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Corruption in PPPs, Incentives and Contract Incompleteness

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Abstract

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1 Introduction

When a contractor operates a highway on behalf of the government, who should bear traffic risk, the contractor or the government? When new sector legislation changes required standards, who should pay the adaptation costs on ongoing projects? When a contractor operates a staff canteen on behalf of a University, should he be allowed to increase coffee price if the price of coffee granules increases? And should all the possible contingencies that may realize during the contract life be regulated by the contract? These questions typically arise for complex procurement projects such as Public Private Partnerships (PPPs), though similar questions on how to allocate risks are common to any outsourcing relationship between a buyer and a seller.¹

Somewhat surprisingly, contracts used in practice provide different answers to the above questions. For example, in PPPs for highways, the World Bank recommends that traffic risk be borne entirely by the contractor,² whilst in the Indian's standardized contract for highways, traffic risk is borne by the contractor unless the fall in traffic is caused by a change in macroeconomic conditions.³ Furthermore, contracts show different degrees of completeness, i.e. different degree of comprehensiveness in the number of contingencies regulated by the contract. In the UK, for example, risk allocation is typically summarized in an extensive "*risk matrix*" appended to the contract, which spells out each specific risk that may arise under the contract and how they will be shared between the contractor and the public authority (HM Treasury 2007). In Italy, instead, risk matrixes are rarely used and the risk allocation is often left vague.⁴

The problem with contingent clauses is that they require realized events to be anticipated, described and verified. This involves contracting costs which may vary with project characteristics, such as complexity or value, with the efficiency of the country's institutions, and with the maturity of the PPP market. Verifying realized contingencies can also be difficult both in terms of the technologies and degree of expertise required. For example, in the case of highways it may be impossible to perfectly ascertain whether a traffic reduction is caused by worse macroeconomic conditions or by higher fuel prices.

In this paper, we investigate the benefits and costs of writing complete contracts in a risky environment. We study the three-tier relationships between a public authority (principal), a public official (supervisor) and the firm (the agent), in a public procurement context where project revenues are affected by the contractor's operating effort and by exogenous shocks.

¹PPP's are concession contracts where the supplier takes responsibility for building and managing a public infrastructure. PPP's are widely used across Europe, Canada, the U.S. and a number of developing countries in sectors such as transport, energy, water, IT, prisons, waste management, schools, hospitals and others. For an in depth discussion of the economics of PPP contracts, see Iossa and Martimort (2013).

²See Provision 5.2 in the contract model available on: <http://ppp.worldbank.org/public-private-partnership/library/road-concession-toll-road-agreement-example-1>

³<http://infrastructure.gov.in/mca.htm>

⁴See Giorgiantonio and Parisi (2011).

Contingencies may realize at contract execution stage that exogenously affect the revenue from operations. Covering those contingencies in contractual clauses involves contracting costs that are privately observed by the public official. Incentives to the contractor are provided through a payment structure that allocates revenue risk between the contractor and the public authority. Contingent clauses may provide for the contractor to receive monetary compensations when shocks occur. Contingent clauses are triggered by self-reports made by the contractor.

We show that when the state is verifiable, optimal risk-sharing calls for contingent clauses to fully compensate the contractor for revenue shocks outside his control. By tightening the link between effort and performance, full insurance on exogenous events reduces the cost of providing incentives for operational effort. The value of a complete contract thus lies in the better insurance that it provides, which in turns also helps to give stronger incentives for operational effort. Complete contracts are higher powered.

When instead the state is not verifiable, contract manipulation may occur and this has an impact on the choice of the contract. The contractor may misreport his information, always claiming that a negative shock hit operations, in order to obtain a compensation from the public authority. To prevent such misreporting, full insurance becomes suboptimal, which implies that more risk is left to the contractor and a higher risk premium is paid. The complete contract thus becomes less efficient, but an incomplete contract leaves the firm even more exposed to risks, and it thus fares worse than the complete contract. This incomplete contract may however be chosen if the contracting costs of writing contingent clauses are high.

The possibility that different contracts are optimal depending on the level of contracting costs captures the benefit from delegation of contracting to the informed public official: By observing the level of contracting costs, the public official can make better contractual choices than a centralized uninformed authority, and thus choose complete contracting only when contracting costs are sufficiently low relative to the benefit from lower risk premia and better incentives. But discretion can be abused. As incomplete contracts are associated with higher risk premia, they constitute a higher stake for corruption. The corrupt supervisor has incentives to choose incomplete contracts too often, compared to what the upper-tier public authority would like him to do.

Depending on specific conditions, we show that there exists a trade-off between the agency cost of delegated contracting and the agency cost of delegated service provision. To tackle this trade-off, the public authority will reduce the discretion allowed to the public official, by reducing the difference in payments and in risk transfer between the complete and the incomplete contracts. Nonetheless, the residual discretion allowed to the public official still creates distortionary policies in terms of contract choice: Delegation of contracting results in incomplete contracts being chosen too often.

Our comparative statics then shows that we should expect more complete contracting

when uncertainty is greater, as this factor increases the benefit of insuring the private contractor against exogenous shocks. More complete contracting is also optimal when institutions are stronger, or when the PPP market is more mature, as then contracting costs are lower. By increasing contracting costs, complex PPP projects, instead, will exhibit relatively more incompleteness.

We then show that corruption weakens these effects, making excessive incompleteness arise in equilibrium. The cost of corruption is thus greater when the value of complete contracting is highest, as is the case for projects with high uncertainty, greater risk aversion of the contractor and weak institutions. Intuitively, more uncertainty or a greater risk aversion are two factors which necessitate to raise the risk premium left to the contractor to induce his participation. But such shifts in parameters also enlarge the difference in those premia between the complete and the incomplete contracting scenarios. It thus becomes more attractive for the biased *PO* to distort his decision in favor of incomplete contracting. The optimal institutional response exhibits a similar bias. To the extent that small and medium size companies (SMEs) are less able to diversify risks than larger corporations and thus may be considered as having a greater risk aversion, our result also suggests that we should observe more incomplete contracts in sectors where contractual stakes represent a significant share of the contractor's activities.

In practice, uncertainty might be significant for projects with volatile demand, such as transport projects in areas that were not previously served by the transport service (e.g. new bridges, motorways or tunnels), or more in general for projects of higher contractual value, such as those for waste management, or energy, as these are typically more complex. In those cases, we thus expect that contracts are more likely to be left incomplete and corruption stakes to be significant. By being associated with greater contracting costs, and thus greater risk premia, weak institutions also make it more valuable for rogue public officials to distort contract choices, thus increasing the cost of corruption.

Our paper emphasizes how incomplete contracting may favor corruption (and vice versa) because of higher risk premia, and that incomplete contracting can be strategically favored by non-benevolent authorities. Whilst the insights of our paper do not confine themselves to PPP practices, they very well capture institutional issues for these complex projects. Corruption practices in public procurement can take place at different stages of the procurement process whether it is planning, tendering, contracting, or execution. Corruption at contracting stage is possibly the most subtle and the most difficult form of corruption to detect, as once a bad contract has been designed, undue benefit for the contractor are difficult to challenge. PPP agreements are particularly vulnerable to corruption because of their complexity and of the central role of the design stage. Contracts are typically kept confidential, and little transparency exist on the contingencies that trigger monetary compensations to the contractor or even on the amounts paid (Hemming, 2006). The incidence of corruption has also

been recorded (Engel et al., 2011).⁵

Furthermore, the planning and design stages of most PPP contracts involves two different layers of the governmental hierarchy: the central government (for example the national Department of Transport) and the local government (a local authority). The former typically coordinates the national PPP program and provides guidelines for contracts and tenders; the latter implements and monitors local projects. Such delegation of contracting may help ensuring that the contract reflects relevant local information (such as contracting costs) but it also exposes the central government to the risk of corruption at the local level. Some countries, such as the UK, have made recourse to standardized contracts designed centrally and imposed locally with minor variations, thus reducing the degree of local discretion. Considering the Indian standardized contract mentioned above, our paper suggests that taking away macroeconomic risk from the contractor is indeed optimal; but, as such contingency may be difficult to verify in practice, an institution such as the World Bank may have to give up such contingent clause in financing and supervising PPP projects in weak institutions. The incompleteness of the standardized World Bank contract is therefore also in line with our predictions. Finally, it has been observed that when institutions are stronger (in the sense that bureaucrats are more accountable), contract completeness is greater (see Jakobsen and Sande, 2010) as our results predict.

The paper is organized as follows. Section 2 discusses the related literature, and explains our contribution within each strand. Section 3 presents our model. Section 4 discusses the case of strong institutions where productivity shocks are verifiable, and analyzes the value of complete contracts. Section 5 studies the case of non-verifiable shocks with a benevolent public official but costly contracting. Section 6 allows for corruption between the public official and the contractor on the contract choice. We also discuss there some policy implications of our results Section 7 proposes alleys for further research Proofs are relegated to an Appendix.

2 Related Literature

On costly contracting and endogenous contract incompleteness. In a seminal paper, Dye (1985) assumes that the cost of writing contracts increases with the number of contingencies, and shows that the complexity of writing contracts can indeed be a source of contractual incompleteness. Battigalli and Maggi (2002) take this approach to endogenize contract completeness. They study when it is preferable to leave discretion to the agent, by not specifying the agent's task with sufficient precision, or have a rigid contract where

⁵Furthermore, in PPP practice, self-monitoring is often used, with the contractor verifying the contingencies that have realized and his own degree of compliance with the contractual obligations whilst the contract manager, hired by the public authority, supervises the process (see http://www.partnershipsuk.org.uk/uploads/documents/OTF4ps_ContractIn_Managers_guide.pdf).

the agent's obligation is not sufficiently contingent to the external state; information is symmetric. Bajari and Tadelis (2001) introduce asymmetric information on the cost of making contracts adaptations when unanticipated events realize, but the insurance motive is absent as the contractor is risk neutral. They show that fixed-price contracts are more costly to renegotiate than cost-plus contracts, therefore, they must be used when incentives are important and the optimal contract is relatively complete. Kvaloy and Olsen (2009) explicitly analyze the relationship between contracting costs and the power of incentive schemes when the probability of court enforcement increases with contracting costs. They show that there is no monotonic relationship between contracting costs and incentives intensity, and that an increase in those costs may lead to higher-powered incentives.⁶

We contribute to this literature by drawing a new link between insurance, incentives and contract completeness: Complete contracts bring the benefit of allowing better risk allocation, which in turn weakens moral hazard. We also highlight how more complete contracts may result in more risk transfer to the contractor on certain events, but less risk transfer on others. Incentives are nevertheless always strengthened.

On corruption and contract design. Our paper is related to the literature on corruption in principal-agent-supervisor relationships dating back to Tirole (1986) and Laffont and Tirole (1993). This literature has shown that in standard adverse selection models, the stake of corruption is given by the informative rent of the firm. Reducing this stake calls for an allocation of resources that is less sensitive to the supervisor's information. Contract forms to fight corruption need to be low powered and with less risk transfer, but this comes at the cost of weakened incentives. Collusion-proofness may also prevent that corruption arises at equilibrium. In our context, the stake of corruption is instead given by the risk premium, corruption occurs with positive probability in equilibrium, and leads to more incomplete contracts being chosen, an effect not previously discussed.

There is also a related literature on how corruption concerns affect bidding procedures in tender offers (Burget and Perrry 2007, Burget and Che 2004, and Compte and al. 2005). We depart from these papers in several respects. First, we do not model the competition among agents for the right to contract although we go deeper in the analysis on how detailed those contracts are. Adding this important feature of real world environment would not change our main focus which is to determine the optimal degree of incompleteness under the threat of corruption. Second, our focus on a three-tier hierarchy allows us to stress the optimal institutional response to the threat of corruption which is to modify the kind of contracts offered.

