Cost Overruns in Long-Term Projects: Competing or Complementary Explanations?

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October 1992
Working Paper nº 192

ABSTRACT

We look at three different models expressly devoted to analyzing why cost overruns are so pervasive in long-term procurement. The first two models explain cost overruns in the context of long-term relationships between a sponsor and a contractor while the third explains cost overruns as a result of the selection bias inherent to prevalent procurement practices. We also provide a comparative assessment of this literature and discuss whether these different contributions can be seen as complementary or simply competing.

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The author thanks Vítor Gaspar and Vasco Santos for helpful comments and suggestions. The usual disclaimer applies.
1. INTRODUCTION

The construction of large-scale manufacturing facilities, power plants, transportation systems and weapons systems accounts for a significant part of annual economic activity in developed economies. Contractual performance on large-scale, long-term projects is routinely characterized by cost overruns. Evidence of such occurrences abounds and frequently receives extensive media coverage. Peck and Scherer (1962) estimated that for U.S. defense programs development costs exceeded original predictions by 220 percent on average, and in some cases by as much as 14 times. More recent estimates in different countries in both North America and Europe as well as the recent debate in Europe over the construction of an European fighter jet also indicate that procurement costs are a very serious problem. In fact, anecdotal accounts of cost overruns on major construction projects abound. Mead, et al. (1977) report that the San Francisco area’s subway system BART had an estimated cost of USD 996 million in 1966 and a final cost of USD 1.76 billion in 1976. The Alaskan pipeline had an estimated cost of USD 900 million in 1990 and came in at an astonishing USD 7.7 billion in 1977.

Table 1 presents more evidence of cost overruns by providing a summary comparison between average original cost estimates and average final costs for nuclear power plants, by year of order, 1966-1972, based on November 1984 data. Table 2, on the other hand, shows that the phenomenon of cost overruns is quite widespread affecting not only military procurement and nuclear power plants construction but also all sorts of public sector procurement, namely highway construction and irrigation projects.

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1 See several issues of The Economist, in June and July of 1992, which explicitly address this issue. The recent purchase of three MEKO frigates by the Portuguese government constitutes another example where procurement rules have led to sizeable cost overruns (see Expresso, 1989, several issues).
Table 1
COST ESTIMATES AND REALIZED COSTS, NUCLEAR POWER, 1966-72

<table>
<thead>
<tr>
<th>Year of order</th>
<th>Av. original estimate ($/KW)</th>
<th>Av. final cost ($/KW)</th>
<th>Av. percent cost overrun</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>147</td>
<td>299</td>
<td>103</td>
</tr>
<tr>
<td>1967</td>
<td>150</td>
<td>352</td>
<td>135</td>
</tr>
<tr>
<td>1968</td>
<td>155</td>
<td>722</td>
<td>363</td>
</tr>
<tr>
<td>1969</td>
<td>179</td>
<td>890</td>
<td>397</td>
</tr>
<tr>
<td>1970</td>
<td>228</td>
<td>1331</td>
<td>484</td>
</tr>
<tr>
<td>1971</td>
<td>258</td>
<td>1313</td>
<td>409</td>
</tr>
<tr>
<td>1972</td>
<td>418</td>
<td>2258</td>
<td>440</td>
</tr>
</tbody>
</table>

Source: Survey of Nuclear Plant Construction Cost, EIA, 1984

Table 2
SUMMARY OF COST ESTIMATING EXPERIENCE

<table>
<thead>
<tr>
<th>Items estimated</th>
<th>Actual/estimated cost</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weapons, 1950s</td>
<td>1.89</td>
<td>55</td>
</tr>
<tr>
<td>Weapons, 1960s</td>
<td>1.40</td>
<td>25</td>
</tr>
<tr>
<td>Public works</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway</td>
<td>1.26</td>
<td>49</td>
</tr>
<tr>
<td>Water projects</td>
<td>1.39</td>
<td>49</td>
</tr>
<tr>
<td>Building</td>
<td>1.63</td>
<td>59</td>
</tr>
<tr>
<td>Major construction</td>
<td>2.18</td>
<td>12</td>
</tr>
<tr>
<td>Energy process plants</td>
<td>2.53</td>
<td>10</td>
</tr>
</tbody>
</table>

