The Interaction of Implicit and Explicit Contracts in Construction and Procurement Contracting

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Abstract

Recent empirical work on construction and procurement contracting finds that repeated interaction leads toward use of lower powered explicit contracts (e.g., cost-plus contracts instead of fixed-price contracts). I present a theoretical model of construction and procurement contracting that captures the trade-off between the flexibility of cost-plus contracts and the high-powered incentives of fixed-price contracts. I then analyze the effect of implicit contracting supported by repeated interaction on explicit contract choice to demonstrate a rigorous intuition for this empirical finding.

1 Introduction

Recent empirical work on construction and procurement contracting investigates the impact of repeated interaction on the choice between fixed-price and cost-plus contracts. The two papers that address this question most directly (Corts and Singh, 2004, and Kalnins and Mayer, 2004) both find that repeated interaction leads toward use of cost-plus contracts. I argue in this paper that this can be explained by an analysis that pays careful attention to the strengths and weaknesses of fixed-price and cost-plus contracts as the basis for implicit contracting sustained through repeated interaction.

The earlier literature on fixed-price and cost-plus contracting (Crocker and Reynolds, 1993, and Bajari and Tadelis, 2001) argues that the primary trade-off between these contract types is flexibility versus incentives. Fixed-price contracts provide strong cost-minimization incentives for the agent, but their inflexibility implies that the principal may incur recontracting or renegotiation costs if project modifications are desired and also that agents will find such contracts acceptable only if left some surplus to compensate for unforeseen contingencies. In contrast, cost-plus contracts provide flexibility, but create essentially no incentive for cost-minimization since the agent is fully reimbursed for its costs. The implication is that fixed-price contracts are optimal for projects where incentives are more important than flexibility, while cost-plus contracts are optimal when the opposite holds.

As Williamson (1975) observes, any complex contract such as a fixed-price construction or procurement contract is necessarily incomplete and requires mechanisms for adjusting contract terms

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ex post. The symmetry of information, the verifiability of information, and the presence or absence of repeated relationships, among other factors, determine whether a particular set of contracts and adjustment mechanisms enable efficient procurement. Chakravarty and MacLeod (2009) show that the change order mechanism used in the American Institute of Architects standard fixed price contract enables efficient procurement when costs of modifications are verifiable. I show in this paper that either cost-plus or fixed-price contracts can support (approximately) efficient procurement, even when both effort and the costs of modifications are unverifiable, as long as implicit contracting is powerful enough (i.e., as long as firms are patient enough or interact often enough). Even more importantly, I analyze the case in which implicit contracting is only a partial solution and efficient procurement is not possible, and I show how the presence of repeated contracting affects the choice between augmented cost-plus and fixed-price contracts.

Consider the effect of repeated interaction, which is not considered by the previous literature on fixed-price and cost-plus contracting. Suppose that repeated interaction facilitates implicit contracting on previously noncontractible variables by holding out the promise of further contracting in the future. One possibility is that the parties might use an "augmented cost-plus" contract in which an explicit cost-plus contract is paired with an implicit agreement to continue contracting only if the agent exerts sufficient effort. In this case, one might say that the principal is "trusting" the agent to work hard, while preserving flexibility through the explicit cost-plus contract, or that the principal is combining implicit incentives for effort with explicit incentives for fair bargaining. An alternative possibility is that the parties might use an "augmented fixed-price" contract in which an explicit fixed-price contract is paired with an implicit agreement to renegotiate for modifications at (some reasonable markup over) the agent's cost. In this case, one might say that the principal is "trusting" the agent to renegotiate fairly, or that the principal is combining implicit incentives for fair bargaining with explicit incentives for effort. This raises a seemingly simple question: as implicit contracting becomes stronger (because interactions are more frequent or the contracting parties are more patient), should the parties increasingly use fixed-price or cost-plus contracts? Put another way, as "trust" becomes more important, should the principal choose a contract that requires trusting the agent to work hard or a contract that requires trusting the agent to renegotiate fairly?

This question presents no immediate answer, though the empirical results described above suggest that, as repeated contracting becomes more important, the principal increasingly chooses to use a flexible cost-plus explicit contract and to trust the agent to work hard. The analysis in this paper gives a theoretical explanation for this result: such an augmented cost-plus contract maintains a more even balance between present deviation opportunities and the future value of the relationship than the alternative augmented fixed-price contract, and it is therefore cheaper to satisfy the agent's incentive constraint under the augmented cost-plus contract. Put differently, implicit incentives for effort are more effective than implicit incentives for fair bargaining because effort choice offers many frequent, small opportunities to deviate from the implicit agreement, which are not too costly to offset. In contrast, the renegotiation over project specification changes happens only infrequently, driving a wedge between present deviation opportunities and the future value of the relationship. When these infrequent opportunities arise they present a strong incentive to deviate, and satisfying the incentive constraint in these cases is very expensive. As a result, increases in the strength of implicit contracting (the frequency of interaction or the players' patience) may lead to a switch to cost-plus contracts in scenarios where the optimal one-shot contract is fixed-price.

This paper builds squarely on the existing literature on cost-plus and fixed-price contracts. The *explicit* contracting environment of this paper is similar to that of Bajari and Tadelis (2001) in that it combines incentive problems with the possibility of recontracting for modifications to project specifications. That paper suggests the optimality of these two extreme contract forms and describes their relative strengths and weaknesses. However, neither that paper nor any other theoretical treatment of cost-plus and fixed-price contracts models the use of these explicit contracts as a part of a repeated contracting relationship. The *implicit* contracting environment of this paper is similar to that of Baker, Gibbons, and Murphy (1994), who also focus on implicit contracting in the presence of explicit contracts, but who do not consider modifications to the project, fixed-price contracts, or the attendant recontracting problems. They analyze a standard agency model in which the only contracting problem is the provision of effort incentives and the explicit contract represents performance pay tied to imperfect measures of the agent's behavior. Not only is their setting very different, but their research question is quite different as well. They are interested in whether stronger explicit contracts (made possible through better monitoring) undermine or strengthen implicit contracts, and they find that both are possible. They find that strong explicit contracting may improve spot market transactions and eliminate rents from the continued relationship, reducing the incentive to adhere to an implicit contract. They also find that stronger explicit contracts may increase the value of the continued relationship, increasing the incentive to remain in a repeated contracting relationship. In contrast, I do not consider changes to the explicit contracting regime.

