Delegating relational contracts to corruptible intermediaries

Marta Troya-Martinez and Liam Wren-Lewis*

September 9, 2015

Abstract

This article explores the link between productive relational contracts and corruption. Responsibility for a contract is delegated to a supervisor who cares about both production and kickbacks, neither of which are explicitly contractible. We characterize the optimal supervisor-agent relational contract and show that the relationship between joint surplus, kickbacks and production is non-monotonic. We then show that delegation to a supervisor may increase a principal's payoff by easing the time-inconsistency problem of paying ex-post incentive payments. For the principal, the optimal supervisor has incentives that are partially, but not completely, aligned with her own.

JEL classifications: D73, D86, L14.
Keywords: Relational contracts, delegation, corruption.

*Troya-Martinez: New Economic School, mtroya@nes.ru. Wren-Lewis: Paris School of Economics, liam.wren-lewis@parisschoolofeconomics.eu. We are grateful to Heski Bar-Isaac, Simon Board, Mikhail Drugov, Matthew Ellman, Florian Englmaier, Matthias Fahn, William Fuchs, Elisabetta Iossa, Jonathan Levin, Rocco Macchiavello, Jim Malcomson, David Martimort, Gerard Padró i Miquel, John Vickers and the participants of AEA, ASSET, BGSE Summer Forum, CSAE, CMPO, EEA, ES World Congress, GREThA, and ISNIE conferences, Workshop on Relational Contracts and the seminars at HSE, LMU Munich, NES, Oxford, Paris I, PSE and UAB for many insightful comments. Any remaining errors are our own.

A wide range of important economic activities depend on self-enforcing implicit contracts.[1] Responsibility for these contracts is frequently delegated to intermediaries - firms delegate to managers, governments to bureaucrats. Indeed, recent papers have suggested that decentralization can significantly improve firms' productivity (Bloom, Sadun and Van Reenen, 2012; Bloom et al., 2013). However, these papers also find that delegation is held back by a lack of trust, as intermediaries may extract kickbacks in the form of bribes or non-monetary private benefits. Since these forms of corruption are not legally enforceable, they also depend on self-enforcing relational contracts.

If intermediaries are corruptible, when and how should relational contracts be delegated? This paper provides answers to this question by extending a standard principal-agent relational contracting model to include an intermediary supervisor. We find that delegation can enhance credibility since the supervisor cares less than the principal about payments to the agent. However, if the supervisor cares too little about making payments, then she will over-pay the agent in exchange for kickbacks. Overall, therefore, delegation may or may not be beneficial for the principal.

A key contribution of the paper is to elucidate two key trade-offs faced by the principal when delegating. First, the principal must decide how much the supervisor's payoffs should be aligned with her own. A more closely aligned supervisor is less tempted by corruption, but she also has more difficulty in committing to reward the agent. Second, the principal must decide how much surplus will be shared between the supervisor and agent, which in our model is equivalent to how much corruption to allow. Interestingly, if there is a cap on the payments that the supervisor can make, then the relationship between surplus and the agent's effort is non-monotonic. As surplus increases, relational contracting is facilitated. At first this will sustain greater payments to reward the agent, inducing greater effort as well as higher kickbacks. However, when the payment cap is reached, the supervisor will pay the agent regardless of production, increasing kickbacks but reducing the agent's motivation. With both trade-offs, therefore, allowing a little corruption benefits the principal, but too much will damage production.

The paper begins in Section 1 by drawing out evidence from the economic literature on the relevance of relational contracts that sustain both production and corruption. We find important examples of such 'dual' contracts in inter-firm trade, employment relations and public procurement. Moreover, we detail suggestive evidence that the dual nature of these relationships leads to potentially interesting

[1] For instance, Antras and Foley (2015) and Macchiavello and Morjaria (2015) provide evidence that such relational contracts play an important role in international supply chains, whilst Gibbons and Henderson (2013) and Blader et al. (2015) argue that that variation in effective intra-firm relational contracts can explain significant differences in performance.

interactions and trade-offs which motivate our analysis.

Section 2 then sets out a simple principal-agent relational contracting model which serves as a benchmark and the foundation for our extension. This baseline model is essentially a version of Levin (2003) containing moral hazard. In particular, an agent exerts continuous hidden effort towards producing a binary payoff for a principal and in return receives compensation that is partly discretionary.

We then extend this model in Section 3 by replacing the principal by a supervisor. The key difference between the supervisor and the principal is that the former only receives a fraction of the total profit. The amount of discretionary bonuses that the supervisor can pay each period is subject to a cap, but the supervisor and agent can also exchange discretionary side-payments.[2] To our knowledge, ours is the first paper to build a model where corrupt relational contracts exist alongside productive ones.

A first insight from the model is that the two parts of the relational contract interact with each other in important ways. There is a positive interaction, as the expected stream of future kickbacks allows the supervisor to credibly promise to pay higher bonuses, and these bonuses may then be used to incentivize greater effort. But there is also a negative interaction, because the supervisor must trade off inducing effort and inducing bribery when self-enforcement is a binding constraint.

We then characterize optimal relational contracts between the supervisor and the agent. Stationary contracts are optimal and may use variation both in bribes and in bonuses as means to incentivize effort. The choice of incentive mechanism and the amount of effort that results depend on the discounted surplus that is split between the supervisor and agent. If this surplus is very high, then self-enforcement is not a problem, and the supervisor will always pay the maximum possible bonus to the agent in exchange for kickbacks. In this way, the supervisor and agent capture the maximum amount of surplus from the principal, and effort can still be induced through variations in bribes. However, it is more credible for the supervisor to incentivize effort through variation in bonuses than in bribes, because the supervisor does not pay for the full cost of any bonus. As a result, once surplus falls below a certain level, the optimal contract will also involve variation in bonuses, and eventually this variation will be the only tool used to incentivize effort.

A notable result that follows is that the agent's effort is non-monotonic in the joint supervisor-agent surplus. This contrasts with the standard principal-agent case where effort is weakly increasing in the joint surplus. The reasoning is that, as with principal-agent contracting, increasing surplus always increases the amount of effort it is possible to induce. However, it may also simultaneously decrease the level of effort which the supervisor and agent wish to induce. In particular, when surplus is

[2]The terms side-payments, bribes, and kickbacks are used interchangeably.

low, bonuses are used to incentivize effort. Therefore, higher effort increases joint supervisor-agent surplus in two ways: it increases the probability of high output and it increase the probability of a larger bonus. On the other hand, when surplus is high, bonuses are always high, and hence the only benefit to the supervisor and agent of effort is that it increases the probability of high output. Thus the supervisor and agent desire a higher level of output when surplus is lower.

This result has important implications for policies designed to reduce fraud or corruption in contexts where relational contracts are valuable. Many policies aimed at reducing corruption involve disrupting relational contracts, such as increasing personnel rotation or avoiding conflicts of interest. The above result suggests that, in some circumstances, weakening supervisor-agent relations may simultaneously cut corruption and improve output, but in other circumstances there will be a trade-off.

Section 4 then analyzes how and when the principal should delegate. We assume that the principal sets key paramaters before the supervisor-agent game begins, including the fixed transfer paid to the agent, the limit on discretionary bonuses, and the extent to which the supervisor's preferences are aligned with her own. A notable result is that the principal will choose the supervisor's preferences to be partly, but not completely, aligned with her own. More closely aligned preferences mean that supervisor-agent relational contracting is more difficult, and hence the principal has to give them more surplus. Indeed, a supervisor with preferences exactly aligned will never be optimal since reducing effort slightly below the first-best is a second-order cost for the principal while giving up surplus is first-order. On the other hand, a supervisor that cares less about profit is more tempted to pay bonuses all the time, and at the extreme a supervisor that doesn't care at all about profits will induce no effort. The optimal supervisor therefore always lies somewhere between the two extremes.

A final result of our analysis is that, when the principal is constrained by relational contracting, delegating to a corruptible supervisor can improve the principal's payoff. This is because the supervisor has a comparative advantage in enforcing the relational contract. In particular, the supervisor has more credibility when paying promised bonuses; she cares less about making such payments and yet values the relationship with the agent because of the expected stream of future kickbacks. In other words, the agent can punish the supervisor by withholding the promised kickback if the supervisor reneges on her promises. If relational contracting is sufficiently difficult, then delegating induces higher effort and increases the principal's payoff. On the other hand, if direct relational contracting is relatively easy, the principal will prefer not to delegate to the supervisor in order to avoid having to share with her part of the surplus.

We consider a number of alternative specifications and extensions in Section 5 of the paper. This includes giving the supervisor a more general payoff function and making side-payments costly. We show that first-best effort will only be induced if we allow seemingly unrealistic contracts and discuss to what extent side-transfers could be replaced by direct payments from the principal. Finally, Section 6 concludes, considering avenues for future theoretical and empirical work. Mathematical proofs of all lemmas and propositions are then given in the appendix.

This article fits into an increasing body of work on relational incentive contracts; Malcomson (2013) provides a useful survey. Models in this literature have so far focused on situations with only two players and, when delegation has been considered, it is generally direct delegation of decisions to the agent (Alonso and Matouschek, 2007; Goldlücke and Kranz, 2012; Li, Matouschek and Powell, 2015). They therefore cannot consider possibilities for corruption, which is typically modeled as involving collusion between an agent and an intermediary against the interests of a principal (see Banerjee, Mullainathan and Hanna, 2013, for a recent survey).

Our model also relates to the literature which considers how delegation to an intermediary can be used as a solution to commitment problems.[3] Perhaps the paper in this literature which is closest to ours is that of Strausz (1997), which considers how delegating monitoring to a intermediary may improve the principal's payoff through a 'commitment effect' when the principal is tempted not to pay promised bonuses. The paper differs in focus from ours by concentrating mainly on the impact of principal-supervisor collusion and, although supervisor-agent collusion is considered, it is assumed that all collusion is automatically enforced. Moreover the supervisor can only effectively trigger bonus payments when the agent performs the (binary) action well and, when a signal is observed, it reveals the truth of the agent's action. The combined effect of these assumptions it that, unlike in our model, supervisor-agent collusion has no impact on the maximum payoff the principal can achieve.[4]

A recent paper which also considers how delegated cooperation can be maintained is that of Hermalin (2015). He builds a model whereby 'wining and dining' helps sustain a productive relationship between two firms' managers, and also considers the

[3] Earlier papers in this literature include Vickers (1985), Katz (1991), and Kockesen and Ok (2004). Like much of this literature, we assume that the intermediary's payoff function is observed by the agent. However, since in our context part of the supervisor's payoff comes directly from the agent, our results may be less vulnerable to principal-supervisor renegotiation than those of other papers - see Section 5.2.1 for more details.

[4] One paper that shows how corruption may mitigate a commitment problem is Olsen and Torsvik (1998), who find that the possibility of supervisor-agent collusion can reduce the ratchet effect. Their model differs from ours in that it studies a problem of adverse selection rather than moral hazard, and corruption itself is assumed to be enforceable. Also related is the paper of Salant (1995) who considers how the revolving door may help to solve underinvestment. Martimort (1999) analyzes the dynamics of corruption in a model where corrupt contracts are self-enforced but does not consider how this interacts with other commitment problems.

risks involved when the managers can collude against shareholders. The paper argues forcefully that an advantage of managers being able to reward each other is that principals cannot directly observe inter-firm cooperation, and we essentially follow this logic in the core model by not allowing the principal to directly reward cooperation.[5] A key difference between this paper and ours is that collusion is not sustained through relational contracting and indeed only occurs when side-payments are costless for the managers. As a result, they find that allowing cross-firm managerial rewards is always beneficial for shareholders.

1 Examples of 'dual' relational contracts

Before detailing our model, we find it useful to consider a range of examples of relationships that frequently sustain both productive and corrupt implicit contracts. In particular, we believe that there are three domains where our analysis is particularly salient: inter-firm relationships delegated to sales or purchasing managers, firm-employee relationships delegated to managers, and government-firm relationships delegated to bureaucrats.

1.1 Inter-firm relationships

It is now well established that relational contracts play a key role in transactions between firms, particularly when courts are weak or trade is international - see, for example, the recent studies of Antras and Foley (2015) and Macchiavello and Morjaria (2015). A typical example is a firm purchasing goods where it is difficult or impossible to fully observe the quality before purchase. In this case, the purchasing firm may rely on a relational contract, inducing the selling firm to produce high quality goods through the threat of partial non-payment or the termination of the relationship.

Many of these inter-firm relationships are delegated to intermediaries who do not fully own the firm, particularly when firms become large and have many relationships. A purchasing manager is a typical example of such an intermediary, as they often have some discretion as to the clients they purchase from or the prices that are paid. Hence a purchasing manager can be seen as having control of a relational contract in the way modeled in this paper.