N = number of projects
Actual cost in real terms adjusted for inflation
Source: Merrow, et al. (1979)

From the vantage of professional economists this phenomenon offers at least two distinct sources of interest. First, is there a satisfactory explanation? Such an explanation would obviously have to account for whether it matters that the sponsor of such projects is typically a government agency rather than a private enterprise and would also have to account for whether it matters that the scale of the project is usually very
large. Second, is this something economists should worry about? In other words, do cost overruns constitute *prima facie* evidence of gross inefficiency in government procurement and, if so, are there any recommendations that we as economists can make as a partial remedy?

Though there has been considerable recent theoretical work on procurement, e.g., Baron and Besanko (1984, 1987), Laffont and Tirole (1988) Riordan (1986), Tirole (1986), much of this work does not explicitly address the issue of cost overruns. Until recently economists simply provided partial, sometimes *ad-hoc* explanations for cost overruns, e.g., the inability to forecast costs accurately, non-competitive letting of contracts and simple mismanagement of available resources. The first papers explicitly devoted at explaining cost overruns were those of Lewis (1986), Arvan and Leite (1990) and Gaspar and Leite (1989/90).

Lewis rationalizes cost overruns in long-term government sponsored procurement as the outcome of the bilateral relationship between sponsor and contractor in which neither party can credibly commit itself to a given course of action over time. In Lewis's set-up the history of cost realizations provides information to the sponsor in estimating a parameter, known by the contractor, which governs the cost distribution. Furthermore, he assumes that, when the cost distribution is unfavorable, the contractor can exert cost reducing effort, unobserved by the sponsor, to improve cost performance. In sequential equilibrium, the contractor with the unfavorable cost distribution initially exerts substantial effort which is reduced as the project nears completion. Thus, the cost distribution for a task at the end of the project dominates the cost distribution for a task in the beginning of construction, in the sense of first order stochastic dominance. Lewis interprets this effect as cost overruns.

Unlike Lewis, Arvan and Leite develop a model in which the compensation
scheme offered to the contractor is endogenous. As in Lewis, they consider a dynamic contract game between a sponsor and a contractor concerning a project that requires a finite number of tasks to be completed before the benefit from the project can be realized. Focusing on the case where the sponsor cannot precommit to compensation per task and where the contractor is not bound to complete the project, the authors show that in equilibrium both the distribution of costs per task, and the per period (endogenous) compensation scheme rise as the project nears completion. This twofold effect of an unfavorable shift in the cost distribution and the tilt in the compensation scheme is interpreted by the authors as cost overruns.

Gaspar and Leite (1989/1990) do not focus on the long-term structure of these procurement contracts but, instead, center their attention on the selection bias of prevalent (and optimal) selection rules concerning the assignment of these contracts. They show that when a sponsor receives a noisy though unbiased estimate of project costs from a pre-specified number of potential contractors and then chooses the contractor signaling the lowest ex ante expected cost, the sponsor on average underestimates the project's costs. That is, they show that the mere existence of a selection mechanism is enough to explain the ex post bias of an ex ante unbiased prediction. This is the phenomenon they identify with cost overruns. Furthermore they show that, on average, cost overruns are larger when the cost signal is less accurate. Hence, cost overruns are more likely to occur in large-scale, long-term projects in which costs are less predictable.

The remainder of this paper is organized as follows. Section 2 presents an abridged version of Lewis model together with a discussion of its main implications and shortcomings. In section 3 we present a slightly modified version of Arvan and Leite’s framework coupled with a discussion of
its implication for the understanding of the phenomenon of cost overruns. In section 4 we provide Gaspar and Leite’s assessment of the previous contributions and briefly describe their framework and results. Finally, in section 5 we provide a comparative assessment of these three contributions evaluating their complementary nature.