On delegated contracting. Delegation of contracting to an agent whose objective differs from that of the principal has been shown to be potentially advantageous to facilitate com-

⁶See Halonen and Hart (2013), and discussion therein, for explanations as to why incomplete contracts may arise even absent contracting costs.

mitment in a variety of settings going from industrial organization (Besanko and Spulber, 1993), macroeconomics (Rogoff, 1985) to public finance (Persson and Tabellini, 1993), and bargaining (Fershtman, Judd and Kalai, 1991).⁷ Commitment is not an issue in our context. Instead, delegation is justified in the first place by the comparative advantage and expertise that lower tiers of the public chain of command have in assessing contracting costs. That benefit must be traded off with the possible bias that those corrupt tiers may have in favoring contractors by choosing vague contract terms. We focus on the agency costs of delegating contracting, and emphasize a trade-off between these agency costs and those related to the delegation of service provision. An implications of our results is the potential benefit from centrally designed contractual clauses which leave some but not full discretion to public officials, thus explaining the use of standardized contracts in PPPs.⁸

On concession contracts. Finally, from a more applied side, our paper is related to the literature on PPPs, dating back to Hart (2003), Bennett and Iossa (2006) and Martimort and Pouyet (2008). In Iossa and Martimort (2012) we showed that the better risk allocation obtained when states are verifiable helps to improve the gain from bundling. The paper however does not consider the possibility of corruption. Martimort and Pouyet (2008) study corruption in PPPs but the focus is on corruption at planning stage. The firm may bribe a public official to secure that the service is provided through a PPP - which provides higher rent - rather than through a traditional model of procurement.

3 The Model

Overview. Consider a public authority (thereafter *PA*) willing to procure the provision of a public service to a private contractor. This provision requires to build and operate an infrastructure. Examples of such delegation include of course transportation, water production and sanitation, waste disposal, clinical and educational services etc. Although different in details, contracting modes in those settings share a common timeline. The time horizon consists of three stages: contract-design, building and operations. In the contract-design stage, the contractor submits a project, and there is uncertainty about how to write the contract, given the shock realizations that may occur during the project implementation. Different contingencies may realize. For instance, the legal standards of service may change due to a new legislation or macroeconomic conditions may fluctuate, affecting future revenues from the service. Including these contingencies in the contract is costly. This cost is privately observable by the public official (thereafter *PO*) after the project is submitted. The public

⁷Bennett and Iossa (2007) consider the issue in the case of service provision under PPPs in an incomplete contract framework.

⁸In a different context, Hiriart and Martimort (2012) study how delegating regulatory rights to lower tiers of a public chain of command who may be biased also introduces a trade-off between a loss of control and the informational advantage of such decentralized regulation.

official reports this cost to the *PA* who finalizes the contract design, choosing between a complete or an incomplete contract.

In the second stage, the infrastructure is built, and exogenous shocks may realize which affects the revenues of the service. When a complete contract has been chosen at the contract-design stage, the payment to the contractor and the revenue sharing rule are adjusted according to the realized contingency. When instead parties have only agreed upon an incomplete contract earlier on, the payment and the revenue sharing rule remain unchanged.⁹ The third stage is the operational stage, where the provision of the service begins. The contractor exerts operational effort which affects realized revenues. non-verifiable exogenous shocks may occur at this stage.

In this setting, we analyze the optimal degree of contract completeness, studying how the optimal payment and revenue sharing rule should be designed under different assumptions on the verifiability of revenue shocks and on the benevolence of the *PO*.

3.1 The Set-Up

We now present the model in more details.

Production technology. For services where users pay (concession model), the revenues from the service are stochastic and defined as:¹⁰

$$R = R_0 + e + \theta + \zeta.$$

Only those revenues can be verified. Revenues-sharing rules are thus the only possible contracts available in our environment. The costs of providing the service is normalized at zero.¹¹

Various variables impact on revenues beyond a baseline level R_0 that can be obtained even in the absence of any effort.¹²

- First, revenues increase with the effort e which is exerted by the contractor at the operating stage. This captures for example the higher demand from users of transport

⁹We assume that in this case, because of high transaction costs, renegotiation cannot occur. This assumption can be viewed as a proxy for scenarios where renegotiation towards a more complete contract would be feasible but would be inefficient because it would take place under asymmetric information.

¹⁰Following Iossa and Martimort (2013), R can be used interchangeably to denote also the benefit from the service, for those services where users do not pay (PFI model). In this case, the contractor does not appropriate these benefits directly but it receives a payment linked to an index of R .

¹¹Contractors in PPP projects are often involved in a variety of service provisions and there are large common costs which make it difficult to attribute to a particular project. This is especially true in developing countries as noticed by Laffont (2005) and Estache and Wren-Lewis (2009). For the same reason we assume that the contractor's profits on the specific projects are also non-verifiable. Also, the non-verifiability of operating costs is a key feature of complex projects like PPPs.

¹²For essential services with rigid demand or where the contractor operates in a condition of monopoly, R_0 is high.

services when service reliability, on-the train services, or the efficiency of the ticketing system are greater. The cost of effort counted in monetary terms is $\frac{e^2}{2}$.

- Second, revenues also depend on a shock θ that occurs at the building stage.¹³ For simplicity we assume that the revenue shock θ has zero mean and can only take two values $\bar{\theta} = (1 - \nu)\Delta\theta > 0$ and $\underline{\theta} = -\nu\Delta\theta < 0$ with respective probabilities ν and $1 - \nu$.
- Third, revenues are also impacted by a random variable ζ that represents a demand or productivity shock that occurs during the operational stage and whose occurrence involves prohibitive verifiability costs.¹⁴ We further assume that ζ is normally distributed with zero mean and variance σ^2 .

Information. Our model entails both elements of adverse selection and moral hazard.

- The revenue R is verifiable and can be contracted upon through a revenue sharing rule.¹⁵
- The realization of θ is unknown to all parties at the contracting stage. This *a priori* creates a motive for insurance. Later on, the contractor learns the value of this shock and thus gets an informational advantage. Truth-telling constraints thus have to be satisfied at this stage.
- The contractor's effort e is non-verifiable. The contractor chooses the effort e ex post, i.e., once he already knows θ . This simple formulation allows us to capture how the contractor can adapt his second-stage effort to productivity shocks in the environment. Contracts must induce effort provision.

Contracts and contracting technology. Because revenues are verifiable, revenue sharing agreements between the public authority and the contractor are feasible. Following Holmström and Milgrom (1987, 1991), we assume that those contracts are linear. Those payments thus entail a fixed fee and a share of revenue for the contractor. A fixed fee is useful to provide insurance against risk while leaving a share of the revenue has some incentives properties. We adopt the accounting convention that the government keeps all the revenue R and pays the contractor an amount:

$$t(R) = \alpha + \beta R.$$

¹³In transport concessions, building excavation may reveal archeological sites delaying construction, oil prices may vary, macroeconomic conditions may change affecting future demand, and so on

¹⁴In transport concessions, demand can be affected unpredictably by competition from other modes or facilities, from the conditions affecting the wider network, such as economic activity levels or tourism demand, and it is difficult to disentangle the effect of each of these factors.

¹⁵In transport projects, for example, revenues can be verified through electronic ticketing systems, whilst in energy projects they can be specified through computerized billing systems.

The parameter β represents the share of revenues kept by the firm while α is a fixed fee.

In the sequel, we will distinguish between two kinds of contracting modes that differ in how they respond to contingencies.

- With *complete contracts*, PA can offer a full menu of options $\{(\alpha(\hat{\theta}), \beta(\hat{\theta}))\}_{\hat{\theta} \in \Theta}$ contingent on the report $\hat{\theta}$ made by the contractor on the realization of the productivity shock. The payment scheme then writes as:

$$t(\hat{\theta}, R) = \alpha(\hat{\theta}) + \beta(\hat{\theta})R.$$

From the Revelation Principle,¹⁶ there is of course no loss of generality in restricting the analysis to such direct and truthful mechanisms.

- With *incomplete contracts*, PA is restricted to offer a rigid option $(\alpha_\infty, \beta_\infty)$ that applies under all circumstances: The incomplete contracts do not need to rely on a precise communication of the state of nature by the contractor. The payment schemes becomes:

$$t_\infty(\theta, R) = \alpha_\infty + \beta_\infty R.$$

Observe that, under incomplete contracting, extracting the contractor's private information is useless, as the contract is rigid and inflexible with respect to the realized state. Separating allocations can only be offered if the contract is complete. As we shall see below, the value of such state-contingent clauses is that they allow to improve on both insurance and incentives.

To justify that incomplete contracts may emerge as optimal responses to contractual frictions, we simply assume that the PO in charge incurs an exogenous cost $z \geq 0$ of processing and understanding messages on non-verifiable contingencies. This cost reflects the complexity of the project¹⁷ or the opportunity cost of not devoting time to more directly productive activities.^{18,19}

¹⁶Myerson (1982).

¹⁷To illustrate, the cost of verifying an econometric report on the impact of fuel prices on traffic demand for a large motorway may be significantly greater than the cost of verifying whether an earthquake has caused the collapse of the project building.

¹⁸The cost z might also be interpreted as a cognitive cost. See Tirole (2009) and Bolton and Faure-Grimaud (2009) for some more micro-foundations. Cognitive costs have a broad range of interpretations, including the PO 's psychic cost of focusing on issues they are unfamiliar with, or the fees paid to lawyers and consultants for advice on contracting.

¹⁹Observe that all contracting costs come from verifying messages on non-verifiable states. In contrast with Dye (1985), we thus ignore the possible cost of writing different contingencies. Such cost would also arise even if the state of nature were verifiable but it is useful to write different contracting clauses for different realizations of this shock. Yet, Section 4 below shows that, had the productivity shock and the operating effort been both verifiable, the optimal contract would be independent of the state of nature. Hence, even if the contracting cost was bearing on contingencies per se (and not messages on those contingencies when they are non-verifiable), there would be no reason to incur such writing costs since a rigid contract suffices.

The cost z is a random variable distributed on \mathbb{R}_+ according to a positive density function $g(z)$ with a cumulative (atomless) distribution function $G(z)$ ($G'(z) = g(z)$). We assume that the (strict) monotone hazard rate property holds, i.e., $G(z)/g(z)$ is strictly increasing.

This cost is privately observed by PO and such information is thus a potential source of rent at this lower tier of the chain of command. This assumption captures in a nutshell the fact that the decentralization that inevitably occurs in large public organizations might potentially come with agency costs when different layers of public hierarchies have conflicting objectives.

Objectives. Let us describe the three players' objective functions in details.

- PA is risk neutral and maximizes the share of revenues it gets net of the costs of paying the agent and net of the cost z of writing complete contracts if he chooses so.²⁰ Formally, with complete contracts, this objective writes as:

$$E_{\theta,\zeta}((1 - \beta(\theta))R - \alpha(\theta)) - z.$$

Instead, with an incomplete contract, PA can save on contracting costs and his objective becomes:

$$E_{\theta,\zeta}((1 - \beta_\infty)R - \alpha_\infty).$$

- The contractor is risk averse with a constant degree of absolute risk aversion $r \geq 0$. We denote by $v(x) = 1 - \exp(-rx)/r$ the corresponding utility function defined over monetary payments x . The assumption of risk aversion captures the fact that a PPP project might represent a large share of the contractor's activities so that there is little scope for diversification. The contractor cares about the certainty equivalent of his payoffs from running the service.

The contractor's outside opportunity provides an exogenous payoff normalized at zero. Depending on whether contracts are complete or incomplete respectively, the contractor participates whenever

$$v(\mathcal{V}) = E_{\theta,\zeta} \left(v \left(\alpha(\theta) + \beta(\theta)R - \frac{e^2}{2} \right) \right) \geq 0 \text{ or } v(\mathcal{V}_\infty) = E_{\theta,\zeta} \left(v \left(\alpha_\infty + \beta_\infty R - \frac{e^2}{2} \right) \right) \geq 0.^{21}$$

²⁰The assumption of risk neutrality for the public authority might certainly be questioned in the case of small local governments for whom PPP projects may represent a significant share of their overall budget. For a large country, the existing deadweight loss in the cost of taxation may as well introduce a behavior towards risk, if the PPP project were to represent a large share of the budget. We make this assumption as it gives a simple benchmark. Indeed, in the absence of moral hazard, the optimal risk allocation requires that the public sector bears all risks. Lewis and Sappington (1995) and Martimort and Sand-Zantman (2006) analyze the consequences of having risk averse governments in various procurement settings.