In some ways, the paper most closely related to the present paper is Baker, Gibbons, and Murphy (2002). That paper is quite different in its focus, as it examines how implicit contracting (which they call relational contracting) affects the choice of whether to vertically integrate, rather than how it affects the choice of contract form in an arm's-length relationship. However, the paper is closely related to the present paper in two ways. First, it examines the interaction between the strength of implicit contracting and a *dichotomous* choice about how the relationship is explicitly structured (albeit a make-or-buy choice rather than a contract-form choice). Second, that paper's extremes of integration and nonintegration share similarities with this paper's cost-plus and fixed-price contracts, respectively. Specifically, cost-plus contracts involve retention of control rights by the principal combined with low-powered explicit incentives, like integration. Fixed-price contracts involve delegation of some control rights to the agent combined with high-powered explicit incentives, like nonintegration. I discuss similarities and differences with their results in the body of the paper, after proving my results.

Section 2 presents the model and defines the basic contracts. Sections 3 presents the analysis of optimal one-shot explicit contracting, while section 4 analyzes repeated contracting. Section 5 concludes.

2 Model

A principal P contracts with an agent A, chosen from among many identical agents, for the completion of a project. There are two components of the cost of completing the project to specifications X: a verifiable cash cost S, which can be reduced through the agent's effort, and a nonverifiable cost of effort borne directly by the agent. Effort level $e \geq 0$ costs the agent $\frac{e^2}{2}$. Effort is not verifiable, but it is observable to the principal with a lag; in a repeated contracting setting, the principal perfectly observes the effort level from the previous period prior to contracting for the current period.

Effort is only sometimes effective in reducing cash costs. With probability γ, effort e translates into effective effort $\widehat{e} = e$; with probability $1-\gamma$, effective effort $\widehat{e}$ is 0 regardless of the effort chosen. Cash costs are determined by effective effort $\widehat{e}$; specifically, $S(\widehat{e}) = c(1 - \widehat{e}/\gamma)$.[1] This implies that the expected cash cost is $E[S|e] = c(1-e)$. I assume throughout that c is small enough to ensure nonnegative cash costs for any effort level up to and including the first-best effort level–specifically, $c < \gamma$.

Throughout most of the paper, one can simply think in terms of effort levels e, which fully determine both expected cash costs and actual costs of effort, disregarding effective effort $\widehat{e}$. I model the effect of effort in this way for a specific reason; the randomness introduced through the effective effort construct makes it impossible to infer or "back out" the agent's effort level from the observed cash cost. Without such a construct, the verifiability of cash costs S renders effort effectively verifiable, eliminating the agency problem altogether and making it easy to achieve the first-best effort level with a simple one-shot explicit contract. I assume throughout that γ is small enough that such contracts are not effective.

Completion of the project to specifications X, which is verifiable, yields a gross payoff of w to the principal. Assume $w > c$, so that completion of the project to specification X is always efficient, even if the agent exerts no effort. With probability p, the principal learns during work on the project (and after the agent has chosen e) that an alternative specification Z is more efficient than specification X. Completion of a project to specification Z, which is also verifiable, increases net project value by Δ; specifically, at additional cash cost d the agent can achieve this modification, which yields additional value to the principal of $v \equiv d + \Delta$. This cost d is distributed according to the density g, which has positive support over the interval $(0, \infty)$. The realized cost d of modification is observable to both principal and agent; however, it is not contractible. Due to specific knowledge of the project, only the agent that has already begun work on the project can complete the project to specifications Z at this cost; it is prohibitively costly for another agent to improve the project in this way.

Both the principal and the agent are risk-neutral. However, agents are wealth-constrained and cannot enter contracts that provide a total payoff (after accounting for effort costs) of less than $-\frac{c^2}{2}$ in any state of the world.[2]

Assuming all efficient project modifications are pursued, expected net project value for a given effort level e is $w - c(1-e) - \frac{e^2}{2} + p\Delta$. The first-best level of effort, regardless of whether modifications are eventually sought, is therefore $e^* = c$. Substituting this back into the expression for the project value yields the first-best expected net project value:

$$V^* = w - c(1 - \frac{c}{2}) + p\Delta.$$

To summarize, a period of the game unfolds in five stages, numbered as follows. In a repeated contracting setting, these periods continue indefinitely with all players discounting future profits with a discount factor of δ.

0. In a repeated setting, the principal observes the agent's effort e in the prior period, though it is not verifiable.

1. The principal makes a take-it-or-leave-it offer to an agent. This contract offer may incorporate both explicit and implicit components. The explicit component of the contract may take one of two forms, fixed-price (FP) or cost-plus (C+). The agent accepts or rejects this contract offer.[3]

2. The agent chooses effort level e and begins working toward completing the project to specifications X.

3. The principal learns whether a modification to specification Z is efficient. The principal may request changes in the project; this may require renegotiation, depending on the initial contract.

4. The agent completes the project. The project specifications are observed, as is the agent's actual cash cost S. Both are verifiable. Contracts are enforced and payments made.

2.1 Explicit Contracts

The principal may offer the agent either of two types of explicit contract–a fixed price contract (FP) or a cost-plus contract (C+).[4] It is well-established in the economics literature that these are the most prominent types of construction and procurement contracts in practice. See, for example, Bajari and Tadelis (2001), Chakravarty and MacLeod (2009), Corts and Singh (2004), Crocker and Reynolds (1993), and McAfee and McMillan (1986). In addition, Bajari and Tadelis (2001) provide suggestive theoretical arguments for focusing on these contracts. They study a contracting model that is highly similar to the one presented here, in that the central contracting problems are the provision of incentives for cost-reducing effort and the threat of ex post holdup when specification changes are desired. They show that these two contract types are optimal among linear contracts. They also argue–based on monitoring and enforcement costs, multi-task problems, and other considerations– that these two forms are likely to outperform many nonlinear contracts as well. Since my objective in this paper is to overlay repeated interaction on a basic static contracting problem, I restrict attention to these two common and much-studied types of static explicit contracts throughout the paper. I show in the Appendix that, as in Bajari and Tadelis (2001), these two contract types are in fact optimal among linear contracts in the present model; I also argue that contracts that would outperform them are infeasible under reasonable assumptions.