2. CONTRACTOR’S REPUTATION BUILDING AND COST OVERRUNS
IN AN ADVERSE SELECTION MODEL

2.1. The rationale

Lewis provides a rationale for the occurrence of cost overruns in long-term government sponsored procurement: these are seen as the outcome of the bilateral relationship between a sponsor, e.g., a government agency, and a contractor, e.g., a large corporation in charge of developing a new high-tech product or building a new power plant. Neither party can commit itself to a course of action over time: Also, this relationship is modeled as a repeated contract game in which neither party can guarantee performance: the sponsor cannot guarantee a level of payment and the contractor cannot commit itself to a given cost of supply. The sponsor learns about cost after completing each task. The project requires completion of many tasks, which are performed sequentially, and there is uncertainty about the cost involved in task completion. The history of cost realizations provides information to the sponsor. The contractor, who is assumed to be the more informed party, can exert cost reducing effort, unobserved by the sponsor, to improve the cost distribution. In sequential equilibrium, the contractor with the unfavorable cost distribution initially

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2 If such commitments were possible, the incentives for strategic behavior, which we observe in this setting, would be eliminated.
exerts substantial effort, which is reduced as the project nears completion. Hence, the cost distribution for a given task towards the end of the project dominates the cost distribution for a task at the beginning of the project in the sense of first order stochastic dominance. This effect is interpreted as cost overruns.

2.2. The model

In a Kreps and Wilson (1982) type model consider the relationship between a sponsor and a contractor over the construction of a long-term project. Assume the project requires a pre-specified number of tasks, $N > 1$, for completion. For simplicity assume each task lasts one period. Let $i$ be an index which refers both to the number of tasks and the number of periods remaining till project completion; $i = 1, 2, \ldots, N$. Let $B$ denote the benefit accruing to the sponsor in the event the project is completed. It is assumed that the benefit to the sponsor is zero in the event that the project is not completed.

It is assumed that the expected cost of completing each task is the same. The cost of completing a given task is uncertain, and it can turn out to be either high or low. Let $\bar{c}$ and $\underline{c}$ represent the high and low costs, respectively, with $\bar{c} > \underline{c}$. Upon completion of each task, the contractor is paid a fixed fee, $\bar{c}$, plus cost and a bonus if the task is completed at low cost. The bonus, given by $\delta (\bar{c} - \underline{c})$ with $\delta \in [0,1]$, is a fraction of the cost savings realized by the sponsor when the task is completed at low cost.

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3 Notice that, by making the time horizon for completion exogenous, the possibility of project delays is ruled out. This allows us to isolate causes of cost escalation in long-term contracting more directly.

4 By assuming that these costs do not change over time, possible cost reductions arising from learning are ignored.
Hence, the contractor is paid $\bar{c} + c + \delta (\bar{c} - c)$ if the cost of completing a given task is low, and $\bar{c} + c$ if the cost is high. It is assumed that the sizes of the fixed fee and bonus are determined through either pre-contract competition or negotiation between the sponsor and the contractor. They both share the same information about the type of project when the terms of the contract are established, precluding the sponsor from learning about the type of project from observing the terms accepted by the contractor.

The probability of completing a given task at low cost depends on whether the project is easy or hard. The difference between easy and hard projects is captured as follows.

**Assumption 1:** Let $r$ be the probability that the contractor will complete a task at low cost given that the project is easy, and let $s$ be the probability that the contractor will complete a task at low cost given that the project is hard, where $0 \leq s < r \leq 1$.

From Assumption 1 we can define the expected cost of a given task to the sponsor from an easy and hard project, respectively, as

$$E_e(P) = \bar{c} + r [c + \delta (\bar{c} - c)] + (1-r) \bar{c}$$

$$E_h(P) = \bar{c} + s [c + \delta (\bar{c} - c)] + (1-s) \bar{c},$$

where the subscripts $e$ and $h$ correspond to easy and hard projects, respectively.

Once work starts, the contractor learns whether the project is easy or hard. The sponsor cannot observe the type of project, but it has some belief that the project is an easy one with probability $q \in [0,1]$. This
probability is reviewed through time, contingent on observed costs.