It is well known that such delegation carries risks of kickbacks or other corrupt behavior. In a survey of Indian firm-owners by Bloom et al. (2013), they note that

[5] Section 5.2.1 discusses this assumption and considers how results would change if such payments were allowed.

many *"did not trust non-family members. For example, they were concerned if they let their plant managers procure yarn they may do so at inflated rates from friends and receive kickbacks"*. Similarly, Bloom, Sadun and Van Reenen (2012) find multinationals decentralize less in low-trust environments, and argue that one reason is that the CEO *"may worry about the plant manager taking bribes from equipment sellers"*. Another example concerns the Chinese practice of Guanxi, which has been noted to have negative effects in addition to the positive value for businesses of enhancing relationships (Warren, Dunfee and Li, 2004).

In this context, Cole and Tran (2011) provide evidence that these two aspects of relational contracts may be interlinked. In particular, they describe the kickbacks that are made by two firms to intermediaries within the organizations that they supply. In one case, they note that relational contracts are needed because quality is not contractible and hence *"the supplier allows the client to hold back roughly 20 percent of the contract value until one month after delivery, until the client is satisfied that the product meets the specified quality"*. Then, apparently in order to encourage the final transfer, a *"kickback is paid only after all contract payments have been made."*. In another case, where it is *"difficult to verify the quantity and quality"*, the agent *"usually specifies the kickback amount in advance but typically does not start paying until the first deposit is made"*. As we will see, making kickbacks conditional on the supervisor releasing payments is a key aspect of the model below.

1.2 Labor relations and organizational structure

A large portion of the relational contracting literature has focused on labor relations within an organization (see, for instance, MacLeod and Malcomson, 1989; Baker, Gibbons and Murphy, 2002). Employees are frequently rewarded for effort with promotions, wage increases, or bonuses based on unverifiable subjective performance evaluations rather than contracted measures of output. In many organizations these relational contracts are delegated to intermediary managers who have a substantial amount of control over such incentives.

The difficulties of delegating relational contracts in this setting are also well known. For instance, in considering the failure of General Motors, Helper and Henderson (2014) note that *"senior management could announce a commitment to long-term relationships, ... [but] neither blue collar employees nor suppliers appear to have believed that the local managers with whom they had to deal would adhere to a relational contract"*. Furthermore, we again see a potential risk of supervisor 'corruption' with Milgrom (1988), Fairburn and Malcomson (2001), and Thiele (2013) each considering the possibility of employees wastefully engaging in collusion or 'influence activities'.[6]

The dual nature of relational contracts in this context lead to conflicting implications as to their value. For instance, Francois and Roberts (2003) argue that factors enabling relational contracts increase employee productivity and innovation, while Martimort and Verdier (2004) argue that the same factors increase the ability of supervisors and employees to collude and hence dampen economic growth. A similar dispute arises when discussing the use of 'travel allowances' in African government bureaucracies which, due to weak accounting standards, can serve effectively as cash bonuses (Nkamleu and Kamgnia, 2014). On the one hand, these are argued to provide an important mechanism through which managers can use relational contracts to incentivize unverifiable effort amongst employees. On the other hand, it is argued that repeated interactions allow civil servants simply to collude to extract the payments. Clearly both interpretations are possible, but it is difficult to evaluate which is more potent without understanding how the two types of contract may operate within the same relationship.

1.3 Regulation and public procurement

It is increasingly recognized that implicit relational contracts have an important role to play in systems of government regulation and public procurement (Board, 2011; Spagnolo, 2012). In such a situation, discretionary performance incentives include the timing of payment installments, favoritism for future contracts, regulatory rulings or the non-application of explicit contract clauses. Spagnolo (2012) gives evidence that allowing discretion improves the quality of government procurement, because otherwise governments are limited in their ability to enforce contract performance. In regulation, effective expropriation is a discretionary tool available to the government to enforce conducive behavior from the regulated firm (Wren-Lewis, 2013). Frequently, control of these discretionary tools are delegated to bureaucracies including procurement departments and independent regulators.

The potential for collusion between bureaucrats and firms through regulation and procurement is well known. Lambsdorff and Teksoz (2005) suggest that such corruption is typically maintained by relational contracts, and detail a number of relevant cases. They find that *"pre-existing legal relationships can lower transaction costs and serve as a basis for the enforcement of corrupt arrangements"*. Moreover, Iossa and Martimort (2014) argue that corruption may then lead to formal contracts being less

[6] These papers implicitly assume that such manager-employee collusion can be automatically enforced, and hence do not explore how this behavior relates to relational contracts. Thiele (2013) considers a principal who may operate a relational contract with the agent, but assumes that delegation to a corruptible supervisor results in all contracts becoming court-enforceable.

complete, since supervisors are attracted to the greater potential for corruption that contract incompleteness brings.

The dual nature of these relationships thus creates a tension, since policies that hamper corrupt contracts typically also hamper productive ones. For instance, Board (2011) describes how US government procurement evaluation panels were instructed to ignore subjective information, including prior performance, in order to reduce corruption. This then resulted in a reduction in relation specific investment. In a similar effort to reduce corruption, Russia changed its procurement rules in the mid-2000s to reduce the discretion of bureaucrats. Whilst there appears to have been some limited success in reducing the importance of government 'connections' in winning bids, evidence suggests that the new system has serious difficulties preventing contract breaches since reputation can no longer be taken into account (Podkolozina and Voytova, 2011). In this context, there thus appears to be a tradeoff between reducing corruption and facilitating productive relational contracting.

2 Benchmark: Principal-agent contracting

We start by providing a benchmark where the principal implements an incentive relational contract with the agent. The basic model corresponds to the moral hazard model of Levin (2003) simplified by considering the case of binary output.

2.1 The basic model

A principal oversees the performance of an agent in an infinitely repeated relationship.[7] As in Levin (2003), the agent's compensation consists of a fixed payment w_t and a non-contractible payment b_t, which can depend on the output produced by the agent Y_t. In the context of inter-firm relationships, we can think of w_t as the upfront payment, and b_t being the part of the payment paid after inspection of the product quality Y_t. In the context of repeated government procurement, b_t could also include the tolerance given for higher future bids or prompt installment payment.

At the beginning of each period, the principal offers the agent the compensation package. The agent either accepts or rejects - let $d_t \in \{0, 1\}$ denote the agent's decision. If the agent rejects the offer, then the principal and the agent get their outside options ($\underline{\pi}$ and $\underline{u}$, respectively) If instead the agent accepts, he chooses an effort $e_t \in [0, 1]$ incurring a cost $c(e_t)$, where $c(0) = 0$, $c'(0) = 0$ and $c''(\cdot) > 0$. The agent's effort generates a binary stochastic output $Y_t \in \{0, y\}$ where $0 < y$. The output is high ($Y_t = y$) with probability e_t.

[7] The principal is female while the agent is male. The supervisor introduced in the next section is also female.

The information structure corresponds to the one of moral hazard. The effort e_t is the agent's private information. Everyone observes the output Y_t .

Both players share the same discount factor $\delta \in (0, 1)$. At the beginning of any period $t \geq 1$, the principal and agent's payoff functions respectively are:

$$\pi_t = \mathbb{E}\left[(1-\delta)\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left\{d_\tau\left[Y_\tau - b_\tau - w\right] + (1-d_\tau)\,\underline{\pi}\right\}\right]$$
$$u_t = \mathbb{E}\left[(1-\delta)\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left\{d_\tau[w + b_\tau - c(e_\tau)] + (1-d_\tau)\,\underline{u}\right\}\right]$$

2.2 The optimal principal-agent contract

Note first that, if the output Y_t were contractible, the first best value of e_t would be that which maximizes every period the joint surplus, $ye_t - c(e_t)$, which gives

$$c'(e^{FB}) = y$$

When the output is not verifiable (and hence not contractible), a relational contract between the principal and agent is needed to incentivize the effort. We follow Levin (2003) in defining a self-enforcing contract as optimal if no other self-enforcing contract generates higher expected surplus. Levin (2003) shows that, if we are concerned with optimal contracts, then there is no loss of generality in focusing on stationary optimal contracts (Theorem 2), and we can thus arrive at our first proposition:

Proposition 1. *When the future relationship is very valuable, principal-agent relational contracting achieves first best effort. Otherwise, the equilibrium effort induced in the optimal principal-agent relational contract will be lower and decreasing in the value of the future relationship.*

In order to implement the first-best level of effort, it must be that the relationship is sufficiently valuable that the principal can credibly promise to pay a bonus of y when output is high, i.e. we require that the following inequality holds:

$$y \leq \frac{\delta}{1-\delta}(e^{FB}y - c(e^{FB}) - \underline{\pi} - \underline{u}) \tag{1}$$

The right hand side of the this inequality is the discounted joint surplus generated by the principal-agent relationship. When the future relationship is not valuable enough - for instance, because discounting is high - then the principal cannot credibly pay the amount of bonus needed to implement the first best effort. Instead, the bonus b will be the largest which can be credibly promised given this discounted future value, and since $c'(e) = b$, we will have downward distortion in the effort. The effort induced, e^{PA}, is then given by the following equation:

$$c'(e^{PA}) = \frac{\delta}{1-\delta}(e^{PA}y - c(e^{PA}) - \underline{\pi} - \underline{u}) \tag{2}$$

A possible way to implement this equilibrium effort is to have bonuses take one of two values, with $b_t(y) = c'(e^{PA})$ and $b_t(0) = 0$. Within any optimal contract effort e^{PA} is induced every period and the relationship never breaks down. The wage w is then chosen to split surplus appropriately.

3 Supervisor-agent contracting

In this section we essentially replace the principal with a supervisor who has a slightly different payoff function and different instruments. After describing the new version of the game, we proceed to solve for the optimal supervisor-agent contract. This thus forms the first step in setting up the three-tier principal-supervisor-agent hierarchy which we consider in Section 4 by reintroducing the principal into the game.

3.1 Introducing the supervisor

We now consider that relational contracting takes place between the agent and a supervisor, instead of the principal. In particular, we change the model in three ways.

First, the supervisor discounts the elements in the principal's payoff by an amount $\alpha \in (0, 1]$. That is, an output Y only produces a benefit of αY for the supervisor, and the compensation $b_t + w$ given to the agent only produces a negative payoff of $\alpha(b_t + w)$ for the supervisor. Essentially, the supervisor only receives a share α of the principal's profit, which is fixed over time.[8]

Second, at each time t a side-transfer can be made between the agent and the supervisor, which costs the agent S_t and gives the supervisor a benefit of S_t. The side-transfer is a kick-back in the sense that it is paid by the agent to the supervisor. The kickback is paid in two parts - the first part, s_t^F, is paid before output is realized, whilst the second part, $s_t(Y_t)$, is paid after output is realized and can depend on output Y_t. Splitting the transfers in this way is done for analytical ease, and is equivalent to the splitting up of compensation between a fixed part w_t and a variable

[8]We choose this form of supervisor payoff as it is the simplest which generates the key intuitions of the paper - Section 5.2 discusses alternative payoff functions. Varying the cost of bonus payments by a factor α is similar to the setup in Li and Matouschek (2013), only in their case the multiplying factor is temporary and always greater than one.

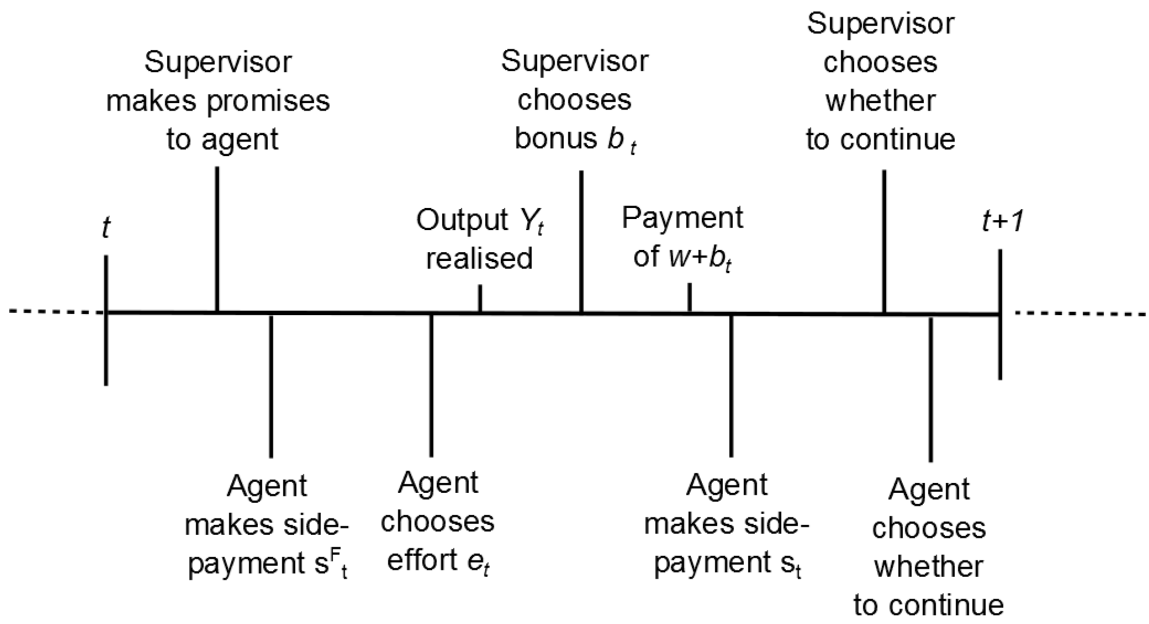


Figure 1: Timeline of supervisor-agent game

part b_t.

