

# Incentive provision when contracting is costly\*

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## Abstract

We analyze optimal incentive contracts in a model where the probability of court enforcement is determined by the costs spent on contracting. The analysis shows that contract costs matter for incentive provision, both in static spot contracts and repeated game relational contracts. We show that there is not a monotonic relationship between contracting costs and incentive intensity, and that an increase in contracting costs may lead to higher-powered incentives. Moreover, we formulate hypotheses about the relationship between legal systems and incentive provision. Specifically, the model predicts higher-powered incentives in common law than in civil law systems.

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# 1 Introduction

Costly contracting and measurement problems are textbook explanations for why employment contracts often lack explicit statements regarding performance-related pay. Paul Milgrom and John Roberts (1992) state that (p. 330) *"the incompleteness (...) and the shape of the employment contract are all responses to the impossibility of complete contracting. (...) Briefly, they involve the difficulties of foreseeing all the events that might possibly arise over time, (...) the difficulties of unambiguously describing these events (...) and the costs of negotiating acceptable explicit agreements over these many terms even if they could be described"*.

Despite this insight, analyses of the relationship between contracting costs and the shape of the employment contract are scarce. We know little about the relationship between contracting costs and incentive intensity, except that contracting costs are generally regarded as an impediment to incentive pay.

In this paper we analyze optimal incentive provision in a simple principal-agent model with unobservable effort and costly contracting. We invoke the plausible assumption that specifying contract terms to make a contract enforceable is costly. Thus, when the principal offers the agent an incentive contract, she will have spent resources on specifying the desired quality of the agent's output, and contingent bonuses if these quality requirements are delivered. Moreover, we assume that the probability that the incentive contract will be enforced by a court of law is determined by the costs spent on contracting. In particular we assume that contracting increases the

probability that the court can verify the quality of the agent's output and thus that the court can verify whether or not the principal has fulfilled her bonus obligations.<sup>1</sup> Due to incomplete legal enforcement, we also allow the parties to engage in relational contracting. A relational contract relies on self-enforcement and is modelled as a repeated game between the parties.

First, we show that writing an explicit incentive contract is valuable even if the contract is self-enforcing in equilibrium. The reason is that the verifiability level affects the out-of-equilibrium deviation payoff. In contrast, verifiability is seen as having a more direct effect on a spot contract, since here a party deviates in equilibrium. Interestingly, this implies that the contracted-upon incentives (or what we may call explicit incentives) will often be higher-powered in the spot contract than in the relational contract, while at the same time effort will be higher in the relational contract. The model thus provides a rationale for why relational contracts may often be more incomplete than spot contracts, and for why incentives may (seemingly) be higher-powered in spot markets than in relational employment contracts.

Second, we show that there is not a monotonic relationship between contracting costs and incentive intensity. In fact, an increase in contracting costs may lead to higher-powered incentives. One reason is that more costly spot contracts benefit the relational contract since punishment from deviation increases. But interestingly, the incentive intensity in the rela-

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<sup>1</sup>In the aftermath of the 2008 financial crisis, legal disputes about bonus payments have not been uncommon. As a recent example, seventy-two city bankers are suing Dresdner Kleinwort and Commerzbank for €33m (\$47.8m) worth of unpaid bonuses in the biggest case of its kind in the UK, see Financial Times, September 8, 2009.

tional contract may increase even if contracting costs increase *more* at the relational equilibrium than at the spot equilibrium: If relational contracting becomes more costly so that the surplus from the ongoing relationship is reduced, the parties must reduce the temptation to deviate from the relational contract. One way to do this is to increase the verification probability. This may in turn make higher-powered incentives implementable.

Finally, we show that optimal incentive pay depends not only on the level of contracting costs, but also crucially on the *shape* of the contract cost function. And since the shape of this function is partly determined by the legal system, we can formulate hypotheses about the relationship between legal institutions and optimal incentive pay. In particular, we argue that fixed contracting costs are higher, but marginal contracting costs are lower if courts are reluctant to interpret intentions of the contracting parties that are not clearly expressed in the contract. From the common law doctrines collectively referred to as the *parol evidence rule*, courts should look at the outward appearance of the contract, and endorse what the parties objectively appear to have intended. In contrast, courts in civil law systems rely to a larger extent on extrinsic evidence and try to find the real intentions of the parties when contract terms are vague. There is also a tendency towards less formalism and more interpretation in the US. We show that such a less stringent application of the parol evidence rule, or a move from common law to civil law practice, leads to lower-powered incentive contracts in our model.

The remainder of the paper is organized as follows: In Section 2 we discuss the relationship to the literature. Section 3 presents the model and

characterizes optimal contracts. In Section 4 we analyze how optimal incentives in the relational contract vary with contracting costs, and in Section 5 we discuss institutional implications. Section 6 concludes. Proofs not explicitly stated in the text are contained in an appendix.

## 2 Relationship to the literature

Starting with the seminal papers of Townsend (1979) and Dye (1985), costly contracting and imperfect enforcement is increasingly recognized as an important vehicle for understanding the nature of transactional relationships. One strand focuses on the causes and formation of incomplete contracts, see e.g. Hart and Moore (1988), Spier (1992), Anderlini and Felli, (1994, 1999), and Battigalli and Maggi (2002). Most of these papers do not explicitly address or focus on the relationship between contracting costs and incentives, but the general implication is that higher contracting or enforcement costs lead to less efficient contracts.<sup>2</sup>

Another strand focuses on contract design problems, and in particular the tension/trade-off between ex ante contract specifications and ex post renegotiation costs, see Bajari and Tadelis (2001), Schwartz and Watson (2004) and Chakravarty and MacLeod (2009). A general result here is that contracting costs lead to lower-powered incentives. Bajari and Tadelis show that complex procurement projects will tend to use cost plus contracts, while simpler projects use fixed price contracts with higher powered cost saving

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<sup>2</sup>See e.g. Spier, who finds that enforcement costs (in terms of the litigations costs) lead to weaker contracts (Spier, 1992), or simpler (less fine tuned) penalties/damage awards (Spier, 1994). See also Hermalin (2008), who examines the efficiency of endogenous contract incompleteness.

incentives. Assuming that more complex projects have higher contracting costs, the incentive intensity is negatively related to contracting costs in their setting. Similarly, Schwartz and Watson assume that contracting costs increase in the complexity of the transaction, and they show that the efficiency of the contract decreases in contracting costs.<sup>3</sup>

There are two differences between our paper and this literature that has important implications for the relationship between contracting costs and incentives. First, we model contracting costs differently. We do not model the costs of writing a given type of contract or the costs of describing a given contingency. Rather, we simply assume that ex ante investments in contracting affects the *court's ability to verify* whether the parties have fulfilled their contract obligations.<sup>4</sup> This allows us to distinguish between marginal and fixed contracting costs, which plays a crucial role in our analysis. The other important difference is that we also allow for repeated relational contracting, and as we show, the interaction between explicit and relational contracting has an important effect on the relationship between incentives and contracting costs.

In repeated game models of relational contracting, the common assump-

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<sup>3</sup>There is also a literature that relates imperfect employment contracts to macroeconomic phenomena such as unemployment. Related to our work, see in particular Gamey and Watson's (1997) model of contractual fragility, where the robustness of the employment contract is determined by the level of ex ante relationship specific investments.

<sup>4</sup>Ishiguro (2002) and Bull and Watson (2004) also endogenize the probability of verification, but unlike us they consider ex post actions such as evidence disclosure instead of ex ante contracting. The endogenous verifiability/enforcement approach also bears similarities to the law and economics literature on enforcement, such as Mookherjee and Png (1982) and Kaplow and Shavell (1994). Here, enforcement is endogenized by choices made by the enforcement authority, see in particular Kaplow and Shavell who analyze a model where the authorities' investments in accuracy (improved legal procedures, rules of evidence, etc) increase the court's ability to enforce contracts.

tion is that verifiability is exogenously given, and that contracting is costless or prohibitively costly. In the first models dealing with the interaction between formal and informal contracting, such as Schmidt and Schnitzer (1995) and Baker, Gibbons and Murphy (1994), the level of contracting costs does not matter.<sup>5</sup> Recently, however, Sobel (2006), MacLeod (2007), Battigalli and Maggi (2008) and Kvaløy and Olsen (2009) have introduced models where contracting or enforcement costs influence the interaction between legal enforcement and relational contracting. But these papers assume symmetric information and do not deal with incentive problems due to unobservable effort and moral hazard.

