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Almost Anonymous Implicit Contracting

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Abstract

Economists use relational or reputational concerns to explain the implicit enforcement of contracts. Both mechanisms require special assumptions concerning contracting parties' identities; in particular, these assumptions would not hold in one-period settings in which outcomes cannot affect reputation. In such a setting, this paper shows how a signaling mechanism can support the implicit enforcement of contracts that Pareto improve upon the null contract. Furthermore, this mechanism is independent of the discount factor and can outperform the relational contract in a range of cases. We find empirical support for our theory using contracts from financing alliances in the biotech industry.

Keywords: implicit contracts, biotech alliances, identity.

JEL Codes: D29, L24, O31.

1   Introduction

Implicit contracts use long term relationships or reputational concerns to internally enforce contractual duties (Benjamin Klein & Keith B. Leffler 1981, Jonathan Levin 2003, Clive Bull 1987). However, both of these enforcement mechanisms interweave the identity of the contracting parties with the utility of the transaction. In other words, each of a sequence of infinitely or indefinitely repeated interactions can affect the utility of the transaction. This dependency on identity contrasts starkly with the anonymity of market exchange.[1] In this paper, we revisit implicit contracting in contracting environments that rule out the use of implicit enforcement based on the identities of the contracting parties.

We refer to such contracts as almost anonymous since identity only plays a role for the transaction at hand. In an almost anonymous contract, therefore, the extent to which identity can affect the utility of a contract is minimal and null in the limit. To illustrate the almost anonymous implicit contract in a dramatic fashion, we present a model that shows how Pareto-improving contracts involving an implicit bonus can arise in the one-period context. Importantly, this enforcement mechanism escapes the common criticism that contracting parties using implicit enforcement become locked into a narrow pool of possible contracting partners, smoothing the discontinuity between market and contractual exchange.

The key insight is that certain contractual environments permit an implicit bonus to function as a signal about the value of contractual outcomes. This mechanism shares a similar incentive structure to reputational and relational mechanisms but does not rely on the strong assumptions about identity. In particular, in our model, we rely on a multi-stage structure within a single

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[1]This property is an abstraction (few transactions fully satisfy it), but real world transactions may differ in the degree of anonymity. In fact, one can consider market transactions as primitive implicit contracts.

period to accommodate the signaling mechanism that drives the incentives to perform. However, contracting with the same party in the next period is not superior to contracting with a randomly selected party. Indeed, our mechanism works regardless of the possibility of future interaction and in spite of the fact that contractual outcomes, mainly the success or failure to perform, do not credibly affect reputation.

Diverse literatures, from organizational economics to marketing, discuss contracts that exhibit limited use of external enforcement in environments that make reputational markets or repeated interaction unlikely. For example, consider the development of a new product. Because the product is new, the developer may require the help of an innovator with whom the developer has had no prior experience. The innovator will apply effort in order to achieve the desired product. If the innovator is successful, the developer can then market the product. The two parties may face difficulties developing the product because the developer has trouble specifying the new product, the innovator may shirk or the product may not be technically feasible. Each of these reasons is difficult to monitor meaning that reputation cannot credibly enforce the relationship. Furthermore, the value of the innovation is not certain, limiting the role for repeated interaction (at least ex ante). Nevertheless, new products are developed all the time through diverse organizational structures, such as within the firm, through an entrepreneur/financier, and via multi-firm cooperation.[2]

More concretely, consider a recent contract between the Warner-Lambert pharmaceutical company (P for principal or the developer in our context) and Ligand Technologies, a biotech firm (A for agent or the innovator).[3] P hires A to develop a drug to subsequently put through clinical trials, seek approval from the FDA and eventually commercialize the drug. This process is costly, highly uncertain and competitive. P has little expertise in research and development of

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[2]Appendix A discusses additional examples that would fit our setting.

[3]This contract can be found at http://contracts.onecle.com. The authors were made aware of such contract in Ronald J. Gilson, Charles F. Sabel & Robert E. Scott (2009).

the chemical compounds that produce the desired effects. A has little expertise in the FDA approval process and, upon approval, the marketing of the drug. The lack of expertise and the nature of scientific discovery as well as marketing limit the observability of either party's efforts.

The contract uses many ambiguous terms such as "good efforts" and grants generous termination rights to P. Prima facie, neither formal enforcement nor relational enforcement explains how these contracts work. Implicit contracts are often represented as contractible and non-contractible components, such as a contractible salary and a non-contractible bonus payment. The implicit enforcement mechanism enforces the bonus payment. This bonus payment is difficult to enforce without a dynamic, multi-period setting involving reputational concerns or the threat of terminating the relationship. The very nature of this contracting problem, that effort and performance are unobservable to outsiders, makes it difficult for reputation to credibly enforce contractual terms.[4]

The two sides of innovation, developing the product and subsequently producing and marketing the product, give rise to an incentive structure conducive to an implicit contract. On the one side, the developer (P) possesses superior knowledge of the value of a successful innovation. In most cases, the consumer demand for the innovation at the time of product development is uncertain; in fact, by the time the product is developed, the innovation may not be worth marketing at all. In the context of drug development, other competitors may have developed similar drugs or medical science may have advanced new technologies. Thus, P may need to signal the value of the innovation with a bonus payment in order to create incentives for the innovator to remain with the project. On the other side, the innovator has a role both ex ante and ex post. The effort level of the innovator (A) will be hard to monitor, both because effort

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[4]Reputation is likely to work particularly poorly in the examples we have in mind. For instance, Scott Masten & Renáta Kosová (2009) argue that reputation does not function well in enforcing post-sale service agreements (which correspond to the innovator's agreement to provide support in our model).

is unobservable and successful product development is uncertain. Moreover, the specialization of the innovator in producing the local innovation points to the necessity of the innovator's assistance in bringing the product to the market. For example, A needs to assist P in the clinical trials as well as provide support, in case there is an unexpected lawsuit after approval.

The essential elements of our model are mostly familiar: 1) uncertainty – in our model, the principal (and the agent) do not know the value of the innovation; 2) asymmetric information – the principal may observe a signal about the value of the innovation; 3) non-observability – the agent's effort in producing the local innovation is not observable and hence not contractible. In addition to these assumptions, we make one more key assumption for our analysis related to the benefit and cost structure. In our setting, the agent can cause a large increase in the principle's realized value of the transaction at little to no cost to himself. We refer to this type of cost as a support cost and these costs have bite in any setting in which specialization occurs.

In general, this contracting environment forces contractual arrangements closer to the anonymity of market exchange. Under such conditions, contracting constraints may improve the limited efficiency of static self-enforcing agreements, relative to relational or formal contracting. Using data on financing contracts in the biotech industry, we find evidence that supports our model better than the alternative story involving reputation. First, we show that greater anonymity increases the use of implicit enforcement mechanisms. We then show the magnitude of this effect is greater when we restrict attention to contracts that merely stipulate a financing role for the pharmaceutical company. We also demonstrate that the observed effect is exclusive to contract relationships where the deliverables are more easily transferable (less restricted by possible patent protections).

The paper proceeds as follows: We discuss the related literature in section 2. Section 3 presents the model. We include some comparative statics of our model

in appendix B and relegate a few technical details to appendix C. In section 4, we compare our model with the incomplete contracts and implicit contracting paradigms. This comparison allows us to develop an empirical prediction for contractual structure. Section 5 discusses and tests this prediction. Finally, we conclude in section 6.

2   Related Literature

This paper represents a merging of the incomplete contracts and implicit contracting literatures as described by Patrick Bolton & Mathias Dewatripont (2005).[5] On the one hand, we borrow the methodological approach of the incomplete contracting literature by assuming conditions that require contractual incompleteness, and, on the other hand, we focus on incentives as in the implicit contracting literature. Accordingly, in section 4, we discuss the no contract and relational contract benchmarks loosely based on Yeon-Koo Che & Donald B. Hausch (1999) and George Baker, Robert Gibbons & Kevin J. Murphy (2002), respectively, in comparison to our model.

George Baker, Robert Gibbons & Kevin J. Murphy (1994), W. Bentley MacLeod (2003), and Levin (2003) have all studied how the optimal contract is structured in the relational setting where parties to a contract have the possibility and the desire to interact in the future. A specific, especially thoroughly studied, application of the relational setting is franchising, where the principal (franchisor) and an agent (franchisee) engage in a relationship characterized by both nonobservability and noncontractibility on a number of relevant dimensions. Benjamin Klein (1995) argues that the multiperiod logic is essential for the franchising arrangement to be sustainable. Indeed, the threat of terminating the relationship enforces present contractual duties. In contrast, this paper

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[5]Raghuram Rajan & Luigi Zingales (1998) also straddle the incomplete and implicit contracting literatures, but mainly discuss the organizational form of the firm. In terms of Rajan & Zingales (1998), the agent in our model receives access shares to the idea behind the innovation. Power plays less of a role in our context since the agent possesses inferior information.

makes no such presumption. Instead, we focus on a mechanism that would support cooperative exchange in a multi-stage, one-period context.