There are two aspects of any explicit contract in this environment. One aspect is a provision determining who has the authority to direct work on the project and thereby determine the specifications of the completed project. I assume throughout that such a provision can be costlessly enforced. Of course, the allocation of this authority affects what contract offers will be acceptable to the agent, since the agent is aware that the principal may have this authority and is unwilling to accept contracts that yield large negative payoffs in any state of the world. Regardless of who has authority to direct work on the project, the agent determines the effort level. These assumptions are intended to capture important characteristics of real-world contracts. For example, in real-world cost-plus construction contracts, the principal often maintains on-site project management staff directing contractors and subcontractors, but these agents still influence costs significantly by determining how carefully and quickly to work, as well as how much effort to expend on tasks such as project planning and materials procurement.

The second aspect of the contract is the function $h(S)$ relating payments to realized cash costs, which is the only contractible variable aside from whether the project meets the specifications. The two types of explicit contracts are defined as follows.

FP: The agent directs work on the project. The principal agrees to pay the agent a fixed sum f upon completion of the project to specifications X. A modification of specifications, if desired, requires renegotiation with the agent. In this case, an additional fixed sum f' is determined as a payment for completion of the modified project to specifications laid out in the renegotiated contract.

C+: The principal directs work on the project. It can therefore direct the agent to pursue modification of the project, if desired. The principal agrees to pay the agent its realized cash costs upon completion of the project.

2.2 Implicit Contracts

Because some aspects of the stage game are observable but not verifiable and therefore not explicitly contractible (specifically, effort e and the cost d of modifications), there is significant scope for implicit contracting. When this contracting problem is repeated between the same principal and agent it may be possible to support contracts conditioned on these observable but not (explicitly) contractible variables. I will examine two such contracts. In both cases, I assume that deviation from the implicit contract leads to a termination of the relationship; however, this has asymmetric consequences since the principal has access to a large pool of potential agents for subsequent projects.[5] If the agent deviates from the implicit contract, the principal terminates the relationship with that agent for future rounds of contracting, and the agent receives a payoff of zero going forward. If the principal deviates from the implicit contract, I assume, following Baker, Gibbons, and Murphy (1994) and Schmidt and Schnitzer (1995), that in future rounds of contracting the principal is constrained to offer only the optimal explicit contract. This is based on an assumption that no other agent would subsequently enter an implicit contract with such a firm.[6] There are two natural extensions to the static contracts described above.

Augmented FP: The agent directs work on the project. The principal explicitly agrees to pay the agent a fixed sum f^{AFP} upon completion of a project to specifications X. The implicit contract stipulates that if the principal requests a modification of the project to specifications Z, the principal will offer an additional fixed sum $f' = d + b^{AFP}$ for completion of the project to the new specifications Z, and that the agent will accept this new contract. (Recall that d will be observed by both parties at this stage, but is not verifiable.) Both parties agree to continue contracting with each other under these terms until one agent deviates from these terms on some project. For this implicit contract to be sustainable, two conditions must hold: the principal must not wish to offer a lower fixed price on a project completed to specifications Z (essentially claiming a lower value of d than is actually realized), and the agent must not want to refuse this new fixed-price contract at price f' (essentially claiming a higher value of d than is actually realized).

Augmented C+: The principal directs work on the project and can therefore direct the agent to pursue modification of the project from X to Z if desired. The principal explicitly agrees to pay the agent its realized cash costs S upon completion of the project plus a bonus b^{AC+}. The implicit contract may stipulate that the agent will provide any particular level of effort. Both parties agree to continue contracting with each other under these terms until one party deviates from these terms on some project. Note that, for this implicit contract to be sustainable, one condition must hold: the agent must prefer to work hard (there is no explicit incentive to do so) over shirking and terminating the relationship. There is no analogous constraint to check for the principal's deviation since the explicit portion of the AC+ contract fully specifies the principal's obligations to the agent.

3 One-shot interaction

This section derives the payments associated with the optimal static contracts of both types, and characterizes the parameter values for which each contract type is optimal.

3.1 Fixed-price contract

First consider the FP contract. At stage 3, the parties enter a negotiation when a modification to the project is desired. The outside option of the agent is to deliver X and receive f, yielding $f - c(1-e) - \frac{e^2}{2}$. The outside option of the principal is to pay f for X and receive $w - f$. The total surplus achieved when renegotiation delivers Z is $w - c(1-e) - \frac{e^2}{2} + \Delta$. Thus, the additional value on the table for bargaining is Δ. Under standard bargaining assumptions, the two parties split this surplus, and the agent agrees to complete the project to specifications Z for an additional payment of $f' = d + \frac{\Delta}{2}$. Since this renegotiation is in no way affected by the choice of effort, the agent chooses e in stage 2 to maximize $f - c(1-e) - \frac{e^2}{2}$. The first-order condition implies that the agent chooses $e^{FP} = e^* = c$.

In stage 1, the principal maximizes its payoff by offering the lowest fixed price f that will be accepted. Since the agent's payoff when no change in specifications is desired is $f - c(1 - \frac{c}{2})$, and since this is lower than the payoff when changes are desired, the principal's optimal take-it-or-leave-it offer is $f^{FP} = c(1 - \frac{c}{2})$. The agent's wealth constraint implies that the principal cannot simply claw back the agent's expected renegotiation profits through a lower fixed price that yields a negative payoff for the agent when there is no desired project modification. Thus, the agent does capture some surplus under the fixed price contract despite the fact that the principal makes a take-it-or-leave-it contract offer. The principal's surplus under the FP contract, which is given here both in terms of the fundamentals and in terms of the divergence from the first-best, is:

$$V^{FP} = w - c(1 - \frac{c}{2}) + \frac{p}{2}\Delta = V^* - \frac{p\Delta}{2}.$$

Note that throughout the paper, V^i refers to the principal's surplus under contract i, *not* the total surplus under contract i. In the case of the first-best, V^* refers to both the total surplus and the principal's surplus with complete contracts and take-it-or-leave-it contract offers.