The contribution of this paper is thus to analyze costly contracting and endogenous verifiability in an otherwise standard moral hazard model. Following Kvaløy and Olsen, we assume that there is a probability  $v < 1$  that output can be verified by a court of law. But in contrast to that paper, we consider here situations where the agent's actions are unobservable (moral hazard) and where performance payments therefore are essential to motivate the agent. Thus we analyse here bonus pay contracts, which are different from straight contracts for the exchange of goods and services. The presence of asymmetric information in terms of unobservable effort does affect the analysis of the relationship between costly formal contracting and relational contracting. But we show that qualitative results similar to those in the symmetric model also apply to standard incentive problems with moral hazard.

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<sup>5</sup>Schmidt and Schnitzer (1995) and Baker, Gibbons and Murphy (1994) analyze models with both verifiable and non-verifiable variables, but the verifiability of a given action or signal is exogenously given. Other models that address the relationship between verifiable and non-verifiable variables are Bernheim and Whinston (1998) and Pearce and Stacchetti (1998).

This is important because the asymmetric model gives sharper empirical predictions and clearer institutional implications. Instead of analyzing the relationship between contracting costs and output quality, we are here concerned with the relationship between contracting costs, legal institutions and incentives (performance pay), and the latter is easier to measure and compare across countries, firms and industries.

In the present paper, we also to a larger extent discuss the institutional implications of our work. Thus it is more related to a small literature addressing the relationship between optimal contracts, legal institutions and contract law, see Kornhauser and MacLeod (2011) for a review. Schwartz and Watson (2004) argue, like us, that contract law affects contracting costs and that interpretive rules allowing for extrinsic evidence will tend to increase contracting costs for a given project complexity. In this respect, our paper is also related to the economics literature on contract interpretation, see in particular Shavell (2006) who shows how different interpretive rules may affect contracting costs.<sup>6</sup>

### 3 Model

We consider a relationship between two risk neutral parties,<sup>7</sup> a principal and an agent, where the agent produces either high ( $q_H$ ) or low ( $q_L$ ) value for the principal. The probability of producing  $q_H$  depends on the agent's effort, and for simplicity is given by the effort level:  $e = \text{prob}(q_H)$ . Effort costs are

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<sup>6</sup>See Hermalin, Katz and Craswell (2007) for a comprehensive review of the law and economics of contracts.

<sup>7</sup>Risk aversion is discussed at the end of Section 3.1 and in the appendix.



given by  $C(e)$ , where  $C'(e) > 0$ ,  $C''(e) > 0$  for  $e > 0$ , and  $C(0) = C'(0) = 0$ . We assume that output is observable to both parties, but that the agent's effort level is unobservable to the principal, so the parties must contract on output: the principal pays a fixed salary  $s$ , and a contingent bonus  $\beta_i$ ,  $i \in (H, L)$  if the agent delivers quality  $q_i$ .

As in Kvaløy and Olsen (2009) we assume that there is a probability  $v \in [0, 1)$  that the contracted quality can be verified.<sup>8</sup> We follow the standard assumption from incomplete contract theory saying that if the variables in a contract are non-verifiable, then the contract is not enforceable by a court of law. The probability of verification,  $v$ , can thus be interpreted as the probability of legal enforcement of the *bonus contract*,  $\beta_i$ . If the court verifies quality, it can verify whether or not the parties have fulfilled their obligations regarding the contracted bonus payments.<sup>9</sup>

The probability  $v$  is assumed to depend on the level of contracting: the more the parties invest in specifying contract terms, the higher is the probability that the court can verify the realized quality. We let  $K(v)$  be the cost that must be incurred to achieve verifiability level  $v$ , and we interpret  $K$  as the costs associated with writing explicit contracts specifying the quality of the agent's output.

To keep the model simple, we assume that values accrue directly to the principal in the process of production, so that the agent cannot hold

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<sup>8</sup>By not allowing for  $v = 1$ , we assume that perfect verifiability is prohibitively costly. This is in line with the standard assumption ( $v = 0$ ) in the relational contract literature.

<sup>9</sup>In contrast to the model in Kvaløy and Olsen (2009), the court cannot enforce ex ante actions from the agent, i.e. the principal cannot go to court based on output realizations alone, since low output can be due to bad luck. Hence, the agent must here be incentivized by contingent bonuses.

up values ex post. The model then best describes situations where the agent provides ongoing services like consulting, maintenance, IT services, HR services, administrative services, etc.

We analyze a repeated relationship where the following stage game ( $\Gamma$ ) is played each period:

1. The principal makes an investment  $K(v)$  in writing a contract with verifiability level  $v$ , where  $v$  is common knowledge, and offers a contract  $(s, \beta_L, \beta_H)$  to the agent. If the agent rejects the offer, the game ends. If he accepts, the game continues to stage 2.
2. The agent takes action  $e$  and quality  $q_i$  is realized.
3. The parties observe  $q_i$ , and the contracted fixed salary  $s$  is paid. Then the parties choose whether or not to honor the contingent bonus contract  $\beta_i$ . Specifically, the party who, according to the contract is due to make a payment, chooses what (feasible) payment ( $\beta'_i$ ) to make.<sup>10</sup>
4. The other party may accept or decline the payment. If accepted, the game ends, with payoffs  $s + \beta'_i - C(e)$  and  $q_i - s - \beta'_i - K(v)$  for the agent and the principal, respectively.
5. If the payment is declined, the case goes to trial. If the court verifies quality, it rules according to a breach remedy that is ex ante common knowledge. If the court does not verify quality, the agent and the principal obtain payoffs  $s - C(e)$  and  $q_i - s - K(v)$ , respectively.

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<sup>10</sup>So, as in Levin (2003), the decision to honor or deviate (offer  $\beta'_i \neq \beta_i$ ) belongs to the principal if  $\beta_i > 0$  and to the agent if  $\beta_i < 0$ . The deviation is feasible if  $\beta'_i = \alpha\beta_i$ ,  $\alpha \geq 0$ , and within the bounds for payments from the party in question.

A spot contract is taken to be a perfect public equilibrium (PPE)<sup>11</sup> of this stage game. We deduce the optimal spot contract below, applying a standard breach remedy. We then move on to analyze the infinite repetition of the stage game  $\Gamma$ . A relational contract between the parties describes a PPE of this infinitely repeated game.

With respect to the breach remedy, we assume that the parties apply expectation damages (ED), which entail that the breacher has to compensate the victim so as to make her equally well off as under contract performance. ED is the most typical remedy and is also regarded as the most efficient remedy in the seminal literature on optimal breach remedies (Steven Shavell, 1980; and William P. Rogerson, 1984). Given (UCC §2-718 (1987)) and RESTATEMENT (SECOND) OF CONTRACTS §356, which prevents courts from enforcing terms stipulating damages that exceed the actual harm, no party-designed damage rule can do better than expectation damages in our model.

We assume that payments from either party cannot be arbitrarily large. In particular, it is assumed that the agent is protected by limited liability,<sup>12</sup> in the sense that the fixed salary as well as net payments must exceed some lower (negative) exogenous bound:  $s \geq -m_1$  and  $s + \beta_i \geq -m_1$ . Note that this allows the contract to specify a 'punishment' in terms of a negative bonus for, say, bad performance ( $\beta_L < 0$ ), but this punishment cannot be too large. A negative fixed payment  $s$  is also allowed, implying that the

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<sup>11</sup>In a PPE each player's strategy is based on 'public' information (not on privately observed efforts) and the strategies constitute at each stage a Nash equilibrium for the remainder of the game.

<sup>12</sup>Risk aversion as an alternative assumption to limited liability is discussed at the end of the next section.

principal may extract rents from the agent.