In a related paper, Massimo Motta & Thomas Rønde (2002) start from Baker, Gibbons & Murphy (2002) to explain why a principal would honor informal bonus payments in both the static and repeated context. If the agent's contribution to the value of the project is considerable, then the principal will pay the bonus to discourage the agent from leaving with enough knowledge to develop a similar technology for the competitor. Akhmed Akhmedov & Anton Suvorov (2007) also stress the importance of a competitor in ensuring the payment of a noncontractible bonus. In their setting, the principal does not know the outside offers an agent might have. This uncertainty drives up the payment given to the agent for specific investments. In contrast, our model concentrates on the value of the project to the principal. The principal has an incentive to pay since, without payment, the agent will believe that ex post the principal attaches little value to the project. Hence, the agent sees little reason to continue offering support for the project. Thus, our model comes closer to the anonymity of market exchange since an agent's competitors are irrelevant. David Martimort, Jean-Christophe Poudou & Wilfried Sand-Zantman (2009) also study the agent's incentives not to run with the idea once described by the principal.[6] We assume the agent does not buy the license to produce the good from the principal, for example, because of liquidity constraints or because of lack of the necessary commercial knowledge to make the product a success.

As early as Bengt Holmström & John Roberts (1998), the literature has noticed that vertical integration often does not occur when we might expect it to, either from the transaction costs perspective (Oliver Williamson 2001) or the property rights perspective (Sanford J. Grossman & Oliver Hart 1986). Our model, along with relational contracting, can contribute to understanding

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[6]Symmetrically, the principal must be motivated not to describe the idea to competing agents, for example, by a stake in the agent's future revenues – see Sudipto Bhattacharya & Sergei Guriev (2006).

this puzzle since we show how the scope of contractual solutions widens. Furthermore, we can speculate why two parties might prefer to contract instead of vertically integrating in the first place. Gilson, Sabel & Scott (2009) argue that parties use formal contracts not only to align incentives but also to identify what particular interests parties might share. Our paper adds to this literature by showing explicitly how learning about common interests reduces the scope for opportunism and hence becomes an attractive option when it is costly to vertically integrate.

Josh Lerner & Ulrike Malmendier (forthcoming) show how the assignment of control rights can limit opportunistic behavior in R&D alliances. In the optimal contract, the financing firm can terminate the relationship early and maintain the control over what had been researched by the researching firm through broad licensing rights. Lerner & Malmendier (forthcoming) argue this contractual structure functions to limit multi-tasking by preventing the financing firm from opportunistically terminating the relationship while giving incentives for the research firm to work on the specified project. In contrast, our model does not require multi-tasking to generate incentive misalignment nor effort to be observable. Termination is an integral part of the signaling mechanism that gives incentives for the research firm to exert effort. In this light, our model provides a complementary explanation to Bengt Holmström (1989) for why small firms innovate more than large firms. Our model shows one possible pathway for implicit contracts to support large firms' desire to contract out innovation (given the large agency costs associated with innovation), further reducing the value of innovating inside the firm.

A secondary aim of this paper is to better understand the conditions under which self-enforcement can substitute or complement more formal enforcement mechanisms. Restricting attention to only courts and third-party enforcers may miss important contractual solutions.[7] Robert E. Scott (2003) cautions against

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[7]Laura Poppo & Todd Zenger (2002) argue and demonstrate empirically that these relational

9

formal law discouraging norms of reciprocity. Carl Shapiro (1983) has a good example of how excessive formality inhibits the use of reputation. Formal law can also crowd out the use of the mechanism in this paper by interfering with the signaling mechanism. Even though incompleteness results in less than optimal investment in new technologies (Daron Acemoglu, Pol Antras & Elhanan Helpman 2007), contractual incompleteness may provide an avenue for technological innovation when formal enforcement is costly or not possible. In fact, Philip Scranton (2000) puts forth the thesis that specialty goods innovations, innovations that fit particularly well into our setting, were the main driving force of the second industrial revolution in the US. Finally, our mechanism has an attractive property from a development perspective. Long-term certainty provides the incentives for relational exchange whereas it is precisely the potential for resolving the *short-term uncertainty* that enforces exchange in our model. The drawback of long-term certainty as Rachel E. Kranton (1996) argues is that it makes reciprocal exchange persist even though a more efficient system of market exchange exists.

3   The Model

There is a principal (she) and an agent (he) who are both risk-neutral. In the innovator/developer example, the principal is the innovator and the agent is the developer. The principal has an idea about introducing a new product to the market. This product may or may not be valuable. The value to the consumer is V with probability p (and the principal, who markets the product, appropriates all of the value in the form of the price she charges); with the remaining probability $1 - p$, the product is of zero value. The principal has full bargaining power over the surplus; the agent's opportunity income is W_a.

Introducing the new product requires both costs and luck. There are four

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mechanisms complement formal enforcement.

components to the costs: setup costs c_f, production costs c_p, marketing costs, c_m and support costs, c_s. The agent chooses noncontractible effort level, e, normalized to the probability that the product will, in fact, be produced. The agent bears production costs $C(e) = \frac{e^2}{2k}$, where k is low enough to make sure all relevant effort choices are in $[0, 1]$. If the agent succeeds in developing the new product, he delivers it to the principal who then has to spend fixed (small but positive) private marketing costs, c_m, to market it. Marketing the product also requires the agent to spend (also small but positive) support costs c_s.[8] We assume that support costs are noncontractible, both ex ante (because the nature of support needed is not foreseeable at the time of the contract) and ex post (because when support is needed the agent, who has developed the product, possesses superior and likely exclusive information about what kind of support is actually needed as well as expertise in delivery of such support). Nonconctractibility, both ex ante and ex post, rules out contracting for support (be that with the same agent or someone else), so the principal is forced to seek agent's assistance in providing it, who in turn, facing small but positive costs, will only provide support if motivated to do so, in our case by his stakes in successful development of the project.[9]

If the product makes it to the market and turns out to be successful, the agent derives some positive private, nonalienable, noncontractible utility, which improves his opportunity income, W_a, and also lowers his fixed costs, c_f, in the future. This utility results from being involved in the commercial aspect of product development. Through offering support, the agent learns about consumer preferences and the feasibility of certain kinds of products. This

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[8]Some examples of products with positive support costs are durable goods, organic practices/certification, debugging, etc. See Masten & Kosová (2009) in a symmetric information and complete contracts setting.

[9]For example, consider the example of a researcher submitting to a journal: how can you contract for revise and resubmit? Nobody other than the author can deliver revisions and she will only do so if she feels that the benefits (value of a publication multiplied by the probability of publishing) outweigh costs; otherwise she can always alter the text in a meaningless but zero costs way (such as by deleting all points on which asked to elaborate) and so address the letter of the criticism (by eliminating the matter) without addressing the point of it. For other examples, see appendix A.

knowledge will aid the agent in the future.

The relationship between the principal and the agent unfolds as follows:

1. Principal decides whether to attempt customized product (she will always choose in favor whenever she has an idea).

2. Principal contacts an agent and describes specification of the input. She offers him contractible salary s (to be paid upfront) and noncontractible bonus b, to be paid if the agent delivers the product.

3. If the contract is accepted, the agent bears fixed costs c_f and chooses effort level e.

4. With probability q the principal gets to privately observe the value of the product to the consumer (i.e., learns whether it is V or zero). This event is independent on the value.

5. The input is developed (or not) and delivered to the principal. If the input is not developed, the game ends.

6. The principal decides whether to honor her promise to pay the bonus.

7. The agent decides whether to provide support; if he decides not to, the game ends.

8. The principal decides whether to market the product (at private costs c_m); if decides not to, the game ends.

9. Output is produced and offered to the customer.

10. If it turns out to be successful (i.e., valued at V by the market) the agent gets expertise $\triangle W_a$ and his (discounted) costs of starting new projects in the future are reduced by $\triangle c_f$.

We assume that $\triangle W_a = \triangle c_f$, that is, the extra expertise which the agent derives from successfully completing the project is purely general and not specific to the project. Technically this assumption is needed to simplify developing

the multiperiod model: that way neither principals nor agents have any preferences about whom to be matched with (higher reservation wage is fully offset by lower setup costs for this agent). Or, more concretely, consider the paper submission process: if a paper gets published, the author gets both credit and expertise, meaning that he is more efficient in writing subsequent papers (not necessarily for the same journal) but also that inviting him as a coauthor is now more difficult since his opportunity costs of time (in terms of participation in other potential projects) is now higher. This $\triangle W_a$ has to be high enough compared to support costs c_s so as to induce the agent to provide support if he believes that the principal has not received a negative signal. This amounts to assuming $c_s \leq \frac{p}{p+(1-p)(1-q)} \triangle W_a$.

Why would the principal honor her promise to pay the bonus? If not paid, the agent will believe that the principal lost hope in the product (i.e., got a negative signal). If no bonus is given, the agent will not bother to provide support because he infers that the principal will not market the hopeless product and hence even small support costs are not worth spending. It is in order to signal that she still believes in the product (i.e., either got no signal or got a positive signal about the value to the customer) that the principal will pay the promised bonus.