3.2 Cost-plus contract

Now consider the C+ contract. At stage 3, the agent complies with requests for modifications to the project by assumption. It is clear that in determining effort e in stage 2, there is no incentive to exert effort as the agent's net payoff is $-\frac{e^2}{2}$. Thus, the principal's surplus under the C+ contract, again given both in terms of the fundamentals and in terms of the divergence from the first-best, is:

$$V^{C+} = w - c + p\Delta = V^* - \frac{c^2}{2}.$$

3.3 Optimal static contracting

Since the principal's surplus under the fixed-price and cost-plus contracts can be written as the first-best surplus less a cost of renegotiation and a cost of low effort, respectively, it is straightforward to compare the costs of each and determine when each is optimal. Comparing V^{C+} with V^{FP} demonstrates that $V^{FP} > V^{C+}$ if and only if $c^2 > p\Delta$. This yields the first proposition.

Proposition 1 *In a one-shot contracting problem, the principal offers a fixed price contract rather than a cost-plus contract if the gain from solving the incentive problem outweighs the expected costs of the hold-up problem. This holds when the marginal effect of effort on costs (c) is high enough, the probability of renegotiation (p) is low enough, or the surplus on the table in a renegotiation (Δ) is small enough (specifically, if $c^2 > p\Delta$).*

It is worth reiterating here that the expressions for V derived above describe the value of the project *to the principal*. The social value is always first best under the fixed-price contract since it implements e^*, while the social value under the cost-plus contract is never first best since it induces no effort. The principal only chooses the cost-plus contract when the expected value captured by the agent in renegotiation under a fixed-price contract is so large that the principal would rather capture the entirety of the smaller total surplus achieved through the cost-plus contract. This distinction is obviously not central to the model, as the costs of renegotiation could easily be modeled as social costs, such as legal costs, architectural or engineering fees for redefining specifications, or costs of delay.

It is interesting to consider what alternative contracts might improve on the performance of the two static explicit contracts modeled here. In particular, two kinds of hybrid contracts that combine features of the fixed-price and cost-plus contracts illustrate the shortcomings of these two standard contracts. Chakravarty and Macleod (2009) describe how the American Institute of Architects standard fixed price contract addresses revisions to project specifications in a way that achieves the first-best in a model similar to this one. That contract specifies a fixed price for the original specifications, but stipulates that revisions to the original specifications must be accommodated by the agent, who is compensated only for the incremental costs attributable to the modification. In the present model, such a contract would be effective in inducing effort while eliminating the extraction of surplus by the agent, but only if the cost d of the modification were contractible. I maintain the noncontractibility of this cost d to preserve the cost of renegotiation and the threat of holdup in the model, which much of the contracting literature takes to be of central importance across a wide variety of settings.

An alternative hybrid contract was considered extensively in a working paper version of this paper. That is a contract that specifies an original fixed price, but then reverts to cost-plus (for the cost of the entire project, not just the modification) whenever a modification is required. Such a contract behaves much like a cost-plus contract in that it preserves the flexibility for the principal to direct project modifications, although it does induce some effort and therefore outperforms the pure cost-plus contract. Its interaction with implicit contracting is completely analogous to that of the cost-plus contract, and little would be gained by explicitly considering that contract here.

4 Repeated interaction

This section considers the possibility of repeated contracting and examines the effectiveness of the implicit contracts that this repeated contracting enables. I consider in turn the two types of implicit contracts, deriving the optimal payments for each. I then examine how the choice between these contracts varies with features of the environment, including the discount factor and the frequency of renegotiation.

4.1 The optimal augmented fixed-price contract

First consider the augmented FP contract. Since the gross payment to the agent is independent of effort, regardless of whether the project is modified or not, the agent chooses the first-best level of effort e^*. There are two conditions to check for the sustainability of the implicit contract: the principal must not want to offer a smaller f' than that specified in the implicit contract, and the agent must not want to refuse the specified f' when modification to Z is desired.

It is easiest to analyze the agent's constraint first. As in the static game, the agent can secure half of the additional surplus, $\frac{1}{2}\Delta$, by refusing the promised f' and forcing a renegotiation. However, the agent forfeits the additional profit promised in the implicit contract, b^{AFP}. This net gain, if any, must be weighed against the long-run profits lost from continued contracting. Since the agent's deviation from the implicit contract leads to zero profits, this is simply the discounted future profits of the augmented FP contract: $\frac{\delta}{1-\delta}[f^{AFP} - c(1-\frac{c}{2}) + pb^{AFP}]$. Thus, the implicit contract is sustainable if

$$\frac{\Delta}{2} - b^{AFP} \leq \frac{\delta}{1-\delta}[f^{AFP} - c(1-\frac{c}{2}) + pb^{AFP}].$$

Since f^{AFP} and b^{AFP} are choice variables for the principal in offering the initial contract, they can be chosen in any combination to ensure sustainability of the implicit contract from the agent's perspective–that is, the principal can offer the "carrot" that ensures successful implicit contracting through either a higher f or a higher b. However, one can see that the principal always uses the re-contracting bonus b to provide additional profits to the agent. The inequality above for sustainability of the implicit contract can be rewritten as

$$\frac{\Delta}{2} + \frac{\delta}{1-\delta}[c(1-\frac{c}{2})] \leq b^{AFP} + \frac{\delta}{1-\delta}[f^{AFP} + pb^{AFP}].$$

The problem is one of finding the cheapest way to satisfy this constraint–that is, choosing f^{AFP} and b^{AFP} to raise the RHS of the inequality as cheaply as possible. Based on only the square-bracketed term on the RHS of this equation, the two payments are equally cost-effective in securing compliance with the implicit contract since this term simply reflects the future expected surplus foregone by defection. Notice however, that b appears again on the RHS of the inequality. That is, increases in b offer an additional advantage that increases in f do not. Specifically, increases in b affect the incentive to renegotiate by affecting the immediate consequences, or the foregone revenue in the period of deviation. This is above and beyond the impact of increases in b on the future value of the repeated relationship. As a result, the principal would like to keep f as low as possible and raise b to ensure cooperation. Since the contract must satisfy the agent's wealth constraint, the minimum acceptable f^{AFP} is $f^{AFP} = f^{FP} = c(1-\frac{c}{2})$, the same as in the static case. Substituting this into the incentive constraint above and solving for the minimum b^{AFP} that satisfies it yields $b^{AFP} = \frac{\Delta}{2}[\frac{1-\delta}{1-\delta(1-p)}]$.