²¹ $E_x(\cdot)$ denotes the expectation contractor with respect to any random variable x .

- A benevolent *PO* has preferences aligned with those of *PA*. Instead, a corrupt *PO* also cares about the monetary benefits he withdraws from being in charge and possibly corrupt. We leave to Section 6 the details of this formulation.

4 Benchmarks

4.1 Verifiable Effort and Productivity Shocks

When the effort and the productivity shock θ are both verifiable, *PA* can easily provide full insurance against productivity shocks to the risk averse contractor. He can also impose an effort target at the operating stage and use the fixed fee to reap all surplus from the contractor.

The first-best effort level is given by:

$$e^* = \arg \max_e e - \frac{e^2}{2} \equiv 1.$$

Note that the marginal impact of effort on revenue and its disutility are both independent of the realized shock θ . Therefore, e^* is independent of θ . How much operational effort the contractor should put into the project is independent of the specific contingencies that may realize during the building stage.²²

The contractor bears no revenues risk and always receives the same payment:

$$\beta(\theta) = 0 \text{ and } \alpha(\theta) = \frac{e^{*2}}{2} \quad \forall \theta.$$

That fixed fee just covers the cost of exerting the first-best effort level.

4.2 Verifiable Productivity Shocks

We now characterize the optimal contract when productivity shocks are verifiable and thus complete contracting is costless. This benchmark allows us to identify the value of writing complete contracts. We shall here disregard the possibility of corruption between the contractor and *PO* and assume that *PO* is benevolent and shares *PA*'s objectives.

When the productivity shock θ is verifiable, the contract provides state-contingent clauses that specify a compensation $\alpha(\theta)$ and a revenue sharing formula $\beta(\theta)$ for each realized contingency θ . As we will see below, these state-contingent clauses help to achieve the dual objective of inducing operational effort and providing insurance to the risk averse contractor against the shocks that can occur during project implementation. The payment scheme

²²In practice there may be instances where higher effort has a higher productivity the greater the demand level. For example, the maintenance effort for a motorway has an impact on revenues that increase with the demand value. Although relevant in practice, we focus on the case of constant marginal productivity as we shall show that even in this case asymmetric information on θ affects equilibrium effort.

then writes as:

$$t(\theta, R) = \alpha(\theta) + \beta(\theta)R.$$

Thanks to the CARA specification and the normality of shocks, we can write the certainty equivalent of the contractor's payoff when θ is observed as:

$$U(\theta) \equiv \arg \max_e \alpha(\theta) + \beta(\theta)(R_0 + \theta + e) - \frac{e^2}{2} - \frac{r\sigma^2\beta^2(\theta)}{2}. \quad (1)$$

At the operational stage, once he has observed θ , the contractor chooses his effort optimally. This leads to the following moral hazard incentive constraint:

$$e(\theta) = \beta(\theta) \quad \forall \theta \in \Theta. \quad (2)$$

The quantity $\frac{r\sigma^2\beta^2(\theta)}{2}$ is the risk premium that compensates the contractor for bearing the risk of exogenous shocks ζ during operations. Because effort is non-verifiable, the contractor must bear some revenue risk to be incentivized and the effort is positive whenever $\beta(\theta) > 0$. This risk premium increases with the contractor's degree of risk aversion r , with uncertainty at the operational stage σ^2 , and with the share of revenues $\beta(\theta)$ kept by the contractor in state θ .

Substituting for the above value of effort from (2) into (1) yields:

$$U(\theta) = \alpha(\theta) + \beta(\theta)(R_0 + \theta) + (1 - r\sigma^2)\frac{\beta^2(\theta)}{2} \quad \forall \theta \in \Theta. \quad (3)$$

This allows us to write the contractor's ex ante participation constraint as:

$$E_\theta(v(U(\theta))) \geq 0. \quad (4)$$

The characteristics of the optimal contract when θ is verifiable are gathered in Proposition 1.

Proposition 1 *Assume effort is non-verifiable but θ remains verifiable. The optimal complete contract is such that:*

1. *The contractor is fully insured against exogenous events occurring at the building stage:*

$$U^{mh}(\bar{\theta}) = U^{mh}(\underline{\theta}) = 0; \quad (5)$$

2. *The contractor keeps a share of revenues $\beta^{mh} < 1$ that is independent of the realized shock*

$$\beta^{mh} = \frac{1}{1 + r\sigma^2} < 1 \quad \forall \theta \in \Theta; \quad (6)$$

3. *Effort is suboptimal*

$$e^{mh} = \frac{1}{1 + r\sigma^2} < 1. \quad (7)$$

Proposition 1 suggests that contracts between the public and private sectors should include state-contingent clauses providing for monetary payments to compensate the contractor for all the predicted events affecting his profits that are exogenous, and thus outside his control. This is nothing else than a consequence of Holmström (1979) “*Informativeness Principle*”; the verifiable information on the productivity θ should not be used for incentive purposes since it is not informative on the agent’s effort. When input prices increase, when there is a national strike slowing down production or when there is a change in legislation that increases the cost of operations, the firm should receive a compensation by the authority. Contingent clauses provide insurance on shocks unrelated to the firm’s effort and thus do not weaken incentives.²³ The fixed fee $\alpha^{mh}(\theta)$ should reflect this insurance motive:

$$\alpha^{mh}(\underline{\theta}) - \alpha^{mh}(\bar{\theta}) = \Delta\theta\beta^{mh} > 0 \Leftrightarrow U^{mh}(\underline{\theta}) = U^{mh}(\bar{\theta}). \quad (8)$$

Furthermore, for each contingency that realizes at the building stage, the contract should specify a revenue shares β^{mh} that trades off the value of incentives with the risk premium that must be paid for bearing risk at operational stage, $\frac{r\sigma^2\beta}{2}$. On the one hand, a higher share of revenues raises incentives for operational effort since e is indeed increasing in β . On the other hand, a higher share of revenues raises the level of risk transferred to the contractor and thus the risk premium. Note that even if the contractor is fully insured against the shock θ , for any positive revenue share β , he bears revenue risk on all those shocks ζ that may occur during the operations. The risk premium due to the contractor is then higher the higher is β , the risk aversion of the contractor r and the uncertainty σ^2 . Because of this trade-off, the optimal share of revenues kept by the contractor remains less than one.

5 The Choice Between Complete and Incomplete Contracts with a Benevolent Public Official

In this section, we characterize the optimal contract when both the effort and the productivity shock are non-observable and thus non-verifiable by a Court although they are of course known by the contractor. We also assume that contracting is costly, but the *PO* in charge has the same preferences as *PA*. This benchmark allows us to understand how the contracting cost z affects the choice of contract and its design, when there is no risk of corruption.

Indeed, when shocks that occur during the building phase are non-verifiable, and *PA* writes a complete contract, he needs to extract the information from the contractor on the realized contingency. As we shall see, this entails two different kinds of contracting costs.

The first kind of costs that we should consider comes from the fact that the contractor has now private information on θ . The impact of those costs are well known. Complete

²³This result arises because only the net revenues $R' = R - \theta_i = e + \zeta$ matter for incentives purposes. The marginal benefit of effort on revenues is indeed independent of the revenues risk θ . In practice, shocks in revenues, such as a change in macroeconomic conditions, do not affect the productivity of operational effort devoted for example to reduction in congestion or increase safety on a highway.

contracts have to satisfy a truth-telling constraint to induce the contractor to report the true value of the productivity shock. As a result of this constraint, the contractor should bear some endogenous risk. Thus full insurance is no longer optimal. This results in a costly risk premium paid to the contractor. To reduce this cost, the contractor's share of revenues diminishes which dampens incentives to exert effort.

Second, and this is a more novel aspect of our modeling, writing a complete contract under asymmetric information entails a contracting cost z that is borne to verify the contractor's reports on different contingencies. This cost is privately observed by PO and will be taken into account when he chooses between complete and incomplete contracting. An important question is whether delegating the task of designing such contract creates additional agency costs. As we shall see, there are no such costs when PO is benevolent. Agency costs will instead arise when the PO is corrupt.

5.1 Complete Contracting

To see how the different contracting costs articulate, let us first consider the design of a complete contract. To this purpose, it is convenient to redefine the contractor's returns as:

$$U(\theta) = \max_{(e, \hat{\theta})} \alpha(\hat{\theta}) + \beta(\hat{\theta})(R_0 + \theta + e) - \frac{e^2}{2} - \frac{r\sigma^2\beta^2(\hat{\theta})}{2}.$$

Incentives at the operating stage are again entirely determined by the share of revenues kept by the contractor, i.e.,

$$e(\hat{\theta}) = \arg \max_e \alpha(\hat{\theta}) + \beta(\hat{\theta})(R_0 + \theta + e) - \frac{e^2}{2} - \frac{r\sigma^2\beta^2(\hat{\theta})}{2} \equiv \beta(\hat{\theta}) \quad \forall (\theta, \hat{\theta}) \in \Theta^2.$$

From this, we obtain the more compact expression of the contractor's returns as:

$$U(\theta) = \max_{\hat{\theta} \in \Theta} \alpha(\hat{\theta}) + \beta(\hat{\theta})(R_0 + \theta) + (1 - r\sigma^2) \frac{\beta^2(\hat{\theta})}{2}.$$

This expression encompasses the incentive compatibility constraints that are both necessary and sufficient to induce truthful revelation once θ is known. A contract satisfying these constraints prevents a contractor having faced a shock $\bar{\theta}$ to pretend having faced a more averse shock $\underline{\theta}$, and vice versa. As standard in screening environments in a framework with two productivity shocks,²⁴ the contractor wants to report a negative shock when instead a good shock has hit. The relevant (binding) incentive compatibility constraint is thus:

$$U(\bar{\theta}) - U(\underline{\theta}) \geq \Delta\theta\beta(\underline{\theta}). \quad (9)$$

By underreporting his productivity, the contractor offers a lower estimate of revenues at the operational stage and receives a greater fixed fee (i.e., $\alpha(\underline{\theta}) > \alpha(\bar{\theta})$). With such strategy,

²⁴See Laffont and Martimort (2002, Chapter 2) for instance.

the contractor appropriates an extra rent worth $\Delta\theta\beta(\underline{\theta})$. This rent is strictly positive unless $\beta(\underline{\theta}) = 0$. Setting $\beta(\underline{\theta}) = 0$ would of course remove the incentives to lie, which is good on the adverse selection side, but it would also destroy all incentives to exert effort at the operating stage following a bad shock at the construction stage. Now, the contractor must face a risky allocation of returns to satisfy the truthtelling constraint.

To put it differently, if $\beta(\underline{\theta}) > 0$, the truthful constraint implies that when external events hit construction, the contractor will now have to receive only a partial compensation for the lost revenues. If the contractor were fully compensated, then he would always report having been hit by a negative shock to receive that compensation.

The important insight here is then that leaving some revenues risk to the contractor is indeed necessary to solve the asymmetric information problem on events that occur during the building stage. As the contractor is risk averse, bearing this endogenous risk is costly: The contractor now needs to receive an additional risk premium. To minimize this risk, the truthtelling constraint (9) must be binding at the optimal contract. Next Lemma unveils some properties of the risk premium in that case.

Lemma 1 *The risk premium that must be paid to the contractor for inducing truthful revelation of the realized state at minimal agency cost is:*

$$\varphi(\Delta\theta\beta(\underline{\theta})) = \nu\Delta\theta\beta(\underline{\theta}) + \frac{1}{r}\ln(1 - \nu + \nu\exp(-r\Delta\theta\beta(\underline{\theta}))), \quad (10)$$

where $\varphi(0) = \varphi'(0) = 0$ and $\varphi'(\Delta\theta\beta(\underline{\theta})) > 0$ if $\beta(\underline{\theta}) > 0$.