What is the first best level of effort (i.e., what would the parties have chosen if it were contractible)? With probability e the product gets developed, then with probability $1-(1-p)q$ the principal does not get a negative signal and the two of them do spend their respective c_s and c_m (we assume that $pV > c_m + c_s$, i.e., in case of no signal it is still worth trying) and then earn their V, but have to spend development costs $C(e) = \frac{e^2}{2k}$. Overall, the maximization problem looks like:

$$ e\left[(1-q)(pV - c_m - c_s) + pq(V - c_m - c_s)\right] - \frac{e^2}{2k} - c_f \rightarrow \max_e, $$

so the first best level of effort is

$$e^{FB} = k\left[(1-q)(pV - c_m - c_s) + pq(V - c_m - c_s)\right].$$

Since the effort level is not contractible, the agent, in response to the bonus promise, privately chooses it. The agent realizes that the bonus will only be paid by the principal if she does not get a bad signal (i.e., if either she gets a good signal or no signal at all), which happens with probability $1 - (1-p)q$, and then the agent will have to incur further costs c_s. If the bonus promise is credible, the agent will choose the effort level so as to solve:

$$e(1 - (1-p)q)(b - c_s) - \frac{e^2}{2k} + s - c_f \to \max_e,$$

so he will choose

$$e^* = k(1 - (1-p)q)(b - c_s).$$

The first best level of effort can only be supported by a bonus as high as $b^{FB} = \frac{pV}{1-q+pq} - c_m$. We now show that this high bonus payment is not credible: in case the principal gets no signal, her expected payoff from marketing the product is $pV - c_m < b^{FB}$. In this case, she will prefer not to pay the bonus and not to market the (already developed) product. Therefore, the maximum credible bonus is only $pV - c_m$ which falls short of b^{FB} and hence the agent underinvests in developing the new product. Note that the level of inefficiency is an increasing function of the probability of signal q. For the interested reader, we include some comparative statics in appendix B and appendix C discusses a few technical details concerning this static implicit contract.

There is another implicit contracting arrangement similar to this one, in which the principal only pays the bonus if she receives a good signal about the quality of the project (rather than whenever she does not receive bad signal, as developed above). Although such an arrangement allows for a wider range of

14

credible bonuses – indeed, the principal will now be prepared to pay as much as $V - c_m$ conditional upon receiving good signal – the effort level exerted by the agent for any given level of promised bonus is lower under this alternative arrangement, since the agent knows that he is less likely to receive the bonus if he succeeds in developing the product. This alternative arrangement too fails to deliver first best level of agent effort or first best level of welfare. Which of the two arrangements is preferable depends on the value of parameters, in particular, on the value of q.

Although the first best is not achievable, as a second best outcome, either arrangement allows for more innovations to enter the market than if no level of bonus payment were feasible.

4   No Contract and Relational Contracting Benchmarks

In this section we compare the equilibrium outcome of the model outlined above against two benchmarks: (1) the null contract or incomplete contracting benchmark, in which the agent first chooses effort and then, should his effort in developing the new product be successful, bargains with the principal about the division of surplus and (2) relational contracting, where the principal informally offers bonus to the agent in case his effort is successful, and her incentives to actually pay the bonus are governed by reputation concerns, as in Baker, Gibbons & Murphy (2002).

In order to simplify exposition, we focus on the limiting case when setup costs c_f, marketing costs c_m, agent expertise W_a and support costs c_s tend to zero. In this case, the maximum credible bonus to be paid upon receiving no signal about the value of the project is $b = pV$, the maximum possible level of

effort by the agent is

$$e = k[1 - q + pq]pV < kpV = e^{FB}$$

and the expected value of the implicit contract is $[1 - (1 - p)q]kpV \cdot pV - [1 - (1 - p)q]^2 kp^2 V^2/2 = kp^2 V^2[1 - (1 - p)^2 q^2]/2$. Similarly, the maximum credible bonus to be paid only upon receiving positive signal equals V, it induces effort level $e = kpqb = kpqV < kpV = e^{FB}$ and delivers value of the contract equal to $kp^2 q^2 V^2/2$. Comparing the two contracts, one concludes the former is preferable for $q < 1/\sqrt{1 + (1 - p)^2}$ while the latter is preferable for $q > 1/\sqrt{1 + (1 - p)^2}$. Denoting the value of optimal implicit contract by V_0 we therefore obtain:

$$(1) \qquad V_0 = \begin{cases} kp^2 V^2[1 - (1 - p)^2 q^2]/2, & q \leq 1/\sqrt{1 + (1 - p)^2}; \\ kp^2 q^2 V^2/2, & q > 1/\sqrt{1 + (1 - p)^2}. \end{cases}$$

In order to avoid further dealing with multiple cases we restrict our attention to low values of q; specifically, we assume the following:

Assumption 1. The probability of the principal receiving a signal about the value of the product is low compared to the probability that the value is high: $q \leq \frac{1}{2-p}$.

Under Assumption 1, the value of the optimal contract is $V_0 = kp^2 V^2[1 - (1 - p)^2 q^2]/2$.

Note that in both benchmark cases outlined below, the equilibrium level of the agent's effort never exceeds e^{FB}; therefore, since the value of the relationship is an increasing function of agent's actual effort e for $e \leq e^{FB}$ it suffices to compare the equilibrium level of effort in alternative contractual arrangements. An arrangement that induces higher level of effort is superior.

4.1 No Contract Benchmark

In this subsection, we compare our contractual arrangement to that without any contract, explicit or implicit. Under no contract, the game proceeds as follows. First, the principal describes the product she desires to an agent. The agent then chooses his effort level, e, at costs, $C(e) = e^2/2k$; meanwhile, the principal privately observes her signal about the value of the project (V or 0) with probability q, independently of the actual realization of the value. If the agent succeeds in developing the new product (which is observable by both the principal and the agent), the principal and he then bargain about the division of the surplus ex post. Note that at the time of bargaining information is asymmetric: the agent is unaware of whether the principal received a signal (and what signal) at the bargaining stage.[10]

To keep the exposition tractable, we assume a reduced form bargaining game.[11] In this game, either the agent (with probability $\pi \in [0, 1]$) or the principal (with probability $1 - \pi$) gets to make a single take it or leave it offer to the other party. Following the offer, the game ends; payoffs are either specified in the offer if it is taken or zero to both parties if it is not. Parameter π reflects relative bargaining positions of the two parties: $\pi = 1$ (respectively, $\pi = 0$) corresponds to the agent (principal) having full bargaining power. We assume that the choice of who gets to make the (single) offer is independent of other random variables (i.e., on the value of the project and whether the principal received her private signal or not).

We now solve for the equilibrium level of effort in the no contract setup. First, we solve for the equilibrium in the bargaining game. If the principal makes the offer, she will appropriate the entire ex post surplus by offering the

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[10]An alternative formulation would involve bargaining at an earlier stage, before the principal had a chance to receive her signal; however, we assume that at this stage it is uncertain whether the agent succeeded in developing the product, so there is nothing to bargain about.

[11]We focus on case $q \leq 1/\sqrt{1 + (1-p)^2}$ so as to deal with one particular case for V_0; the complementary case $q > 1/\sqrt{1 + (1-p)^2}$ is analyzed similarly.

agent a minimum price for the product. If the agent makes the offer, he has two meaningful options: offer to supply the product at a price just below V, in which case the principal accepts only if she received a positive signal about the value of the project (which happens with probability pq); or offer to supply the product at price just below pV, in which case the principal accepts if she received either a positive signal or no signal about the value of the product (which happens with probability $1 - (1 - p)q$). Therefore, the choice of the agent depends on which of the two values pV or $[1 - (1 - p)q]pV$ is higher. It is straightforward to conclude that the agent will choose to offer V if $q \geq 1/(2-p)$. His ex post payoff, in case the product is successfully developed, equals πpqV.

Second, we solve for the equilibrium level of agent's effort in the case of no contract. If $q \geq 1/(2-p)$, the agent chooses e to maximize $e\pi pqV - e^2/2k$ and will choose $e = e^{NC} = k\pi pqV$. Comparing e^{NC} to e^{SB}, derived in the previous section, allows to conclude the following:

Proposition 1. Under Assumption 1, the agent's effort and the expected value of the arrangement are always at least as high under implicit contract without reputation (described in section 3) than under no contract, and are strictly higher as long as $\pi < 1$.

Unlike in Che & Hausch (1999), even though the agent's effort is a cooperative investment, contracting can have value. In our setting, the identity of the principal matters: the agent understands differently a principal who does not signal with bonus to one who does. In this sense, if no contract approximates market anonymity, implicit contracting without reputation is almost anonymous.

4.2 Relational Contract Benchmark

In this subsection, we compare our setup with that of Baker, Gibbons & Murphy (2002) in terms of induced agent's effort level and overall efficiency. A relational contract, as defined in Baker, Gibbons & Murphy (2002), involves a bonus b^{RC},

promised by the principal to the agent in the case when the agent succeeds in developing the project. The principal's incentive to honor her promise is reputational: if she fails to do so, neither will the agent in question nor any other agent deal with the dishonest principal in the future, causing her to lose potential value every period on (opportunities for interactions between the principal and an agent are assumed to arise every period in the future).