Third, the supervisor has limited discretion in the amount of official transfer she can pay to the agent. In particular, she is obliged to pay a wage w fixed by the principal, and can only pay a maximum bonus of $\bar{b}$. We assume that both w and $\bar{b}$ do not vary over time and cannot depend on output.

In this new game, at the beginning of each period, the supervisor offers the agent the compensation scheme b_t and asks for discretionary side-transfers s_t^F and s_t from the agent. The new timeline is given in Figure 1, and the payoff functions are given as follows:

$$v_t = \mathbb{E}\left[(1-\delta)\sum_{t=\tau}^{\infty}\delta^{\tau-t}\left\{d_\tau[\alpha(Y_\tau - w - b_\tau) + S_\tau] + (1-d_\tau)\,\underline{v}\right\}\right]$$

$$u_t = \mathbb{E}\left[(1-\delta)\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left\{d_\tau[w + b_\tau - c(e_\tau) - S_\tau] + (1-d_\tau)\,\underline{u}\right\}\right]$$

Here v_t is the payoff of the supervisor in period t, and $\underline{v}$ is her outside option. Let the surplus generated by the relationship between the supervisor and the agent be $g_t = v_t + u_t$.

We assume that only the supervisor and the agent observe the side-transfer S_t and that it is not verifiable.

Note that this new model is entirely equivalent to the model of the previous section if $\alpha = 1$. In this case, side-transfers, bonuses, and wages all become equivalent tools for making transfers between the two players. The fact that bonuses are capped and wages are fixed therefore becomes an irrelevance, because side-transfers are a perfect substitute. Hence we can think of the benchmark principal-agent model as simply the model given in this section when $\alpha = 1$.

3.2 Optimal supervisor-agent contracts

We now solve for optimal supervisor-agent contracts treating w, $\bar{b}$, and α as exogenous. We will investigate which values of these variables the principal would like to choose in Section 4.

We first note that, unlike in principal-agent relational contracting, the surplus generated within the supervisor-agent relationship depends on the compensation scheme. This is because the supervisor only pays for part of the cost of the bonus and wage, yet the agent receives both in their entirety. Bonuses therefore potentially serve a dual purpose of both incentivizing effort and generating surplus directly.

Because of this difference, we cannot instantly assume that contracts will be similar to the principal-agent case. In the following lemmas however, we show that the possibility of side-transfers between the two parties restores us to a situation where we can focus on optimal stationary contracts in a similar way to Levin (2003).

Lemma 1. *If there is a self-enforcing contract between the supervisor and agent that generates expected surplus $g \geq \underline{u} + \underline{v}$, then there is a self-enforcing contract giving expected payoffs u and v so long as $u \geq \underline{u}$, $v \geq \underline{v}$, and $u + v \leq g$.*

This lemma holds because the fixed part of the side payments, s_t^F, can be used to split the surplus between the two parties, and hence we can focus on contracts that generate the largest possible total supervisor-agent surplus. We therefore follow Levin (2003) in defining a self-enforcing contract as optimal if no other self-enforcing contract generates higher expected surplus, and strongly optimal if the continuation contract is optimal for all potential histories, even those off-equilibrium.[9]

Lemma 2. *If an optimal contract exists, there are stationary contracts that are strongly optimal.*

The intuition behind this stationarity result is that any variation in promised continuation values can be transferred into side-payments, in the same way that Levin (2003) shows that any variation can be transferred to bonus payments. We

[9]Note that the concept of strong optimality defined by Levin (2003) is an equilibrium selection device which implicitly assumes that bargaining only takes place at the very beginning of the game. Miller and Watson (2013) construct an alternative condition that assumes players bargain within each period and shows that this typically involves suboptimal play after deviation.

can therefore focus on stationary contracts and drop the t subscripts. Expected payoffs are given according to the following equations:

$$u \equiv (1-\delta)\mathbb{E}_Y\left[w + b(Y) - c(e) - S|e\right] + \delta u$$
$$v \equiv (1-\delta)\mathbb{E}_Y\left[\alpha(Y - b(Y) - w) + S|e\right] + \delta v$$

We define $g(e, b(y), b(0))$ as the expected supervisor-agent surplus:

$$g(e, b(y), b(0)) = \alpha e y + (1-\alpha)(w + eb(y) + (1-e)b(0)) - c(e) - \underline{u} - \underline{v}$$

Then, in any stationary contract, effort is determined by the equation:

$$c'(e) = b(y) - b(0) - s(y) + s(0) \qquad (IC_e)$$

Note that, within stationary contracts, there are two ways that the supervisor can incentivise effort - through variation in bonuses or in bribes. The following lemma then begins to pin down how these tools are used in an optimal contract.

Lemma 3. *In any optimal contract, bonuses are always non-negative, i.e.* $b(Y) \geq 0$ $\forall Y$*. Moreover, bonuses are weakly higher when output is high (*$b(y) \geq b(0)$*) and side-transfers are weakly lower (*$s(y) \leq s(0)$*).*

If the supervisor wants to take surplus from the agent, then she prefers to do so using bribes rather than bonuses. This is because bribes and bonuses are equivalent for the agent, but the supervisor captures the whole value of any bribes given. Moreover, if bribes or bonuses vary as a function of output, then they will do so in a way that encourages effort.

From this lemma, we can see that there will only be two incentive compatibility constraints that may be binding. It is only the supervisor who has a reason to deviate when it comes to the bonus payment, and since bonuses are weakly higher when output is high, this temptation is going to be greatest following high output. On the other hand, it is only the agent that may wish to deviate when it comes to paying the side-transfer, because if the supervisor does not wish to pay the side payment, she already would have deviated by not paying the bonus. These IC constraints are then as follows:

$$(1-\delta)\left(-\alpha b(y) + s(y)\right) + \delta v \geq \delta \underline{v} \qquad (IC_S)$$
$$-(1-\delta)s(0) + \delta u \geq \delta \underline{u} \qquad (IC_A)$$

If explicit contracting on Y was possible, the supervisor and agent would maximize their joint surplus. This is increasing in $b(0)$ and $b(y)$ and hence these would both be at the maximum $\bar{b}$. Effort would then be set at e_{SA}^{FB}, where $c'(e_{SA}^{FB}) = \alpha y$. Such a contract will be sustainable through relational contracting if and only if:

$$\alpha y + \alpha \bar{b} \leq \frac{\delta g(e_{SA}^{FB}, \bar{b}, \bar{b})}{1-\delta} \tag{3}$$

Note the similarity between this inequality and the corresponding one in the principal-agent game, Inequality (1). In both cases, on the right-hand-side is the total discounted future surplus in the relationship, whilst we can consider the left-hand-side as the effective cost of the largest discretionary payment that needs to be made. In the supervisor-agent case, this is the cost of paying a bonus $\bar{b}$ (which costs the supervisor $\alpha\bar{b}$) and a difference in bribes of αy to induce the first-best level of effort.

If Inequality (3) is not met, then the dependence on self-enforcement will be a binding constraint for the supervisor and agent. We can sum together the two IC constraints and then substitute out for the difference in bribes using the effort equation (IC_e), and this then gives us the following joint incentive compatibility constraint:

$$c'(e) + \alpha b(y) - [b(y) - b(0)] = \frac{\delta g(e, b(y), b(0))}{1-\delta} \tag{4}$$

Comparing this equation to the equivalent in the principal-agent case, Equation (2), we can see that the requirement for contracts to be self-enforcing has a slightly more complex impact on the supervisor-agent game. In particular, as the surplus in the relationship decreases, a reduction in effort is now only one possible effect. Alternatively, the supervisor and agent may choose to reduce the size of the high output bonus, or to increase the difference in the bonuses (keeping effort constant). The latter makes relational contracting easier since it is more credible for the supervisor to induce effort using bonuses than using bribes.

The following proposition characterizes optimal contracts as a function of the surplus:

Proposition 2. *If the potential surplus is sufficiently low, then all optimal supervisor-agent contracts involve zero effort. Otherwise, there exist values $\hat{e}$, $\tilde{e}$ and $\tilde{b}$ such that an optimal supervisor-agent contract can be characterized as follows:*

1. ***High discounted surplus:*** *If $\frac{\delta g(\hat{e}, \bar{b}, \bar{b})}{1-\delta} \geq \alpha\bar{b} + c'(\hat{e})$, then only bribes are used to incentivize effort, with bonuses always kept at the maximum - i.e. $b(y) = b(0) = \bar{b}$, $s(y) < s(0)$.*

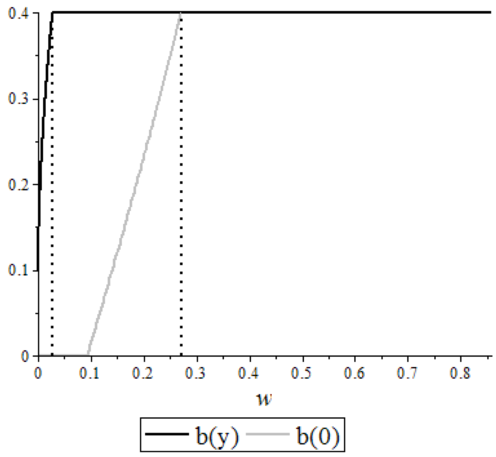
2. ***Intermediate discounted surplus:*** *If $\frac{\delta g(\hat{e}, \bar{b}, \bar{b})}{1-\delta} < \alpha\bar{b} + c'(\hat{e})$ and $\frac{\delta g(\tilde{e}, \bar{b}, \tilde{b})}{1-\delta} > \alpha\bar{b}$, then both bonuses and bribes are used to incentivize effort - i.e. $b(y) = \bar{b} > b(0)$ and $s(y) < s(0)$.*

3. ***Low discounted surplus:*** *If* $\frac{\delta g(\tilde{e},\bar{b},\tilde{b})}{1-\delta} \leq \alpha \bar{b}$, *then only bonuses are used to incentivize effort - i.e.* $b(y) > b(0)$ *and* $s(y) = s(0)$.

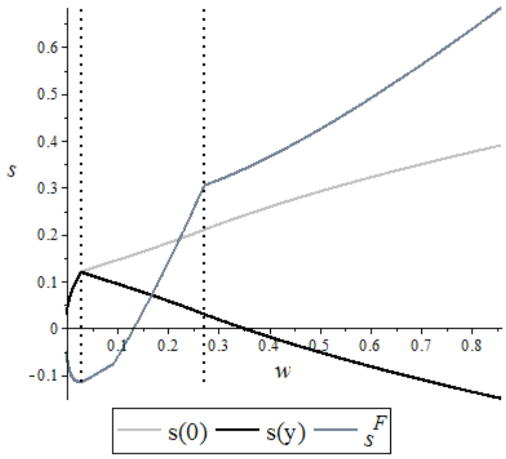
Moreover, effort is a continuous non-monotonic function of the discounted surplus. When discounted surplus is high or low, effort is weakly increasing in the discounted surplus but, when surplus is intermediate and $b(0) > 0$, *effort is weakly decreasing in the discounted surplus.*

Figure 2: Optimal supervisor-agent contract as a function of wage

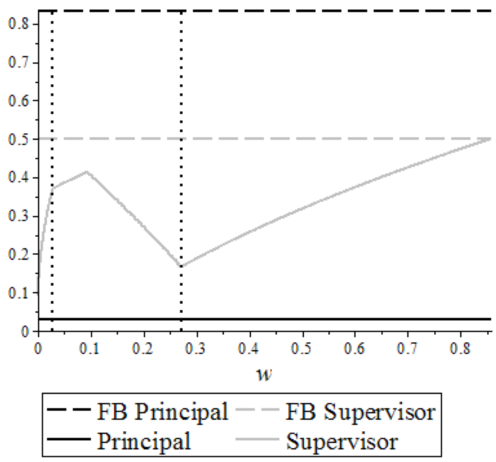
(a) Bonuses



(b) Bribes



(c) Effort



$\bar{b} = 0.4, y = 0.9, c = 1.08, \alpha = 0.6$, and $\delta = 0.55$

The full proof, together with formal definitions of $\hat{e}$, $\tilde{e}$, and $\tilde{b}$ are given in the appendix.[10] $\hat{e}$ is the level of effort induced on the boundary between 'high' and

[10] In particular, see equations (18), (19) and (20) for definitions of these parameters.

