: (a) the agents commit to invest once they have identified* R_k*; (b) if* $R_k = \underline{R}_k$*, then action r is chosen in state* θ_2*; (c) if* $R_k = \overline{R}_k$ *then action s is chosen with probability* χ *and action r with probability* $(1-\chi)$ *in state* θ_2*, where* χ *is given by:*

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}[\nu(\chi S_B + (1-\chi)\overline{R}_B) + (1-\nu)\underline{R}_B)] = 0. \tag{14}$$

Proof of Proposition 8. Note first that if (14) holds, the preliminary contract is acceptable to B. Second, under Assumption A12, A strictly prefers the preliminary contract to thinking ahead and settling on either contracts C_S or C_{x^*}. To see this, consider A's *ex ante* maximization problem with respect to χ and x:

$$\max_{\chi, x}\left\{-I + \frac{\delta\pi}{2} + \frac{\delta}{2}[\nu(\chi S_A + (1-\chi)\overline{R}_A) + (1-\nu)(x\underline{R}_A + (1-x)S_A)]\right\}$$

subject to:

$$-I + \frac{\delta\pi}{2} + \frac{\delta}{2}[\nu(\chi S_B + (1-\chi)\overline{R}_B) + (1-\nu)(x\underline{R}_B + (1-x)S_B)] = 0.$$

Substituting for x, this problem is equivalent to the unconstrained problem:

$$\max_{\chi} \nu(\chi(S_A - \overline{R}_A) + \overline{R}_A) + (1-\nu)S_A + (\underline{R}_A - S_A)\left[\frac{\frac{2I}{\delta} - \pi - (1-\nu)S_B - \nu(\chi(S_B - \overline{R}_B) + \overline{R}_B)}{\underline{R}_B - S_B}\right].$$

Differentiating with respect to χ we observe that the coefficient with respect to χ is strictly positive under Assumption A12, which means that A would like to set χ as high as possible and x as low as possible. The best contract for A is then obtained by setting $x = 0$.

Third, A and B prefer the preliminary contract to C_R under Assumption A3 given that x^* is close to 1, as they then already prefer to think ahead and settle on contracts C_S and C_{x^*} to signing C_R.

Fourth, A's continuation best response following acceptance of contract C_α is to think ahead, for no investment can take place unless A reveals the value of R_k.

Fifth, A is clearly better off disclosing $\underline{R}_k$ under Assumptions A1 and A7. He is also better off disclosing $\overline{R}_k$ under Assumption A13.

Finally, under Assumptions A8 and A9, the agents weakly prefer C_R to C_A, but C_R in turn is dominated by C_α when x^* is close to 1. ||

Lemma 4 (The Congruence Principle). *Under fully transferable utility, it is weakly optimal for the contracting agents to begin by signing a preliminary agreement which establishes how the agents will share the profits from the venture.*

Proof of Lemma 4. Let $\kappa_l^j \in \{\underline{R}_k, \overline{R}_k, \varnothing\}$ denote the payoffs communicated by agent $j = A, B$ to the other agent up to time l, and let $I(\kappa_t^j)$ denote an investment plan specifying a (possibly random) time t contingent on the payoffs communicated by the agents up to time t, at which investment is sunk. Also, let $\{a(\theta, \kappa_{\tau(\theta)}^j)\}$ denote a plan to take action $a(\theta, \kappa_{\tau(\theta)}^j)$ in state θ at (possibly random) time $\tau(\theta)$ contingent on the payoffs communicated by the agents up to time $\tau(\theta) \geq t + 1$.

Then $\rho(a(\theta_2, \kappa_\tau^j))$ denotes the expected revenue obtained in state θ_2 under investment plan $I(\kappa_t^j)$ and action plan $\{a(\theta, \kappa_{\tau(\theta)}^j)\}$, and V denotes the maximum value of the venture at date 0:

$$V = E\left\{ \max_{I(\kappa_t^j); a(\theta, \kappa_{\tau(\theta)}^j)} \delta^{\tau(\theta)} \rho(a(\theta, \kappa_{\tau(\theta)}^j)) - \delta^t I(\kappa_t^j) \right\}.$$

We shall argue that by offering a preliminary contract such that the agents share profits, with $\alpha_k \geq 0$ denoting the share of profits of party $k = A, B$, the proposer can achieve the highest feasible payoff $V - U_{\min}^{\mathrm{R}}$.

Under such a contract, each party's payoff for any given subsequent investment plan $I(\kappa_t^j)$ and action plan $\{a(\theta, \kappa_{\tau(\theta)}^j)\}$ is:

$$\alpha_k E\{\delta^{\tau(\theta)} \rho(a(\theta, \kappa_{\tau(\theta)}^j)) - \delta^t I(\kappa_t^j)\}.$$

Thus both agents have aligned objectives on the choice of investment and action plan given any $\alpha_k \geq 0$ and will agree on a plan that achieves V. It then suffices for the proposer to choose α_B such that

$$\alpha_B E\{\delta^{\tau(\theta)} \rho(a(\theta, \kappa_{\tau(\theta)}^j)) - \delta^t I(\kappa_t^j)\} = U_{\min}^{\mathrm{R}}. \quad ||$$

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