Regarding the principal, we assume that there are also bounds on how large bonuses she may pay out. One reason is limited liability: the principal cannot easily commit to pay wages far above the agent's value added. This constraint resembles Innes (1990), who in a financial contracting setting assumes that the investor's (principal's) liability is limited to her investment in the agent. It is also a question of whether a court would enforce a contract with payments far above the value added. If a contract specifies a payment that is, say, many times higher than the output's value, a court might question the conscionability of the contract.<sup>13</sup> Hence, in addition to the restrictions pertaining to feasible payments from the agent ( $s, s + \beta_i \geq -m_1$ ), we also assume restrictions on feasible payments from the principal such that we must have

$$-m_1 \leq s, s + \beta_i \leq m_2, \tag{1}$$

where  $m_2$  is an exogenous upper bound.

Regarding the bounds, we assume that the principal can pay at least the value added by the agent, and hence that  $m_2$  is no smaller than the largest output value  $q_H$ . For the agent's limited liability bound  $m_1$  we assume, for analytical simplicity, that it is sufficiently large so that the principal would be able to extract all rent from the agent under conditions of full verifiability

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<sup>13</sup>If the plaintiff cannot convincingly argue that the high bonus was due to a low probability of enforcement, the court may argue that the contract is unconscionable. According to RESTATEMENT (SECOND) OF CONTRACTS §208 (1979) "gross disparity in the values exchanged may be an important factor in a determination that a contract is unconscionable", see Cooter and Ulen, 2003 for a discussion.

of output; thus

$$m_2 \geq q_H, \quad m_1 \geq m_F \equiv C'(e^F)e^F - C(e^F), \quad (2)$$

where  $e^F$  is first best effort, given by  $e^F = \arg \max ((q_H - q_L)e - C(e))$ .

### 3.1 The spot contract

Our interpretation of the breach remedy ED is as follows: If the court verifies insufficient payments, it rules that the breacher is to comply with his/her part of the contract and pay  $\beta'_i = \beta_i$  as specified in the contract. If the court verifies that the breacher has more than fulfilled the contract terms, it takes no action.

By backwards induction we start with stage 5, where a payment has been declined. The expected payment in court is  $v\beta_i$ , which implies that a payment is accepted in stage 4 if and only if it is no worse for the receiver than the payment  $v\beta_i$ .

Hence there are several (payoff equivalent) continuation equilibria from stage 3. The paying party may offer  $\beta'_i = v\beta_i$ , which is immediately accepted (i.e. a settlement), or this party may offer a smaller payment ( $|\beta'_i| < v|\beta_i|$ ), which is first declined, then tried in court, and thereby resulting in an expected payment  $v\beta_i$ . We focus here on the settlement equilibrium, primarily because even small litigation costs (which we have ignored, for simplicity) would break the payoff indifference in favor of this equilibrium. In practice, most contract disputes settle before trial, so the settlement equilibrium is also the most realistic one, see Spier (2007). See also Doornik (2008), who

analyzes how contracting behavior affects the probability of ending up in court.

In stage 2, the agent's expected payoff will now be  $s+v(\beta_L+e\Delta\beta)-C(e)$ , where  $\Delta\beta = \beta_H - \beta_L$ . He will choose effort to maximize this payoff, which gives IC and participation (IR) constraints as follows

$$v\Delta\beta = C'(e) \tag{3}$$

$$s + v(\beta_L + e\Delta\beta) - C(e) \geq 0, \tag{4}$$

where we have assumed that his reservation payoff is zero.

Without further constraints, in stage 1 the principal would then maximize her payoff  $q_L + e\Delta q - (s + v(\beta_L + e\Delta\beta)) - K(v)$  subject to IC and IR. Note that first best effort  $e^F$ , given by  $\Delta q = C'(e^F)$ , can be achieved with a bonus  $\Delta\beta = \frac{\Delta q}{v}$ . With no restrictions on bonuses, the principal could then obtain the first best allocation asymptotically by increasing  $\Delta\beta$  and letting  $v$  and thus  $K(v)$  go to zero (assuming  $K(0) = 0$ ).

This is not feasible by our assumptions; in particular, the bonus increment must be bounded ( $\Delta\beta \leq m_1 + m_2$ ). Now, given that the principal is able to extract all rents from the agent, she will capture the entire surplus  $q_L + e\Delta q - C(e) - K(v)$ , where effort is given by  $C'(e) = v\Delta\beta$ . Since no effort will be exerted if  $v = 0$ , the principal will invest in contract specifications if marginal and fixed contracting costs ( $K'(0)$  and  $K(0)$ ) are not too large. Assuming this is the case for those costs, we obtain the following:

**Proposition 1** *The spot equilibrium entails a contract  $(s, \beta, v)$  with  $v > 0$*

and where the bonus increment  $\Delta\beta$  is maximal ( $\Delta\beta = m_1 + m_2 \equiv m$ ), yielding effort less than the first best level ( $e = e^s < e^F$ ) and given by

$$\max_{e,v} [q_L + e\Delta q - C(e) - K(v)] \quad s.t. \quad C'(e) = vm.$$

The agent gets no rent. In equilibrium the parties deviate from the contracted bonus payments, and settle for a smaller payment  $\beta'_i = v\beta_i$ .

The intuition for the bonus increment to be maximal ( $\Delta\beta = m$ ) is simple: Incentives can be strengthened both by increasing  $\Delta\beta$  and  $v$ . Since the principal is able to extract all rents, there is no cost of increasing  $\Delta\beta$ , but a cost of increasing  $v$ . Hence, the principal simply provides maximal incentives  $\Delta\beta$ , constrained by the bounds on wages.

We also see that verifiability and contracting costs have a direct effect on total incentives, since the parties settle on  $v\beta_i$ . Interestingly, this also implies that the contracted-upon (explicit) incentives  $\Delta\beta$  are higher-powered than the total incentives  $v\Delta\beta$ . As we will see in the next section, verifiability and contracting costs have an important effect on incentive provision also when the contracting parties honor the contract in equilibrium.

Before turning to that analysis, we will briefly comment how risk aversion might affect our results. So assume for now that the agent is risk averse. For any bonus offer in stage 3 of the game, it would then be efficient to settle in stage 4 instead of going to trial. Being risk averse, the agent's certainty equivalent (say  $\tilde{\beta}_i$ ) for the 'court lottery' (where he gets the contracted bonus  $\beta_i$  if the court verifies, and no bonus otherwise) is less than the expected bonus payment  $v\beta_i$ . The agent would thus accept any bonus exceeding

the certainty equivalent  $\tilde{\beta}_i$ . This settlement implies that the agent will not be exposed to the risk associated with probabilistic verification, and hence that it will not be costly for the principal to increase this risk by reducing  $v$  and increasing  $\beta_i$  in a way that keeps  $\tilde{\beta}_i$  fixed. On the contrary, the principal will save investment costs by reducing  $v$  this way, and will hence always do so if there are no bounds on the bonuses that can and will be enforced by the court. But given that there is in fact, as we have argued, a bound on enforceable bonuses, we see that the optimal contract under risk aversion will have similar features as the contract in Proposition 1: bonuses in the contract that are set at the maximal level, but which are renegotiated and settled to a lower level in equilibrium. (See the appendix for some details.) Since risk aversion appears to generate qualitatively similar results as risk neutrality and limited liability, while being technically more involved, especially in the repeated game context, we will stick to the latter assumption in this paper.

### 3.2 Relational contract

Since verifiability is costly, and it is uncertain whether a legal court is able to enforce the contract, the parties may also rely on self-enforcement. Through repeated transactions the parties can make it costly for each other to breach the contract, by letting breach ruin future trade. We will now consider such a self-enforcing (relational) contract. In contrast to the spot equilibrium considered above, where the promising party deviates from the contract and settles on a lower bonus ( $v\beta_i$ ), we consider here an equilibrium in which the parties honor the contract in full, even though the court would enforce it



only probabilistically.