Now consider the principal's incentive constraint: the principal must not want to offer a smaller fee f' than the $f' = d + b^{AFP}$ stipulated in the implicit contract once the desirability of project modifications is realized and d is observed. The principal could offer a smaller f', triggering a renegotiation and terminating the relationship for future projects. The result of that renegotiation is that the principal pays the agent the cost of the modification d plus half the surplus. Thus, the principal's gain from deviation is $b^{AFP} - \frac{1}{2}\Delta$, while the principal loses the value of the continued relationship. Note that this "gain" is in fact negative, as the analysis above shows that $b^{AFP} < \frac{\Delta}{2}$. Therefore, the principal never has an incentive to deviate from the implicit contract, regardless of the value of the future relationship that is at stake.

This establishes the optimal augmented FP contract. Substituting these values of b^{AFP} and f^{AFP} into the principal's payoff function gives the principal's payoff under this optimal augmented fixed-price contract:

$$V^{AFP} = V^* - \frac{1-\delta}{1-\delta(1-p)}\frac{p\Delta}{2}.$$

4.2 The optimal augmented cost-plus contract

Now consider the augmented C+ contract. Here, the only element of the contract that relies on implicit enforcement is the provision of effort by the agent. Recall that the principal directly observes the agent's effort in the prior period before contracting for the next period.

The principal can in this case condition future contracting on the agent's choosing any particular effort level in the prior period; call this the target effort level $\overline{e}$. By reneging on this implicit contract and instead choosing to exert no effort, the agent gains the cost of effort $\frac{\overline{e}^2}{2}$ and loses nothing in the current period since the explicit contract guarantees a payment of $S + b^{AC+}$. The agent does, however, lose the present value of repeated contracting possibilities, which is $b^{AC+} - \frac{\overline{e}^2}{2}$. The agent's incentive constraint is therefore $\frac{\overline{e}^2}{2} < \frac{\delta}{1-\delta}[b^{AC+} - \frac{\overline{e}^2}{2}]$, which can be rearranged to yield the minimum bonus b^{AC+} that satisfies the agent's incentive constraint: $b^{AC+} = \frac{\overline{e}^2}{2\delta}$.

The principal then chooses the target effort level $\overline{e}$ to maximize its surplus: $w - c(1-\overline{e}) + p\Delta - \frac{\overline{e}^2}{2\delta}$. This yields $b^{AC+} = \frac{\delta c^2}{2}$. Substituting this into the principal's surplus yields:

$$V^{AC+} = V^* - (1-\delta)\frac{c^2}{2}.$$

4.3 Comparative Statics

Having solved for the optimal implicit contracts of the two types, it is straightforward to compare the expressions for the principal's surplus to determine the circumstances under which each contract type is chosen by the principal. A figure plotting V^{AC+} and V^{AFP} against δ, under the assumption that $p < 1$, provides intuition for many of the results that follow.

<<PLACE FIGURE 1 ABOUT HERE>>

There are a number of important aspects of this figure to note, all of which are directly evident from inspection of the expressions for V^{AC+} and V^{AFP}. First, as the discount factor δ approaches 1, both contracts achieve the first-best project value for the principal. Second, as the discount factor δ approaches 0, each augmented contract type yields a value to the principal equal to the value yielded by the static version of the underlying explicit contract. Third, V^{AC+} connects these endpoints with a straight line, while V^{AFP} connects these endpoints with a convex curve. Fourth, this curve is more convex the smaller is p (and, conversely, it is linear if $p = 1$). Inspection of this figure and manipulation of the algebraic expressions underlying it yield a number of propositions.

Proposition 2 *Comparative statics in the marginal effect of effort, the probability of renegotiation, and the surplus created by renegotiation are analogous to those in the static contracting case: decreases* *in the marginal effect of effort and increases in the probability of renegotiation and the surplus created by renegotiation all make augmented cost-plus contracts relatively more attractive to the principal for any given discount factor (i.e., $V^{AC+} - V^{AFP}$ is decreasing in c and increasing in p and Δ for any δ). Further, decreases in the probability of renegotiation, holding constant the expected surplus on the table during renegotiation, make augmented cost-plus contracts relatively more attractive to the principal for any given discount factor (i.e., $V^{AC+} - V^{AFP}$ is decreasing in p, holding $p\Delta$ fixed, for any c and δ).*

These results can all be shown by taking first derivatives of the expression for the excess value created for the principal through the choice of augmented cost-plus contracts: $V^{AC+} - V^{AFP} = \frac{1-\delta}{1-\delta(1-p)} \frac{p\Delta}{2} - (1-\delta)\frac{c^2}{2} > 0$. There is nothing surprising about the first part of this proposition, but it is reassuring to see that the one-shot comparative statics also apply to the augmented contracts for any discount factor.

The intuition for the second part of the proposition is less obvious, but it speaks directly to the central question of the paper. It shows that it is the infrequency of renegotiation that is the weakness of AFP contracts that prevents them from taking advantage of the power of implicit contracting to the same extent as AC+ contracts. Graphically, it is the infrequency of renegotiation that generates the convexity in V^{AFP}, and it is that convexity that makes AFP contracts underperform AC+ contracts when the static contracts are equally attractive, for example. Understanding why infrequent renegotiation lowers the value of AFP contracts is central to understanding the core results of the paper on comparative statics in δ (which follow in the next proposition).