'intermediate' discounted surplus contracts, and $\tilde{e}$ and $\tilde{b}$ are the effort and low output bonus that occur on the boundary between the 'intermediate' and 'low' discounted surplus contract types.

Figures 2a and 2b depict the bonuses and kickbacks as a function of the wage w for particular parameter values when $c(e) = \frac{1}{2}ce^2$ and the supervisor and agent have equal bargaining powers. Since changes in the wage simply increase the discounted surplus linearly, this is a simple way of varying the discounted surplus. The dotted vertical lines corresponds to the boundaries between the three types of contracts.

The effort achieved by these different contracts is depicted by the solid gray line in Figure 2c. For comparison, the sold black line in this figure represents the effort e^{PA} exerted by the agent if the principal were in charge of the relational contract. Note that this effort is significantly smaller than the one implemented by the supervisor. As a benchmark, the dashed lines represent the first best effort level for the principal (e^{FB}_{PA}) and the supervisor (e^{FB}_{SA}).

In order to give the intuition and understand further the nature of this optimal supervisor-agent contract, we now characterize in detail the three different types of contract given in Proposition 2.

3.2.1 High discounted surplus

If the discounted surplus is very large - such that inequality (3) holds - then the bonuses will always be at the maximum and the effort level will be at e^{FB}_{SA}. However, if wages are slightly below this level, then this contract is not self-enforcing, and effort will be lower as a result. Taken together, for a high surplus, effort will be the largest solution to the following equation:

$$c'(e) = \min \left\{ \alpha y, \frac{\delta g(e, \bar{b}, \bar{b})}{1-\delta} - \alpha \bar{b} \right\} \tag{5}$$

We can see that this comes straight from Equation (4) when the bonus levels are the same.

The reason that a fall in the discounted surplus first leads to a reduction in the effort level, rather than the bonuses, is because for very large discounted surplus the effort level is at its first best, e^{FB}_{SA}. A reduction in effort therefore leads to a second-order cost in terms of the supervisor-agent surplus, whilst the cost of reducing the bonuses is first-order. There will thus always be a range of contracts where bonuses are maximal but effort is lower than the first best.

3.2.2 Intermediate discounted surplus

As the discounted surplus falls further, eventually it will become preferable for the supervisor to reduce bonuses rather than effort. First, they will cut the bonus which is given when output is low, $b(0)$, since cutting this bonus further incentivizes the agent to make effort. This thus allows a reduction in the difference in bribes, and hence further relaxes the incentive compatibility constraint. In this zone, therefore, bonuses remain at the cap when output is high, i.e. $b(y) = \bar{b}$.

In deciding upon the bonus given when output is low, $b(0)$, the players face a tradeoff regarding how to increase the surplus. A higher $b(0)$ directly generates greater surplus, whilst a lower $b(0)$ increases the effort induced. Note that the bonuses will never be negative (from Lemma 3), and hence the bonus when output is low is given in the following equation:

$$b(0) = \max\left\{0, \frac{1-\alpha}{\alpha}\left((1-e)\right)c''(e) - y + \frac{1}{\alpha}\frac{\delta g(e, b(y), b(0))}{1-\delta}\right\} \tag{6}$$

The first term in the non-zero part of this expression stems from the loss in supervisor-agent surplus that a reduction in $b(0)$ produces - the more likely negative output is to occur, the higher this loss. The second term then stems from the reduction in expected output that an increase in $b(0)$ produces through the change in effort induced. The final term represents the relational contracting constraint, and the fact that a higher wage and hence overall surplus allows $b(0)$ to be higher.

The effort level e is then the largest solution of the following equation:

$$c'(e) = \bar{b} - b(0) + \frac{\delta g(e, \bar{b}, b(0))}{1-\delta} - \alpha\bar{b} \tag{7}$$

From this equation, it is clear that bribes are doing some work to incentivize effort, and in particular we must have $s(0) - s(y) = \frac{\delta g(e,\bar{b},b(0))}{1-\delta} - \alpha\bar{b}$. If we substitute in Equation (6), we can see that effort is weakly decreasing in the discounted surplus when $b(0) > 0$. This is because, as the discounted surplus decreases, $b(0)$ decreases and hence the agent and supervisor have a further incentive to increase effort. Instead, when $b(0) = 0$, a lower discounted surplus leads to lower effort, as can be seen in Equation (7). In this case, a lower surplus forces the supervisor to reduce the spread in bribes and hence the effort. This non-monotonicity in effort is illustrated in Figure 2c.

3.2.3 Low discounted surplus

Finally, as the discounted surplus becomes lower, the supervisor can no longer credibly promise to vary bribes as a function of effort. The bonus given when output is high is the maximum the supervisor can credibly promise, i.e.

$$b(y) = \frac{1}{\alpha}\frac{\delta g(e, b(y), b(0))}{1-\delta} \tag{8}$$

The low bonus is again given according to equation (6). Effort in this case is entirely determined by the difference in the bonus levels, i.e. it is the largest solution to the following equation:

$$c'(e) = b(y) - b(0) \tag{9}$$

3.2.4 Discussion

Proposition 2 tell us that it is the value of discounted surplus relative to the bonus cap that determines the type of optimal contract. Hence, if there is no effective bonus cap (i.e as $\bar{b} \to \infty$), then the optimal supervisor-agent contract will always be of the 'low surplus' variety - that is, where bribes are not used to incentivize effort. The intuition behind this is straightforward - if there is no effective cap on bonuses, there is no reason to use bribes to induce effort, since they are simply more costly in terms of the relational contracting requirements. Bribes will only be used to induce effort when bonuses are effectively capped.

It is important to note that the role of the bonus cap depends crucially on the value of α. In particular, we arrive at the following lemma:

Lemma 4. *If $\alpha \leq \delta$, then the optimal contract has bonuses at the cap when output is high ($b(y) = \bar{b}$).*

The intuition behind this lemma is that, for low α, the supervisor creates so much surplus by paying higher bonuses that the average bonus level can never be constrained by relational contracting. In other words, although promising a higher bonus requires more credibility, it also creates more value in continuing the supervisor-agent relationship. In other words, if neither bonus is at the cap, then we can consider increasing both simultaneously. In this case, the effective value created is α times the size of the bonus, and this is discounted by δ when it comes to the relational contracting constraint. Hence, when $\alpha \leq \delta$, this second effect weakly dominates, and increasing both bonuses simultaneously does not tighten the joint incentive compatibility constraint.

This thus completes the characterization of the optimal supervisor-agent contract, treating the parameters w, α and $\bar{b}$ as exogenous. We can now proceed to the three-tier hierarchy and consider how the principal would optimally set these parameters.

4 Delegation by the principal

In this section, we first add a principal into the supervisor-agent game to create a three-tier hierarchy. The principal sets the parameters w, $\bar{b}$, and α at the beginning of the game, and then plays no part in the relational contract.[11] The principal is constrained such that these parameters cannot vary over time or as a function of output.[12] We then analyze the optimal value of these parameters when the principal has to delegate. Finally, we compare the principal's payoff with delegation to her payoff without delegation, as analyzed in the principal-agent benchmark.

We assume that, if delegation occurs, the benefits of output and the costs of bonuses are shared between the supervisor and principal. Hence the principal's payoff function is as follows:

$$\pi_t = \mathbb{E}\left[(1-\delta)\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left\{d_\tau\left[(1-\alpha)(Y_\tau - b_\tau - w)\right] + (1-d_\tau)\,\underline{\pi}'\right\}\right]$$

In order to keep the total surplus constant with or without delegation, we assume that $\underline{\pi}' = (1-\alpha)\underline{\pi}$ and $\underline{v} = \alpha\underline{\pi}$.[13]

The supervisor and agent's payoff functions are as given in the previous section, and we assume that the principal can commit to the sharing rule and the bonus cap. Note that, in this simple setting, if the principal could write the same contract with the agent she would be better off delegating directly to the agent. However, we can imagine a situation where there are many identical agents whose individual output y_{it} is not contractible, but whose collective output $Y_t = \sum_i y_{it}$ is contractible. In this circumstance, as the number of agents becomes large, the principal will do better by delegating to a supervisor who oversees all of them than contracting with each agent on the collective output.[14]

[11]This may be, for instance, because she transfers the technology to monitor output to the supervisor, or because she commits that she will not interact directly with the agent.

[12]Section 5.2.2 considers the possibility of allowing the wage to vary over time. Another way in which the principal could improve her payoff would be to replace the bonus cap with some sort of cap on 'average' bonuses which take into account the variable need to pay a high bonus in equilibrium. In practice, however, such a restriction may be too complex and subject to renegotiation since the principal would like to 'reset' the bonus cap after several periods of high output.

[13]The principal can get her outside option through delegation simply by setting $\alpha = 0$. For analytical ease, we will consider a situation where the principal gets her outside option and the supervisor gets zero as being without delegation.

[14]We do not prove this formally here, but a closely related point is made by Rayo (2007). He studies repeated moral hazard with multiple agents in a context where it is possible to contract both

We also assume that the principal has all the bargaining power with respect to the supervisor and agent. This assumption is not necessary, but is essentially the most interesting case; if the principal were to have a low bargaining power, then she would have to transfer surplus to the supervisor or agent regardless of the need to sustain relational contracting. Giving the principal the bargaining power therefore makes delegation less tempting and highlights the potential tradeoff between inducing effort and reducing corruption.

We begin by writing the principal's payoff under delegation as a function of the supervisor-agent surplus. Since the supervisor-agent contract will be stationary, we can write the principal's payoff as follows:

$$\pi = ey - c(e) - g - \underline{u} - \underline{v} \tag{10}$$

where g is the surplus received by the supervisor and agent. Note therefore that the principal effectively only cares about the effort exerted and the surplus given to the supervisor-agent relationship; holding these constant, she is indifferent to the various potential compensation schemes.

4.1 How should the principal delegate?

The following proposition describes how the principal should set the parameters w, α and $\bar{b}$ in order to maximize their payoff:

Proposition 3. *If the principal delegates, she will set w and $\bar{b}$ such that the bonus is zero when output is low and is at the cap when output is high. The optimal value of α for the principal lies strictly between* 0 *and* 1*.*

This proposition effectively states that, if the principal has to delegate, she would prefer to delegate to a supervisor who cares only partially about the principal's payoff. On the one hand, she wishes α to be low to exploit the fact that this makes relational contracting easier; easier relational contracting reduces the amount of surplus the principal needs to give to the supervisor and agent. On the other hand, she wishes α to be high to increase the effort that the supervisor is willing to induce. The optimal α therefore strikes a balance between these two forces.

In particular, the optimal α for any level of induced effort e is given according to

explicitly on aggregate output and implicitly on individual output. He shows that, when outputs y_{it} are sufficiently noisy signals of e_{it}, it is optimal for the effective principal to contract relationally with the other agents rather than use explicit contracting.

the following function:

$$\alpha(e) = \max\left\{\frac{(1-e)\,c''(e)}{(1-e)\,c''(e)+y-c'(e)}, \frac{(1-e)c'(e)+c(e)}{(1-e)c'(e)+ye}\right\} \tag{11}$$

This value of α is dictated by the need for the principal to ensure that the supervisor wishes to pay no bonuses when output is low. The first term ensures that the supervisor is not tempted to marginally increase $b(0)$; that is, the supervisor would not prefer to induce effort $e-\epsilon$ and pay a small bonus when output is low. The second term ensures that the supervisor does not prefer the alternative corner solution of no effort and bonuses always at the maximum. The principal must set α sufficiently high such that the supervisor is not interested in either of these alternatives.

The principal can control the level of effort induced through varying the wage level and bonus cap, and will therefore induce an effort e^* which maximizes her payoff function, i.e.

$$e^* = \arg\max_{e}\left\{ey - c(e) - \frac{1-\delta}{\delta}c'(e)\alpha(e)\right\} \tag{12}$$

4.2 When should the principal delegate?

We have therefore considered the optimal way for the principal to delegate a relational contract to a supervisor. In some situations, delegation may be obliged - the leader of the government or large firm may simply be unable to manage all relevant relational contracts themselves. In other situations, the principal may have the choice between delegating the relational contract to a supervisor, or managing it herself. In this section, we briefly consider when such delegation may be in the principal's best interest.