A *relational contract* is a perfect public equilibrium of the infinitely repeated game where the stage game  $\Gamma$  is played every period. In long-term relationships, ongoing investments in contract modifications are common. But contract modifications do not necessarily imply that equilibrium  $v$  is changed. In fact, we consider stationary contracts where the verification equilibrium level  $v$  and the effort level  $e$  do not change across periods. Such a case arises when e.g., new technological developments or market demands imply that the contents of output  $(q_L, q_H)$  change, but neither the costs required to produce the object with value realizations  $(q_L, q_H)$ , nor the costs to obtain verification level  $v$ , do change. Then contract modifications are required even if costs  $C(e)$  and  $K(v)$  are unaffected. In Section 4.1 we briefly analyze a setting where the initial contract may be employed for the whole duration of the relationship so that contracting costs are incurred just prior to the first stage game.

We consider stationary trigger strategies, where the parties revert to the equilibrium of the stage game forever if a party deviated from the contract in any history of play.<sup>14</sup> The conditions for implementing a *relational incentive contract* are then satisfied if the parties honor the contract for both high and low output  $q_i$ ,  $i \in \{L, H\}$ . More specifically, let  $\sigma_{sa}$  and  $\sigma_{sp}$  denote the equilibrium strategies of the stage game for the agent and the princi-

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<sup>14</sup>Levin (2003) shows that stationary contracts are optimal in a setting with no limited liability (no restrictions on payments). Fong and Li (2010) analyse relational contracting with limited liability for the agent, and show that non-stationary contracts can be optimal when the principal faces a trade-off between rent extraction and efficiency. Our assumptions imply that the principal can (via the fixed fee  $s$ ) extract all rents from the agent, and hence that such a trade-off doesn't arise here.

pal, respectively, and let  $(s, \beta, v)$  denote the per-period set of actions to be played in the PPE of the repeated game. The trigger strategy for the principal ( $\sigma_{rp}$ ) specifies play in accordance with  $(s, \beta, v)$  if there have been no deviations from  $(s, \beta, v)$  in the past (in earlier periods or within the period), and reversion to play in accordance with the spot contract (strategy  $\sigma_{sp}$ ) otherwise.<sup>15</sup> The agent's trigger strategy ( $\sigma_{ra}$ ) is similar; it specifies play in accordance with  $(s, \beta, v)$  if there have been no deviations in the past, and reversion to the spot contract (strategy  $\sigma_{sp}$ ) otherwise.

In the relational contract equilibrium, the agent trusts the principal to honor the contract, and hence chooses effort according to

$$\Delta\beta = C'(e) \tag{5}$$

Participation for the agent requires

$$\pi_A = s + \beta_L + e\Delta\beta - C(e) \geq 0 \tag{6}$$

Now, each party will honor the contract if the net present value from honoring is greater than the net present value from reneging. This will hold here if the total temptation to deviate is smaller than the future loss incurred by breaching the contract, which (as shown in the appendix) is captured by

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<sup>15</sup>Specifically: in period 1, play  $(s, \beta, v)$  in stage 1; i.e., invest  $K(v)$  and offer contract  $(s, \beta)$ . In stage 3 offer  $\beta'_i = \beta_i$  if the agent supplied  $q_i$  in stage 2 and  $(s, \beta, v)$  was played in stage 1; play according to  $\sigma_{sp}$  in stages 3 and 4 if not. In stage 4, accept if  $(s, \beta, v)$  was adhered to in stages 1-3, follow  $\sigma_{sp}$  otherwise. Then, in period  $t > 1$ , play as in period 1 if  $(s, \beta, v)$  was played in all preceding periods; play  $\sigma_{sp}$  if not.

the following condition

$$\frac{\delta}{1-\delta} [q_L + e\Delta q - K(v) - C(e) - u] \geq C'(e)(1-v), \quad (7)$$

where  $u$  is the total spot surplus and  $\delta$  is a common discount factor. The right hand side here is the largest one-period gain that can be obtained by deviating from the bonus contract, namely  $\Delta\beta(1-v)$ , where  $\Delta\beta = C'(e)$  by (5). The left hand side is the future total loss incurred when the relational contract is broken. The condition thus says that to deter deviations, this loss must be no smaller than the total temptation to deviate. In the appendix we also show that the limited liability constraints (1) are not binding for the principal when she maximizes surplus subject to (7), and that the optimal contract can be implemented with non-negative bonuses (no fines);  $\beta_H > \beta_L = 0$ . We obtain the following result.

**Lemma 1** *In the relational contract the principal extracts the entire surplus. The contract yields effort and verification levels given as solutions to*

$$\max_{e,v} [q_L + e\Delta q - K(v) - C(e)] \quad s.t. \quad (7)$$

In contrast to the spot equilibrium, the relational equilibrium entails that the bonuses specified in the contract are actually paid, instead of being settled on lower payments ( $v\beta_i$ ). Hence, since a party deviates in equilibrium in the spot contract, verifiability has a more direct effect there than in the relational contract. In the latter, the verifiability level affects bonuses via the out-of-equilibrium deviation payoff.

Interestingly, this implies that the contracted-upon incentives (or what we may call explicit incentives) will often be higher-powered in the spot contract than in the relational contract, while effort at the same time will be higher in the relational contract. Recall that the spot contract specifies the maximal bonus  $\Delta\beta = m > \Delta q$  and that the agent's effort, given by  $C'(e) = vm$ , is below the first best level. In the relational contract it is the case that for sufficiently high discount factors, say  $\delta \in (\delta^F, 1)$ , the principal can implement first best effort, given by  $C'(e^F) = \Delta q$ , at zero contracting costs.<sup>16</sup> The bonus is then  $\Delta\beta = \Delta q$ , and thus lower than the bonus specified in the spot contract. As  $\delta$  decreases below  $\delta^F$ , contracting costs must increase and/or incentives and effort must be reduced to maintain implementability. But for a range of discount factors below  $\delta^F$ , effort will still be higher and contracting costs lower in the relational contract than in the spot contract, since specified bonuses are actually implemented in the relational contract.

The model thus provides a rationale for why incentives may (seemingly) be higher-powered in spot market contracts than in relational employment contracts, while at the same time the latter can be more incomplete: Explicit incentives  $\Delta\beta$  must be higher-powered in spot contracts since they are not fully implemented in equilibrium. As a consequence, investments in contracting pay off since verifiability affects incentives directly via the settlement equilibrium. Relational contracts, however, can be more incomplete since verifiability affects the relational bonus only via the out of equilibrium deviation payoff.

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<sup>16</sup>This follows from (7) with  $v = K(v) = 0$ , letting  $\delta \rightarrow 1$ .

However, this does not mean that contract investments do not play a role in the relational contract. If the contract cost function  $K(v)$  has sufficiently small marginal and absolute (fixed) costs at  $v = 0$ , the optimal contract will entail interior solutions ( $0 < v < 1, e > 0$ ), implying that contract investments are valuable even if the contract is self-enforcing in equilibrium. The optimal contract and hence the optimal bonuses will thus depend on the form of the contract cost function, also under relational contracting. In the next section we examine how the optimal bonus is influenced by variations in this cost function.

## 4 Contract costs and optimal incentives

In this section we will point out two relationships between contracting costs and optimal incentives that we find particularly interesting, one regarding the level and one regarding the slope of the cost function. In the next section we will discuss institutional implications.