Following Baker, Gibbons & Murphy (2002), we focus on an equilibrium that involves the agent quitting the relationship forever (and no agent entering it in the future) upon the principal failing to pay the bonus when it is due, i.e., when the agent successfully produces the product. Our setup, with the principal receiving a signal about profitability of the project prior to deciding whether to honor her promise to pay the bonus, allows for a richer strategy space than does the original Baker, Gibbons & Murphy (2002) formulation. Indeed, there are now three potentially profitable long term contracts, desirability and feasibility of which we have to assess; these three types differ in the range of signaling situations in which the principal is prepared to honor her bonus promise. The most direct expansion of the original model involves the principal honoring her promise to pay the bonus irrespective of whether she obtains a signal, in particular, when she obtains negative signal. A relational contract, which can be referred to as 'no negative signal' contract, involves the principal honoring her promise to pay the bonus as long as she does not receive negative signal, i.e., she either receives a positive signal or no signal at all. Finally, a 'positive signal' contact may involve the principal only honoring her promise to pay the bonus if she obtains a positive signal about the value of the project.

It is not possible to compare contracts of these types, either with each other or with repeated static implicit contract, on an a priori basis. The contracts can easily be ranked in terms of incentives for the agent. For any *given* level of the bonus, the level of effort induced by the contracts of the three types above is decreasing (in the order presented), since the probability that the agent will

19

receive the bonus decreases for any given level of effort. However, the *range* of feasible bonuses possible under each type of contract has a countervailing effect. The range expands as the probability of payment decreases since the principal's incentive compatibility constraint is less demanding – i.e., compared to the standard relational contract, higher bonuses are feasible if both the principal and the agent understand that the principal will not pay the bonus if she gets a negative signal, and yet even higher bonuses are feasible if the principal is only expected to pay the bonus if she gets a positive signal. Importantly, the following lemma allows us to restrict the analysis to just one type of reputational contract.

Lemma 1. Self-sustaining reputational contracts in which the principal (i) only honors her promise to pay the bonus if she does not receive negative signal or (ii) only honors her promise to pay the bonus if she receives a positive signal deliver a level of effort no greater than that delivered by a repeated optimal static implicit contract.

Proof of Lemma 1. We first prove part (ii). At any offered bonus b, the agent, realizing that the bonus will only be paid with probability pq if he delivers the product, will choose effort level e so as to maximize $pqeb - e^2/2k$ and so will choose $e = kpqb$. Assume for a moment that the credibility of the bonus payment is not an issue; the principal will then want to choose bonus b so as to maximize the per period value of the relationship (by optimally choosing wage s the principal can always leave the agent at his reservation utility level). This ex ante period value of the relationship is given by $pqeV - e^2/2k$ (which implies possible ex post losses: the product will not be developed if the principal fails to receive a positive signal about it, even though the project may still be profitable) and is maximized at $e = kpqV$, which can be supported by bonus $b = V$, credible not only in a repeated but also in a static relationship – conditional on receiving positive signal the principal will be willing to offer any amount up to the value of the project V. Therefore, repeated interaction 'positive signal' contract cannot

improve upon the static 'positive signal' contract with bonus $b = V$, which proves part (ii) of Lemma 1.

Proving part (i) is slightly more complex. Similar to the above, the agent, when offered bonus b, understanding that the principal will only honor her promise to pay the bonus if she does not get a negative signal, chooses effort level e to maximize $(1 - (1 - p)q)eb - e^2/2k$ and hence will choose $e = (1 - (1 - p)q)bk$. For any level of bonus b the principal will be able to offer wage $s = -\frac{k}{2}(1 - (1 - p)q)^2b^2$ so that the agent is indifferent between accepting the contract and not.

For any level of bonus b denote by $U(b)$ the present discounted value of the reputational contract that involves the principal reneging on the bonus payment if and only if she does receives a negative signal; denote by V_0 the value of one period static implicit contract that involves the optimal bonus (i.e., bonus $pV/(1 - q(1 - p))$ for $q \leq \sqrt{\frac{1}{1+(1-p)^2}}$). Then the following equation holds for $U(b)$:

$$
\begin{aligned}
U(b) &= \frac{k}{2}(1 - (1 - p)q)^2b^2 + (1 - (1 - p)q)bk)\frac{U(b)}{1 + r} \\
(2) \quad &+ \ (1 - (1 - p)q)bk \cdot (1 - (1 - p)q)\left[\frac{pV}{(1 - (1 - p)q)} - b + \frac{U(b)}{1 + r}\right] \\
&+ \ (1 - (1 - p)q)bk \cdot (1 - p)q\frac{V_0}{r}.
\end{aligned}
$$

Expression (2) is intuitive. The discounted present value of the contracting arrangements consists of the salary expense, $-s$, in the first term. The second term follows from the fact that, with probability $1 - e$, the agent fails to develop the required product and the relationship passes on to the next period with a value of $U(b)/1 + r$ where r is the interest rate faced by the principal. The third term in (2) accounts for the fact that, with probability $e \cdot (1 - q(1 - p))$, the product is successfully developed; in this case, the principal pays the bonus, markets the product, receives expected payoff $U(b)/1 - q(1 - p)$ and the relationship passes on to the next period. Finally, for the last term, with

probability $eq(1-p)$ the product is developed, but the principal learns bad news about it, decides to renege on bonus payment and the relationship is destroyed, in which case the principal receives V_0 in every period starting from the next period.

From (2) it is straightforward to compute that:

(3)
$$U(b) = (1+r)k(1-(1-p)q)b\frac{(1-(1-p)q)b/2 + pV - (1-(1-p)q)b + (1-p)qV_0/r}{r + kb(1-(1-p)q)(1-p)q}.$$

It is easy to verify that $U(b)$ obtains unique maximum at some point b^* such that $pV < b^* < pV/(1-(1-p)q)$. Note that $U(pV) = (1+r)V_0/r$ for $q \leq 1/\sqrt{1+(1-p)^2}$ – a reputational contract where the promised bonus is equal to the maximum credible static bonus is equivalent to the optimal repeated static contract, if the latter involves the principal paying the bonus upon receiving no signal. For $q < 1/\sqrt{1+(1-p)^2}$ it immediately follows that $U(pV) < (1+r)V_0/r$.[12]

The last step is to verify that no promise to pay a bonus higher than pV is incentive compatible for the principal. Indeed, the principal must be willing to pay the bonus upon receiving no signal about the profitability of the project. If she does, she loses b but gains on average pV in the current period, while maintaining the relationships worth $U(b)/1 + r$ from next period on; if instead she reneges on the bonus payment, she saves b but forgoes pV and relationships slide to the repeated static informal contract, worth V_0 in every period starting

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[12]An alternative interpretation of the relational contract could require that no agent contracts (inclusive of static implicit contracts) with the principal following a failure to honor the bonus payment. We choose to employ the notion of the outside option that once the principal reneges on her promise to pay bonus, the agent – and any other agent – still trust her enough to sustain a one-shot relationship. This assumption is nontrivial, given that this one-shot relationship involves signaling and hence presumes some degree of trust between the parties. Indeed, there is another equilibrium in the game, which involves the principal offering zero bonus and the agent not believing in any bonus promise and hence choosing zero effort; this equilibrium arguably exhibits less trust than the one proposed in section 3. While assuming either continuation equilibrium upon the principal breaking her promise to pay bonus – an off-equilibrium event – requires further motivation, either assumption is consistent with the logic presented below but we focus on this notion in order to isolate the marginal value of using the relational contract when static implicit contracts are available.

next period; therefore, the principal's incentive compatibility constraint looks like[13]

$$(4) \qquad -b + pV + \frac{U(b)}{1+r} \geq \frac{V_0}{r}.$$

Since $U(pV) \leq (1+r)V_0/r$ as noted above, to demonstrate that constraint (4) is never satisfied for $b > pV$ it suffices to show that $U'(b) \leq 1+r$ for these values of b. This is straightforward to check. This completes the proof of Lemma 1.

Therefore, the only reputational contract that remains to be considered is the one where the principal always honors her promise to pay the bonus in equilibrium, even upon receiving negative signal about the value of the project. If bonus b is credible, the agent will be choosing effort e so as to maximize $eb - e^2/2k$ and so will chose $e = bk$. The principal's (ex ante) period payoff, net of agent's compensation, will then equal $V(b) = epV - e^2/2k = kbpV - kb^2/2$.[14] The principal's incentive compatibility condition that assures her willingness to pay bonus b is then given by

$$b \leq \frac{V(b) - V_0}{1+r} + \frac{V(b) - V_0}{(1+r)^2} + \cdots = \frac{V(b) - V_0}{r}.$$

If r is low enough (i.e., $r \leq (kp^2V^2/2 - V_0)/pV$) so that the first best level of bonus $b = pV$ is credible, then the reputational mechanism proposed by Baker, Gibbons & Murphy (1994) delivers first best level of effort $e^{FB} = kpV$; if r is high enough so that no positive level of bonus is credible (i.e., $r > kpV - \sqrt{2kV_0}$) then the reputational contract arrangement is not feasible, and the only option is repeated static implicit contract. For an intermediate level of interest rate there is a maximum credible bonus $b < pV$, which delivers effort level $e < kpV$.

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[13]This is not the only principal's incentive compatibility constraint – the other one is that the principal should indeed be willing to renege on the bonus promise upon receiving a negative signal. This other constraint is, however, not binding for any $b \geq pV$.