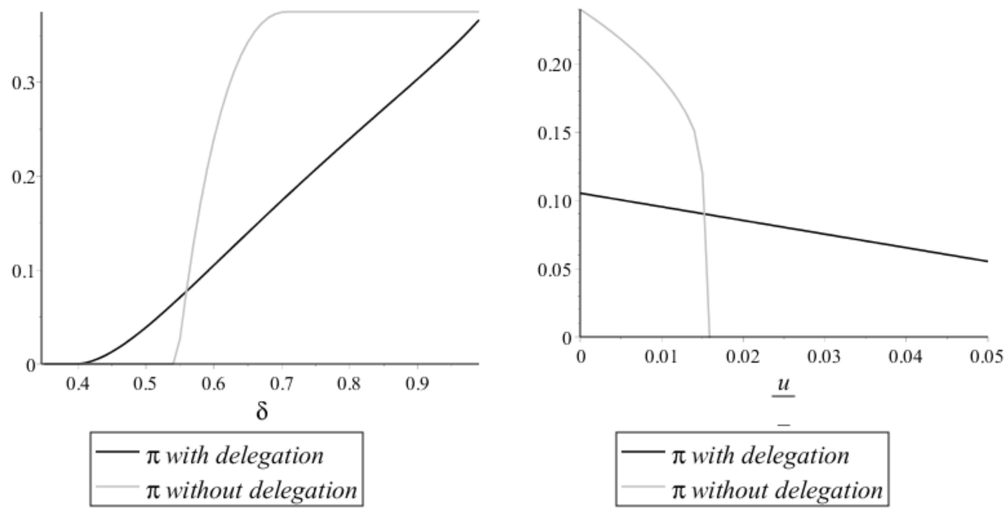
We assume that if the principal delegates then she does so optimally, as outlined in the previous subsection. We then arrive at the following proposition:

Proposition 4. *If relational contracting is easy - i.e. δ is high and $\underline{u}+\underline{\pi}$ is low - then it is best for the principal not to delegate. If relational contracting is difficult - i.e. δ is low or $\underline{u}+\underline{\pi}$ is high - then it is best for the principal to delegate.*

The intuition behind this proposition is straightforward. If relational contracting is very easy, then there is no reason to delegate. The principal and agent can implement effort close to first best on their own, and the principal has no reason to share surplus with the supervisor through corruption. On the other hand, if relational contracting is very difficult, then the principal and agent will only be able to sustain a very small amount of effort if they contract directly. The principal would therefore prefer to generate more effort through delegation, since the extra surplus

Figure 3: Principal's payoffs with and without delegation

(a) Discount factor, δ (b) Agent's outside option, $\underline{u}$



$y = 0.9, c = 1.08$ and $\underline{\pi} = 0$. When not plotted, $\delta = 0.55$ and $\underline{u} = 0$

that is generated is more than enough to compensate for the part that is lost through corruption.

This can be seen in Figure 3, which shows the best payoffs that the principal can achieve with and without delegation as a function of the various parameters when $c(e) = \frac{ce^2}{2}$. We can see, for instance, that when δ is small, the principal cannot achieve a payoff above the outside option with or without delegation. As δ increases, it becomes possible to achieve a payoff above the outside option with delegation, but not without. Even once a relational contract without delegation becomes possible, delegating remains the best option until some critical value of δ, after which it is no longer preferable for the principal to delegate.

Overall we can see that delegating relational contracts to an intermediary may be in the principal's best interest, but this will not always be the case. In particular, delegation is likely to be most beneficial when the relational contracting environment is difficult, but not extremely so. If discount factors are very low or monitoring is very weak, the cost of including positive effort when delegating to corruptible intermediaries will outweigh the potential benefits.

5 Alternative specifications and extensions

In Section 1 we discussed a variety of contexts where authorities may delegate relational contracts to corruptible intermediaries. Across these varying contexts, one key aspect that is likely to vary are the tools at the disposal of the principal. In some instances the principal may indeed be able to choose the amount of profit sharing, α, as assumed in our model, but in other circumstances α may be an exogenous parameter given by the supervisor's intrinsic motivations. On the other hand, in some scenarios the principal may have greater liberty in designing the contract with the supervisor than we have considered here. Moreover, we have assumed that side-payments between the agent and supervisor are always costless, but in many situations a risk of detection may mean that such transfers are costly.

In this section, we consider a number of alternative ways in which we could set up our model and how this will affect our results. We begin by considering how the principal would behave if α was exogenous, and then consider the case where she has more instruments at her disposal. Finally, we briefly sketch how the results would change were there to be a cost to side-payments, which includes the case where corruption is impossible.

5.1 Exogenous α

The assumption that α is chosen by the principal may be reasonable in contexts where the principal designs the supervisor's contract, but unreasonable in others. Chassang and Padró i Miquel (2014), for instance, argue that payoff functions are rarely available as policy instruments in settings with corruption. In particular, it may be more appropriate to consider α as an exogenous paramater if the principal cannot choose who she delegates to, or if there are no mechanisms through which she can share profit with the supervisor.

If α is sufficiently high, then the principal will induce an optimal 'low surplus' contract similar to that described in Proposition 3. However, this is only optimal if α is relatively high. Otherwise, any possible low surplus contracts will have very low effort levels, since the supervisor and agent would generally prefer intermediate or high surplus contracts. In other words, the supervisor and agent would rather use their relational contracting to pay higher bonuses when output is low rather than to induce effort. Hence, when α is low, the principal is better off allowing the supervisor no discretion with the bonuses (i.e. setting $\bar{b} = 0$). Delegation in this setting will certainly decrease the principal's payoff.

5.2 Additional instruments for the principal

In Section 4, we found that that the effort level which maximizes total surplus will never be implimented when the principcal delegates. It is natural to ask whether this result would change if the principal had a greater number of instruments at her disposal. We begin by considering the case where she can pay the supervisor a fixed wage, and then consider the situations where she can extract an initial transfer from the supervisor or agent and share output and costs in different fractions.

5.2.1 A wage for the supervisor

In the model above, only the agent receives a wage from the principal. In general therefore corruption will occur in the optimal contract as it is the means by which the supervisor and agent can split the surplus between themselves. Were the principal able to make a similar wage payment to the supervisor, wages could then be tailored such that the optimal contract involves no bribes between the agent and supervisor in equilibrium. In this sense, corruption is not strictly necessary to derive the benefits of delegating to a supervisor, but instead there simply needs to be a regular stream of payments received by the supervisor that are conditional on the relationship being maintained.

However, in order to do set up an optimal contract without corruption, the principal will need to know the exact bargaining power between the supervisor and the agent, and hence one interpretation of corruption is that it is the result of a lack of information for the principal.

Allowing for such a wage does not change any of the results in the model above, since the principal is indifferent between paying the supervisor directly and paying them through corruption. However, even if there are no side-transfers in equilibrium, note that without the possibility of side-transfers we would not obtain *strongly* optimal contracts in the sense of Levin (2003), as the only punishments the agent could now use would be termination or reduced effort. Since these are both inefficient, such punishments may be subject to renegotiation and hence may not be credible.

Moreover, Hermalin (2015) provides an important reason why incentivizing intermediary cooperation through side-payments may be more effective than an explicit incentive scheme - the principal may not observe when the intermediary is cooperating. In our model we have implicitly assumed that cooperation is observable by stating that the supervisor immediately gets her outside option if the agent terminates the relationship. If instead the supervisor were to continue receiving the same payments from the principal even after termination, then any principal-supervisor transfer would also increase the supervisor's outside option. In this case, therefore, side-payments would be much more effective at inducing relational contracting than a supervisor wage.

Finally, the principal may wish to deliberately set up the supervisor in a way to rule out direct transfers in order to reduce the potential for future contract renegotiation. This, for instance, can be seen as part of the reasoning behind making regulator's 'independent' and outside of government ministries. Katz (1991) shows that, if unobservable renegotiation is possible, then delegation loses much of its ability to solve commitment problems.[15] For instance, in our case the principal will be tempted to lower the bonus cap to zero once output has been produced, but the supervisor will not accept such a renegotiation unless she can be compensated. In this way, receiving payments directly from the agent may be a more credible way to solve the commitment problem than the principal promising to make payments directly.

5.2.2 Initial transfer from the supervisor or agent

An important assumption in our model with delegation is that the wage w paid to the agent is fixed over time. Hence, when setting the wage, the principal faces a trade-off; a higher wage costs the principal directly, but it also increases the supervisor-agent discounted surplus and hence allows for greater effort. However, if the wage was allowed to vary over-time, the principal would face no such trade-off - she could set future wages high to ensure that the supervisor-agent discounted surplus was large, but then set a very low, potentially negative, initial wage to extract this surplus ex-ante.

In the extreme, allowing an initial fee to be paid by the supervisor and/or agent would allow the principal to achieve the first best. In particular, she could set $\alpha = 1$, extract all the surplus via an ex-ante transfer, and then set future wages to be sufficiently large that the supervisor can credibly promise to pay bonuses of size y. Note, however, that if direct principal-agent relational contracting cannot sustain such a contract, then this will require a wage larger than the per-period surplus. In some sense, therefore, the principal is improving her payoff not by delegation, but by being able to borrow in the first period and then invest in a financial product that only pays out if the relationship is sustained.

A realistic model allowing for initial transfers would therefore demand that the wages (or total compensation) be capped at some level $\overline{w}$ that at most was equal to the per-period surplus. Any credit constraints on the side of the supervisor or agent would further lower this wage cap. Under such a model, the principal would be able to achieve a higher payoff with delegation than in Section 4 so long as $\overline{w}$ was greater than the optimal wage without initial transfers. However, first best would only be achievable if it was achievable without delegation since, from Equation (11), this would require $\alpha = 1$. This is because, with $\alpha < 1$, the supervisor and agent would always prefer to set effort below first best and set a positive $b(0)$, since the loss from the reduction in effort is second-order. Overall, therefore, allowing wages to vary

[15]Kockesen and Ok (2004) show that it is indeed the renegotiation condition that is critical, since without renegotiation delegation can have strategic commitment effects even if the original contract is unobserved.

over time in a reasonable way will still not allow the principal to acheive first-best through delegation if she cannot achieve it through direct relational contracting.

5.2.3 A more general sharing rule

In the model above we have assumed that the supervisor receives a simple share, α, of the principal's net profit. This creates a tension for the principal when setting α - a lower value makes supervisor-agent relational contracting easier, but it also decreases the value the supervisor places on output. A more general contract would place a different weight on output to that which is placed on bonuses. For instance, we can consider the following objective functions for the principal and supervisor:

$$\pi_t = (1-\delta)\mathbb{E}\left[\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left\{d_\tau\left[(1-\alpha_Y)Y_\tau-(1-\alpha_b)b_\tau-w^S-w\right]+(1-d_\tau)\,\underline{\pi}'\right\}\right]$$
$$v_t = (1-\delta)\mathbb{E}\left[\sum_{\tau=t}^{\infty}\delta^{\tau-t}\left\{d_\tau\left[\alpha_Y Y_\tau-\alpha_b b_\tau+w^S+S_\tau\right]+(1-d_\tau)\,\underline{v}\right\}\right]$$

where w_S is a wage paid by the principal to the supervisor, and α_Y and α_b represent the weights placed on output and bonuses respectively. We assume that $\alpha_b \geq 0$ and $\alpha_Y \leq \overline{\alpha_Y}$, where $\overline{\alpha_Y}$ is some exogenous upper bound.

In this case, the nature of the supervisor-agent optimal contracts do not change substantially.[16] Regarding the principal's optimal behavior, we would now replace Proposition 3 with the following:

Proposition 3′. *The principal will set w, w^S and $\overline{b}$ such that the bonus is zero when output is low and is at the cap when output is high. Moreover, she will set α_Y at the maximum possible value $\overline{\alpha_Y}$, and α_b strictly less than 1. If $\overline{\alpha_Y} \leq 1$, then effort will be strictly below the level that maximizes total surplus, e^{FB}.*[17]

As in the standard model, the principal will induce a 'low surplus' contract in order to maximize the effort undertaken given the surplus transferred. She will now set the weight on output, α_Y, at the maximum $\overline{\alpha_Y}$, as this allows her to set a lower value of α_b. This can be seen in the following expression, which gives the optimal value for α_b to induce any effort level e:

$$\alpha_b(e) = \max\left\{0, \frac{((1-e))\,c''(e)-\alpha_Y y}{(1-e)\,c''(e)-c'(e)}, 1-\frac{\alpha_Y ey-c(e)}{(1-e)c'(e)}\right\} \tag{13}$$

[16]We do not write a version of Proposition 2 here, but the details can be found in the proof of Proposition 3′.

[17]If $\overline{\alpha_Y} > 1$, then the principal effectively receives a negative share of profits. It is common in the literature to focus on non-negative shares, as in practice negative shares may be difficult to implement (Rayo, 2007).

A lower weight placed on the bonuses is helpful for the principal because this makes relational contracting between the supervisor and agent easier. Since the principal can always extract surplus from the supervisor through the direct wage, there is no reason not to set α_Y as large as possible. This discourages the supervisor from paying bonuses when output is low, and hence the principal can afford to reduce α_b.

Clearly the principal can achieve a higher payoff with this more general sharing rule than in the standard model above. Indeed, it may even be optimal for her to set $\alpha_b = 0$. This essentially makes relational contracting between the supervisor and agent unnecessary, because the supervisor has no temptation not to pay promised bonuses. Hence, in this case, the principal can give the supervisor and agent their outside options and keep all the surplus for herself.