First, we address the cost level issue. Since contracting costs are used to explain the lack of incentive pay, one might expect that higher contracting costs reduce the level of incentive pay. However, we can show that an increase in contracting costs may actually lead to higher-powered incentives (i.e. higher  $\Delta\beta$ ). To show this we consider a function  $K(v, \kappa)$  with  $K_\kappa \geq 0$ , and examine how incentives and effort vary with the parameter  $\kappa$ . It turns out that the elasticity of the marginal cost function is an important determinant for how variations in  $\kappa$  affect incentive provision. This elasticity can be expressed as  $(1 - v)K_{vv}/K_v$ , since this ratio measures the relative

increase in marginal costs per percentage reduction in the probability of non-verification  $(1 - v)$ . We find the following:

**Proposition 2** *Given a relational contract equilibrium  $(v^*, e^*)$ , consider a cost variation that leaves marginal costs unaltered at  $v^*$  ( $K_{v\kappa}(v^*, \kappa) = 0$ ). This variation will lead to higher-powered incentives and higher effort iff*

$$[1 - (1 - v)K_{vv}/K_v][K_\kappa(v^*, \kappa) - K_\kappa(v^s, \kappa)] > 0$$

where  $v^s$  is the spot equilibrium level. Hence, such a cost increase will lead to higher-powered incentives if the marginal contract cost function is inelastic, in the sense that  $(1 - v)K_{vv}/K_v < 1$ , and if costs increase more at the relational equilibrium  $v = v^*$  than at the spot equilibrium  $v = v^s$  (so that  $K_\kappa(v^*, \kappa) > K_\kappa(v^s, \kappa)$ ). The cost increase will also lead to higher-powered incentives if the marginal contract cost function is elastic, and if costs increase less at the relational equilibrium  $v = v^*$  than at the spot equilibrium  $v = v^s$ .

The proposition demonstrates that endogenous contracting costs and the opportunities for the parties to engage in relational contracting create a non-trivial relationship between contracting costs and incentive intensity. Under plausible assumptions an increase in contracting costs may lead to higher-powered incentives and thus higher effort.

We see that there are two factors that matter here: i) the marginal contract cost elasticity and ii) the relationship between the relational contract and the spot contract, represented by the effect on their cost differential.

The influence of the latter factor complements insights from previous literature (e.g. Baker, Gibbons and Murphy, 1994), that less attractive outside options (worse spot contracts) may benefit the relational contract. The importance of the cost elasticity is more striking since it shows that incentive intensity in the relational contract may increase even if contracting costs increase more at the relational equilibrium than at the spot equilibrium, i.e. even if the outside option becomes relatively more attractive. In particular, if there is no cost change at the spot equilibrium, and hence no deterioration of outside (spot) options, the cost increase at the relational equilibrium will lead to higher incentives in the relational contract if the marginal cost function is inelastic.<sup>17</sup>

The intuition is as follows: If contracting becomes more costly, the surplus from the ongoing relationship is reduced. In order to sustain the relationship, the parties must reduce the temptation to deviate from the relational contract, and from (7) we see that this can be achieved by either implementing lower-powered incentives (lower  $\Delta\beta$ ) or by increasing the verification probability  $v$ . But we also see from (7) that if the principal chooses to increase  $v$ , this may in turn make higher-powered incentives implementable. The elasticity of the marginal cost function  $K_v(\cdot)$  is important in this respect. The response in  $v$  to a change in  $K$  is larger, the less elastic  $K_v(\cdot)$ . When  $K_v(\cdot)$  is inelastic, a higher  $K$  can make it optimal to increase  $v$  so much that

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<sup>17</sup>Comparing with the symmetric information model in Kvaløy and Olsen (2009), it is worth noting that, while the relational contract constraints are different, the comparative statics results are to some extent similar, in particular with respect to the role played by the elasticity of marginal costs. But the interpretation of these results are different, since we are here concerned with bonus payments as opposed to quality aspects of the delivered goods.

the principal finds it feasible to also increase incentive provision.

Having analyzed variations in cost levels, we now turn to variations in slopes. We find the following:

**Proposition 3** *Given a relational contract equilibrium  $(v^*, e^*)$ , consider a cost variation that (i) increases marginal costs at  $v^*$  ( $K_{v\kappa}(v^*, \kappa) > 0$ ) and (ii) leaves absolute costs unaltered at  $v = v^*$  and at the spot equilibrium  $v = v^s$  (so that  $K_\kappa(v^*, \kappa) = K_\kappa(v^s, \kappa) = 0$ ). This variation, which implies increased marginal contracting costs for the given  $v^*$ , will lead to lower-powered incentives and lower effort.<sup>18</sup>*

The intuition is rather simple: Higher marginal contracting costs make it more expensive to increase the verifiability level. This leads to lower  $v$  in equilibrium, which in turn reduces the implementable bonus. Note the difference from Proposition 2. There we showed that higher fixed contracting costs may lead to higher  $v$  and thus higher-powered incentives. The two propositions thus demonstrate the importance of distinguishing between variations in marginal and in fixed contracting costs in this setting.<sup>19</sup>

<sup>18</sup>Note that a cost function with three parameters, e.g a polynomial  $K(v) = a + bv + dv^2$ , allows for variations where the slope is varied at one point ( $v^*$ ), while the cost level is kept unchanged at  $v^*$  and at some other point ( $v^s$ ).

<sup>19</sup>While cost variations of the type considered in Propositions 2 and 3 are certainly feasible, one may also see variations in both marginal and fixed contracting costs at the same time. For example, a locally higher marginal cost at  $v^*$  may be accompanied by a change in the absolute cost level at the spot equilibrium  $v^s$ , i.e.  $K_\kappa(v^s, \kappa) \neq 0$  while  $K_{v\kappa}(v^*, \kappa) > 0$  and  $K_\kappa(v^*, \kappa) = 0$ . As can be seen from the proof of Proposition 2, such a change will still lead to lower-powered incentives if (but not only if) we have  $[1 - (1 - v)K_{vv}/K_v]K_\kappa(v^s, \kappa) \geq 0$ .



#### 4.1 Contract investments only in the first period

We have assumed that contract investments must be made each period, but one might also think of settings where an initial contract may be employed for the whole duration of the relationship. This would apply to simpler contractual relationships where no contract modifications are required over time. We will now briefly consider this alternative, and first point out that Proposition 3 still applies: higher marginal contracting costs - leaving fixed costs unaltered - lead to lower-powered incentives. Second, we will see that the qualitative result from Proposition 2 also remains valid: higher fixed contracting costs - leaving marginal costs unaltered, may lead to higher-powered incentives. The precise conditions for when the latter occurs are, however, somewhat different from the conditions stated for repeated contracting costs.

Assume now that after the first investment is made at the start of period 1, no further investments are required as long as the initial contract is adhered to. In the case of breach, however, it seems reasonable to assume that new contracts must be set up to govern the ensuing spot trades.

After the initial investment (at stage 1 in the first period), the verification level  $v$  supporting the relational contract is given. Assuming that new and repeated investments are required for spot trading, the spot surplus  $u$  will be determined as before, and will thus be independent of  $v$ . In the relational contract, contracting cost  $K(v)$  is irrelevant after the initial investment, and by similar arguments as before we then get the following enforceability

condition:

$$\frac{\delta}{1-\delta} [q_L + e\Delta q - C(e) - u] \geq C'(e)(1-v) \quad (8)$$

This condition has the same interpretation as the previous enforceability condition (7), but the sunk cost  $K(v)$  no longer enters in the per period surplus that will be lost if the contract is broken. The principal will maximize the total discounted surplus, including the initial investment, subject to this condition. This is equivalent to maximize the average surplus  $-(1-\delta)K(v) + q_L + e\Delta q - C(e)$  subject to (8).

Comparative statics for this problem reveal that Proposition 3 remains true in this setting. The type of cost variation considered there, involving increased marginal costs, induces reduced incentives in the relational contract. On the other hand, a cost variation where marginal costs are left unaltered ( $K_{v\kappa}(v^*, \kappa) = 0$ ) now turns out to induce higher-powered incentives iff the following condition holds:

$$[1 - (1-v)K_{vv}/K_v + a^*K_v] [-K_\kappa(v^s, \kappa)] > 0, \quad (9)$$

where  $a^* = \delta/C'(e^*) > 0$ , and  $K_\kappa(v^s, \kappa)$  is the cost effect in the spot contract. Consider a reduction of fixed costs ( $K_\kappa < 0$ ), implying in particular reduced costs and higher surplus in the spot contract. We see that this will now certainly induce higher-powered incentives in the relational contract if the marginal cost function is inelastic ( $(1-v)K_{vv}/K_v < 1$ ). On the other hand, we also see that an increase of fixed costs can induce higher-powered incentives in the relational contract only if the marginal cost function is *elastic*. In fact, one can see that there will be a range of parameters where

such a cost increase will indeed induce higher-powered incentives.<sup>20</sup>

Hence, for simpler contractual relationships where contracting costs are incurred only prior to the first transaction, the main message still applies: Contracting costs matter for incentive provision, and there is not a monotonic relationship between contracting costs and incentives. In order to understand incentive provision one has to understand both the level of contracting costs, the shape of the contract cost function and the frequency with which contract costs must be incurred.