[14]Following Baker, Gibbons & Murphy (2002), we assume that the principal has full ex ante bargaining power and so can appropriate the entire ex ante expected surplus by choosing an appropriate salary s – possibly negative – to pay the agent irrespectively of how successful the project is.

Note that at q close to zero or one even at moderate level of interest rate r, the reputational contract is not feasible since V_0 approaches first best value $kp^2V^2/2$ and hence the threat point fails to be unattractive enough to prevent the principal from reneging on her bonus promise.

5   Empirical Analysis

We choose to test our theory using contracts between pharmaceutical companies (the principal) and biotech firms (the agent). Gilson, Sabel & Scott (2009) highlight this class of contracts, exemplified by the contract between a large pharmaceutical firm, Warner-Lambert, and a small biotech firm, Ligand. The pharmaceutical firm covers the marketing and commercialization of the drug and the costly process of FDA approval while the small biotech firm develops the drug (or several chemical compounds). The pharma company funds the research stage and offers a royalty on the revenues of the drug if it is finally marketed. This royalty should provide incentives to the biotech firm but the pharmaceutical company can easily avoid paying this royalty. First, the contract allows the pharmaceutical company to terminate the contract with little advanced warning. Second, while the parties may agree on whether or not the specific compound achieves the desired effect, they may have very different ideas about the commercial possibility and success of the drug. The biotech firm can do little to market the drug because of lack of capital.[15] Ligand has some protection if Warner-Lambert opportunistically terminates. Warner-Lambert would not be able to market the drug for a specified period of time.

The optimal contract would be to assign strong termination rights to the agent (weak termination rights to the principal) but this is not feasible since effort is unobservable and nonverifiable. Gilson, Sabel & Scott (2009) argue that

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[15]In Gilson, Sabel & Scott (2009), the argument is presented that after the development stage, no uncertainty remains and that a unanimous decision about continuing can be reached. But this is a strong presumption considering that the FDA process is by no means a certain process nor is consumer demand if approval occurs.

relational mechanisms explain the data better than standard static contract theory. However, their data do not perfectly conform to the predictions of the relational story either.[16] Moreover, as Gilson, Sabel & Scott (2009) argue, reputational enforcement, while possible, is unlikely since observing who shirked is extremely difficult in such an environment. We agree with Gilson, Sabel & Scott (2009) that contracts between biotech and pharmaceutical companies face considerable limitations, however, we argue that these limitations also apply to enforcement by relational mechanisms. How then are these contracts enforced?

In this situation, Warner-Lambert who has experience both with the FDA and commercializing drugs likely will be in a better position to judge the value of marketing, which in our model corresponds to receiving a private signal after the drug gets developed but before the final FDA approval occurs. Warner-Lambert communicates to Ligand about the product's potential success. Continuation implies a positive view of commercial success and termination implies a negative view. After the initial research phase most of the cost that Ligand would face has been sunk, however, small support costs remain. Ligand still assists with the clinical trials and with the defense of possible lawsuits. This description of Warner-Lambert and Ligand fits our model reasonably well. In particular, by choosing the biotech industry, we already assume the agent's effort is unobservable, uncertainty in the value of the product, and that there are support costs and expertise benefits. Using our model, we can develop an empirical prediction about the relationship between anonymity and implicit enforcement that differs from the standard prediction for relational and reputation models. Specifically, we expect that an increase in the degree of anonymity should increase the use of implicit enforcement in this particular context.

One important issue deserves discussing before we turn to the data and

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[16]For example, the relational mechanisms they consider are statistically insignificantly related with the severity of contract termination. However, a variable that is strongly positively related to the severity of termination is whether or not the contract is in the product development stage, a finding that is consistent with our notion of implicit contracting.

results. The parties may have signed the contract as a matter of course in the business transaction. In the seminal piece on relational contracting, Stewart Macaulay (1963) points out that parties to the contract often have no desire to actually enforce the contract. Indeed relational and reputation may govern the "off the shelf" contracts. In this case, the original contract is not designed to be enforceable (corresponding to the no contract benchmark) or is a mere formality in the extreme. We rely on the "No contract" benchmark as the enforcement alternative to our mechanism.

5.1   Data description

We use the same data as Lerner & Malmendier (forthcoming).[17]   The data set consists of 584 contracts in the biotech industry regarding the financing of research and development activity.[18] Each observation contains information on contractual terms such as termination rights, residual control rights, contracting parties' functions as well as information about what field of research, contracting history, number of patents each firm holds, measures of financial health and whether or not the firm is a major player in the industry.

Summary stats here

For the measure of implicit enforcement, we use a binary variable indicating the presence of an unconditional termination right for the pharmaceutical company. Both BGM and our mechanism require that the pharmaceutical company be able to terminate the relationship regardless of the effort given by the

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[17]We thank the authors and Recombinant Capital for making this data set publicly available.

[18]Lerner & Malmendier (forthcoming) use contracts from 1980-2001 but reduce the sample to limit "undesirable heterogeneity." They state: "We eliminated a number of the summarized transactions in the Recombinant Capital database in an effort to minimize "undesirable" heterogeneity. The eliminated contracts are: research agreements involving universities, medical centers, other non-profit organizations, and government agencies; research agreements where one of the parties had a controlling interest in the other, either through a majority equity stake or through a purchase option (e.g. an alliance between a firm and one of its R&D limited partnerships); 'Renegotiated agreements,' i.e., we excluded cases in which the two parties had a previous research collaboration covering the same set of technologies; 'Marketing-only alliances' i.e., alliances with neither a research nor a product development component; Contracts with more than two firms."

biotech firm. The court may make it difficult to enforce such an agreement if the contract does not explicitly allocate this right to the pharmaceutical company. Thus, we use as the measure of implicit enforcement an indicator of whether pharma has an unconditional right to terminate the relationship. Strong termination rights assigned to the principal is not a feature of the optimal contract if enforcement weren't an issue.

The contracts list the following reasons for termination: 1. Bankruptcy and insolvency; 2. Breach or misbehavior; 3. Termination of some predetermined agreement; 4. Party believes continuing would be unwise, for some reason; 5. 3rd party intervention; 6. Change in control in other party; 7. Mutual agreement; 8. Without cause, any time; 9. Without cause, within certain period. We classify 4, 8 and 9 as unconditional termination rights. Our measure is a stricter one than the one used by Lerner & Malmendier (forthcoming) who include 2 along with 4, 8 and 9. We believe that 2 is too conditional on context, regardless of whether it is enforceable in court. As a robustness check, we run our main specification using the measure of unconditional termination rights proposed by Lerner & Malmendier (forthcoming).

As the measure of anonymity, we use whether the contracting parties specify a lead product. We treat research alliances specifying a lead product as ones characterized by greater anonymity. The alternative to specifying a lead product is to enter a research alliance under the assumption that the product to be developed will be discovered at a later date. This particular treatment of anonymity rests on several implicit steps (i.e. steps not modeled explicitly) that seem to be justified by the literature. We have in mind the following story. First, since we cannot empirically disentangle the discount rate, the probability of future interaction and the value of interaction in future periods, we assume that the discount rate is similar for all contracting parties. For ease of exposition, we assume, in addition, that the value of interacting in the future is equal for discovery stage and specified lead product partnerships (ex-

ante). This leaves all the action in the effective discount rate (discount rate times the probability of future interaction). Second, specifying a lead product means that the pharmaceutical company has a particular task for the biotech firm and hence evaluation of the contractual performance is less costly. Other things being equal, less costly evaluations occur more frequently. Third, since evaluation opens the door to terminate the relationship, the effective discount rate is higher for contracts that specify a lead product.[19]

One counterargument to the way we operationalize anonymity is that discovery stage contracts are longer in duration, meaning fewer contracts (and possibly model periods) can be signed over the lifetime of the firm. We argue against this view because in the relational model, firms are infinitely lived; and, in real life, the firm's lifetime is highly dependent of contract history. In our data, the length of the contract is longer for discovery stage contracts by about half a year on average, statistically significant at the 10% level.[20] However, the share of research alliances that occur three years after the signing of the contract out of the total research alliances observed is 21% for those that specify a lead product and 32% for those that do not and this difference is statistically significant at the 1% level.[21]

5.2   Econometric specification

According to our model, the effective discount rate does not matter for the use of implicit enforcement. However, given the alternative enforcement mechanisms, in practice, the presence of anonymity in a contract will require an increased use of strong termination rights relative to the status quo contract (either optimal

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[19]Additional arguments are that for specified lead products there is less room for developing relation-specific capital. Contracts without a specified lead product are characterized by less anonymity because there is more scope to build relation-specific capital. Since we hold the discount rate and value of future interaction constant, we imagine that the probability of future interaction is higher for discovery stage partnerships because of the greater synergy of future projects, byproducts of joint research and social network effects.

[20]We do not use this as a control because 80% of the sample has missing observations

[21]This difference remains statistically significant if one controls for the time of contract signing.

28

or "off the shelf"). Using weak termination rights leaves more room for the court to rule against termination in case of a bad signal. Thus, strong rights must be put in the contract to protect the signaling mechanism from court interference ex-post. External enforcement of the contract is always an option for the parties but, given the contracting environment, it does not achieve the first-best.