However, if $\overline{\alpha_Y} \leq 1$, the principal can still not achieve the first best through delegation. To see this, suppose that $\overline{\alpha_Y} = 1$ and the supervisor is inducing first-best effort. In this case, the loss to the supervisor and agent from reducing effort marginally is second order, whilst the gain from paying bonuses when output is low will be first-order for any $\alpha_b < 1$. This can be seen in the second term of Equation (13) and is clearly worse for any $\overline{\alpha_Y} < 1$. Hence, although a more flexible contract will certainly help the principal, under reasonable assumptions it will still not allow her to achieve the first best effort level.

5.3 Costly corruption

In order to keep the main model simple, we have assumed that side-transfers between the supervisor and agent are costless except to the extent that they need to be enforced with relational contracting.[18] However, it may be reasonable to consider a potential inefficiency involved in such transfers. For instance, they may be detected by a policing authority who may then punish the actors. As a consequence, payments may be made in an inefficient way to avoid detection. Indeed, it may also be reasonable to assume that in some contexts side-transfers are so costly that they can essentially be ruled out entirely.

A typical modeling assumption in the literature on corruption is to assume that if the agent pays a side-transfer s to the supervisor, then the supervisor only receives an amount κs. Adding such a parameter to our model would make it substantially more complex, but we can sketch two important changes that would result.[19]

[18] This self-enforcing need does indeed induce an important cost, since otherwise the supervisor and agent could collude on paying $\overline{b}$ independent of Y even when relational contracting was impossible. Hence in general the need to self-enforce side-payments that depend on bribes, even if they do not depend on Y, is costly for the supervisor and agent and makes delegating more attractive for the principal.

[19] Our results thus contrast with Strausz (1997), who in an alternative model finds that the

First, if corruption is costly or impossible, we will no longer be able to restrict our attention to stationary contracts when considering optimal supervisor-agent contracts. In particular, since the supervisor can no longer extract the value of future bonuses from the agent, she may prefer to induce effort through promising future bonuses rather than by giving the bonuses immediately. In this sense, optimal supervisor-agent contracts would be very similar to the relational contracts described in Fong and Li (2015), which can be seen as an example of the 'backloading' principal expounded by Ray (2002). A notable difference would be that, if the cost of corruption is sufficiently low, then the supervisor would rather threaten the agent with having to pay bribes than with termination or reduced output.

Second, with a reduced risk of corruption, the principal will be able to set a lower value of α and still avoid bonuses being paid when output is low. Indeed, if side-payments are impossible, then the principal can set $\alpha = 0$ and induce the first best effort. This result would be somewhat 'knife-edge' in the main model considered in this paper, since behaviour would be very different with $\kappa = \epsilon$ or $\alpha = \epsilon$ for any $\epsilon > 0$. However, this is not the case if we allowed for the principal to pay the supervisor a direct wage or α to be split into α_Y and α_b. Thus, in general, the principal would prefer for corruption to be more difficult, so long as she has an alternative mechanism for reducing the supervisor's relative cost of paying bonuses.

6 Conclusions

This paper has analyzed the impact of delegating relational contracts to corruptible intermediaries. We have shown that, when there is a cap on bonuses, delegation substantially changes the form of the optimal relational contract from the standard principal-agent case. In this situation, bonuses become a tool for extracting rent from the principal, and this leads effort to be non-monotonic in the relationship surplus. We have also considered the effect of delegating on the principal's welfare. We found that there may be situations where delegation is indeed not used due to fear of corruption, consistent with the example of the small business owner who is unable to grow due to a lack of trust in intermediary managers. However, there may also be situations where delegation in fact improves the principal's payoff, precisely because the supervisor is willing to accept side-transfers. This may help us to understand

outcome is the same whether or not supervisor-agent collusion is permitted. We would obtain the same result if we made two changes to our model that would bring the models closer. First, if we allowed the principal to make transfers to the supervisor that were conditional on both output and the bonus paid, then the principal would be able to fight corruption by paying the supervisor to set $b(0) = 0$. Second, if we then assumed there was no noise in output, i.e. $e^{FB} = 1$, then the principal could promise very generous incentives without ever having to pay them, and hence could eliminate the threat of corruption without cost.

why governments continue to employ corrupt bureaucrats, despite the apparent cost.

An interesting next step will be to test the results of this paper in empirical work. Though side-payments are likely to be difficult to measure directly, it should be possible to test results regarding other parameters, such as the link between output, bonuses and wages. Moreover, observing variation in delegation decisions may help us to understand whether principals are behaving in a way consistent with this model. A potentially under-explored area may be investigating firm owners' concerns with employee fraud in inter-firm relationships, particularly in developing countries where explicit contracts are weak.

There are also multiple theoretical extensions to the model which it may be interesting to pursue. For instance, we have assumed here that the supervisor's preferences are known, but in reality there is likely to be uncertainty as to 'how corrupt' any individual is. Removing this assumption, possibly in a similar way to Chassang (2010) or Chassang and Padró i Miquel (2014), may reveal interesting insights into how corruption and effort evolve over time. Alternatively, we may ask whether corrupt relational contracts make supervisors more likely to stick with the same, potentially inefficient, firm. In this regard, the recent papers by Halac (2012) and Board (2011) may provide useful approaches.

References

Alonso, Ricardo, and Niko Matouschek. 2007. "Relational Delegation." *The RAND Journal of Economics*, 38(4): 1070–1089.

Antras, Pol, and C. Fritz Foley. 2015. "Poultry in Motion: A Study of International Trade Finance Practices." *The Journal of Political Economy.*

Baker, George, Robert Gibbons, and Kevin J. Murphy. 2002. "Relational Contracts and the Theory of the Firm." *The Quarterly Journal of Economics*, 117(1): 39–84.

Banerjee, Abhijit, Sendhil Mullainathan, and Rema Hanna. 2013. "Corruption." In *The Handbook of Organizational Economics.* , ed. Robert Gibbons and John Roberts, 1109–1147. Princeton University Press.

Blader, Steven, Claudine Gartenberg, Rebecca Henderson, and Andrea Prat. 2015. "The Real Effects of Relational Contracts." *American Economic Review*, 105(5): 452–56.

Bloom, Nicholas, Benn Eifert, Aprajit Mahajan, David McKenzie, and John Roberts. 2013. "Does Management Matter? Evidence From India." *The Quarterly Journal of Economics*, 128(1): 1–51.

Bloom, Nicholas, Raffaella Sadun, and John Van Reenen. 2012. "The Organization of Firms Across Countries." *The Quarterly Journal of Economics*, 127(4): 1663–1705.

Board, Simon. 2011. "Relational Contracts and the Value of Loyalty." *The American Economic Review*, 101(7): 3349–3367.

Chassang, Sylvain. 2010. "Building Routines: Learning, Cooperation, and the Dynamics of Incomplete Relational Contracts." *The American Economic Review*, 100(1): 448–465.

Chassang, Sylvain, and Gerard Padró i Miquel. 2014. "Corruption, Intimidation, and Whistle-blowing: a Theory of Inference from Unverifiable Reports." National Bureau of Economic Research NBER Working Paper 20315.

Cole, Shawn, and Anh Tran. 2011. "Evidence from the Firm: A New Approach to Understanding Corruption." In *International Handbook on the Economics of Corruption Vol. II.* , ed. Susan Rose-Ackerman and Tina Soriede, 408–427. Edward Elgar Publishing.

Fairburn, James A, and James M Malcomson. 2001. "Performance, Promotion, and the Peter Principle." *The Review of Economic Studies*, 68(1): 45–66.

Francois, Patrick, and Joanne Roberts. 2003. "Contracting Productivity Growth." *The Review of Economic Studies*, 70(1): 59–85.

Gibbons, Robert, and Rebecca Henderson. 2013. "What Do Managers Do? Exploring Persistent Performance Differences Among Seemingly Similar Enterprises." In *The Handbook of Organizational Economics.* , ed. Robert Gibbons and John Roberts, 680–731. Princeton University Press.

Goldlücke, Susanne, and Sebastian Kranz. 2012. "Delegation, Monitoring, and Relational Contracts." *Economics Letters*, 117(2): 405–407.

Halac, Marina. 2012. "Relational Contracts and the Value of Relationships." *The American Economic Review*, 102(2): 750–779.

Helper, Susan, and Rebecca Henderson. 2014. "Management Practices, Relational Contracts, and the Decline of General Motors." *The Journal of Economic Perspectives*, 28(1): 49–72.

Hermalin, Benjamin E. 2015. “Why Whine about Wining and Dining?” *Journal of Law, Economics, and Organization.*

Iossa, Elisabetta, and David Martimort. 2014. “Corruption in PPPs, Incentives and Contract Incompleteness.” CEIS Working Paper 317,.

Katz, Michael L. 1991. “Game-playing Agents: Unobservable Contracts as Precommitments.” *The RAND Journal of Economics*, 22(3): 307–328.

Kockesen, Levent, and Efe A Ok. 2004. “Strategic Delegation by Unobservable Incentive Contracts.” *The Review of Economic Studies*, 71(2): 397–424.

Lambsdorff, Johann Graf, and Sitki Utku Teksoz. 2005. “Corrupt Relational Contracting.” In *The New Institutional Economics of Corruption.* , ed. Johann Graf Lambsdorff, Markus Taube and Matthias Schramm, 154–168. Routledge.

Levin, Jonathan. 2003. “Relational Incentive Contracts.” *The American Economic Review*, 93(3): 835–857.

Li, Jin, and Niko Matouschek. 2013. “Managing Conflicts in Relational Contracts.” *the American Economic Review*, 103(6): 2328–2351.

Li, Jin, Niko Matouschek, and Michael Powell. 2015. “Power Dynamics in Organizations.” *Mimeo.*

Macchiavello, Rocco, and Ameet Morjaria. 2015. “The Value of Relationships: Evidence from a Supply Shock to Kenyan Rose Exports.” *American Economic Review.*

MacLeod, W Bentley, and James M Malcomson. 1989. “Implicit Contracts, Incentive Compatibility, and Involuntary Unemployment.” *Econometrica*, 57(2): 447–480.

Malcomson, James M. 2013. “Relational Incentive Contracts.” In *The Handbook of Organizational Economics.* , ed. Robert Gibbons and John Roberts, 1014–1065. Princeton University Press.

Martimort, David. 1999. “The Life Cycle of Regulatory Agencies: Dynamic Capture and Transaction Costs.” *The Review of Economic Studies*, 66(4): 929–947.

Martimort, David, and Thierry Verdier. 2004. “The Agency Cost of Internal Collusion and Schumpeterian growth.” *The Review of Economic Studies*, 71(4): 1119–1141.

Milgrom, Paul R. 1988. "Employment Contracts, Influence Activities, and Efficient Organization Design." *The Journal of Political Economy*, 96(1): 42–60.

Miller, David A, and Joel Watson. 2013. "A Theory of Disagreement in Repeated Games with Bargaining." *Econometrica*, 81(6): 2303–2350.

Nkamleu, Guy Blaise, and Bernadette Dia Kamgnia. 2014. "Uses and Abuses of Per-diems in Africa: A Political Economy of Travel Allowances." African Development Bank Group, AfDB Working Paper 196.

Olsen, Trond E, and Gaute Torsvik. 1998. "Collusion and Renegotiation in Hierarchies: A Case of Beneficial Corruption." *International Economic Review*, 413–438.

Podkolozina, Elena, and Tatiana Voytova. 2011. "Blacklisting in Russian Public Procurement: How it Doesn't Work." *Higher School of Economics Research Paper No. BRP*, 1.

Ray, Debraj. 2002. "The time structure of self-enforcing agreements." *Econometrica*, 70(2): 547–582.

Rayo, Luis. 2007. "Relational Incentives and Moral Hazard in Teams." *The Review of Economic Studies*, 74(3): 937–963.

Salant, David J. 1995. "Behind the Revolving Door: a New View of Public Utility Regulation." *The Rand Journal of Economics*, 26(3): 362–377.

Spagnolo, Giancarlo. 2012. "Reputation, Competition, and Entry in Procurement." *International Journal of Industrial Organization*, 30(3): 291 – 296.

Strausz, Roland. 1997. "Delegation of Monitoring in a Principal-Agent Relationship." *The Review of Economic Studies*, 64(3): 337–357.

Thiele, Veikko. 2013. "Subjective Performance Evaluations, Collusion, and Organizational Design." *Journal of Law, Economics, and Organization*, 29(1): 35–59.

Vickers, John. 1985. "Delegation and the Theory of the Firm." *The Economic Journal*, 95: 138–147.

Warren, Danielle E., Thomas W. Dunfee, and Naihe Li. 2004. "Social Exchange in China: The Double-Edged Sword of Guanxi." *Journal of Business Ethics*, 55(4): pp. 355–372.

Wren-Lewis, Liam. 2013. "Commitment in Utility Regulation: A Model of Reputation and Policy Applications." *Journal of Economic Behavior & Organization*, 89: 210–231.