## 5 Discussion

In the last section, we saw that both the shape of the contract cost function and the level of contracting costs matter for incentive design. The contract cost function reflects the necessary costs to achieve a given probability of legal enforcement, and will thus depend on the complexity of the transactions and the quality of the performance measures, as well as the strength of enforcement institutions and the practice of legal courts.

The shape of the contract cost function is related to one of the main questions in the literature on contract law: How do and should courts interpret contract terms, and when do and should courts imply terms to which the contracting parties have not explicitly agreed. There are important differences between the common law system and the civil law system in this

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<sup>20</sup>Suppose  $(1 - v)K_{vv}/K_v > 1$  for  $v \geq 0$ , and moreover that absolute costs are initially zero for  $v = 0$ . Let  $\delta^F$  be the minimal discount factor for which the first-best ( $e = e^F, v = 0$ ) can be implemented in the relational contract. Assuming  $K_v = 0$  at  $v = 0$ , there will then be a range of discount factors smaller than  $\delta^F$  where equilibrium  $v$  and  $K_v$  are positive but small, and hence the first bracket in condition (9) is negative. The whole expression is then positive.

respect, and the questions also cause lively debates among legal scholars (Scott, 2000).

Generally, courts in the common law system are less willing than civil law courts to interpret intentions of the contracting parties that are not clearly expressed in the contract, or to consider extrinsic evidence that contradicts or adds to the written terms of the contract. There is, as we will discuss below, a tendency towards less formalism and more contextual interpretation in the US, but from the common law doctrines collectively referred to as the *parol evidence rule*, courts should emphasize the outward appearance of the contract, and endorse what the parties objectively appear to have intended. If the contract is ambiguous, the court should generally not admit evidence of what the parties may have thought the meaning to be. In contrast, courts in civil law systems rely to a larger extent on extrinsic evidence and emphasize finding the true intentions of the contracting parties when contract terms are vague. Extrinsic evidence may include witnesses to oral agreements, or documents from meetings or negotiations. Hence, if the parties by mistake express terms in the contract that differ from their real subjective intentions, then the contracts can be set aside. On the basis of Articles 1109 and 1110 in the French Civil Code, and Article 1362 in the Italian Civil Code, courts sometimes nullify contracts because of discrepancy between the written contract and the parties' intentions.<sup>21</sup>

A consequence of these different legal institutions is that the marginal effect on enforceability of investing in detailed contracts is higher in common

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<sup>21</sup>See Beale et al. (2010) for a comprehensive comparison of contract law across countries. See also Moskwa (2004) for a nice overview of interpretations of commercial contracts in the European Civil Code.

law systems than in civil law systems, and thus that marginal contracting costs are higher in civil law. But for low contracting costs, the parties can achieve a higher probability of legal enforcement in civil law than in common law systems. To see this, note that the prospects of predictable contextual interpretations allow parties to write simpler contracts and thus reduce contracting costs (Shavell, 2006). Detailed explicit contracting is less important if other evidence about the parties' intentions can be used in court. But since more complex contracts present more interpretive issues than simple ones, and since the court's interpretations are not perfectly predictable, more reliance on extrinsic evidence and contextual interpretations will increase contracting costs for complex contracts (Schwartz and Watson, 2004). The parties may spend resources on contracting without necessarily improving the legal enforceability of the contract.

With respect to our model, this suggests that the cost function  $K(v)$  will tend to be flatter, but will have a higher intercept in common law compared to a civil law system. It further suggests that we may interpret a change where  $K_{\kappa v}(v^*, \kappa) > 0$  and  $K_{\kappa}(v^*, \kappa) = 0$  as a marginal move from common to civil law practice. Proposition 3 suggests that such a move from common law to civil law leads to lower-powered incentives.

Interestingly, empirical studies indicate a higher frequency of performance related pay in central common law countries like the US, the UK and Australia than in civil law countries such as France and Italy (see Brown and Heywood, 2002 for an international comparison on performance pay). A recent study by Fernandes et al. (2010) also shows that CEO equity-based pay is more prevalent in common law countries. In order to test our

hypothesis, one could look at the relationship between performance pay and judicial formalism, as indexed by Djankov et al. (2003).

The result in Proposition 3 can also illuminate the ongoing debate about the application of the parol evidence rule in Common law. The trend has been towards decreased stringency in its application (Hermalin et al. 2007). In particular, the Uniform Commercial Code in the US has been enacted in order to regulate incomplete commercial contracts.<sup>22</sup> But several scholars writing in the law and economics tradition are critical to this trend and argue for a re-invigoration of the parol evidence rule and more formalism in contract interpretation (see in particular Scott, 2000, and Schwartz and Scott, 2004). Their main argument is that subjective interpretation and gap-filling of contracts require courts to be more competent than the contracting parties. Scott (2000, p. 852) states that "if the state selects the "wrong" interpretive strategy or performs its regulatory function in an inconsistent manner, the costs of contracting will rise". Scott also shows that the UCC has increased the risk of unpredictable interpretation and that many have actually opted out of the Code to ensure that contractual language is subject to predictable interpretation.

In our model we may interpret a marginal change where  $K_{\kappa v}(v^*, \kappa) > 0$  and  $K_{\kappa}(v^*, \kappa) = 0$  as a marginal move away from the strict interpretation of the parol evidence rule. More emphasis on UCC makes  $K(v)$  steeper, but with a lower intercept. Hence, for low contracting costs, the UCC can

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<sup>22</sup>The UCC addresses most aspects of commercial law, and is generally viewed as one of the most important developments in American law. Deciding disputes that fall under the UCC has many similarities to deciding disputes that fall under the French Civil Code (Cooter and Ulen, 2003).

help the parties to achieve a higher probability of enforcement, but marginal costs of contracting will typically be higher when the parol evidence rule is applied less stringently. Proposition 3 suggests that this will lead to lower-powered incentives. Our model thus highlights the importance of marginal contracting costs. Higher fixed contracting costs are not necessarily detrimental to incentives. As shown by Proposition 2, higher fixed contracting costs may actually lead to higher-powered incentives. It is higher *marginal* contracting costs that weaken incentives.

Now, higher contracting costs may not only stem from institutional factors. An increase in the cost to achieve a given enforcement level can for example stem from higher job complexity. The costs associated with describing a job's tasks and operational performance metrics are likely to be higher the more complex the job. The result in Proposition 2 then says that, under certain conditions, higher job complexity may generate higher-powered incentives. The intuition is that higher job complexity may lead the principal to increase the level of contracting such that the probability of verification increases. This in turn makes the parties able to implement higher-powered incentives. Interestingly, higher-powered incentives are more common in human capital intensive industries (see e.g. Long and Shields, 2005 and Barth et al., 2008), and one reason may be that knowledge-intensive jobs require more detailed contracts.

Related to this, more complex jobs also require stronger monitoring technology if the principal wants to evaluate performance. One may in fact reinterpret the contracting costs in our model as being some kind of monitoring costs: The principal invests in a monitoring technology, which raises

the probability that the court will be able to verify the agent's performance. Proposition 2 then shows that a weaker monitoring technology (higher costs) may either lead to higher-powered or lower-powered incentives, complementing the standard results (see Demougin and Fluet, 2001).

## 6 Conclusion

In this paper we have endogenized the probability of legal enforcement in an otherwise standard moral hazard model. We have assumed that the probability of contract enforcement is determined by the level of ex ante (costly) contracting, and analyzed both a static and repeated game version of the model

The main message from the paper is that contract costs matter for incentive provision, both in the static spot contract and in the repeated relational contract. Interestingly, there is not a monotonic relationship between contracting costs and incentive intensity. Higher contracting costs may lead to higher-powered incentives.