There is now a trade-off between providing insurance to the contractor and inducing truthtelling. Full insurance becomes too costly, as the contractor would always report that a negative shock hit the project during construction to maximize his compensation. Expression (9) tells us that in order to ensure truth-telling, the contract needs to create a gap in returns between the good and the bad states. This gap increases with the share of additional revenues that the contractor can appropriate by underreporting the shock, $\Delta\theta\beta(\underline{\theta})$. This explains why the risk premium is increasing with $\beta(\underline{\theta})$.

Equipped with the expression of the risk premium (10), we rewrite the certainty equivalent of the firm's payoff as:

$$\mathcal{V} = E_{\theta}(U(\theta)) - \varphi(\Delta\theta\beta(\underline{\theta})).$$

Taking into account the expression of effort in terms of the share of revenues kept by the contractor, the *PA*'s expected payoff with complete contracting (net of contracting costs worth $z \geq 0$) can in turn be written as:

$$E_{\theta} \left(\beta(\theta) - \frac{(1 + r\sigma^2)}{2}\beta^2(\theta) - U(\theta) \right) - z = \mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - z.$$

Here, we define the expected surplus of the relationship net of the risk premium in terms of the shares of revenues ($\beta(\bar{\theta}), \beta(\underline{\theta})$) kept by the contractor for each possible realization of the shock θ as:

$$\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) = E_{\theta} \left(\beta(\theta) - \frac{(1+r\sigma^2)}{2} \beta^2(\theta) \right) - \varphi(\Delta\theta\beta(\underline{\theta})).$$

As a benchmark for the subsequent analysis, consider the case where it is always costless to write down a complete contract (i.e., $G(\cdot)$ has a unit mass point at $z = 0$). The optimal contract maximizes the expression of PA 's expected payoff just found above subject to the contractor's participation constraint. The solution is described in the following Proposition.

Proposition 2 *Suppose that effort and revenues shocks are both non-observable and non-verifiable and that complete contracting is costless. The optimal complete contract is such that²⁵*

1. *the contractor is only partially compensated for revenues shocks at the building stage,*

$$U^{nv}(\bar{\theta}) - U^{nv}(\underline{\theta}) = \Delta\theta\beta^{nv}(\underline{\theta}) > 0; \quad (11)$$

2. *the contractor keeps a lower share of the revenues when a negative revenue shock hits,*

$$0 < \beta^{nv}(\underline{\theta}) < \beta^{nv}(\bar{\theta}) = \beta^{mh} < 1$$

where

$$\beta^{nv}(\underline{\theta}) = \left(1 - \frac{\Delta\theta}{1-\nu} \varphi'(\Delta\theta\beta^{nv}(\underline{\theta})) \right) \beta^{mh}. \quad (12)$$

Since the contractor may underreport favorable events, he is only partially compensated following adverse events so as to make such strategy less attractive. Leaving such ex post risk to the contractor requires to pay a risk premium $\varphi(\Delta\theta\beta^{nv}(\underline{\theta})) > 0$. To reduce this risk premium, PA reduces the revenues share only when negative shocks are reported, $\beta^{nv}(\underline{\theta}) < \beta^{mh}$. Yet, in our context which mixes elements of both adverse selection and moral hazard, this reduction of the revenues share following adverse events in turn dampens incentives to exert effort at the operational stage. No such reduction arises when a good shock hits, a “no distortion at the top” result which is familiar from the screening literature.

5.2 Incomplete Contracting

As another benchmark for the subsequent analysis, consider now the case where it is infinitely costly to write a complete contract so that contracts are necessarily left incomplete. This is of course a special case of the complete contracting scenario with the proviso that the revenues sharing rule $(\beta_{\infty}, \alpha_{\infty})$ is independent of any announcement on the realized shock

²⁵We index this case with a superscript nv in the sequel.

θ . We may again define the contractor's return in state θ as $U_\infty(\theta)$ and notice that his effort at the operational stage is again entirely defined by his share of revenues, namely $e(\theta) = \beta_\infty$.

Because payments are now independent of the realized state θ , there is no **possible insurance against that shock**. In that case, (9) is now satisfied with an equality:

$$U_\infty(\bar{\theta}) - U_\infty(\underline{\theta}) = \Delta\theta\beta_\infty. \quad (13)$$

A rigid contract that does not adjust with the realized contingencies imposes an exogenous risk on the contractor which is proportional to the contractor's share β_∞ of revenues. To compensate for this risk, which is of course very similar to that arising in the complete contracting scenario, a risk premium of $\varphi(\Delta\theta\beta_\infty)$ must now be paid to the contractor.

Next Proposition characterizes the optimal incomplete contract.

Proposition 3 *Suppose that effort and revenues shocks are both non-observable and non-verifiable. The optimal incomplete contract is such that*

1. *the contractor fully bears the risk of exogenous shocks at the building stage,*

$$U_\infty^{nv}(\bar{\theta}) = U_\infty^{nv}(\underline{\theta}) + \Delta\theta\beta_\infty^{nv}; \quad (14)$$

2. *the contractor keeps a share of revenues that is independent of the realized shock and that lies in between the shares of revenues implemented under complete contracting,*

$$\beta_\infty^{nv}(\underline{\theta}) < \beta_\infty^{nv} < \beta_\infty^{nv}(\bar{\theta}) = \beta_\infty^{mh} < 1 \quad (15)$$

with

$$\beta_\infty^{nv} = \beta_\infty^{mh} (1 - \Delta\theta\varphi'(\Delta\theta\beta_\infty^{nv})); \quad (16)$$

3. *effort is suboptimal and lies in between the efforts implemented under complete contracting*

$$e^{nv}(\underline{\theta}) < e_\infty^{nv} < e^{nv}(\bar{\theta}) = e^{mh} < 1; \quad (17)$$

4. *the risk premium is greater under incomplete contracting than with complete contracting.*

Writing an incomplete contract has two consequences on the shape of the optimal contract. On the one hand, the fact that the contract cannot be contingent on the realized shock θ forces the contractor to bear some risk. Inducing his participation thus requires that PA pays a risk premium $\varphi(\Delta\theta\beta_\infty)$. This feature is very similar to what happens under complete contracting where such risk was endogenously imposed by the truth-telling constraint (9).

On the other hand, an incomplete contract implements a share of revenues which is pooling across all values of the shock. This pooling value lies in between the shock-contingent values obtained with complete contracting. Decreasing β_∞ to reduce the risk premium $\varphi(\Delta\theta\beta_\infty)$ and provide more insurance has now the perverse effect of also dampening effort

even when $\bar{\theta}$ realizes. As a result, PA finds it less attractive to reduce β_∞ . The contractor bears more risk under incomplete contracting:

$$\beta_\infty^{nv} > \beta^{nv}(\underline{\theta}).$$

As we will see below, this result is of particular importance when we consider the possibility of a corrupt PO acting on behalf of PA .

5.3 The Optimal Degree of Incompleteness

Suppose a benevolent PO chooses when to write a complete contract. Such delegation is *a priori* attractive because PO has private information on the realization of the contracting costs that must be incurred to complete a contract. Such PO only cares about the PA 's payoff, i.e., he thus chooses a complete contract whenever the PA would find it ex post optimal to do so. Excluding corner solutions, this condition identifies a cut-off value z^* such that for all $z \leq z^*$ a complete contract contingent on the realized state is written, whilst for all $z > z^*$ an incomplete contract is preferred. The cut-off z^* is defined as follows:

$$z \leq z^* = \mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - (\mathcal{W}(\beta_\infty, \beta_\infty) - \mathcal{V}_\infty). \quad (18)$$

To illustrate, suppose that PA commits to offer the optimal complete and incomplete contracts described in Sections 5.1 and 5.2 above. In particular, we know that those contracts extract all surplus from the contractor, $V^{nv} = V_\infty^{nv} = 0$. The corresponding cut-off z^{nv} would then be strictly positive:

$$z^{nv} = \mathcal{W}(\beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta})) - \mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv}) > 0. \quad (19)$$

The right-hand side can be interpreted as the value of writing a complete contract when the shock is verifiable. The cut-off defined through (19) turns out to be optimal when PO is benevolent as we will see below.

Turning now to the characterization of this optimal cut-off rule, it should be rather intuitive that the contracting problem now lies somewhere "in between" the outcomes achieved when there are no contracting costs and when those costs are infinite. Formally, the optimal cut-off rule, the corresponding revenues shares and contractor's payoffs now altogether maximize PA 's expected payoff defined as follows:

$$(\mathcal{P}) : \quad \max_{(z^*, \beta_\infty, \beta(\underline{\theta}), \beta(\bar{\theta}), \mathcal{V}, \mathcal{V}_\infty)} \int_0^{z^*} (\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - z) dG(z) + (1 - G(z^*)) (\mathcal{W}(\beta_\infty, \beta_\infty) - \mathcal{V}_\infty)$$

subject to the cut-off condition (18) and the firm's participation constraints (namely (A4) and (A5) in the Appendix) that ensure a positive payoff to the contractor whether the relationship is run under a complete or an incomplete contract.

Importantly for what follows, notice that a pointwise optimization of the maximand with respect to z^* would give us a first-order condition that is nothing else than (18). In other words, the *PA* would like to commit ex ante to a cut-off rule that is indeed ex post optimal when the *PO* in charge of this delegated choice has similar preferences. This suggests that this condition (18) is actually redundant. Yet, in view of preparing for the analysis to come when *PO* is corrupt, we keep this more general formulation.

The following Proposition then characterizes the optimal governance and especially the optimal level of contractual incompleteness.

Proposition 4 *Suppose that effort and revenues shocks are both non-observable and non-verifiable and that PO is benevolent. The optimal governance structure is such that*

1. *a complete contract is chosen if and only if contracting costs are small enough:*

$$z \leq z^{nv} = \mathcal{W}(\beta^{mh}, \beta^{nv}(\theta)) - \mathcal{W}(\beta_{\infty}^{nv}, \beta_{\infty}^{nv});$$

2. *the complete (resp. incomplete) contract chosen when $z \leq z^{nv}$ (resp. $z \geq z^{nv}$) is characterized in Proposition 2 (resp. 3);*
3. *the contractor always breaks even whether a complete or an incomplete contract is chosen:*

$$\mathcal{V}^{nc} = \mathcal{V}_{\infty}^{nc} = 0.^{26} \tag{20}$$

For z sufficiently large, it is preferable to leave contracts incomplete. For z sufficiently small, the benefit of improving insurance and providing better incentives with a complete contract instead justifies incurring contracting costs.

Proposition 4 further shows that there is a complete dichotomy between finding the main features of the contracts (whether it remains incomplete or not) and finding the set contingencies under which either contractual mode dominates. The incomplete contract saves on contracting costs but also has the contractor bear more undue risk than under a more complete contract. To reduce overall risk, the power of incentives is reduced.

This insight is related to what has been suggested by other scholars considering the cost of incompleteness of contracts due to ex post adaptations. In Bajari and Tadelis (2001) for instance, the contractor is risk neutral so the insurance motive is irrelevant. More complete contracts are however valuable because they reduce the need for renegotiation in case adaptations are needed. Since renegotiation is more costly with fixed-price contracts than with cost-plus ones, high powered incentives (fixed price contracts) characterize more complete contracts. In our setting, instead, renegotiation is not an issue, and complete contracts are more high powered because the cost of transferring risk is lower.

²⁶The superscript *nc* stands for “no corruption”.

The level of contractual completeness is captured by the value of the cutoff z^{nv} . Since the interests of PA and PO are aligned, there are no agency costs of delegating the contract choice to PO and there are benefits of doing so when the latter is able to precisely assess what the contracting costs are.