The contractor is at a disadvantage in achieving low-cost outcomes when working on a hard project. However, we further assume that a contractor working on a hard job may approximate the cost of an easy job if it works harder. Let \( \rho \) be the probability of achieving costs \( c \) in completing a given task on a hard project. The cost \( E(\rho) \) of obtaining \( \rho \) is assumed to verify the following assumption:

**Assumption 2:**

\[
E(\rho) = \begin{cases} 
\bar{c} & \text{for } \rho = s \\
\bar{c} + \gamma (\rho - s) & \text{for } s < \rho \leq r.
\end{cases}
\]

Assumption 2 simply means that to reach a performance level \( \rho (\geq s) \) a contractor must incur an additional cost, which is assumed to be proportional to the difference \( \rho - s \). We further assume that these expenditures to enhance contractor performance cannot be observed by the sponsor and that performance cannot be improved on easy projects.\(^5\)

Moreover, we shall assume, in deriving the equilibrium of the model, that the sponsor correctly perceives the performance-enhancing strategy of a difficult project contractor. From this the sponsor can update his estimate of \( q \) on the basis of observing the cost of completing the last task. Let \( (q|c) \) and \( (q|\bar{c}) \) be the Bayesian updated probabilities, given that the last task was completed at low cost and high cost, respectively. These probabilities are given by:

\(^5\) The level, \( s \), is determined by the innate abilities of the contractor, as well as by the bonus provided by the sponsor as an incentive for contractors to produce at low costs.

\(^6\) This last assumption makes the analysis more tractable, but eliminates some potentially interesting behavior where contractors of easy projects try to signal their project type to the sponsor.
\[ q|C = q \frac{r}{(q(1-r) + (1-q)(1-p))} \]  \hspace{1cm} (3)

\[ q|\bar{C} = q \frac{(1-r)}{(q(1-r) + (1-q)(1-p))}. \]  \hspace{1cm} (4)

To close the model we still have to specify the contract between the sponsor and the contractor. In this model, the sponsor pays the contractor for completing each individual task, i.e., the contract between the sponsor and the contractor consists of a series of short-term agreements in which the contractor is paid a fixed fee plus a bonus during each period in which the project is funded. After each task, the project's rating, \( q \), is updated on the basis of recent contractor performance. If, at any stage, the benefits to be received at the end of the project exceed the perceived future costs to the sponsor, the project is continued for one more task. Otherwise, the project is cancelled, and both sponsor and contractor are assumed to receive zero after that point. In other words, under the terms of the contract, the project proceeds from one phase to the next if and only if it is mutually beneficial to continue.

2.3. Characterization of equilibrium contracts

We now turn to examining the Bayes-Nash equilibrium properties of the model. The basic intuition can be captured from a simplified version of the model in which contractors cannot enhance their performance on difficult jobs through hard work. In this context, suppose that the sponsor must make a final and irreversible funding decision in phase \( i \). \( q_i \) being the probability that the project is deemed easy at stage \( i \). We shall further assume that:

\[ \text{...} \]
(1) $B \geq E_e(P)$, and that

$$D_N^{N-1} B < D_N E_e(P),$$

where $D_i = \sum_{j=0}^{i-1} d^j$ is the sum of discount factors ranging from 0 to $i - 1$.

Assumption (1) simply implies that the project will always be funded if the number of remaining tasks is sufficiently small, whilst Assumption (ii) indicates that the discounted value of completing the project is bounded by the highest and lowest expected present value costs of construction and development. In general terms, the project will be funded to completion with $l$ stages left if $q_i \geq \tilde{q}_i$, where $\tilde{q}_i$, which is the acceptable reputation value when reputation building is not possible, is defined by $d^{i-1} B - D_i E(P(\tilde{q}_i)) = 0$, with $E(P(\tilde{q}_i)) = (1 - \tilde{q}_i) E_e(P) + \tilde{q}_i E_e(P)$.\(^7\) Solving the above equation for $\tilde{q}_i$, it turns that:

$$\tilde{q}_i = \frac{E_e(P)}{E_e(P) - E_e(P)} - \frac{d^{i-1} B}{D_i (E_e(P) - E_e(P))}.$$ \hspace{1cm} (5)