The critical limitation of AFP contracts is that renegotiation happens in only some periods, driving a wedge between the current temptation to cheat and the future gains from adhering to the implicit agreement. Given an *expected* level of surplus paid to the agent in renegotiation ($\frac{p\Delta}{2}$), which is what determines the attractiveness of the static FP contract, a less frequent renegotiation (smaller p) implies a larger surplus (Δ) on the table in any period when specification changes are requested. In the (infrequent) event that modification is desirable, the temptation of the agent to hold up the principal is large, and a large bonus must be paid to ensure compliance with the implicit contract. That is, the bonus must be large enough to offset a $\frac{\Delta}{2}$ incentive to renege, even when the expected profit loss associated with the explicit contract is only $\frac{p\Delta}{2}$. Though the mix of p and Δ does not matter for the expected profit loss to the principal in the static contract, and therefore does not influence static contract choice, it very much matters to the prospect of implicit contracting. It is much less costly to use repeated interaction to overcome frequent, small incentives to cheat than to overcome rare opportunities to gain significant profits through deviation.[7] The AC+ contract, in contrast, offers a bonus in every period and an opportunity to renege on the implicit contract in every period. There are no unusual periods in which the incentive to cheat becomes atypically large and requires a larger bonus; this permits the principal to induce adherence to the implicit contract at a more modest cost to the principal.[8] This in turn allows the AC+ contract to better harness the power of implicit contracting; as the next proposition shows, this implies that under some circumstances increases in the discount factor will lead principal to switch from preferring an AFP contract to preferring an AC+ contract, which is the central result of the paper.

Proposition 3 *If the principal is indifferent between AC+ and AFP contracts for some discount factor, then the AC+ contract is preferred for all higher discount factors and the AFP contract is* *preferred for all lower discount factors (i.e., if there exists $\delta^* \epsilon [0, 1)$ such that $V^{AC+}(\delta^*) = V^{AFP}(\delta^*)$, then $V^{AC+}(\delta) > V^{AFP}(\delta)$ for all $\delta \epsilon (\delta^*, 1)$ and $V^{AFP}(\delta) > V^{AC+}(\delta)$ for all $\delta \epsilon [0, \delta^*)$). In addition, as implicit contracting becomes more powerful both the augmented cost-plus and augmented fixed price contracts yield the principal a value approaching the first-best project value (i.e., V^{AC+} and V^{AFP} approach V^* as the discount factor δ approaches 1).*

The first part of this proposition is the central result of the paper, and it is also immediately obvious from the figure and the discussion of the preceding proposition. It implies that, consistent with the empirical evidence, increasing the power of implicit contracting through more frequent interaction or more patient players may make AC+ contracting more attractive and induce changes in contract form. The second part of this proposition is essentially a folk theorem for repeated contracting in this setting. Not surprisingly, as players become very patient, the threat of lost future contracting possibilities becomes strong enough to prevent agents from either shirking under cost-plus contracts or holding up the principal under fixed price contracts.

The final proposition addresses the determination of the threshold discount factor above which AC+ contracts are preferred.

Proposition 4 *Changes in the marginal effect of effort, the probability of renegotiation, and the surplus created by renegotiation that make AC+ contracts relatively more attractive (i.e., decreases in c and increases in p and Δ) also increase the range of discount factors for which AC+ contracts are preferred, lowering the threshold discount factor at which the principal is indifferent between AFP and AC+ contracts.*

This can be seen from the figure. Decreases in c raise V^{AC+}, while increases in p and Δ lower V^{AFP}. Both kinds of changes push the point of indifference to the left, to a lower discount factor. This implies that the switch to AC+ induced by a higher discount factor will happen at a lower threshold, and thus with less frequent repeated interaction, the stronger the static cost-plus contract is relative to the static fixed-price contract.

The relative attractiveness of the two contracts is of course also determined by the contracting environment and by the specific assumptions I have made. In particular, an alternative bargaining assumption that gave the principal more than half the surplus on the table in a renegotiation, for example, would make the FP and AFP contracts relatively more attractive to the principal. However, there is no reason to believe that the comparative statics or other qualitative results of the paper would vary with an alternative bargaining assumption. Similarly, changes to the effort observability assumptions would affect the attractiveness of C+ and AC+ contracts. For example, observable effort within a period would allow a static contract–specifically, a contract in which the principal retained the flexibility to direct work but used strong incentives on observable effort to force the first-best effort level–would achieve the first best project value for the principal. Finally, if effort was not perfectly observable with a one-period lag (as it is in the present paper), but instead was only coarsely observable, the AC+ contract would be less attractive, as the principal would not be able to condition continued contracting on the precise effort level desired ($\bar{e}$).[9] Again, there is no reason to believe that the qualitative results of the paper would be affected by such alternative assumptions.

Having now proved my results, it is worth making a more detailed comparison to the analysis of Baker, Gibbons, and Murphy (2002), which I had argued in the introduction is in many ways the most similar paper in the literature. Recall that they focus on the integration/nonintegration decision, but that there are many similarities between integration and cost-plus contracts and between nonintegration and fixed-price contracts. Their main result is that "integration affects the parties' temptations to renege on a relational contract, and hence affects the best relational contract the parties can sustain"; they also derive a number of related results, including that "the optimal integration decision can depend on the discount rate," and that "holding constant the optimal integration decision in the static model..., the optimal integration decision [under repeated contracting] can depend on the payoff levels." (Baker, Gibbons, and Murphy (2002), p. 42) These same statements hold in the present paper, where "explicit contract form" is substituted for "integration" and "integration decision."