In practice, we may expect to see more incomplete contracts for more complex projects, because their verification costs will be higher (thus z is likely to be large). Project complexity is more significant, especially in waste management, complex IT, and large transport projects. However, as the experience with PPPs matures, past cases provide useful information that reduce verification costs, and thus we should observe more complete contracts for more mature PPP markets. We should also expect more complete contracting when uncertainty is greater, as it increases the benefit of insuring the private contractor against exogenous shocks.²⁷

There is little testing of contract design in the economics literature (see Masten and Saussier, 2000, for a review), Crocker and Reynolds (1993) study jet engine procurement and find that the degree of contract completeness reflects the characteristics of the transaction, and in particular the trade-off between contracting costs (in the spirit of Williamson, 1979) and better incentives or less costly renegotiation. Contracts tended to provide more flexible price adjustments as technological uncertainty increased. They interpret this finding as a response to the increase in contracting costs that greater uncertainty may generate (as it does for us project complexity); the same finding is however also consistent with our prediction that greater uncertainty raises the benefit of more efficient risk sharing provisions.

6 The Choice Between Complete and Incomplete Contracts with a Corrupt Public Official

In practice, public institutions can be highly corrupt, with corruption present at different levels of the chain of command. Corruption in PPP contracts has been widely recorded (see e.g. Wren-Lewis, 2011, and Auriol and Straub, 2011). In Europe, concerns of such corruption have been emphasized (see European Parliament, 2012) and lead to new rules on transparency of contractual clauses in public procurement contracts.

To take into account the possibility of corruption in our model, we now remove the assumption that PO and PA share the same objectives. We allow for the possibility that PO may favor the contractor when negotiating contract terms. As we shall see, this discretion

²⁷It is easy to show that, up to a term of second order, z^{nv} increases with $\Delta\theta$ when $\Delta\theta$ is small enough. Indeed, a simple Taylor expansion yields:

$$\frac{\partial z^{nv}}{\partial \Delta\theta} = r\nu(1 - \nu)\Delta\theta (\beta_{\infty}^{nv} - \beta^{nv}(\theta)) > 0.$$

that is delegated to *PO* may create agency costs and distort contractual arrangements when preferences of different layers of the government differ.

6.1 *PO's* Preferences and the Stake For Corruption

We have seen in the previous section that for z sufficiently high, an incomplete contract is optimal, whilst for z small enough the benefits of better insurance and higher incentives that the complete contract provides justifies incurring contracting costs. However, when *PO* has preferences which are not aligned with those of *PA*, he may receive a bribe from the contractor in order to bias the selection towards one contracting mode over the other. We will model such corruption with a simple reduced form. *PO* now gives also an extra weight $\gamma \in [0, 1)$ on the firm's payoff in state θ in his objective function.²⁸ Formally, *PO's* payoff under complete contracting can be written as:

$$E_{\theta, \zeta}((1 - \beta(\theta))R - \alpha(\theta)) - z + \gamma E_{\theta}(U(\theta)) = \mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - z - (1 - \gamma)\mathcal{V} + \gamma\varphi(\Delta\theta\beta(\underline{\theta}))$$

where we have taken care of the fact that under complete contracting,

$$\mathcal{V} = E_{\theta}(U(\theta)) - \varphi(\Delta\theta\beta(\underline{\theta})).$$

Instead, *PO's* payoff under incomplete contracting becomes:

$$E_{\theta, \zeta}((1 - \beta_{\infty})R - \alpha_{\infty}) + \gamma E_{\theta}(U_{\infty}(\theta)) = \mathcal{W}(\beta_{\infty}, \beta_{\infty}) - (1 - \gamma)\mathcal{V}_{\infty} + \gamma\varphi(\Delta\theta\beta_{\infty})$$

where now

$$\mathcal{V}_{\infty} = E_{\theta}(U_{\infty}^{nv}(\theta)) - \varphi(\Delta\theta\beta_{\infty}).$$

To evaluate *PO's* incentives to choose between complete and incomplete contracting, let us suppose in a first pass that the optimal contractual arrangements found in Proposition 4 are still offered even if *PO* is corrupt. We are interested in finding conditions under which such biased *PO* might still choose to write a complete contract. As a preliminary step, observe that the comparison of (12) and (16) and the fact that φ is strictly increasing on its positive domain altogether imply that $\beta_{\infty}^{nv} > \beta^{nv}(\underline{\theta})$. It immediately follows that:

$$\varphi(\Delta\theta\beta^{nv}(\underline{\theta})) < \varphi(\Delta\theta\beta_{\infty}^{nv}).$$

Under incomplete contracting, the risk left on the contractor is greater than under complete contracting, and the risk premium needed to ensure his participation is thus also higher. *PO* now chooses a complete contract when:

$$z \leq z^* = \mathcal{W}(\beta^{mh}, \beta^{nv}(\underline{\theta})) - \mathcal{W}_{\infty}(\beta_{\infty}) + \gamma(\varphi(\Delta\theta\beta^{nv}(\underline{\theta})) - \varphi(\Delta\theta\beta_{\infty}^{nv}))$$

²⁸For some micro-foundations, see the Appendix.

$$= z^{nv} + \gamma(\varphi(\Delta\theta\beta^{nv}(\underline{\theta})) - \varphi(\Delta\theta\beta_{\infty}^{nv})) < z^{nv}.$$

The pro-firm PO has thus a bias towards choosing an incomplete contract too often compared to what a benevolent PO (or the PA himself) would do.

We now turn to the more general scenario where the revenue sharing rules $(\beta_{\infty}, \beta(\underline{\theta}), \beta(\bar{\theta}))$, the corresponding risk premia $(\varphi(\Delta\theta\beta(\underline{\theta})), \varphi(\Delta\theta\beta_{\infty}))$ and the payoffs $(\mathcal{V}, \mathcal{V}_{\infty})$ that are proposed to the contractor are arbitrary. A biased PO chooses to implement a complete contract when $z \leq z^*$ where:

$$z^* = \mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - (1 - \gamma)\mathcal{V} - (\mathcal{W}(\beta_{\infty}, \beta_{\infty}) - (1 - \gamma)\mathcal{V}_{\infty}) + \gamma(\varphi(\Delta\theta\beta(\underline{\theta})) - \varphi(\Delta\theta\beta_{\infty})). \quad (21)$$

PO chooses a complete contract if the gains in expected surplus net of contracting costs outweighs the benefits of a greater risk premium under incomplete contracting. He chooses an incomplete contract otherwise. Constraint (21) can be viewed as a pure moral hazard constraint characterizing how a biased PO modifies contractual modes.

A comment on communication mechanisms and optimal delegation. Our analysis focuses on the case where the choice between incomplete and complete contracting is always delegated to PO . An alternative would be for PA to always choose between the two contracting modes by himself upfront even if he has no precise knowledge of contracting costs at the time of doing so. This would mean committing ex ante either to always implement a complete contract or to always focus on an incomplete contract irrespective of the realized contracting costs.²⁹ In full generality, PA could also commit to a mechanism that, on top of the requested revenue sharing parameters for both complete and incomplete contracts, would also stipulate a probability $x(\hat{z})$ of implementing a complete contract as a function of PO 's report on the contracting costs z he has observed.³⁰ This delegation mechanism is certainly in line with Holmström (1984) and the more recent literature on mechanism design in the absence of monetary transfers (Melumad and Shibano 1991, Alonso and Matoushek 2008, and Martimort and Semenov 2006 among others). Following the machinery developed by that literature, incentive compatibility for PO requires:

$$z \in \arg \max_{\hat{z} \geq 0} x(\hat{z})(\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - z - (1 - \gamma)\mathcal{V} + \gamma\varphi(\Delta\theta\beta(\underline{\theta}))) \\ + (1 - x(\hat{z}))(\mathcal{W}(\beta_{\infty}, \beta_{\infty}) - (1 - \gamma)\mathcal{V}_{\infty} + \gamma\varphi(\Delta\theta\beta_{\infty})).$$

Simple revealed preferences arguments immediately show that $x(z)$ is weakly decreasing in z and thus almost everywhere differentiable. If there is a discontinuity point, say z^* , with x_0 and x_1 being respectively the left- and the right limits of $x(z)$ at z^* , those constants must

²⁹The implicit assumption here is that those costs may be ex post observable although not verifiable; a standard assumption in the incomplete contracts literature.

³⁰It can be easily checked that there is no benefits for PA to make the revenue sharing parameters depend on PO 's announcement \hat{z} .

satisfy the monotonicity requirement $x_0 \leq x_1$, the payoff must be continuous. Necessarily the only possibility for z^* is thus that it satisfies (21). At any point of differentiability z , i.e., on the right and the left of z^* , incentive compatibility amounts to:

$$\dot{x}(z)(\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - z - (1 - \gamma)\mathcal{V} - (\mathcal{W}(\beta_\infty, \beta_\infty) - (1 - \gamma)\mathcal{V}_\infty) + \gamma(\varphi(\Delta\theta\beta(\underline{\theta})) - \varphi(\Delta\theta\beta_\infty))) = 0.$$

From this, it follows that $x(z)$ is constant on the intervals $[0, z^*)$ and $(z^*, +\infty]$.

Finally, observe that the principal's objective being linear in the probability $x(z)$, the optimal mechanism with non-trivial delegation (i.e., where PA does not keep full control on contractual choice) should necessarily have x_0 and x_1 being corner solutions:

$$0 = x_0 < x_1 = 1.$$

This is precisely the property satisfied when the choice of the degree of incompleteness is delegated to PO who follows the cut-off rule (21).

6.2 Optimal Contracts and Levels of Incompleteness under Corruption

When the contractual choice is delegated to a biased PO , the contracting problem may be rewritten as:

$$(\mathcal{P}^{co}) : \max_{(z^*, \beta_\infty, \beta(\underline{\theta}), \beta(\bar{\theta}), \mathcal{V}, \mathcal{V}_\infty)} \int_0^{z^*} (\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - z) dG(z) + (1 - G(z^*)) (\mathcal{W}(\beta_\infty, \beta_\infty) - \mathcal{V}_\infty)$$

subject to the cut-off condition (21) and the contractor's participation constraints with either complete or incomplete contracting.

Remember that (21) defines a decision rule that is not ex post optimal from PA 's viewpoint since it favors too much the choice of an incomplete contract. When facing such distortion, PA has two options: First, he could choose to leave different contractual options as they are, and simply accept that an incomplete contract will be selected too often. Second, he may choose to modify the shape of those options so as to affect indirectly the choice of PO as to which contract applies, making the complete contracting mode more attractive.

Of course, the optimal institutional response to the corrupt behavior of PO mixes all those elements. The following Proposition derives the optimal contracting package in this environment with corruption. To get clear results and ensure quasi-concavity of the problem despite it is highly nonlinear, we consider the case where the bias γ is not too large.

Proposition 5 *Assume that γ is not too large. The presence of corruption has three different effects on the optimal contractual arrangement.*

1. *Conditionally on the revenue sharing rules $(\beta^{co}(\bar{\theta}), \beta^{co}(\underline{\theta}), \beta_\infty^{co})$ offered under both contracting modes, the incomplete contract remains chosen too often, i.e., when $z \geq z^{co}$, where:³¹*

$$z^{co} \leq \mathcal{W}(\beta^{co}(\bar{\theta}), \beta^{co}(\underline{\theta})) - \mathcal{W}(\beta_\infty^{co}, \beta_\infty^{co}). \quad (22)$$

³¹The superscript *co* stands for *corruption*.

2. The complete contract option is modified so that the contractor now bears more revenue risk when a negative revenue shock hits:

$$\beta^{nv}(\underline{\theta}) \leq \beta^{co}(\underline{\theta}) \leq \beta^{co}(\bar{\theta}) = \beta^{mh}. \quad (23)$$

3. The incomplete contract option is also modified so that the contractor now bears less revenue risk:

$$\beta_{\infty}^{nv} \geq \beta_{\infty}^{co} \geq \beta^{co}(\underline{\theta}).$$

The contracts designed for the case of a benevolent PO are now no longer optimal, as they would induce a biased PO to select an incomplete contract too often. The optimal contractual arrangement now trades off the agency costs of delegated contracting with the agency costs of delegated public service provision. The design of the complete and incomplete options reduce the distortion in the decision rule followed by PO but it is now at the cost of introducing new distortions in the contractual options offered to the contractor.