Since the shape of the contract cost function is partly determined by the legal institutions, we can also formulate hypotheses about the relationship between legal institutions and incentive provision. Specifically, we argue that the model predicts higher-powered incentives in common law than in civil law practise.

The paper offers a simple framework that is well suited for analyzing the relationship between relational incentive contracts and legal institutions. The model can be extended to incorporate other legal variables such as lit-



igation costs and alternative breach remedies. Variations of this framework could also be applied to other topics where repeated games and legal institutions are important, such as optimal firm boundaries, public versus private ownership, and the sustainability of cartels and collusive agreements.

## Appendix

**Proof of Proposition 1.** Given that all rents can be extracted, the principal will clearly make  $\Delta\beta$  as large as possible, ie. set  $\Delta\beta = m$  (otherwise costs could be saved by reducing  $v$ ), and hence solve the maximization problem stated in the proposition. Let  $(e^s, v^s)$  be the maximizers. It only remains to show that extracting the agent's rents by payments that satisfy the feasibility constraints (1) is feasible. To this end let

$$\beta_L = ([e^s C'(e^s) - C(e^s)] - m_1) \frac{1}{1 - v^s}, \quad s = -m_1 - \beta_L, \quad \beta_H = m + \beta_L$$

Then  $s + \beta_L = -m_1$ ,  $s + \beta_H = m_2$  and the agent's rent is

$$s + v^s(\beta_L + e^s \Delta\beta) - C(e^s) = -m_1 - \beta_L + v^s \beta_L + [e^s C'(e^s) - C(e^s)] = 0$$

By the assumption  $m_1 > m_F$  in (2) we have  $\beta_L < 0$  and hence  $s > -m_1$ .

So it remains to verify  $s < m_2$ , which will follow from  $\beta_H > 0$ .

Since by definition  $(1 - v^s)\beta_L > -m_1$  we have

$$(1 - v^s)\beta_H = (1 - v^s)(m + \beta_L) > m - mv^s - m_1 = m_2 - mv^s,$$

where  $mv^s = C'(e^s)$  by IC. Since by assumption  $m_2 \geq q_H \geq \Delta q$  (for  $q_L \geq 0$ ), and since  $C'(e^s) \leq C'(e^F) = \Delta q$  we thus see that  $\beta_H > 0$ , completing the proof.

### Risk aversion

Suppose here that the agent is risk averse with utility function  $u(w) -$

$C(e)$ , where  $w$  is the monetary payment, and consider the spot contract game. In stage 4 the agent's certainty equivalent bonus  $\tilde{\beta}_i$  for the court lottery is given by

$$u(s + \tilde{\beta}_i) = vu(s + \beta_i) + (1 - v)u(s) \quad (10)$$

Since the agent will settle on  $\tilde{\beta}_i$ , the principal will offer this bonus in stage 3. Thus in stage 2, when the agent takes effort, his expected utility is

$$eu(s + \tilde{\beta}_H) + (1 - e)u(s + \tilde{\beta}_L) - C(e) \quad (11)$$

In stage 1, the principal's payoff is then

$$-K(v) + q_L + e\Delta q - s - e\tilde{\beta}_H - (1 - e)\tilde{\beta}_L \quad (12)$$

For given  $v$ , let  $\tilde{\beta}_H^*, \tilde{\beta}_L^*, s^*$  be the bonuses and fixed payment that solve the standard moral hazard problem of maximizing the principal's payoff (12), given that the agent chooses effort to maximize (11), plus a participation constraint for the agent. (Expected utility (11) must exceed some reservation utility  $u_0$ .) This solution is independent of  $v$ , and if bonuses can be set freely, the principal can implement this solution by setting the bonuses  $\beta_i$  in the contract sufficiently large such that the settlement bonuses determined by (10) satisfy  $\tilde{\beta}_i = \tilde{\beta}_i^*$ . If bonuses can be set freely, there is thus no cost for the principal to reduce  $v$ . Since she can save on investment costs, she will then reduce  $v$  as much as possible; in the limit to zero, implying in the limit infinitely large bonuses in the contract.

Given that there are bounds on bonuses, it is clear that at least one of the bonuses will be maximal. A reduction of  $v$  will then influence the settlement bonus  $\tilde{\beta}_i$  in (10), inducing a deviation from the (second best) bonus  $\tilde{\beta}_i^*$ , and hence be costly for the principal in terms of reduced surplus. There will then be an optimal  $v$  trading off this cost against the saved investment expenses. (Formally the optimal solution maximizes (12) subject to the IC and IR constraints derived from (11), plus the constraints (10) and feasibility constraints for the bonuses  $\beta_i$ .) We see that the solution will have qualitatively similar features as the solution in Proposition 1, such as bonus(es) in the contract being maximal and being renegotiated and settled to lower levels at a later stage.

### **Proof of Lemma 1**

Consider the relational contract. If there is a deviation from the contracted bonus  $\beta_i$  in stage 3, the parties will revert to the spot contract strategies, and hence settle on  $v\beta_i$  in stage 4. The parties will honor the relational contract if the net present value from honoring is greater than the net present value from renegeing. This holds for the principal in stage 3 iff

$$-\beta_i - \frac{\delta}{1-\delta}\pi_P \geq -v\beta_i + \frac{\delta}{1-\delta}u, \quad i = L, H,$$

where  $u$  is the principal's spot payoff (equal to the total spot surplus) and  $\pi_P = q_L + e\Delta q - K(v) - s - \beta_L - e\Delta\beta$  is the payoff (per period) under relational contracting. Since the agent receives his reservation payoff of zero

in the spot contract, he will honor the relational contract iff

$$\beta_i + \frac{\delta}{1-\delta}\pi_A \geq v\beta_i + 0, \quad i = L, H,$$

where  $\pi_A$  is his payoff as given in (6). Since  $\beta_H > \beta_L$  to provide incentives, the relevant enforceability constraints will be the constraint corresponding to  $\beta_L$  for the agent, and the constraint corresponding to  $\beta_H$  (with  $\beta_H \geq 0$ ) for the principal. These constraints can be written as

$$\frac{\delta}{1-\delta} [q_L + e\Delta q - K(v) - s - \beta_L - e\Delta\beta - u] \geq \beta_H(1-v) \quad (13)$$

$$\beta_L(1-v) + \frac{\delta}{1-\delta} [s + \beta_L + e\Delta\beta - C(e)] \geq 0 \quad (14)$$

In addition we have feasibility constraints  $-m_1 \leq s, s + \beta_i \leq m_2, i = L, H$ . The optimal contract for the principal maximizes her (per period) payoff  $\pi_P = q_L + e\Delta q - K(v) - s - \beta_L - e\Delta\beta$  subject to all constraints. (The constraints include the IC constraint (5) for the agent, and so by construction of the contract no deviations can be profitable in stages 1-2.)

We now show that the enforceability conditions (13)-(14) can be replaced by (7). Consider first (14). If this constraint doesn't bind, then  $\beta_L$  can be reduced, keeping  $s + \beta_L$  and  $\Delta\beta$  fixed, without violating any constraints. This will reduce  $\beta_H$  and thus strictly relax (13), and then  $v$  can be reduced, increasing the payoff  $\pi_P$ . Hence it is optimal to have (14) binding, and thus  $\beta_L \leq 0$  by the IR constraint (6).

Substituting for  $\beta_L(1-v)$  from (14) and for  $\Delta\beta$  from (5) into (13), we then see that the relational enforceability conditions are equivalent to

condition (7).