From (5) and (1) above it can be shown that there exists some period $L \geq 1$, satisfying $D_L E_e(P) < B d^{L-1}$ and $D_{L+1} E_e(P) > B d^L$ such that:

$$\tilde{q}_i = 0, \quad L \geq i > 0$$

$$1 > \tilde{q}_{i+1} > \tilde{q}_i \geq 0, \quad N < i \leq L.$$ \hspace{1cm} (6)

This condition indicates that in phase $L$ the sponsor is locked in to finishing the project, since expected benefits $d^{L-1} B$, exceed the highest

\(^7\) Note that $q_i$ can be seen as a reputation index, in the sense that it represents the sponsor's belief that the project is an easy one.
expected costs of completion, $D_n E (P)$. Before this lock-in period, the requirements for funding are more stringent as the number of tasks left to be completed is bigger, since greater costs must be incurred to achieve the same benefits.

Turning to the more general model in which investment in reputation may occur, it can be shown that, in this more general framework, the sponsor's funding decisions satisfies properties similar to (6). As described above, the contract between the sponsor and the contractor consists of a series of short term agreements. The contractor is paid a fixed fee plus a bonus for low-cost outcomes during each period that the project is funded. The cost of enhancing performance, $E(p)$, cannot be observed by the sponsor, and it is a private cost borne by the contractor. Since, by assumption, the contractor is content to continue working, given that its contract fee exceeds its reservation wage, the contract is terminated only if the sponsor believes that the project is not worth funding anymore.

Following Kreps and Wilson (1982b), a sequential equilibrium for this game must satisfy the following conditions: (i) in each stage both the sponsor and the contractor are aware of the current "state" of the game, as characterized by the project's current rating; (ii) both players hold consistent conjectures about each other's strategies, and this information is used to obtain a Bayesian update of the contractor's rating on the basis of previous contractual performance; and (iii) strategies satisfy a credibility requirement, i.e., for any state of the game, each player's strategy is optimal for the continuation of the game, given the hypothesized strategy of the opponent.

The game is solved by backward induction. In this model the game is effectively over in period $L$, when the sponsor is locked in. To characterize the equilibrium in each period prior to period $L$, further notation must be
introduced. Let $\lambda_{L+i}(q)$ represent the expected returns for the contractor of reputation $q$ in period $L+i$ and $\tilde{\delta}_{L+i}(q)$ the expected return for the sponsor in phase $L+i$ if it funds the project in phase $L+i$, with $\Delta_{L+i}(q) = \max \{0, \tilde{\delta}_{L+i}(q)\}$. In equilibrium there will be a sequence of critical ratings $q_i^*$ such that the project is cancelled in period $l$ unless $q_i = q_i^*$.

The following proposition can now be stated.

**Proposition 1:** The acceptable rating levels $q_i^*$ are strictly declining as $l$ decreases to some period $L$, where $q_i^* = 0$ for all $i \leq L$; $\lambda_{L+i}(q)$ and $\Delta_{L+i}(q)$ are both increasing in $q$.\(^8\)

This shows that in equilibrium the acceptable reputation values decline as the project nears completion. Not only do the cut-off reputation values decrease as the project approaches lock-in but also, once the sponsor is locked in to finishing the project, it will continue funding regardless of the project’s rating. In fact, it turns out that if funding is approved in period $L+1$, then the sponsor becomes locked in. The model predicts that in equilibrium there is a positive probability that a hard project will survive to phase $L+1$ without being cancelled. Before that period, contractors will occasionally be forced to keep costs down to maintain their project’s rating. Once the sponsor is locked in contractors will cease to care about reputation and their level of performance will deteriorate in hard projects. In other words, the contractor with the unfavorable cost distribution initially exerts substantial effort, which is reduced as the

\(^8\) This is a simplified version of the proposition presented in Lewis (1986), p.152. Its proof would require the adoption of a further assumption which we omit in this presentation. That would be necessary to ensure the existence and uniqueness of equilibrium.
project nears completion. Therefore, the cost distribution for a given task towards the end of the project dominates the cost distribution for a task at the beginning of the project, in the sense of first order stochastic dominance. This is the effect which is interpreted as cost overruns.