The main features of the optimal contractual arrangement that result from this trade-off can be best understood by inspecting the decision rule (21). Indeed, the excessive bias of the PO towards incomplete contracting can be countered by making the contractor's contracts under both scenarios more similar in terms of the risk borne. This in turn is obtained by increasing the risk premium $\varphi(\Delta\theta\beta(\underline{\theta}))$ under complete contracting while also reducing its value $\varphi(\Delta\theta\beta_{\infty})$ under incomplete contracting. More risk is thus borne with a complete contract when a bad shock hits and less risk is borne with an incomplete one independently of the shock realization.

This reduced difference between the two contractual choices lowers altogether the discretion allowed to the PO . In this sense it provides a rationale for a widely spread practice in PPP projects, which is to provide national guidelines on contractual clauses or even, to design centrally standardized contract terms that are then implemented locally, with minor variations. We shall come back to this point below.

Yet, even when the optimal response to the threat of corruption has been taken into account, the optimal decision rule remains excessively biased towards incomplete contracting even though this bias is now mitigated. In a sense, the choice between complete and incomplete contracting is obtained as a compromise between the preferences of PA and PO .

To better understand the nature of the distortions needed under the threat of corruption, we now provide a number of instructive comparative statics. To simplify those comparative statics and get nice results (that might nevertheless hold under broader circumstances), we proceed in the limiting case where both γ and $\Delta\theta$ are small enough.

Proposition 6 *Suppose that γ and $\Delta\theta$ are small enough. Up to terms of higher-order magnitude, we have the following approximation:*

$$z^{nv} - z^{co} = \frac{\gamma r^2 \nu^3 (1 - \nu)}{(1 + r\sigma^2)^2} \Delta\theta^4. \quad (24)$$

The cost of corruption, in the sense of $z^{nv} - z^{co}$ being higher (i.e., a greater bias towards incomplete contracting with a non-benevolent *PO*), will be greater with:

1. a greater degree of risk aversion r ,
2. more uncertainty at operational stage ($\Delta\theta$ greater),
3. weaker institutions (γ greater).

More uncertainty or a greater risk aversion are two factors which necessitate to raise the risk premium left to the contractor to induce his participation. But such shifts in parameters also enlarge the difference in those premia between the complete and the incomplete contracting scenarios. It thus becomes more attractive for the biased *PO* to distort his decision in favor of incomplete contracting. The optimal institutional response exhibits a similar bias.

In practice, uncertainty might be significant for projects with volatile demand, such as transport projects in areas that were not previously served by the transport service, or more in general for projects of higher contractual value, such as those for tunnels, motorways, waste management, or energy, as these are typically more complex. In those cases, we thus expect that contracts are more likely to be left incomplete and corruption stakes to be significant.

To the extent that small and medium size companies (SMEs) are less able to diversify risks than larger corporations and thus may be considered as having a greater risk aversion, our result also suggests that we should observe more incomplete contracts in sectors where contractual stakes represent a significant share of the contractor's activities.

It is well known that renegotiation of contract terms opens the door to contractual agreements that favors private interests. There exists indeed ample evidence that corruption explained the widespread use of post-contractual renegotiations in Latin America concessions (Guasch, 2004, Guasch and Straub, 2009). Corruption is not the only channel by which non-benevolent policy-makers may influence renegotiation. Engel, Fisher and Galetovic (2009) discuss evidence from Chilean renegotiations of PPP contracts, and argue that governments had incentives to renegotiate PPP contracts and elude spending limits to favor their re-election of current governments.³² Our analysis is somewhat complementary to that line of research since we show that corruption may also have a role at the *ex ante* stage when parties decide how detailed their agreements should be. Weak institutions which are more prone to corruption may also be associated with incomplete deals. Because those incomplete deals are also the most likely to be renegotiated, the impact of corruption on contract design and economic performances is likely to be even more significant than suggested by the earlier literature that focused only on its *ex post* role.

³²Awareness of this risk was a key justification for enforcing regulations which limit renegotiations, such as the limits on the percentage of the contract value that can be renegotiated.

We have been silent on whether decentralization of contracting (PO chooses contract terms knowing contracting costs) is actually optimal. Decentralization allows to use local information (z), not available centrally, but at the risk of abuse of power. Centralization implies more national control but less use of local information. We can therefore think of centralization as the case where the PA chooses contract terms without information on contracting costs; she will either always use a complete contract or an incomplete contract, depending on which one is highest. In particular, the PA will use a complete contract if and only if:

$$\mathcal{W}(\beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta})) - Ez > \mathcal{W}(\beta_{\infty}^{nv}, \beta_{\infty}^{nv}).$$

When PO is benevolent, a revealed preference argument shows that decentralization is preferred to centralization. A benevolent PO has the same interest as the PA and will therefore condition the contract on the local information on z in an optimal way. As the PO uses the threshold z^{nv} to make his contractual choice, then decentralization of contracting is preferred to adopting rigid national contracts.

When the PO is nonbenevolent, instead, the divergence of interests between PO and PA implies that decentralization now comes at a cost of biased contract decisions. We show in the Appendix however that the benefit of decentralization will remain, provided risk aversion and or uncertainty are sufficiently low and institutions are not too weak (γ small). In this case, the difference in cutoff rules ($z^{nv} - z^{co}$) is small, as suggested by Proposition 6.³³ We state this result formally below.

Corollary 1 *Suppose that γ and $\Delta\theta$ are small enough. A sufficient condition for delegation of contracting to remain optimal is that there is low uncertainty at operational stage ($\Delta\theta$ small) or risk aversion (r) is small or institutions are not too weak (γ).*

An implication of Propositions 5 and 6 and Corollary 1 is that, under those conditions, whilst the central authority should reduce the discretion of the PO by designing centrally standardized contracts that follow specific guidelines, eliminating discretion altogether is suboptimal: Some discretion on contractual clauses should be left to local PO .

7 Conclusion

This paper presents a theory that links the degree of incompleteness of contracting arrangements with the degree of corruption of public officials in charge of crafting those contracts. Our paper predicts that incomplete contracts may be chosen too often when institutions are weak, because of the high risk premium they generate. Fighting corruption requires

³³This role of institutions is in line with the insights of the political science literature, the “Ally Principle”, according to which more delegation to better informed lower tiers would occur when corruption is less of a concern. See Epstein and O’Halloran (1999), Bendor and Meirowitz (2004) and Huber and Shipan (2006) among others.

to decrease the discretion of contracting authorities by making greater use of centrally determined guidelines on contracts, or even standardized contracts designed centrally and applied locally, as the ones used in the UK or by the World Bank.

Several issues have been left out of our analysis and would deserve further analysis.

First, this paper has been silent on whether the central authority may be corrupted. This is a standard assumption in the incentive theory approach to corruption, although it is clear that corruption may indeed occur also at central level. In practice, institutions in place at a given point in time can be highly corrupted, with corruption present at different levels of the hierarchy. This is the "grabbing end of corruption" discussed by Shleifer and Vishney (1993). Comparing centralization and decentralization of contracting in such scenario could be an interesting topic of further research.

Second, we have also been silent on the exact institutional contexts surrounding contracting. In particular, our analysis does not make any explicit distinction between the concession model (where users pay) and the Private Finance Initiative (PFI) model (where the contractor recoups his revenues from the government since users do not pay). It would be interesting to explore the different costs of corruption in PFI models as in concession contracts. In the PFI model, the compensation paid to the contractor takes the form of an increase in the unitary payment paid by the authority which is financed through public funds. In the concession scenario, which are self-financed, the compensation paid to the contractor takes the form of an increase in users' fees which is financed by users. Being the users the residual claimant of the tariff increase, the concession contracts will typically receive more ex post monitoring than the PFI model, making the deal more transparent.³⁴ Since transparency helps monitoring, it is reasonable to expect that concession contracts will suffer less from post-tendering corruption than PFI contracts. This insight however needs further investigation.

Third, more works should be devoted to the analysis of contracting costs. In this paper, we have focused on the costs of verifying messages over non-verifiable states of nature but other costs which may be related to the difficulties in foreseeing those contingencies, in processing information or related to bounded rationality considerations could be introduced. In the absence of any theoretical headways that could help modeling those directions, we believe that our simple approach already brings much information on the choice between complete and incomplete contracting and that its lessons are likely to be robust to other specifications. Lastly, we have taken a reduced form approach when assuming that only one contingency may realize. In practice, projects may be of different degrees of complexity and more complex projects may entail more relevant contingencies. Studying which contingency should be specified in the contract and which should not, taking into account of the contracting costs of different contingencies and the overall risk of corruption, may constitute an interesting alley for further research.

³⁴For a similar point in the context of privatization, see Martimort and Straub (2009).

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Appendix

Proof of Proposition 1. The principal's expected payoff can be written as:

$$E_{\theta, \zeta} (1 - \beta(\theta))(R_0 + e(\theta) + \theta + \zeta) - \alpha(\theta) = E_{\theta} \left(\beta(\theta) - \frac{(1 + r\sigma^2)}{2} \beta^2(\theta) - U(\theta) \right). \quad (A1)$$

When θ is verifiable, the optimal contract maximizes the above expression subject to the contractor's participation constraint:

$$\nu v(U(\bar{\theta})) + (1 - \nu)v(U(\underline{\theta})) \geq 0. \quad (A2)$$

It is clearly optimal to have full insurance and fully extract the contractor's ex ante payoff so as to get (5). This is obtained by means of a fixed fee $\alpha^{mh}(\theta)$ tailored to the realization of θ so that

$$\alpha^{mh}(\theta) + \beta^{mh}\theta + \frac{(\beta^{mh})^2}{2} = 0.$$

The first-order optimality condition with respect to $\beta(\theta)$ then yields the revenues sharing rule (6) and the optimal effort (7). ■

Proof of Lemma 1. The contractor's expected utility can be written as:

$$v(\mathcal{V}) = E_{\theta}(v(U(\theta))).$$

The risk premium φ is then defined as

$$\mathcal{V} = E_{\theta}(U(\theta)) - \varphi$$

or putting things differently, using the CARA specification, as

$$\exp(-r(E_{\theta}(U(\theta)) - \varphi)) = E_{\theta}(\exp(-rU(\theta))).$$

Simplifying yields:

$$\exp(-r(\nu\Delta U - \varphi)) = 1 - \nu + \nu \exp(-r\Delta U)$$

where $\Delta U = U(\bar{\theta}) - U(\underline{\theta})$. Taking logarithms of both sides, we finally obtain:

$$\varphi(\Delta U) = \nu\Delta U + \frac{1}{r} \ln(1 - \nu + \nu \exp(-r\Delta U)). \quad (A3)$$

with

$$\varphi'(\Delta U) = \frac{\nu(1-\nu)(1-\exp(-r\Delta U))}{1-\nu+\nu\exp(-r\Delta U)} > 0.$$

Finally, the expression of the risk premium given in (10) follows from inserting the value of ΔU obtained when the incentive constraint (9) is binding. ■

Proof of Proposition 2. First, we may write the principal's problem in full generality as:

$$(\mathcal{P}'_0) : \max_{(\beta(\theta), U(\theta), \mathcal{V})} E_\theta \left(\beta(\theta) - \frac{(1+r\sigma^2)}{2} \beta^2(\theta) - U(\theta) \right) \text{ subject to (9) and} \\ \mathcal{V} \geq 0 \quad (\text{A4})$$

where, using the CARA specification and following steps in Lemma 1, we have

$$\mathcal{V} = E_\theta(U(\theta)) - \varphi(\Delta U)$$

and where $\varphi(\Delta U)$ is defined as in (A3). Inserting into the maximand of (\mathcal{P}'_0) , we get:

$$(\mathcal{P}'_0) : \max_{(\beta(\theta), U(\theta), \mathcal{V})} E_\theta \left(\beta(\theta) - \frac{(1+r\sigma^2)}{2} \beta^2(\theta) \right) - \mathcal{V} - \varphi(\Delta U) \text{ subject to (9) and (A4).}$$