Absent constraints on payments, the principal would then (by means of the fixed fee  $s$ ) extract all of the agent's rent and set the bonuses so as to maximize the total surplus (her own payoff)  $q_L + e\Delta q - K(v) - C(e)$  subject to constraint (7). Since effort is smaller than first-best, this will entail payments such that

$$\begin{aligned}\Delta\beta &= C'(e) < C'(e^F) = \Delta q \\ 0 &= s + \beta_L + e\Delta\beta - C(e) < s + \beta_L + e^F C'(e^F) - C(e^F)\end{aligned}$$

Setting  $\beta_L = 0$  we see that these payments satisfy (by our assumptions (2) regarding  $m_1, m_2$ )  $\beta_H = \Delta\beta < \Delta q \leq m_2$ , and  $0 > s > -e^F C'(e^F) + C(e^F) \geq -m_1$ . Hence they satisfy the constraints (1), and are thus feasible for the principal. This shows that the constraints (1) are not binding, and hence proves the lemma.

### **Proof of Propositions 2 and 3.**

To simplify notation, we set  $q_L = 0$  in this proof. We will here accommodate both recurring and one-shot up front investments; the latter being considered in Section 4.1. With recurring investments the optimal contract maximizes  $f(e, v, \kappa) = e\Delta q - C(e) - K(v, \kappa)$  subject to.  $f(e, v, \kappa) \geq \frac{1-\delta}{\delta} C'(e)(1-v) + u$ . With one-shot investments the problem is to maximize  $f(e, v, \kappa) + \delta K(v, \kappa)$  subject to  $f(e, v, \kappa) + K(v, \kappa) \geq \frac{1-\delta}{\delta} C'(e)(1-v) + u$ . To accommodate both cases, let  $\gamma \in \{0, 1\}$  be an indicator and consider the

problem

$$\max_{e,v} (f(e, v, \kappa) + \gamma\delta K(v, \kappa)) = e\Delta q - C(e) - K(v, \kappa) + \gamma\delta K(v, \kappa) \quad \text{s.t.}$$

$$G(e, v, \kappa, \delta) = f(e, v, \kappa) - H(e, v, \kappa, \delta) \geq 0, \quad (15)$$

where

$$H(e, v, \kappa, \delta) = \frac{1-\delta}{\delta} C'(e)(1-v) + u(\kappa) - \gamma K(v, \kappa) \quad (16)$$

Here  $u(\kappa)$  denotes the spot surplus, and we note from Proposition 1 that  $u'(\kappa) = -K_\kappa(v^s, \kappa)$ , where  $v^s$  is the equilibrium spot verification probability

Let  $L = (f + \gamma\delta K) + \lambda G$  be the Lagrangian for this problem. Given sufficient second order conditions, standard comparative statics yield

$$e'(\kappa) = \frac{1}{D} ([L_{vv}G_e - L_{ev}G_v] G_\kappa + [L_{e\kappa}G_v - L_{v\kappa}G_e] G_v), \quad (17)$$

where  $D > 0$  is the determinant of the bordered Hessian of  $L$ .

Note that from  $L = (f + \gamma\delta K) + \lambda G$ ,  $G = f - H$  and the first-order conditions (FOCs)  $f_k + \gamma\delta K_k = -\lambda G_k$ ,  $k = e, v$ , we have

$$\begin{aligned} G_k L_{ij} &= G_k (f_{ij} + \gamma\delta K_{ij}) + G_k \lambda G_{ij} \\ &= (f_k - H_k)(f_{ij} + \gamma\delta K_{ij}) - (f_k + \gamma\delta K_k)(f_{ij} - H_{ij}) \\ &= f_k H_{ij} - H_k f_{ij} + \gamma\delta (G_k K_{ij} - K_k G_{ij}) \end{aligned}$$

Substituting this into the formula for  $e'(\kappa)$ , taking into account  $K_e = K_{ev} = f_{ev} = 0$ ,  $f_{e\kappa} = H_{e\kappa} = G_{e\kappa} = 0$  and  $H_{vj} = -\gamma K_{vj}$ ,  $f_{vj} = -K_{vj}$ ,  $j = v, \kappa$ ,

yields, after some algebra:

$$\begin{aligned} e'(\kappa)D &= [H_e K_{vv} - f_v H_{ev} - \gamma f_e K_{vv} + \gamma \delta (G_e K_{vv} + K_v G_{ev})] G_\kappa \quad (18) \\ &\quad + [-H_e K_{v\kappa} + \gamma f_e K_{v\kappa} - \gamma \delta G_e K_{v\kappa}] G_v \end{aligned}$$

Now, for  $\gamma = 0$  we have  $G_\kappa = f_\kappa - H_\kappa = -K_\kappa - u'(\kappa)$ , where, as noted above  $u'(\kappa) = -K_\kappa(v^s, \kappa)$ . Substituting for  $f_v = -K_v$  and noting that  $H_e/H_{ev} = -(1-v)$ , we then obtain from (18)

$$e'(\kappa)D = \{[-(1-v)K_{vv} + K_v][K_\kappa - K_\kappa(v^s, \kappa)] - (1-v)K_{v\kappa}G_v\}(-H_{ev}),$$

where  $H_{ev} = -\frac{1-\delta}{\delta}C'' < 0$  and we have from FOC  $G_v = -f_v/\lambda = K_v/\lambda > 0$ .

In Proposition 2 we have  $K_{v\kappa} = 0$  and hence see that  $e'(\kappa)$  has the same sign as the expression stated there. From the IC condition ( $\Delta\beta = C'(e)$ ) it follows that effort and incentives covary, and this proves the proposition.

In Proposition 3 we have  $K_{v\kappa} > 0$  and  $0 = K_\kappa = K_\kappa(v^s, \kappa)$ , and since  $G_v > 0$  as noted above, we see that  $e'(\kappa)$  has the same sign as  $-K_{v\kappa}$ . This proves Proposition 3.

### Up front investments

For up front investments, where  $\gamma = 1$ , we have from (15)-(16)  $G_\kappa = f_\kappa - H_\kappa = -u'(\kappa) = K_\kappa(v^s, \kappa)$ . Substituting this and  $G_e = f_e - H_e$ ,  $G_{ev} = 0 - H_{ev}$  into the comparative statics formula (18) we obtain

$$\begin{aligned} e'(\kappa)D &= [H_e K_{vv} + K_v H_{ev} - f_e K_{vv} + \delta(f_e - H_e)K_{vv} - \delta K_v H_{ev}] K_\kappa(v^s, \kappa) \\ &\quad + [(1-\delta)G_e] K_{v\kappa} G_v \quad (19) \end{aligned}$$



From the Lagrangean  $L = (f + \delta K) + \lambda G$ ,  $G = f - H$  and the FOCs  $f_k + \delta K_k = -\lambda G_k$ ,  $k = e, v$ , we have first  $f_e = -\lambda(f_e - H_e)$  and thus  $f_e = \frac{\lambda}{1+\lambda}H_e > 0$ , and second  $G_e G_v = -f_e(1 - \delta)K_v/\lambda^2 < 0$ . The latter inequality shows that  $e'(\kappa) < 0$  when  $K_{v\kappa} > 0$  and  $K_\kappa = 0$ , and hence that the analogue of Proposition 2 holds in this case.

Substituting now for  $H_e - f_e = \frac{1}{1+\lambda}H_e$  in (19) we obtain, when  $K_{v\kappa} = 0$

$$\begin{aligned} e'(\kappa)D &= \left[ K_v(1 - \delta)H_{ev} + (1 - \delta)\frac{1}{1 + \lambda}H_e K_{vv} \right] K_\kappa(v^s, \kappa) \\ &= \left[ (1 + \lambda) - (1 - v)\frac{K_{vv}}{K_v} \right] [-K_\kappa(v^s, \kappa)] \frac{K_v(1 - \delta)}{1 + \lambda}(-H_{ev}), \end{aligned}$$

where we have used  $H_e/H_{ev} = -(1 - v)$ . From the FOC  $f_v + \delta K_v = -\lambda G_v$  and (15)-(16) we obtain  $(-1 + \delta)K_v = -\lambda\frac{1-\delta}{\delta}C'(e)$ , and hence  $\lambda = \delta K_v/C'(e)$ . Substituting this into the last equation above, and noting that  $H_{ev} < 0$ , we see that when  $K_{v\kappa} = 0$  we have  $e'(\kappa) > 0$  precisely when (9) holds. This completes the proofs.

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