Despite these similarities, there are also important differences in the results, as well as important differences in the foundations of the models and in the economic situations to which they apply. Most notably, Baker, Gibbons, and Murphy (2002) show that in their model the spot-market outcome cannot be replicated inside a firm because integration provides too great a temptation for the principal to renege on the relational contract. This is not true in my model; for example, if the principal is indifferent between the two contract forms in the static case, the implicit contract based on a cost-plus contract (analogous to integration) is always better than the spot-market fixed-price contract (analogous to nonintegration), regardless of the discount factor. In fact, the implicit contract based on a cost-plus contract (analogous to integration) is always better even than the implicit contract based on a fixed-price contract (analogous to nonintegration), for any given discount factor. That is, in my model the cost-plus contract (analogous to integration) actually makes *better* use of the power of repeated contracting, contrary to the spirit of Baker, Gibbons, and Murphy (2002)'s results. The reason lies in the nature of the control rights and incentive problems in the two models. In Baker, Gibbons, and Murphy (2002), under integration the principal has a strong incentive to renege on its implicitly-enforced bonus payment to the agent because of its strong control rights and weak explicit contract. This is the nature of integration; cost-plus, while analogous in many ways, is fundamentally different. Under cost-plus contracts in my model, the principal is bound by a stronger explicit contract (the principal is explicitly committed to paying cash costs and a bonus) and thus, in a sense, has weaker control rights. As a result, the principal never has a meaningful incentive to renege, in the sense that it is always the agent's incentive constraint that is binding. This strong explicit contract intrinsic to cost-plus contracts overturns the weakness inherent to integration in the model of Baker, Gibbons, and Murphy (2002), and renders cost-plus contracts the more effective foundation for implicit contracting.

5 Conclusion

The most common types of contracts in the context of construction and procurement contracting are fixed-price and cost-plus contracts, which are burdened with recontracting costs and incentive problems, respectively. When repeated interaction allows implicit contracting, the parties may be able to alleviate these problems through the promise of profitable future interactions that are contingent on good behavior. However, it is not immediately clear whether the principal should prefer to use the power of implicit contracting to trust the agent to work hard, with a flexible but low-powered explicit contract, or to trust the agent to renegotiate fairly, with a high-powered but inflexible explicit contract.

The analysis of this paper illuminates the strengths and weaknesses of these different types of implicit contracts. Implicit contracts based on explicit cost-plus contracts (AC+ contracts) provide implicit incentives for effort and eliminate the difficulties of renegotiation by leaving direction of the project under the control of the principal. The value created for the principal by such a contract is limited by the frequency of repeated interaction and the strength of implicit contracting. Implicit contracts based on explicit fixed-price contracts (AFP) provide explicit incentives for effort and implicit incentives for fair renegotiation. The strength of implicit incentives under this contract is limited both by the frequency of repeated interaction and by the frequency of renegotiation. In periods that new project specifications are desired, the incentive to renege looms large, and large bonuses are required to ensure adherence to the implicit contract. This renders AFP contracts inferior to AC+ when renegotiation is infrequent. As a result, stronger implicit contracting (due to more patient players or more frequent interaction) leads to use of weaker explicit contracts. This finding is consistent with the empirical literature on construction and procurement contracting (Corts and Singh, 2004, and Kalnins and Mayer, 2004).

Given the relatively scarcity of evidence on the interaction of implicit and explicit contracts, further empirical work on this topic would be valuable. In addition to giving a theoretical foundation to the hypothesis that repeated interaction should lead toward more use of low-powered cost-plus explicit contracts, the results suggest one further testable hypothesis, which is that the switch to cost-plus explicit contracts should happen more readily (at a lower discount factor, or frequency of interaction) in settings where cost-plus contracts are relatively more attractive in the absence of repeated contracting.

Notes

[1]The scaling of the marginal impact of effective effort by $1/\gamma$ facilitates analysis by allowing γ to capture solely the ease of inference of effort from cash costs. Without this scaling, γ would conflate this effect with the marginal return to effort.

[2]This can be thought of as a specific kind of risk aversion, or as a contraint on legally permissible contracts. It serves a specific purpose in creating an incentive problem between risk-neutral parties by ruling out the "sell the firm" solution. Allowing the agent some positive wealth accommodates the randomness in effective effort, allowing the agent to cover the cost of effort even when effort proves ineffective and the agent is therefore not compensated for that effort.

[3]Technically, it makes sense to model the contract determination process as a take-it-or-leave-it offer by the principal only when the contract is exclusively explicit. Formally, I analyze implicit contracting by identifying the set of implicit contracts that satisfy all relevant participation and incentive constraints and then choosing the contract most favorable to the principal. This maintains the analogy to the take-it-or-leave-it explicit contracting case, but it means that I have adopted a particular selection rule for choosing from among many possible equilibrium implicit contracts. In fact, the agent would always prefer the static fixed price contract to the implicit augmented fixed price contract described later, but the assumption is that the principal, who is on the short side of the market, can dictate the terms of the contract (within the set of acceptable contracts) regardless

of whether that contract is explicit or implicit.

[4]Note that throughout the paper I use the term "explicit contract" to refer to the written court-enforceable agreement between the parties. Similarly, I use the term "implicit contract" to refer to the self-enforcing agreement between the parties, adherence to which is supported through repeated contracting. This implicit contract may be, in the everyday sense of the word, quite explicit. In the theoretical analysis, I am of course very precise about what this contract entails; as a practical matter, it is irrelevant whether this contract is discussed explicitly between the parties or is tacit. For purposes of this paper, an agreement is an implicit contract if it is not court enforceable and an explicit contract if it is.

[5]While these agents are not identical once a project has begun (recall that only the agent already engaged can alter the specifications to Z at cost d), at the beginning of each new project the agents are identical.

[6]Note that these assumptions that the relationship is terminated and that the principal has access only to explicit contracts subsequent to breech of an implicit contract lead to contracts that are not, in general, renegotiation-proof. The principal and (some) agent would in general find an implicit contract attractive despite the prior breakdown. Like Baker, Gibbons, and Murphy (1994) and Schmidt and Schnitzer (1995), I do not consider renogiation-proof equilibria, although Macleon and Malcolmson (1989) demonstrate how such an analysis may be carried out.