Mathematical Appendix

This appendix proves the Lemmas and Propositions in the text above. Proposition 1 follows directly from Theorem 6 in Levin (2003) and hence we do not provide a proof here.

Consider a supervisor-agent contract that in its first period calls for payments $b(Y)$, s^F, $s(Y)$ and effort e. If the offer is made and accepted and the discretionary payments made, the continuation contract gives payoffs $u(Y)$, $v(Y)$ as a function of the observed outcome Y. Let u, v be the expected payoffs under this contract:

$$u \equiv (1-\delta)\mathbb{E}_Y\left[w + b(Y) - s^F - s(Y) - c(e)|e\right] + \delta\mathbb{E}_Y\left[u(Y)|e\right]$$
$$v \equiv (1-\delta)\mathbb{E}_Y\left[\alpha(Y - w - b(Y)) + s^F + s(Y)|e\right] + \delta\mathbb{E}_Y\left[v(Y)|e\right]$$

We follow Levin (2003) in defining this contract as *self-enforcing* if and only if the following conditions hold:

i The parties are willing to initiate the contract: $u \geq \underline{u}$ and $v \geq \underline{v}$

ii The agent is willing to choose e:

$$e \in \arg\max_e \mathbb{E}_Y\left[b(Y) - s(Y) + \frac{\delta}{1-\delta}u(Y)|e\right] - c(e) \qquad (IC_E)$$

iii For all Y, both parties are willing to make the discretionary payments b:

$$(1-\delta)\left(-\alpha b(Y) + s(Y)\right) + \delta v(Y) \geq \delta\underline{v} \qquad (ICb_S)$$
$$(1-\delta)\left(b(Y) - s(Y)\right) + \delta u(Y) \geq \delta\underline{u} \qquad (ICb_A)$$

iv For all Y, both parties are willing to make the side-payment:

$$(1-\delta)s(Y) + \delta v(Y) \geq \delta\underline{v} \qquad (ICs_S)$$
$$-(1-\delta)s(Y) + \delta u(Y) \geq \delta\underline{u} \qquad (ICs_A)$$

v Each continuation contract is self-enforcing - i.e. the pair $u(Y)$, $v(Y)$ correspond to a self-enforcing contract that will be initiated in the next period.

Proof of Lemma 1. Consider changing the first period side payment s^F in the contract above. This changes the expected payoffs u, v, but not the joint surplus. The new contract is also self-enforcing provided that $u \geq \underline{u}$ and $v \geq \underline{v}$. $\square$

Proof of Lemma 2. First, define g^* to be the maximum supervisor-agent surplus generated by any self-enforcing contract. Then, note that any optimal contract must have $u(Y) + v(Y) = g^*$ for all Y, since otherwise we could increase $v(Y)$ and arrive at a contract with a self-enforcing contract with a higher surplus.

Now, take an optimal contract as defined above and define new side payments, $s^*(Y)$, and a continuation value u^* such that:

$$s^*(Y) = s(Y) - \frac{\delta}{1-\delta}u(Y) + \frac{\delta}{1-\delta}u^* \tag{14}$$

$$u^* = \mathbb{E}_Y\left[w + b(Y) - s^F - s^*(Y) - c(e)|e\right] \tag{15}$$

This generates a contract that is stationary and gives an expected continuation value of u^*, and hence we simply need to show that this is also self-enforcing. The participation constraints (condition i) will be met since $u^* \geq \min_Y u(Y)$, and we know $u(Y) \geq \underline{u}\ \forall Y$ from the participation constraints the original self-enforcing contract. Similarly, $v^* = g^* - u^* \geq g^* - \max_Y u(Y) \geq \underline{v}$. Similarly, it can be seen that the incentive compatibility constraints are met by substituting in the equations (14) and (15). The final condition is straightforward since the stationary contract itself generates payoffs u^* and v^*. The contract is optimal since it generates surplus g^* each period (since bonuses and effort are unchanged). Finally, we can then define the fixed side-payments, s^F, such that the expected payoffs are (u, v). $\square$

Proof of Lemma 3. For the first part, consider an optimal contract with $b(Y) < 0$ for some Y. Then consider an alternative contract with bonus $b'(Y) = 0$ and side payment $s'(Y) = s(Y) - b(Y)$. It is simple to check that all the self-enforcing constraints are still satisfied. Moreover, this contract has a higher surplus, and therefore the original contract cannot be optimal.

For the second part, let us consider the case of bribes first. Suppose the opposite, i.e. $s(y) > s(0)$. If positive effort is being made, we must therefore have $b(y) > b(0)$. Moreover, since $s(y) \leq \frac{\delta}{1-\delta}(u - \underline{u})$, we instantly have $s(0) < \frac{\delta}{1-\delta}(u - \underline{u})$. Now, consider an alternative contract with bonus $b'(0) = b(0) + \epsilon$ and bribe $s'(0) = s(0) + \epsilon$, and other values as before. In this alternative contract, surplus is greater since effort is unchanged and bonuses are higher. Yet, since (ICs_A) is not binding when $Y = 0$, then for some $\epsilon > 0$ this contract is self-enforcing and hence the original contract is not optimal. In the case of bonuses, if $b(y) < b(0)$, then we can similarly consider an alternative contract with bonus $b'(y) = b(y) + \epsilon$ and bribe $s'(y) = s(y) + \epsilon$. □

Lemma 5. *In any optimal contract with positive effort and* $b(0) < b(y)$*, then* $s(0) = \frac{\delta}{1-\delta}(u - \underline{u})$.

Proof of Lemma 5. We show proof by contradiction. Suppose ICs_A is not binding when $Y = 0$. Now, consider an alternative contract with bonus $b'(0) = b(0) + \epsilon$ and bribe $s'(0) = s(0) + \epsilon$, and other values as before. In this alternative contract, surplus is greater since effort is unchanged and bonuses are higher. Yet, since (ICs_A) is not binding when $Y = 0$, then for some $\epsilon > 0$ this contract is self-enforcing and hence the original contract is not optimal. □

Lemma 6. *In any optimal contract with positive effort and* $b(y) < \bar{b}$*, we have* $s(y) = s(0)$.

Proof of Lemma 6. Suppose $s(y) < s(0)$. Now, consider an alternative contract with $b'(y) = b(y) + \epsilon$ and $s'(y) = s(y) + \epsilon$, and other values as before. In this alternative contract, surplus is greater since effort is unchanged and bonuses are higher. Yet, since (ICs_A) is not binding when $Y = 0$, then for some $\epsilon > 0$ this contract is self-enforcing and hence the original contract is not optimal. □

Proof of Proposition 2. Since $c'(0) = 0$, a zero-effort contract will only be optimal if it is not possible to sustain any relational contract with $e > 0$. It then follows straightforwardly that there must be a critical value of potential discounted surplus (i.e. of values w, δ, $\underline{u}$ and $\underline{v}$) such that relational contracting is possible if and only if potential discounted surplus is above this level.

It is straightforward to show that, if the discounted surplus is sufficiently high that inequality (3) holds, then the first-best supervisor agent contract will be self-enforcing. For instance, consider a contract where $s(0)$ is set such that (IC_A) is binding, and $s(y)$ is set at the appropriate effort level such that $e = e^{FB}$. Then substituting in inequality (3), we find that (IC_S) holds.

For the rest of the proof we therefore proceed to consider the cases where inequality (3) doesn't hold, i.e. where $\frac{\delta g(e_{SA}^{FB}, \bar{b}, \bar{b})}{1-\delta} < \alpha\bar{b} + \alpha y$. We first show formally that this implies that both IC constraints are binding, i.e. that equation (4) holds. We then look for the contract which maximizes the joint supervisor-agent surplus given this and other constraints.

First, consider an optimal contract with (IC_S) not binding. Then we can show $e \geq e_{SA}^{FB}$ and $b(y) = b(0) = \bar{b}$. If $e < e_{SA}^{FB}$, then consider an alternative contract with bribe $s'(y) = s(y) - \epsilon$, which is also self-enforcing but induces higher effort. If $b(y) < \bar{b}$, then from Lemma 6 we have $s(y) = s(0)$, and hence $b(0) < b(y)$, which means we can consider a contract with $b'(y) = b(y) + \epsilon$ and $b'(0) = b(0) + \epsilon$. But this contract is self-enforcing for some $\epsilon > 0$ and has higher surplus. Finally, if $b(0) < \bar{b}$, then, from Lemma 3, $s(0) \geq s(y)$ and hence we can consider a contract with $b'(0) = b(0) + \epsilon$ and $s'(y) = s(y) - \epsilon$. But this contract is self-enforcing for some $\epsilon > 0$ and has higher surplus.

Second, consider an optimal contract with (IC_A) not binding. Again we can show $e \geq e_{SA}^{FB}$ and $b(y) = b(0) = \bar{b}$. If $e < e_{SA}^{FB}$, then consider an alternative contract with $s'(0) = s(0) + \epsilon$, which is also self-enforcing but induces higher effort. If $b(0) < \bar{b}$, then consider a contract with $b'(0) = b(0) + \epsilon$ and $s'(0) = s(0) + \epsilon$, and other values as before. But this contract is self-enforcing for some $\epsilon > 0$ and has higher surplus. Finally, Lemma 5 tell us that $b(0) = b(y)$.

Hence if either IC constraint is not binding, we must have $b(y) = b(0) = \bar{b}$ and $e \geq e_{SA}^{FB}$. Moreover, summing the two constraints together, rearranging and then substituting into (IC_e) gives us:

$$\alpha\bar{b} + c'(e) < \frac{\delta}{1-\delta}\left(v + u - \underline{v} - \underline{u}\right) \leq \frac{\delta g(e_{SA}^{FB}, \bar{b}, \bar{b})}{1-\delta}$$

But since $e \geq e_{SA}^{FB}$, we must have $c'(e) \geq \alpha y$, which leads us to a contradiction of the initial assumption.

Hence, if $\frac{\delta g(e_{SA}^{FB}, \bar{b}, \bar{b})}{1-\delta} < \alpha\bar{b} + \alpha y$, then both IC_A and IC_S are binding. Furthermore, the bonus cap and Lemma 3 gives us three further potentially binding constraints: $0 \leq b(0)$, $b(y) \leq \bar{b}$ and $s(y) \leq s(0)$. We know from Lemma 6 that at least one of these constraints must be binding. Let us first therefore consider the set of optimal contracts where only one of the constraints is binding. We then consider the cases where at least two of the constraints are binding.

If only one of the three constraints are binding, we have three unknowns (e, $b(y)$ and $b(0)$) and two equations (the joint IC constraint and whichever of the three inequalities is binding). In terms of $b(y)$, we note that surplus and effort are increasing in $b(y)$ and hence $b(y)$ must be at an upper bound, with either $b(y) = \bar{b}$ or determined according to the joint IC, i.e. $b(y) = \frac{1}{\alpha}\frac{\delta g(e, b(y), b(0), w)}{1-\delta}$. We therefore maximize the joint payoff $u + v$ with respect to e and $b(0)$ under the joint IC constraint (4). This can be expressed in the following Lagrangian:

$$\begin{aligned}\mathbb{L}(e,b(0)) =& \alpha ey + (1-\alpha)(w + eb(y) + (1-e)b(0)) - c(e) \\ &+ \mu\left[\alpha ey + (1-\alpha)(w + eb(y) + (1-e)b(0)) - c(e)\right. \\ &\left.-\underline{v} - \underline{u} - \frac{1-\delta}{\delta}\left(\alpha b(y) + c'(e) - b(y) + b(0)\right)\right]\end{aligned}$$

Maximizing the Lagrangian separately with respect to e and $b(0)$, and then substituting out for μ the following possible interior solution:

$$c'(e) = \alpha y + (1-\alpha)(b(y) - b(0))) - (1-\alpha)(1-e)c''(e) \tag{16}$$

In this case, $b(0)$ is given according to the joint IC, i.e.

$$b(0) = (1-\alpha)b(y) - c'(e) + \frac{\delta g(e, b(y), b(0), w)}{1-\delta} \tag{17}$$

In order to complete the proof, we now note that the conditions for this contract type to be optimal are therefore the conditions for this solution to be interior. We therefore consider the various boundary constraints that might be met, and what happens in each case.

From Lemma 3, we require that $b(0) \geq 0$. From equation (17), this means we require $\frac{\delta g(e,b(y),0)}{1-\delta} \geq \alpha b(y) + c'(e)$. If discounted surplus is below this, then we will have $b(0) = 0$, rather than the value given by (17).