Placing the contract characteristics on a quadrant that has the effective discount rate (low to high) on one axis and termination rights (weak to strong) on the other, our mechanism will tend to impart a positive correlation, pulling the data towards the high effective discount rate, strong termination rights regime. We argue that the mechanism proposed by BGM will either not be feasible given the contracting environment or tend to impart a more negative correlation to the observed contractual pairs. The model of BGM offers a clear alternative hypothesis if we interpret anonymity as the effective discount rate. Then, anonymity should be negatively correlated with the use of implicit enforcement in the BGM set-up.[22] Greater anonymity drives down the effective discount factor, making the BGM contract less feasible.

We assume that we observe a collection of contracts, independent from each other, whose characteristics have been selected as if they were part of a constrained optimal contract. That is, we consider the observed contracts as if they were chosen with information and enforcement constraints taken into account. Contracting parties decide whether to govern the contract with implicit enforcement. The environment, firm, and contracting pair characteristics influence how valuable each enforcement mechanism is to contracting parties.

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[22]Lerner & Malmendier (forthcoming) test a model of moral hazard and multi-tasking in which residual control rights coupled with strong termination rights are given to the financing firm in the optimal contract. They assume the agent's effort(s) is observable and tasks are observable but not verifiable whereas we do not make such an assumption. Our results differ from Lerner & Malmendier (forthcoming). Absent in their model is the main reason for relational contracting in BGM and our model, the assumption that the principal has a moral hazard problem. Thus, we look at the presence of strong termination rights in general and do not need to consider interactions with other characteristics of the agent.

We test our theory using the following specification:

$$(5) \qquad UTR_{it} = \alpha + X_{it}\beta + \gamma A_{it} + year_t + firm_i + \epsilon_{it}$$

The unit of observation i is a contract signed in year t. The main dependent variable UTR indicates the presence of unconditional termination rights for the financing firm. The variable A represents the measure of how anonymous the contract is. The parameter γ is the coefficient of interest observed through our measure of anonymity and X represents a set of controls. We control for financial health of the research firm and the number of previous alliances in all specifications. We include year effects and a partial set of firm fixed effects. We follow Lerner & Malmendier (forthcoming) who give an individual fixed effect to each major pharmaceutical company and use the remaining category to include all other financing firms. They argue that this set of firm fixed effects addresses concerns about endogeneity. Given the use of fixed effects, we elect to use a linear probability model for the main specification.

We run a more specific test of our mechanism by exploiting transfer rights in the contract. Our mechanism assumes that contractual output is transferable. Here, we exploit the variation within contracts that have unconditional termination rights. Thus we test the following specification as a more refined test of our mechanism, which is additionally robust to whether or not the "standard" contract is designed to be enforceable.[23] Our model requires that exercising termination rights is valuable to the principal and that the agent does not benefit from the relationship in any way other than the contractual payments. This may not be true if the research firm has patents in the field. This could potentially confound our results since more experienced research firms with better

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[23]Since termination rights for the financing firm are not optimal they are less likely to appear in the "off-the-shelf" contract, unconditional termination rights may reflect an intention to enforce the contract externally.

patent coverage in the field may be both more likely to be involved in the discovery stage at contract signing and less likely to agree to strong termination rights for the financing firm. To control for this possibility, we include whether or not the research firm has patents as a control.

In order to test our refined hypothesis, we run the following specification:

(6)

$$UTR + CR_{it} = \alpha + X_{it}\beta + \gamma A_{it} + \phi transferable * A_{it} + \psi transferable_{it} + year_t + firm_i + \epsilon_{it}$$

The new dependent variable $UTR + CR$ is a contract that gives unconditional termination rights and control rights of the product to the financing firm. The variable $transferable$ indicates the number of patents that the research firm has. The remaining variables are the same as above.

5.3 Empirical Results

We first summarize the main findings: 1) the proxy for anonymity is positively related to strength of termination rights; 2) as in David T. Robinson & Toby E. Stuart (2007), we find no empirical evidence for relational contracting using alternative measures such as relationship history; 3) we do find some support for reputation using a measure of financial health.

In table 3, we see the main result in column 1. Specifying a lead product, on average, increases the likelihood of unconditional termination rights for the financing firm by 11 percentage points and is statistically significant at the 5% level. The effect is robust to the inclusion of firm fixed effects, shown in column 2. Columns 3 and 4 add controls for relationship history and financial health. The reputation of the financing firm does not appear to play a role. In column 4, financial health of the research firm is statistically significant with a positive coefficient, suggesting that an important consideration in the use of implicit enforcement is whether the research firm is financially constrained. In

31

column 5, we run an ordered logit model using a count variable for the number of unconditional rights as a dependent variable. The results are very similar no matter which specification we use.

Table 3 here

To test how robust this main result is, we exclude the larger biotech financing firms so that all contracts are between a biotech research firm and a pharma financing firm. Column 1 of table 4 shows that the magnitude of the effect increases to 13 percentage points and is still statistically significant at the 5% level. Column 2 demonstrates this result including firm fixed effects.

Recall that our contracting mechanism involves a salary, s, that is likely to be negative. Negative compensation for drug development may not be observed explicitly. This can be done behind the scenes, e.g., by specifying a low level of unconditional compensation, insufficient to even cover the costs of manpower while developing the drug. Only a healthy research firm can tolerate being underpaid for long enough (counting on internal resources to compensate its employees) to be part of a relationship like the one we have in mind. Moreover, a research firm that is financially in trouble may be less likely to be around to provide support when it is needed. In column 3, we run the same regression but including the interaction term between financial health and specifying a lead product. The interaction term is positive and jointly significant at the 10% level with the specified lead dummy.

We then exclude all those contracts that explicitly mention a collaborative role for the financing company, possibly suggesting there are some additional inputs by the pharma firm that may influence the contractual structure. Again, we see the effect is positive and significant. In columns 5 and 6, we broaden the measure of unconditional termination rights to exactly copy the definition that (Lerner & Malmendier forthcoming) use (that is, we include the right to terminate if the other party breaches) for specifications both with and without firm fixed effects. The effect remains although it is diminished.

Table 4 here

To test our story more directly, we take a closer look at the contract terms and the extra-contract legal protections that might govern the transferability of the contractual outputs. Table 5 presents the results (on the sample of biotech/pharma contracts). In column 1, we simply control for the number of related patents that the research firm has. The effect of interest is virtually unchanged. To test whether our mechanism is more likely to work when this transferability problem is absent, we interact this term with the main variable of interest. Column 2 shows that the effect on the interaction term is positive but not significant (joint significance holds). However, the lack of significance may be due to the fact that when transferability is an issue, we need to account for who keeps the control rights for the product. As an outcome variable, we must now consider unconditional termination rights that also give residual control to the financing firm. Columns 3, 4 and 5 present the results with column 5 presenting the variable of interest, the interaction term between specified lead and transferable. We see that the effect of the interaction term is now 16 percentage points and statistically significant at the 5% level. This result confirms that much of the observed effect of anonymity can be explained by contracts with outputs that are, in principle, transferable.

Table 5 here

6 Conclusion

In the face of dynamic uncertainty, implicit contracts can emerge to support innovations. When the value of a new product is uncertain, the principal can signal this value so that the agent will continue to participate in the production process. The principal's incentives come from an enrichment in the contracting environment, namely, support costs, which are small but potentially very powerful. If support is not given, the product cannot be marketed. This

signaling-based implicit contract is superior to the standard incomplete and relational contracting benchmarks precisely in environments with high interest rates, high uncertainty or poor observability.

We develop an empirical test of the signaling-based implicit contract by deriving mutually exclusive predictions for reputation/relational contracts and the signaling-based contract. Using contracts from the biotech industry, we show that, if contracting parties use implicit enforcement, the empirically observed set of contractual attributes is consistent with contracting parties making use of the signaling mechanism to enforce contractual duties.

We would like to point out that this type of internal enforcement mechanism can be generalized. To illustrate what we have in mind: each economic transaction produces a knowledge by-product. In the most basic case, contracting parties gain the knowledge whether such and such transaction can voluntarily occur at such and such place and time. To push this idea to the extreme, the parties might interpret each exchange, no matter how simple or routine, as an innovation whose value is uncertain ex-ante because contractual performance may depend on factors that constantly change and evolve. If this knowledge is valuable, then incentives exist for each party to perform close to contractual duty because, by doing so, less noisy information is observed about the value of contractual performance to both parties. In such cases, these incentives reinforce expectations about contractual performance, suggesting that the many uncertainties that business transactions commonly face actually act to support the norm to meet one's contractual obligations. At the margin, this mechanism can keep contracting parties from breaking good faith understandings, from seeking costly external enforcement and from restricting the pool of potential contracting partners.