Observing now that $\varphi' > 0$, (9) is thus necessarily binding. The principal's problem can thus be **rewritten as**:

$$(\mathcal{P}_0) : \max_{(\beta(\bar{\theta}), \beta(\underline{\theta}), \mathcal{V})} \mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} \text{ subject to (A4).}$$

Maximizing (\mathcal{P}_0) is then immediate. Of course (A4) is binding at the optimum. Pointwise optimization of the strictly concave function $\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta}))$ with respect to each of its argument respectively gives us the first-order conditions $\beta^{nv}(\bar{\theta}) = \beta^{mh}$, and (12). Observe that the right-hand side of (12) is a decreasing function of $\beta^{nv}(\underline{\theta})$ while the right-hand side is decreasing with a unique solution in $[0, 1]$. ■

Proof of Proposition 3. Following the same steps as in the previous proof, the principal's maximization problem can then be written as:

$$(\mathcal{P}'_\infty) : \max_{(\beta_\infty, U_\infty(\theta), \mathcal{V}_\infty)} \beta_\infty - \frac{(1+r\sigma^2)}{2} \beta_\infty^2 - \mathcal{V}_\infty - \varphi(\Delta U_\infty) \text{ subject to (13) and} \\ \mathcal{V}_\infty \geq 0. \quad (\text{A5})$$

which can be simplified into

$$(\mathcal{P}_\infty) : \max_{\beta_\infty, \mathcal{V}_\infty} \mathcal{W}(\beta_\infty, \beta_\infty) - \mathcal{V}_\infty \text{ subject to (A5).}$$

Clearly, the contractor's participation constraint (A5) is binding at the optimum. The first-order optimality condition for β_∞ then yields (16). Observe that the right-hand side of (16) is a decreasing function of $\beta^{nv}(\underline{\theta})$ while the right-hand side is decreasing with a unique solution in $[0, 1]$. Lastly, observe that

$$\beta_\infty^{nv} > \beta_\infty^{mh} \left(1 - \frac{\Delta\theta}{1-\nu} \varphi'(\Delta\theta\beta_\infty^{nv}) \right).$$

It thus follows from the quasi-concavity of the objective function under complete contracting that

$$\beta_{\infty}^{nv} > \beta^{nv}(\underline{\theta})$$

so that the risk premium under incomplete contracting is greater than under complete contracting. Observe also that $\beta_{\infty}^{nv} < \beta^{mh}$, so that we finally obtain the comparative statics (15). ■

Proof of Proposition 4. Now, consider (\mathcal{P}) where incentive constraint (18) is omitted. Observe that both (A4) and (A5) are necessarily binding at the optimum of such problem so that

$$\mathcal{V} = \mathcal{V}_{\infty} = 0. \quad (\text{A6})$$

Inserting into the maximand and optimizing with respect to z yields the optimality condition (1) which is the same as (18) written for $\mathcal{V} = \mathcal{V}_{\infty} = 0$ so that the condition (18) could indeed be omitted. Finally, Item 2. immediately follows from pointwise optimization. ■

Micro-foundations for PO 's preferences. Suppose that PO and the contractor share perfect knowledge on the realization of θ with some probability q . More precisely, with such probability PO receives at the interim stage hard evidence, $\sigma = \text{"}\theta\text{"}$, stipulating that he will observe the shock θ (whatever its value) when that shock will realize later on. Under those circumstances, information sharing triggers collusive behavior between the contractor and PO . With probability $1 - q$, there is no such informative signal (i.e., $\sigma = \emptyset$) and there won't be any information sharing with the firm. Collusion is not possible under that scenario. If PO does not collude with the contractor, he reports to the principal the realization of the shock when it realizes.

Although the basic sharing rule agreement (say $\{(\alpha(\theta), \beta(\theta))\}_{\theta \in \Theta}$ for a complete contract and $(\alpha_{\infty}, \beta_{\infty})$ for an incomplete one) is not a priori contingent on σ , a system of state-dependent fees can be readjusted to provide full insurance in case an in case PO reports $\sigma = \text{"}\theta\text{"}$ at the interim stage. Those new fees are designed so as to extract the contractor's surplus, so that $U(\theta) = 0$, although the parameter $\beta(\theta)$ or β_{∞} depending on the contracting scenario remains unchanged.

PO cares on both PA 's objective and the possible gains from collusion he may pocket from adopting a collusive behavior. To illustrate, PO 's payoff with a complete contract had any been signed can be expressed as:

$$E_{\theta, \zeta}((1 - \beta(\theta))R - \alpha(\theta)) - z + qkE_{\theta}(\tau(\theta)) = \mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - z - \mathcal{V} + qkE_{\theta}(\tau(\theta))$$

where the parameter $k < 1$ captures the cost of transferring bribes.³⁵ Of course, a similar expression applies with an incomplete contract.

With a complete contract, a collusive deal stipulates bribes $(\tau(\underline{\theta}), \tau(\bar{\theta}))$ which maximize PO 's expected utility subject to the constraint that the contractor's expected payoff from accepting the bribes are greater than zero (we assume that the contractor cannot be rewarded for denouncing a

³⁵Those costs might include the cost that the contractor may bear in organizing corruptible activities, the fact that side-contracts are not easily enforceable (on this issue see Tirole 1992, and Martimort 1999), the risk of being caught for briberies, or the psychological costs that PO may incur when being involved in some illegal activities as in Khalil and Lawarrée, 2006).

rogue deal). Still to illustrate, PO obtains a gains from colluding when a complete contract is offered that is worth:

$$\max_{(\tau(\underline{\theta}), \tau(\bar{\theta}))} kE_{\theta}(\tau(\theta)) \text{ subject to } E_{\theta}(v(U(\theta)) - \tau(\theta)) \geq 0.$$

This side-contract gives full insurance to the contractor. The public official extracts the whole stake from corruption, and obtains an expected benefit from corruption worth:

$$kE_{\theta}(U(\theta)).$$

Taking $\gamma = kq < 1$ and inserting into PO 's objective, we get an overall expression of that objective as stipulated in the text. ■

Proof of Proposition 5. After integrating by parts, we may rewrite the maximand of (\mathcal{P}^{co}) as:

$$G(z^*) (\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - (\mathcal{W}(\beta_{\infty}, \beta_{\infty}) - \mathcal{V}_{\infty}) - z^*) + \int_0^{z^*} G(z) dz + \mathcal{W}(\beta_{\infty}, \beta_{\infty}) - \mathcal{V}_{\infty}.$$

Optimal degree of incompleteness. Let us first fix the revenues sharing rules $(\beta(\bar{\theta}), \beta(\underline{\theta}))$ and β_{∞} under both contracting modes. The maximization problem so obtained is linear in $(\mathcal{V}, \mathcal{V}_{\infty})$ and the maximand is strictly quasi-concave in z^* when $G(z)/g(z)$ is increasing in z . Denoting respectively by $\mu \geq 0$, $\mu_{\infty} \geq 0$ and λ the Lagrange multipliers for (A4), (A5) and (21), we write the Lagrangean for this problem as:

$$\begin{aligned} & \mathcal{L}(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_{\infty}, z^*, \mathcal{V}, \mathcal{V}_{\infty}, \lambda, \mu, \mu_{\infty}) \\ &= G(z^*) (\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - (\mathcal{W}(\beta_{\infty}, \beta_{\infty}) - \mathcal{V}_{\infty}) - z^*) + \int_0^{z^*} G(z) dz \\ & \quad + \mathcal{W}(\beta_{\infty}, \beta_{\infty}) - \mathcal{V}_{\infty} \\ & + \lambda (\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - (1 - \gamma)\mathcal{V} - (\mathcal{W}(\beta_{\infty}, \beta_{\infty}) - (1 - \gamma)\mathcal{V}_{\infty}) + \gamma (\varphi(\Delta\theta\beta(\underline{\theta})) - \varphi(\Delta\theta\beta_{\infty})) - z^*) \\ & \quad + \mu\mathcal{V} + \mu_{\infty}\mathcal{V}_{\infty}. \end{aligned}$$

From the remarks above, this Lagrangean is quasi-concave in $(z^*, \mathcal{V}, \mathcal{V}_{\infty})$. The Karush-Khun Tucker (necessary and sufficient) conditions for optimality with respect to z^* , \mathcal{V} , and \mathcal{V}_{∞} can then be written respectively as:

$$\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - (\mathcal{W}(\beta_{\infty}, \beta_{\infty}) - \mathcal{V}_{\infty}) - z^* = \frac{\lambda}{g(z^*)}, \quad (\text{A7})$$

$$\mu = G(z^*) + \lambda(1 - \gamma), \quad (\text{A8})$$

$$\mu_{\infty} = 1 - G(z^*) - \lambda(1 - \gamma). \quad (\text{A9})$$

We consider (and will find conditions below such that) cases where (A4) and (A5) are both binding. It implies

$$\mathcal{V}^{co} = \mathcal{V}_{\infty}^{co} = 0. \quad (\text{A10})$$

which gives

$$G(z^*) + \lambda(1 - \gamma) \geq 0 \Leftrightarrow G(z^*) + \lambda \geq \gamma\lambda, \quad (\text{A11})$$

and

$$1 - G(z^*) - \lambda(1 - \gamma) \geq 0 \Leftrightarrow 1 - G(z^*) - \lambda \geq -\gamma\lambda. \quad (\text{A12})$$

Inserting (A10) into (A7), using (21) and simplifying, we obtain:

$$\frac{\lambda}{g(z^*)} = \gamma (\varphi(\Delta\theta\beta_\infty) - \varphi(\Delta\theta\beta(\underline{\theta}))). \quad (\text{A13})$$

Observe that $\lambda \geq 0$ when $\gamma \geq 0$ and

$$\beta_\infty \geq \beta(\underline{\theta}). \quad (\text{A14})$$

We will come back on this condition below. Inserting $\lambda \geq 0$ into (A7) and again taking into account (A10) yields:

$$\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{W}(\beta_\infty, \beta_\infty) \geq z^* \quad (\text{A15})$$

which gives us (22) for the optimal sharing rules that are defined below in more details. For further references, we define $z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)$ as the solution (unique from strict quasi-concavity) of the optimization problem with fixed $(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)$.

Optimal revenue sharing rules. We now turn to the analysis of these optimal sharing rules. We define the maximized value of PA 's problem $\mathcal{L}^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)$ as:

$$\begin{aligned} & \mathcal{L}^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty) \\ &= G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) (\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - (\mathcal{W}(\beta_\infty, \beta_\infty) - \mathcal{V}_\infty) - z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) \\ & \quad + \int_0^{z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)} G(z) dz + \mathcal{W}(\beta_\infty, \beta_\infty) - \mathcal{V}_\infty. \end{aligned}$$

Observe that this objective is strictly quasi-concave in $(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)$ at $\gamma = 0$ and that it remains so when γ is small enough as assumed. Denoting now

$$\lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty) =$$

$$g(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) (\mathcal{W}(\beta(\bar{\theta}), \beta(\underline{\theta})) - \mathcal{V} - (\mathcal{W}(\beta_\infty, \beta_\infty) - \mathcal{V}_\infty) - z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)), \quad (\text{A16})$$

we may write the necessary conditions for optimality of $\mathcal{L}^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)$ with respect to $\beta(\bar{\theta})$, $\beta(\underline{\theta})$ and β_∞ , respectively as:

$$(G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) + \lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) \frac{\partial \mathcal{W}}{\partial \beta(\bar{\theta})}(\beta(\bar{\theta}), \beta(\underline{\theta})) = 0, \quad (\text{A17})$$

$$(G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) + \lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) \frac{\partial \mathcal{W}}{\partial \beta(\underline{\theta})}(\beta(\bar{\theta}), \beta(\underline{\theta})) = -\lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty) \gamma \Delta\theta \varphi'(\Delta\theta\beta(\underline{\theta})), \quad (\text{A18})$$

and

$$\begin{aligned} & (1 - G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) + \lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) \left(\frac{\partial \mathcal{W}}{\partial \beta(\bar{\theta})}(\beta_\infty, \beta_\infty) + \frac{\partial \mathcal{W}}{\partial \beta(\underline{\theta})}(\beta_\infty, \beta_\infty) \right) \\ &= \lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty) \gamma \Delta\theta \varphi'(\Delta\theta\beta(\underline{\theta})). \end{aligned} \quad (\text{A19})$$

From (A17), it immediately follows that $\beta^{co}(\bar{\theta}) = \beta^{mh}$ as requested by (23).