Note, however, that the temporal pattern of contractual performance prior to lock-in is difficult to assess. We can identify at least three distinct possibilities. It may happen that the initial rating of a project is so high that it is guaranteed continued funding, regardless of contractor performance. In this case, there will be no systematic variation in construction costs over time. When the initial rating is not so high the contractor is not immune from project cancellation. This means that a contractor facing a series of high cost outcomes may eventually need to work harder in future periods to maintain its project's reputation. In this case, cost performance would improve over the interval prior to lock-in. When initial ratings are low, we may expect a deterioration of contractual performance over time, and project cancellation is possible. The explanation hinges on the fact that in this case the selection process for funding produces a biased sample of contractual performance: only those contractors who were lucky and performed well receive continued funding.\(^9\) This means that the initial level of performance on continuing projects is biased upwards, and that one should not expect these contractors to be able to maintain this higher level throughout the life of the project.

2.4. Final remarks

The model presented above predicts the occurrence of cost overruns in long-term government sponsored projects. Even though the arguments presented

\(^9\) Notice that this is similar to the winner's curse phenomenon observed in bidding.
seem compelling, the approach followed should be improved in at least three
grounds. First, the problem at hand was one of selecting projects to fund
and not the construction of optimal incentive schemes to induce contractors
to devote more effort to their tasks. Indeed, this model does not answer
the question of how to construct optimal incentive schemes that avoid
contractor's shirking. Secondly, the model is weak since the compensation
scheme is given exogenously. One may wonder whether its results would be
sustained if the compensation scheme were determined endogenously, since in
the model the incentive to exert cost reducing effort is provided by
expected future rents and it is not clear why these rents should be present.
Thirdly, the model omits the problem of contractor selection by the sponsor
in the face of contractors' ex ante cost estimates. The two latter points
will be explicitly addressed in the following sections.

3. RISING COMPENSATION SCHEMES IN LONG-TERM PROCUREMENT

3.1. The main argument

Arvan and Leite present a model aiming at explaining the occurrence of
cost overruns which was clearly motivated by the second critique to Lewis's
framework. Instead of taking parametrically the sharing rule by which the
contractor is compensated they address the problem of optimal payment design
under cost uncertainty. They develop a repeated contract game between a
sponsor and a contractor, where the project requires a number of tasks to be
completed before the benefit from the project can be realized. In their
model, there is cost uncertainty and the contractor has private, task
specific information which is relevant in cost determination. Thus, the
sponsor must resolve an adverse selection problem in designing the
remuneration scheme offered to the contractor. When the sponsor cannot precommit to compensation per task and the contractor is not bound to complete the project, it can be demonstrated that, in equilibrium, the compensation path rises as the project nears completion, giving the appearance of cost overruns towards the tail end of the project. In the context of the model we develop in this section, the intuition behind the tilting in the compensation path is quite simple. It results from the fact that the sponsor's attitude towards project completion changes with the number of tasks remaining. Towards the end of the project the sponsor is locked in to complete the project and its prevalent concern is that of contractor drop-out. As a result, the sponsor is willing to make high payments to the contractor during the lock-in phase. Early on in the contract, the sponsor is less concerned about project completion and will cancel the project unless tasks come in at low cost. In the early stages of the project the equilibrium remuneration scheme is cost plus, i.e., the contractor is paid the minimum to satisfy the drop-out constraint. During

10 In this paper we present a simpler version of Arvan and Leite's model. However, this simpler version contains elements of both moral hazard and adverse selection. More specifically, the sponsor must resolve both moral hazard and adverse selection problems in designing the remuneration scheme offered to the contractor. Notice, however, that the results provided by the simpler structure we now adopt are somewhat weaker than those presented in Arvan and Leite, in a sense which will be made clear below.