One could also interpret our mechanism as a contribution to the economic theory of trust and reciprocity. Oliver Hart & John Moore (2008) show how contracts can manipulate expectations about entitlements against which con-

34

tractual parties measure the "fairness" of outcomes. However, their notion of "fairness" is a behavioral trait that deviates from first principles and sits uneasily with traditional economic methodology. In our framework, contractual duties similarly function as a reference point to accurately measure the value of the transaction. Each party can better assess the value of the innovation by interpreting the contractual performance through the specified duties. While there is no notion of fairness in our approach, one could interpret this mechanism as contributing to an economic theory of trust or reciprocity, implying that self-interested behavior can explain cooperative agreements in a broader setting than previously had been recognized. In this light, this type of mechanism may even matter for understanding how institutions scale up during the process of economic development. When formal institutions are prohibitively costly, these self-enforcing agreements can be used as an alternative to violence. This mechanism can expand the extent of the market making it feasible to invest in legal institutions that secure peaceful interactions more broadly.

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Table 1: Definition of Variables

Variable	Definition*
# Unconditional Termination Rights for the Financing Firm	The number of unconditional termination rights that the financier possesses.
Any Unconditional Term. Right for the Financing Firm	An indicator of whether the financier possesses any unconditional termination right.
Specified Lead Product	An indicator=1 if the contract specifies a lead product.
Unknown if Specified Lead	An indicator=1 if it is unknown whether the contract specifies a lead product.
Financial Health Index	An index that tracks the financial health of the biotech firm: "cash burn rate" or the "time until RD company runs out of cash as a variable between 0 (immediately) and 1 (never)"
# Past Alliances	The number of past alliances with biotech firms the financier has had.
Year Contract Signed	The year the contract is signed.
Alliance b/w Biotech and Pharma	An indicator that the financing firm is a pharmaceutical company
Transferable Product	An indicator that patent rights exist for the product.
Transferable and Specified	An interaction term between patent rights and specified lead product.

*All variables taken from (Lerner & Malmendier forthcoming) or constructed from these variables by authors.

Table 2: Summary Stats of Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
# Unconditional Termination Rights for the Financing Firm	0.46	0.73	0	4	580
Any UTR for the Financing Firm	0.35	0.48	0	1	580
Any UTR with Control Rights for the Financing Firm	0.12	0.4	0	2	580
# UTR for the Financing Firm as in (Lerner & Malmendier forthcoming)	0.53	0.77	0	4	580
Any UTR for the Financing Firm as in (Lerner & Malmendier forthcoming)	0.39	0.49	0	1	580
Specified Lead Product	0.63	0.48	0	1	580
Unknown if Specified Lead	0.11	0.31	0	1	580
Financial Health Index	0.62	0.27	0	1	551
# Past Alliances	108.84	92.65	1	324	528
Year Contract Signed	1995.34	3.73	1980	2001	580
Alliance b/w Biotech and Pharma	0.83	0.37	0	1	580
Transferable Product	0.48	0.5	0	1	580
Transferable and Specified	0.32	0.47	0	1	580

Table 3: Anonymity and Termination Rights

Method	Pooled OLS				Ordered Logit
Dep. Var.	UTR				UTR Count
	(1)	(2)	(3)	(4)	(5)
Specified Lead	.110**	.097**	.096**	.091*	.441**
	(.043)	(.043)	(.047)	(.048)	(.224)
# Past Alliances			.0000466	.0001	.001
			(.0003)	(.0003)	(.001)
Financial Health Index				.165**	.823**
				(.083)	(.398)
Time Effects	Yes	Yes	Yes	Yes	Yes
Firm Effects	No	Yes	Yes	Yes	Yes
Obs.	580	580	528	502	502
e(ll)	-378.379	-365.571	-330.828	-311.25	-420.032
R^2	.047	.088	.095	.109	

Columns 1 through 4 in this table present a fixed effects model for an outcome variable that is an indicator of financier's unconditional termination rights. Standard errors are in brackets. The first column uses year fixed effects and the remaining columns use year and firm fixed effects, respectively. Controls are financial health and number of past strategic alliances in the biotech industry. Column 5 presents an ordered logit model that uses the number of unconditional rights as a dependent variable (min=0; max=3).

Table 4: Anonymity and Termination Rights: Robustness Checks

Method	Pooled OLS					
Dep. Var.	UTR				UTR a la LM	
Sample	Biotech-Pharma			B-P Financing	Biotech Pharma	
	(1)	(2)	(3)	(4)	(5)	(6)
Specified Lead	.127**	.122**	.072	.124*	.112**	.099*
	(.053)	(.053)	(.126)	(.069)	(.055)	(.056)
# Past Alliances	.0003	.0003	.0003	.0003	.0003	.0003
	(.0003)	(.0003)	(.0003)	(.0004)	(.0003)	(.0003)
Financial Health Index	.180**	.181**	.128	.151	.196**	.199**
	(.091)	(.092)	(.152)	(.107)	(.095)	(.096)
FHI*Specified Lead			.084			
			(.189)			
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Effects	No	Yes	Yes	Yes	No	Yes
Obs.	421	421	421	307	421	421
e(ll)	-265.772	-257.993	-257.886	-189.008	-280.936	-274.544
R^2	.071	.105	.105	.128	.063	.091

This table presents a fixed effects model with an indicator of unconditional termination rights for the financier as the outcome variable. Standard errors are in brackets. The first and second columns run the same regressions as columns (1) and (2) of table 3 on a restricted sample of only contracts between biotech and pharma. The fourth column is the same as the first column except the sample contains only contracts without specific mention of research collaboration. The fifth and sixth columns repeat columns 1 and 2 only on a dependent variable that uses a more inclusive notion of termination rights (using the definition of unconditional termination rights in (Lerner & Malmendier forthcoming). Controls are financial health and number of past strategic alliances in the biotech industry.

Table 5: Anonymity, Transferability and Termination Rights

	(1)	(2)	(3)	(4)	(5)
Method			Pooled OLS		
Dep. Var.	UTR			UTR+Control	
Sample			Biotech-Pharma		
Specified Lead	.122**	.084	-.055	-.057	-.133**
	(.054)	(.072)	(.042)	(.042)	(.056)
Transferable	.015	-.036		.030	-.074
	(.051)	(.083)		(.040)	(.065)
Transferable*Specified		.078			.158**
		(.099)			(.078)
# Past Alliances	.0003	.0003	.0005**	.0005**	.0004*
	(.0003)	(.0003)	(.0002)	(.0002)	(.0002)
Financial Health Index	.182**	.184**	.019	.021	.025
	(.092)	(.092)	(.072)	(.072)	(.072)
Time Effects	Yes	Yes	Yes	Yes	Yes
Firm Effects	Yes	Yes	Yes	Yes	Yes
Obs.	421	421	421	421	421
e(ll)	-257.942	-257.606	-156.802	-156.488	-154.226
R^2	.105	.106	.102	.103	.113

This table presents a fixed effects model with an indicator of unconditional termination rights for the financier as the outcome variable. Standard errors are in brackets. The first and second columns run the same regressions as column (2) of table 4, adding an indicator for whether or not product rights are transferable and the interaction term with the indicator of specifying a lead product. Columns three through five use a modified dependent variable that accounts for whether or not the financier also has product control rights. The third column reruns column 2 of table 4 on this new dependent variable and the fourth and fifth column rerun columns (1) and (2) on this dependent variable. Other controls are financial health and number of past strategic alliances in the biotech industry.

A   More Examples

To better illustrate the use of this particular enforcement mechanism, we present below a few more examples:

The editor and researcher example: Consider the implicit agreement between a journal editor and a researcher in the paper submission process. The researcher promises to produce high quality research and the editor promises to publish such research if it is marketable; yet many authors of submissions will not publish for the same pairing of editor and journal (simply because most research will not get published) and, the peer-reviewed, double-blind nature of most submissions rules out strong reputational incentives. Nevertheless, many journals are successful at publishing high quality and marketable research without making explicit contracts with any one researcher.

The editor has an interest in publishing high quality articles that the profession will cite. The researcher has similar incentives but clearly has a bias towards publishing his own research, regardless of its quality. Although quality of research may be observable, whether or not the research is marketable is much less certain. Once an editor decides that conditional on certain revisions, a manuscript should be published, the support costs of the authors are minimal compared to the value to the editor of making such revisions in order to market the product (the revealed difference between publishing and not publishing). This asymmetry provides incentives to both submit high quality research and publish marketable research because only through support of the authors do revisions take place (much more costly if non-authors were to do this) and since the editor uses peer review only through passing requirements on quality will the manuscript get published.

There are clear costs to each party to submit to a particular journal, review

the article and decide if it merits publication. The editor may know better than the researcher which articles will sell well for the journal's targeted market but the researcher also has views about what will sell well and can approach different journals if the referee reports are unfavorable. The researcher assumes that if the article is of high quality and the conditions for publication are positive, the editor will publish it. According to our model, if this does not occur (the bonus is not paid) and support is withdrawn. A crucial aspect of our model is the fact that support is withdrawn and consequently the good is not marketed if the bonus is not paid. The bonus payment functions as a signal of the value of the product. If no payment is made, support is withdrawn because there is no reason to provide support for an unsuccessful product. Hence, important for our story, is evidence of withdrawing support after a bad signal despite the fact that these support costs are low. A revise and resubmit can be interpreted positively or negatively. If the revise and resubmit appears to not fit with the perception of the research by the researcher, the researcher may withdraw support and submit the article to a different journal. Again, the costs to revise are small relative to the benefit the journal receives from publishing the revised version. And it is unlikely that reputation and repeated interaction can enforce the journal editor/researcher implicit agreement.