From (A18), we also get:

$$(1 - \nu) \left(1 - \frac{\beta(\underline{\theta})}{\beta^{mh}} \right) - \Delta\theta \varphi'(\Delta\theta\beta(\underline{\theta})) = - \frac{\lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty) \gamma \Delta\theta \varphi'(\Delta\theta\beta(\underline{\theta}))}{G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) + \lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)}. \quad (\text{A20})$$

When $\lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty) > 0$ as requested when (A14) holds, the denominator on the right-hand side of (A21) is negative from (A11). Two implications follows. First, when evaluated at $\beta(\underline{\theta}) = \beta^{mh}$ the derivative of $\mathcal{L}^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)$ with respect to $\beta(\underline{\theta})$ is

$$-\frac{G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) + (1 - \gamma)\lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)}{G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) + \lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)} \Delta\theta\varphi'(\Delta\theta\beta(\underline{\theta})) \leq 0 \quad (\text{A21})$$

where we have used again (A11). From the quasi-concavity of $\mathcal{L}^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)$, we thus deduce that $\beta^{co}(\underline{\theta}) \leq \beta^{mh}$ as requested by (23). Second, we also have

$$(1 - \nu) \left(1 - \frac{\beta(\underline{\theta})}{\beta^{mh}}\right) - \Delta\theta\varphi'(\Delta\theta\beta(\underline{\theta})) \leq 0.$$

Using the quasi-concavity of the objective with a non-corrupt PO , it follows that $\beta^{co}(\underline{\theta}) \geq \beta^{nv}(\underline{\theta})$, again as requested by (23).

From (A19), we finally get:

$$1 - \frac{\beta_\infty}{\beta^{mh}} - \Delta\theta\varphi'(\Delta\theta\beta_\infty) = \frac{\lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)\gamma\Delta\theta\varphi'(\Delta\theta\beta_\infty)}{1 - G(z^*(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)) + \lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty)}. \quad (\text{A22})$$

When $\lambda(\beta(\bar{\theta}), \beta(\underline{\theta}), \beta_\infty) > 0$ as requested when (A14) holds, the denominator on the right-hand side of (A22) is positive from (A12) and thus:

$$1 - \frac{\beta_\infty}{\beta^{mh}} - \Delta\theta\varphi'(\Delta\theta\beta_\infty) \geq 0$$

Using the quasi-concavity of the objective with a non-corrupt PO , it follows that $\beta_\infty^{co} \leq \beta_\infty^{nv}$, again as requested by (23).

Condition on a non-negative multiplier. We now come back on condition (A14). Observe that, when γ is small enough, λ is close enough to zero from (A13). Then, z^{co} is close to $z^{nv} > 0$ so that conditions (A11) and (A12) both hold. $\beta^{co}(\underline{\theta})$ and β_∞^{co} are close to $\beta^{nv}(\underline{\theta})$ and β_∞^{nv} respectively. They thus satisfy (A14) and $\lambda \geq 0$ as requested. ■

Proof of Proposition 6. When γ is small enough, we immediately get from (A13) the following Taylor expansion for λ :

$$\lambda = \gamma g(z^{nv}) (\varphi(\Delta\theta\beta_\infty^{nv}) - \varphi(\Delta\theta\beta^{nv}(\underline{\theta}))) \varphi'(\Delta\theta\beta^{nv}(\underline{\theta})). \quad (\text{A23})$$

Inserting into (A21) and (A22) respectively gives us the following Taylor expansions:

$$\beta^{co}(\underline{\theta}) = \beta^{nv}(\underline{\theta}) + \frac{\beta^{mh}g(z^{nv})}{(1 - \nu)G(z^{nv})} \gamma^2 \Delta\theta (\varphi(\Delta\theta\beta_\infty^{nv}) - \varphi(\Delta\theta\beta^{nv}(\underline{\theta}))) \varphi'(\Delta\theta\beta^{nv}(\underline{\theta})); \quad (\text{A24})$$

$$\beta_\infty^{co} = \beta_\infty^{nv} - \frac{\beta^{mh}g(z^{nv})}{1 - G(z^{nv})} \gamma^2 \Delta\theta (\varphi(\Delta\theta\beta_\infty^{nv}) - \varphi(\Delta\theta\beta^{nv}(\underline{\theta}))) \varphi'(\Delta\theta\beta^{nv}(\underline{\theta})). \quad (\text{A25})$$

Hence, the differences $\beta^{co}(\underline{\theta}) - \beta^{nv}(\underline{\theta})$ and $\beta_\infty^{co} - \beta_\infty^{nv}$ are only of a second-order magnitude in γ . Inserting these findings into (21) gives us

$$z^{nv} - z^{co} = \gamma (\varphi(\Delta\theta\beta_\infty^{nv}) - \varphi(\Delta\theta\beta^{nv}(\underline{\theta}))). \quad (\text{A26})$$

Consider now $\Delta\theta$ small enough so that the risk premium for some arbitrary revenue sharing parameter β can be approximated as:

$$\varphi(\Delta\theta\beta) = \frac{r\nu(1-\nu)}{2}(\Delta\theta)^2\beta^2 \quad (\text{A27})$$

with

$$\varphi'(\Delta\theta\beta) = r\nu(1-\nu)\Delta\theta\beta. \quad (\text{A28})$$

Using, for $\Delta\theta$ small enough, the following approximations of $\beta^{nv}(\underline{\theta})$ and β_∞^{nv} can be respectively obtained from (12) and (16):

$$\beta^{nv}(\underline{\theta}) = \beta^{mh}(1 - r\nu(\Delta\theta)^2\beta^{mh}) \quad (\text{A29})$$

and

$$\beta_\infty^{nv} = \beta^{mh}(1 - r\nu(1-\nu)(\Delta\theta)^2\beta^{mh}). \quad (\text{A30})$$

Using (A27), (A29) and (A30), we get the following approximation:

$$\varphi(\Delta\theta\beta_\infty^{nv}) - \varphi(\Delta\theta\beta^{nv}(\underline{\theta})) = r^2\nu^3(1-\nu)(\Delta\theta)^4(\beta^{mh})^2 \quad (\text{A31})$$

Inserting into (A26), we finally obtain (24). Comparative statics immediately follow. \blacksquare

Proof of Corollary 1. Under centralization, expected welfare is given by the solution to

$$\max \{ \mathcal{W}(\beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta})) - E_z(z), \mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv}) \},$$

where $E_z(z) = \int_0^1 z dG(z)$. With a non-benevolent *PO* expected welfare under decentralization is:

$$EW^{co}(z^{co}, \beta^{co}(\bar{\theta}), \beta^{co}(\underline{\theta}), \beta_\infty^{co}) \equiv \int_0^{z^{co}} (\mathcal{W}(\beta^{co}(\bar{\theta}), \beta^{co}(\underline{\theta})) - z) dG(z) + (1 - G(z^{co}))\mathcal{W}(\beta_\infty^{co}, \beta_\infty^{co}),$$

which is greater than the expected welfare that is obtained if the optimal contracts for a benevolent *PO* are offered:

$$EW^{nv}(\hat{z}^{co}, \beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta}), \beta_\infty^{nv}) \equiv \int_0^{\hat{z}^{co}} (\mathcal{W}(\beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta})) - z) dG(z) + (1 - G(\hat{z}^{co}))\mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv})$$

where

$$\begin{aligned} \hat{z}^{co} &\equiv \mathcal{W}(\beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta})) - (\mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv})) + \gamma(\varphi(\Delta\theta\beta^{nv}(\underline{\theta})) - \varphi(\Delta\theta\beta_\infty^{nv})). \\ &= z^{nv} + \gamma(\varphi(\Delta\theta\beta^{nv}(\underline{\theta})) - \varphi(\Delta\theta\beta_\infty^{nv})) < z^{nv}. \end{aligned}$$

and, clearly

$$EW^{co}(z^{co}, \beta^{co}(\bar{\theta}), \beta^{co}(\underline{\theta}), \beta_\infty^{co}) > EW^{nv}(\hat{z}^{co}, \beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta}), \beta_\infty^{nv}).$$

A sufficient condition for decentralization to remain optimal when *PO* is non-benevolent is then

$$EW^{nv}(\hat{z}^{co}, \beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta}), \beta_\infty^{nv}) \geq \max \{ \mathcal{W}(\beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta})) - E_z(z), \mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv}) \}$$

Let

$$\mathcal{W}(\beta^{nv}(\bar{\theta}), \beta^{nv}(\underline{\theta})) - E_z < \mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv}) \quad (\text{A32})$$

which implies that $W(\beta_\infty^{nv}, \beta_\infty^{nv})$ is the standardized contract chosen under centralization. Under (A32), a sufficient condition for decentralization to remain optimal is thus:

$$\int_0^{\hat{z}^{co}} (\mathcal{W}(\beta_\infty^{nv}(\bar{\theta}), \beta_\infty^{nv}(\underline{\theta})) - z) dG(z) + (1 - G(\hat{z}^{co}))\mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv}) \geq \mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv})$$

or

$$(\mathcal{W}(\beta_\infty^{nv}(\bar{\theta}), \beta_\infty^{nv}(\underline{\theta})) - \mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv})) G(\hat{z}^{co}) \geq \int_0^{\hat{z}^{co}} z dG(z).$$

Using the definition of \hat{z}^{co} , we obtain:

$$z^{nv} G(\hat{z}^{co}) \geq \int_0^{\hat{z}^{co}} z dG(z)$$

or

$$\int_0^{\hat{z}^{co}} (z^{nv} - z) dG(z) \geq 0$$

which is satisfied since $\hat{z}^{co} < z^{nv}$.

Suppose now that (A32) does not hold and that therefore $\mathcal{W}(\beta_\infty^{nv}(\bar{\theta}), \beta_\infty^{nv}(\underline{\theta})) - E_z(z)$ is the optimal standardized contract. Then a sufficient condition for decentralization to be optimal is

$$\int_0^{\hat{z}^{co}} (\mathcal{W}(\beta_\infty^{nv}(\bar{\theta}), \beta_\infty^{nv}(\underline{\theta})) - z) dG(z) + (1 - G(\hat{z}^{co}))\mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv}) \geq \mathcal{W}(\beta_\infty^{nv}(\bar{\theta}), \beta_\infty^{nv}(\underline{\theta})) - E_z(z)$$

i.e.

$$\int_{\hat{z}^{co}}^1 z dG(z) \geq (1 - G(\hat{z}^{co})) [\mathcal{W}(\beta_\infty^{nv}(\bar{\theta}), \beta_\infty^{nv}(\underline{\theta})) - \mathcal{W}(\beta_\infty^{nv}, \beta_\infty^{nv})]$$

or

$$\int_{\hat{z}^{co}}^1 z dG(z) \geq (1 - G(\hat{z}^{co})) z^{nv} \int_{\hat{z}^{co}}^1 (z - z^{nv}) dG(z) \geq 0$$

which is satisfied for $z^{nv} - \hat{z}^{co}$ sufficiently low, that is for $\gamma(\varphi(\Delta\theta\beta_\infty^{nv}(\underline{\theta})) - \varphi(\Delta\theta\beta_\infty^{nv}))$ sufficiently low. The result then follows from Proposition 6, which suggests that for γ and $\Delta\theta$ small enough, up to terms of higher-order magnitude, we have the following approximation:

$$z^{nv} - \hat{z}^{co} \approx \frac{\gamma r^2 \nu^3 (1 - \nu)}{(1 + r\sigma^2)^2} \Delta\theta^4.$$

Thus the benefit of decentralization under corruption, will remain provided, risk aversion and or uncertainty are sufficiently low and institutions are not too weak. ■