[7]This is a general point about repeated contracting that is not specific to this model. It may be clearer to consider a simpler case. Consider δ=0.95. Imagine that you have a package with \$10 cash delivered to a neighbor every day. By paying \$0.50 each time the neighbor brings the package to you (assuming the neighbor has no cost of time) and promising to stick with the deal as long as the neighbor cooperates, you can ensure the neighbor's cooperation: $\$10 - \$0.50 \leq \frac{.95}{1-.95}[\$0.50]$. Now consider the case in which a \$20 package arrives every day with probability $\frac{1}{2}$, which yields the same expected daily loss in the absence of implicit contracting. To ensure cooperation in this case you must offer the neighbor a little over \$1.90 each time the packaged is delivered: $\$20 - \$1.90 \lesssim \frac{.95}{1-.95}(0.5)[\$1.90]$. You are significantly worse off in the second scenario, with an expected daily loss of \$0.95 rather than \$0.50.

[8]This is related to the finding in the literature on tacit collusion (most notably, Rotemberg and Saloner (1986)) that incentive constraints are more binding in high-demand periods, limiting the extent of cooperation sustainable through repeated interaction.

[9]This was explored in detail in a working paper version of this paper. If the principal can tell only whether effort in the prior period exceeded some exogenous threshold e', then V^{AC+} will be a concave curve lying everywhere weakly below the V^{AC+} curve given in this paper, with the point of tangency occurring at the discount factor such that the optimal endogenous threshold $\overline{e}$ equals the exogenous threshold e'.

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7 Appendix

To see that the C+ and FP contracts are the only two potentially optimal contracts when $h(S)$ is linear, consider in turn the two possibilities for the allocation of the authority to direct work. First, consider the case in which the principal has the authority to direct the agent's work. A contract requiring the agent to follow the direction of the principal will by assumption be acceptable to the agent only as part of a contract that specifies a payment that is at least as large as the realized cash costs in every state of the world: $h(S) \geq S$, $\forall S$. Given the restriction to linear contracts and the unbounded support of the distribution of d, this in turn implies $h' \geq 1$. Since the agent's first-order condition implies that the implemented effort level is $e = -h'c + c$ (the agent maximizes $h(S) - S - \frac{e^2}{2}$), positive effort will only be exerted if $h' < 1$, which is incompatible with the prior constraint. Thus, induced effort must be zero, and the cheapest contract that induces zero effort is $h(S) = S$, which is acceptable since the agent incurs no non-cash costs. This is the C+ contract.

Second, consider the case in which the agent directs work on the project. This will necessarily mean that the principal must renegotiate the contract in order to induce changes to the project specifications. Since such a renegotiation happens after the determination of effort, and since the incremental costs (d) and benefits ($d + \Delta$) of modifications are independent of effort, the prospect of renegotiation has no effect on effort choice. As a result, the most attractive such contract (given the mutual risk neutrality of the principal and agent) will be the one that provides the strongest incentives for effort, which is effectively the sell-out contract, the FP contract.

Consider alternative contracts that might seem preferable. One possibility would be a "double fixed-price" contract in which the principal retains authority to direct work and commits up front to two different fixed prices, one for X and one for Z. This is not feasible because of the combination of the unbounded support of the distribution of d and the the agent's wealth constraint.

Another possibility would be to use S to effectively infer effort. For example, a simple contract that respects the agent's wealth constraint and implements the first-best effort level is the following: $h(S) = S + \frac{e^{*2}}{2\gamma} + \epsilon$ if $S = c(1 - e^{*})$, and $h(S) = S$ otherwise. This yields expected agent surplus of $\epsilon > 0$ at $e = e^{*}$ and agent surplus of 0 otherwise, inducing efficient effort. Because of the imperfect inference of effort through cash costs, which is worse as γ approaches 0, paying this bonus for inferred good effort ($\frac{e^{*2}}{2\gamma} + \epsilon$) becomes very costly as γ becomes small. However, without further assumptions, this does remain a feasible contract that respects the agent's wealth constraint and induces first-best effort. In the interest of preserving the effective unverifiability of effort, I assume that there is some maximum enforceable payment M (which may be very large) that courts would force the principal to pay to the agent in compensation for its costs of effort. This is consistent with Chakravarty and MacLeod's (2006) argument that institutional and legal factors constraining the size of contractual penalties and bonuses meaningfully limit the strength of incentives that can be provided through explicit court-enforceable contracts. Therefore, one can think of the restriction to the linear contracts studied in the paper as resulting from an assumption that, given M, γ is small enough that the bonus required in this contract to induce the first-best effort level exceeds M, and that the maximum effort level that can be implemented through such a contract is negligibly different from zero.

Figure 1, Kenneth S. Corts, "The Interaction of Implicit and Explicit Contracts in Construction and Procurement Contracting

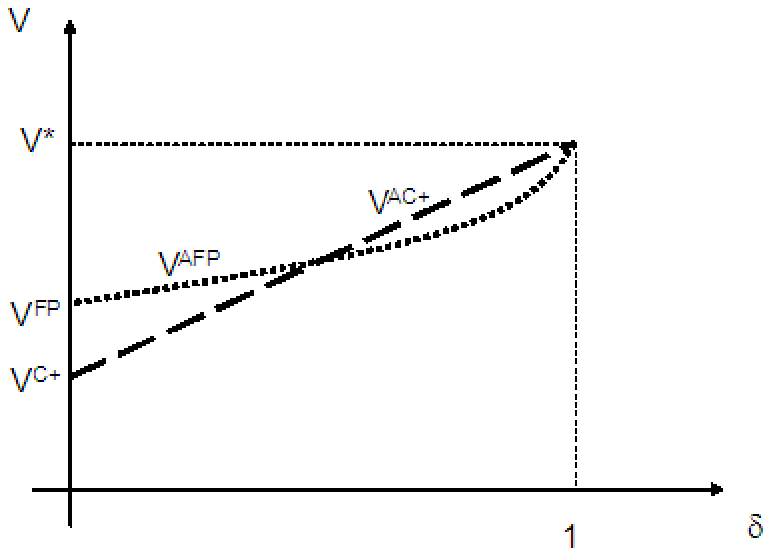

Figure 1