The expansion of trade example: Consider the expansion of trade to new trade partners. An interesting example of this comes from explorers who would trade with local inhabitants but would never interact with them. A ship would stop in a natural harbor, near an inhabited island. Goods would be left on the beach by the inhabitants and the explorers would leave some goods in exchange. Who enforced this peaceful trade? The uncertainty of the value of the goods to the explorers allowed the what was left by them in return to function as a signal. If nothing or minimal goods were left in return, the local inhabitants would withdraw support by either appearing from hiding and expressing dissatisfaction (and non-peaceful interaction) or would not leave out

45

future goods for other explorers. If this support was withdrawn, the explorers would have much greater difficulty marketing the goods they currently possess. One can easily generalize this example to a more modern context when one is considering expanding trade to a partner outside ones group and, hence, group-level enforcement mechanisms do not immediately take force.

B   Comparative Statics

In this section we study how the value of contractual arrangement introduced in section 3 varies with changes in the parameters. We begin this section by commenting on whether the principal would prefer to have a signal about the value of the project if she had a choice. The answer is ambiguous as follows from the logic parallel to that developed by Baker, Gibbons & Murphy (2002) for a verifiable but imperfect signal about the agents effort. The implicit static contract fails to deliver the first best value, but may be the only available option, particularly if the interest rate r is high enough not to allow for any reputational contract. At the same time, for low or moderate values of r, the availability of the signal about the quality of the project deteriorates the efficiency gains since it improves the principal's payoff upon reneging on the bonus promise. Therefore, depending on values of the parameters (in particular, q and r) the principal may or may not prefer to have a technology that produces a signal about the value of the project.

To keep the remaining analysis tractable we focus on the limiting case as in section 4, so that expression (1) for the value of the contractual arrangement applies.

First, we compare two production technologies for the input, one of which requires positive (even arbitrary small) support costs while the other does not. These can be thought of as innovative and traditional processes, respectively. Note that either of these two technologies can be employed in producing a new

good with uncertain consumer value; indeed, the novelty or demand uncertainty associated with the product developed in the relationship that we study does not necessarily translate, at least in theory, into the novelty of the production technology; therefore it is legitimate to consider using a generic technology to develop the new product.

It follows immediately that if the principal, when contracting with the agent, has a choice between traditional and innovative production technologies, with the latter requiring support costs (and both requiring marketing costs, since the product itself is new and of uncertain consumer value) the principal should opt for the latter one. Indeed, positive (however small) support costs are the only mechanism that induces the principal to honor her promise to pay the bonus; once support is not needed anymore, the principal has incentives to renege on her bonus promise; knowing that the agent will not exert effort.

Similarly, if the choice between traditional and innovative production technologies is not contractible (though observable to the principal) and, therefore, is to be made by the agent unilaterally, the agent will opt for the technology that requires support; indeed if he does otherwise, the principal, upon observing that no further action by the agent is required, will have incentives to renege on her promise to pay the bonus. Note that both conclusions do not depend on parameters of the model.[24]

This confirms the earlier motivation of implicit contracts and collaborative innovation. If idiosyncratic uncertainty is present, collaborative relationships appear to be a response. Choosing a technology that requires support gives the appearance of a collaborative relationship even though alternative research

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[24]If the choice of the technology is made solely by the agent and is not observable to the principal even ex post, the problem becomes more complicated. Indeed, if traditional technology is less risky – i.e., has higher probability of success p – the agent has incentives to choose it, when the principal believes he has chosen an innovative technology instead. The result will be a mixed strategy equilibrium with the agent choosing either technology with positive probability and the principal (upon not receiving negative signal about the consumer value of the product) mixing between honoring her promise to pay the bonus and reneging on it, in hope that the technology will require no support.

arrangements are technically feasible. Or, in the case of the movie industry, the talent and the studio may choose to produce the film using support of the talent after the film has been made precisely to better provide incentives for the talent to develop a marketable film.

Next compare two technologies different only in their risk level. That is, assume that there are two ways ($i = 1, 2$) to produce the input, with identical cost parameters k, and identical expected value $p_1 V_1 = p_2 V_2$, but assume that technology 1 is less risky: $p_1 > p_2$ (so that $V_1 < V_2$). Note that the first best level of effort $e = kpV$, as well as the first best value of the arrangement, is identical for the two technologies. It follows immediately from (1) that the value of the arrangement is the same if the bonus is only paid upon receiving a positive signal (indeed, only expected value pV factors in at any step of the calculation); it follows further that when the principal is paying the bonus upon not receiving a bad signal, the value is higher for the less risky project.[25] This result is intuitive. The size of the credible bonus, to be paid whenever the principal does not receive a negative signal, is limited by the expected value of the project, assumed identical across the two technologies. For a fixed bonus level, the agent will exert higher effort if the probability of receiving this bonus, equal to the probability of principal not receiving negative signal, is higher. That probability is higher if the project is less risky.

We have therefore obtained that if the principal has a choice between two technologies with the same expected payoff for any given level of agent's effort, she will choose the less risky one (even though a priori both the principal and the agent are assumed risk neutral). It is straightforward to check that if the choice of the technology is made by the agent, he too will prefer a less risky technology for any given level of bonus. Summarizing, we have the following:

Proposition 2. If two technologies with the same expected value are avail-

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[25] At intermediate values of q the principal will pay the bonus for the high risk project only upon receiving a positive signal, while pay bonus for low risk project upon not receiving negative signal; again, the value of the less risky project is higher.

able, different only in the level of risk, both the principal and the agent will prefer the less risky one. This result is independent of the contractibility of the technology choice.

At first glance, this is a startling result and one that reinforces the difficulty that developing countries with imperfect enforcement of contracts have in innovating. Venture capital from the outside is more attracted to high risk, high return investments than safer innovations that still may fail and even if successful may be expropriated. From a policy perspective, this result may shed light on why some high-risk technologies are not adopted when there is a low risk alternative even when insurance accompanies such technological adoption as in Xavier Giné & Dean Yang (2009). When contracts lack enforceability, parties may not be able to coordinate on the high-risk technology since both face pressure to choose the low risk technology.

Finally, given the suggested trade-off between optimality and anonymity, one might be interested in the comparative statics concerning a change in the degree of anonymity. Essentially, any exogenous imposition of the degree of anonymity reduces to an effective discount rate that makes reputational contracting less attractive but does not affect our mechanism. If the degree of anonymity is endogenous, then the analysis goes through all the same as we discuss in section 5.

C Implicit contracting: further comments.

In this section we offer several remarks about the static implicit contract that we develop.

First, it is important to stress that we assume the size of the bonus to be fully contractible and indeed written into the contract. What is not contractible are the contingencies under which the bonus is due. We have in mind a contract that specifies that once the input is delivered, the principal, upon recognizing

the delivery, must sign the delivery confirmation. A signed confirmation is the document that allows the agent to claim the prespecified bonus; courts can enforce this claim. Signing the document, however, is at sole discretion of the principal; she may choose not to sign it, claiming that the agent did not deliver the input, whether or not the agent actually did; the court is unable to verify the delivery (only whether the delivery confirmation is signed). This view on implicit contracting reduces the principal's strategy space to only two actions, i.e., paying the bonus or not (compared to the setup where the principal could have full discretion over the size of the bonus). If we assume this approach, we do not have to worry about the agent's strategy off the equilibrium path, and, in particular, our equilibrium automatically satisfies requirements on off equilibrium beliefs (such as imposed by the Cho-Kreps intuitive criterion).

It is also natural to consider more general contracts, brought by what can be referred to as a mechanism design approach. Applying the revelation principle we restrict attention to direct mechanisms, in which the principal – the informed party – upon observing that the agent successfully developed the input, announces the state, i.e., whether she has received a signal about the value of the project and, if so, whether the signal is positive or negative. In each state the mechanism will then prescribe the probability with which the project is continued and the bonus to be paid; such mechanism must be incentive compatible, i.e., it must be in the principal's interest to announce the state faithfully. Without loss of generality, we may focus on direct mechanisms that involve zero probability to continue and zero bonus in the state when the principal receives a negative signal. It is routine to check that the contract we suggest (involving bonus of size pV and probability one to continue in both the other states) is indeed the welfare maximizing mechanism under Assumption 1.

Finally, we note that the contract we suggest is immune to the possibility of renegotiation, at least if renegotiation is assumed to take place before the

principal decides whether to pay the bonus. There is no single way to model renegotiation under asymmetric information; for our purposes we can adapt the model proposed by (Oliver Hart & John Moore 1988). If both parties have a limited number of discrete time periods to propose alternative contracts (possibly specifying different bonus payments) after all uncertainty is realized – that is, after the principal observes her signal and the agent develops or fails to develop the input – it is straightforward to conclude that our contract will withstand renegotiation. Indeed, there is little the agent, being the uninformed party, can propose; the principal may propose a contract stipulating a lower bonus, but it would not be rational for the agent to accept, as he will rationally expect that when the time comes to either sign the delivery confirmation or not, the principal will choose to do so for fear that otherwise the agent will infer that she had received a negative signal and will withdraw support.[26]

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[26]This argument does not apply if there is an option to renegotiate after the principal decides whether to pay the bonus or not; we do not study this case here.