Lemma 3 also tells us we require that $b(y) \geq b(0)$, and hence equation (17) gives us that we require $\frac{\delta g(e,b(y),b(0))}{1-\delta} \leq \alpha b(y) + c'(e)$. Note that this automatically holds when $b(y) = \frac{1}{\alpha}\frac{\delta g(e,b(y),b(0))}{1-\delta}$. However, when $b(y) = \overline{b}$, this condition forms an upper bound on the discounted surplus for the solution to be interior. If discounted surplus is above this value, we must have $b(y) = b(0) = \overline{b}$, and hence we are in the 'high surplus' case described in the proposition. At the boundary, we will have $b(0) = b(y)$, and hence we can label the level of effort $\hat{e}$, which from Equation 16 is:

$$c'(\hat{e}) = \alpha y - (1-\alpha)(1-\hat{e})\, c''(\hat{e}) \tag{18}$$

When discounted surplus is above this level effort will be at the largest value possible when $b(y) = b(0) = \overline{b}$, which is given by the joint IC.

Finally, Lemma 3 requires that $s(y) \leq s(0)$. Hence, from the joint IC, an interior solution requires $\frac{\delta g(e,b(y),b(0))}{1-\delta} \geq \alpha b(y)$. At the boundary we will have $\alpha\overline{b} = \frac{\delta g(e,\overline{b},b(0),w)}{1-\delta}$

and hence we can define $\tilde{e}$ and $\tilde{b}$ by substituting this into Equations 16 and 17, giving:

$$c'(\tilde{e}) = \overline{b} - \tilde{b} \tag{19}$$

$$\tilde{b} = \max\left\{0, \frac{1-\alpha}{\alpha}\left(1-\tilde{e}\right)c''(\tilde{e}) - y + \overline{b}\right\} \tag{20}$$

If the discounted surplus is below this level, then the contract is defined by the joint IC and the condition that $s(y) = s(0)$, which thus completes the proof. □

Proof of Lemma 4. We proceed through proof by contradiction. Suppose that $\alpha \leq \delta$ and there exists an optimal contract with $b(y) < \overline{b}$. From Proposition 2, we must be in the 'low surplus' case, and hence $s(y) = s(0)$. Moreover, the joint IC is binding, such that $\alpha b(y) = \frac{\delta g(e,b(y),b(0),w)}{1-\delta}$.

Now consider an alternative contract with bonuses $b'(y) = b(y)+\epsilon$, $b'(0) = b(0)+\epsilon$ and bribes $s'(y) = s'(0)$. Clearly effort remains unchanged, and hence we just need to consider the joint IC constraint. From the definition of $g(e, b(y), b(0))$, we have that $g(e, b(y) + \epsilon, b(0) + \epsilon) = g(e, b(y), b(0)) + (1-\alpha)\epsilon$. Hence

$$\alpha b'(y) = \frac{\delta g(e, b'(y), b'(0), w)}{1-\delta} + \alpha\epsilon - \frac{\delta}{1-\delta}(1-\alpha)\epsilon \leq \frac{\delta g(e, b'(y), b'(0), w)}{1-\delta} \tag{21}$$

Hence, if $\alpha \leq \delta$, then the new contract also satisfies the joint IC. Since surplus is higher, the original could not have been optimal. □

Proof of Proposition 3. We first show that the principal will chose a level of α, w and $\overline{b}$ such that the contract is a 'low surplus' type - i.e. effort is only incentivized via bonuses, and no bonuses are paid when output is low. Given this, we then derive the optimal contract of this type.

The principal wishes to maximize $\pi = ey - c(e) - g$. Written this way, we can see that, conditional on g and the effort level e, she is indifferent to the values α, $\overline{b}$ and w. We first show that, if by transferring surplus g the principal can induce a 'high surplus' contract with effort e_H, then she can also induce a 'low surplus' contract with effort $e_L > e_H$. Hence, the she will prefer to induce low surplus contracts.

Consider a high surplus contract that induces an effort level e_H. The cheapest way for the principal to induce such effort is through setting $\overline{b} = 0$ and transferring surplus $g = \frac{1-\delta}{\delta}c'(e_H)$. Note that the first term of Equation (5) bounds $c'(e)$ by αy, so there is no reason for the principal to set g higher than $\frac{1-\delta}{\delta}\alpha y$. Hence we can restrict our attention to 'high surplus' contracts where $g \leq \frac{1-\delta}{\delta}\alpha y$.

Now suppose that the principal increases $\overline{b}$ and decreases w such that the surplus transferred to the supervisor-agent remains constant. From Proposition 2, increasing

$\bar{b}$ sufficiently will induce a contract of the 'low surplus' variety with effort e_L given by $c'(e_L) = \min\left\{\frac{1}{\alpha}\frac{\delta}{1-\delta}g, y - \frac{1-\alpha}{\alpha}(1-e)c''(e_L)\right\}$. By increasing α (whilst reducing w to keep g constant) the principal can ensure that the first term is the smallest, and hence induce effort e_L such that $\frac{1-\delta}{\delta}c'(e_L) = \frac{g}{\alpha}$. Thus $e_L > e_H$ and the principal will always prefer low surplus contracts to high surplus contracts.

Now suppose that w, $\bar{b}$ and α are such that the optimal supervisor-agent contract is an intermediate surplus contract. Since effort, given by (7), is weakly decreasing in the wage when $b(0) > 0$, it is straightforward to see that the principal can reduce the wage until $b(0) = 0$. If the contract is a low surplus contract at this point, we are done. If the contract is still intermediate (i.e. $s(0) \neq s(y)$), then note that effort is given by the expression $c'(e) = (1-\alpha)\bar{b} + \frac{\delta g}{1-\delta}$, and hence is increasing in $\bar{b}$. Therefore, for a given g, the principal can increase effort by increasing $\bar{b}$ and reducing w to leave g unchanged. In particular, she can increase $\bar{b}$ until no bribes are used to incentivize effort - and hence the contract becomes a contract of the 'low surplus' type.

The principal therefore makes no loss in inducing a low surplus contract. Let us now consider the optimal 'low surplus' contract that the principal wishes to induce.

Using Equations (8) and (9), the principal aims to maximize $\pi = ey - c(e) - \alpha\frac{1-\delta}{\delta}c'(e)$ subject to the constraint that the supervisor/agent will set $b(0) = 0$. This constraint can be split into two parts. First, we require that at the margin, the supervisor/agent does not want to increase $b(0)$, which from Equations (6) and (8) is equivalent to $c'(e) \leq y - \frac{1-\alpha}{\alpha}(1-e)\,c''(e)$. Rearranging in terms of α gives us that we require

$$\alpha \geq \frac{(1-e)\,c''(e)}{(1-e)\,c''(e) + y - c'(e)}$$

Second, we require that the supervisor/agent would not prefer to set $b(0) = b(y) = \bar{b}$. For this to hold, it must be that the supervisor/agent surplus is higher in this 'low surplus' type contract than in any contract with both bonuses at the limit. At the value of α where the surpluses in the two contract types are equal, Equation (5) tells us that there cannot be any positive effort, since the principal sets $\bar{b} = \frac{1}{\alpha}\frac{\delta g}{1-\delta}$. Hence we need to compare the surplus in the 'low surplus' contract with that in a contract which involves no effort and bonuses always at the limit. The difference between these two surpluses is $\alpha ye - (1-\alpha)(1-e)c' - c(e)$, which we require to be positive for a low surplus contract to be implemented. Rearranging in terms of α gives us that we require

$$\alpha \geq \frac{(1-e)c'(e) + c(e)}{(1-e)c'(e) + ye}$$

Note that the principal's payoff function is strictly decreasing in α, and hence she will choose the lowest α such that both inequalities hold, which gives us Equation (11). This thus proves the proposition. □

Proof of Proposition 4. The first part of the proposition is straightforward when we consider that relational contracting is only a constraint in the no-delegation principal-agent relationship under the following condition:

$$c'(e^{FB}) > \frac{\delta}{1-\delta}\left(ye^{FB} - c(e^{FB}) - \underline{\pi} - \underline{u}\right)$$

Since the RHS is clearly increasing in δ, and decreasing in $\underline{\pi}$ and $\underline{u}$, at some level of these parameters the need for self-enforcement does not restrict the contract at all. In this case, it is clearly better for the principal not to delegate since delegation involves ceding some surplus to the supervisor through corruption.

Now let us consider the second part of the proposition. Let us begin by showing the result with respect to the paramater δ. In order for there to be positive effort without delegation, we require a strictly positive value of e that satisfies the following inequality:

$$ye - c(e) - \frac{1-\delta}{\delta}c'(e) \geq \underline{u} + \underline{\pi} \tag{22}$$

Now, let us define $\overline{e}(\delta)$ as the value of e which maximizes the LHS of inequality (22) for a given value of δ. It is straightforward to see that

$$\frac{d}{d\delta}\left(y\overline{e}(\delta) - c(\overline{e}(\delta)) - \frac{1-\delta}{\delta}c'(\overline{e}(\delta))\right) > 0 \tag{23}$$

and hence we can define $\underline{\delta}$ to be such that $y\overline{e}(\underline{\delta}) - c(\overline{e}(\underline{\delta})) - \frac{1-\underline{\delta}}{\underline{\delta}}c'(\overline{e}(\underline{\delta})) = \underline{u} + \underline{\pi}$. In other words, $\underline{\delta}$ is the lowest value of δ such that there exists a relational contract sustaining positive effort without delegation.

Now, for the principal to receive a positive payoff with delegation, we require a value of e that leads to a positive value of the following expression:

$$\pi_D(e) - \underline{\pi} = ey - c(e) - \frac{1-\delta}{\delta}c'(e)\alpha(e) - \underline{u} - \underline{\pi} \tag{24}$$

Note that if we evaluate this expression at $\underline{\delta}$ and $e = \overline{e}(\underline{\delta})$, we obtain the value $\frac{1-\underline{\delta}}{\underline{\delta}}c'(e(\underline{\delta}))(1-\alpha(\overline{e}(\underline{\delta})))$, which is strictly greater than zero. Hence there exists a value ϵ, such that $\pi_D(\overline{e}(\underline{\delta}-\epsilon)) > 0$. Hence the principal can achieve a payoff greater than her outside option under delegation when $\delta = \underline{\delta} - \epsilon$. Since the principal cannot achieve a payoff greater than her outside option without delegation (as $\underline{\delta} - \epsilon \leq \underline{\delta}$), delegation is the best option for the principal. A similar argument holds for the parameters $\underline{\pi}$ and $\underline{u}$. □

Proof of Proposition 3′. First, it is straightforward to derive the equivalent of

Proposition 2 in this case. The boundaries between the different contract types will be as in the original proposition, only with $g(e, b(y), b(0)$ redefined as the new joint supervisor-agent surplus, and the parameter α replaced by α_b or α_y as appropriate. In the low surplus contract, effort and bonuses will be given as follows:

$$b(y) = \frac{1}{\alpha_b}\frac{\delta g(e, b(y), b(0))}{1-\delta} \tag{25}$$

$$b(0) = \max\left\{0, \frac{1-\alpha_b}{\alpha_b}(1-e)\,c''(e) - \frac{\alpha_Y}{\alpha_b}y + \frac{1}{\alpha_b}\frac{\delta g(e, b(y), b(0))}{1-\delta}\right\} \tag{26}$$

$$c'(e) = b(y) - b(0) \tag{27}$$

Following exactly the same logic as in the proof of Proposition 3, the principal will set the parameters so as to induce a 'low surplus' contract. Then, the principal will want to maximize the expression $ey - c(e) - \alpha_b \frac{1-\delta}{\delta} c'(e)$, with respect to e, α_b and α_Y, subject to the constraint that the supervisor and agent will set $b(0) = 0$. As before the principal will therefore wish to choose the lowest value of α_b that does not violate this constraint, and we can see effort will not be larger than first best. As in the previous proof, we can split this constraint into two parts, giving us two requirements on α_b with respect to e and α_Y:

$$\alpha_b\left[(1-e)c'(e)\right] \geq (1-e)c'(e) - (\alpha_Y ye - c(e)) \tag{28}$$

$$\alpha_b\left[(1-e)\,c''(e) - c'(e)\right] \geq (1-e)\,c''(e) - \alpha_Y y \tag{29}$$

The term multiplying α_b in Inequality (29) can be written as $\frac{d}{de}\left[(1-e)c'(e)\right]$. Note that, if this were negative, then the RHS of Inequality (29) would also be negative, and hence the principal could decrease α_b without making this constraint more binding. Moreover, $(1-e)c'(e)$ would be decreasing, and hence by increasing e the principal would be able to relax the constraint (28) and hence decrease α. Hence under the optimal parameters for the principal, we must have $(1-e)c''(e) - c'(e) > 0$.

Since both constraints are made easier by increasing α_Y, the principal will set α_Y at the maximum possible value, and then set α_b at the lowest possible value such that both Inequalities (28) and (29) are met. Rearranging these expression then gives Equation 13.

Finally, since the principal sets e to maximize $ey - c(e) - \alpha_b \frac{1-\delta}{\delta} c'(e)$, we can see that $e < e^{FB}$ if and only if $\alpha_b > 0$. Moreover, if $e = e^{FB}$, and $\alpha_Y \leq 1$, then Inequality (29) implies $\alpha_b \geq 1$. Hence $e < e^{FB}$ if $\alpha_Y \leq 1$. □