11 Arvan and Leite's result is stronger since they demonstrate that the contractor does not achieve cost minimization in equilibrium and that both the distribution of cost per task, given that the task is completed, and the compensation scheme rise as the project nears completion, giving the appearance of cost overruns towards the tail end of the project. The result we present in this paper solely contemplates the tilting in the compensation path since this is the effect we wanted to isolate. Indeed, it is the only effect arising in the simpler version of Arvan and Leite's model which we present in this work.

12 Analogous results concerning the time path of payments have been obtained in the labor contracts literature, e.g., Harris and Holmström (1982), Holmström (1983), Lazear (1979, 1981) and Salop and Salop (1976).
this period there are no rents earned by the contractor. Hence, the overall effect is to make payments rise over time as tasks are completed, giving the appearance of cost overruns.

3.2. The model

As in Lewis, assume that the project requires a pre-specified number of tasks, \( N > 1 \), for completion. For simplicity assume each task lasts one period. Let \( i \) be an index which refers both to the number of tasks and the number of periods remaining till project completion; \( i = 1, 2, \ldots, N \). Let \( B \) denote the benefit accruing to the sponsor in the event the project is completed. It is assumed that the benefit to the sponsor is zero in the event that the project is not completed.

At the start of period \( i \) nature makes a move. Let \( \tilde{t}_i \) denote this random variable and \( t_i \) denote its realization, \( t_i \in \{E, H\} \). Assume \( \tilde{t}_j \) and \( \tilde{t}_h \) are statistically independent for all \( h, j = 1, \ldots, N, h \neq j \). Let \( \text{Prob}(\tilde{t}_j = \text{H}) = \theta, 0 < \theta < 1 \). This probability represents the subjective beliefs of the sponsor concerning the difficulty of task \( i \). \( \tilde{t}_i \) is observed by the contractor but not by the sponsor. \( \theta \) is taken to be common knowledge.

The contractor's decision to complete each task is based on \( x, x \geq 0 \), the per period opportunity profit level the contractor can experience elsewhere and the rents she expects to earn from continuing to participate in the project. If the contractor has decided to complete task \( i \) then it chooses the level of cost reducing effort \( e_i \), \( e_i \in \{0, 1\} \), where \( e_i = 1 \) denotes that the cost reducing effort has been taken and \( e_i = 0 \) that no cost reducing effort has been undertaken.

The sponsor receives a perfectly informative signal of the cost reducing effort, \( a_i \), \( a_i = e_i \tilde{c} + (1 - e_i) \tilde{c} \). We refer to \( a_i \) as the
signalled cost. Signalled cost is but one component of the actual cost involved in completing task \( i \), \( c^a(t_i, \alpha_i) \). The actual cost function is then given by \( c^a(E, \bar{c}) = \bar{c}, \ c^a(E, \bar{c}) = \bar{c} + a, \ c^a(H, \bar{c}) > \bar{c} \) and \( c^a(H, \bar{c}) = \bar{c} \).\(^{13}\) \( c^a = \alpha_i + c^e(t_i, \alpha_i) + c^{ad}(t_i) \), where \( c^e(t_i, \alpha_i) \) denotes the cost to the contractor from taking cost reducing effort and \( c^{ad}(t_i) \) denotes the cost to the contractor due to cost advantage, \( \text{i.e.} \), whether the task is easy or hard. The effort cost component is given by \( c^e(E, \bar{c}) = \bar{c} - \bar{c} - a, \ c^e(H, \bar{c}) > \bar{c} - \bar{c}, \) and \( c^e(t_i, \bar{c}) = 0 \) for \( t_i = E, H \). The task advantage term is given by \( c^{ad}(E) = -(\bar{c} - \bar{c} - a) \) and \( c^{ad}(H) = 0 \).

Notice that in this formulation of the model cost reducing effort is efficient, in the sense of minimizing actual costs in period \( i \), only if the task is easy. Also note that we have designed the actual cost function so that actual cost coincides with signalled cost when the task is easy, if the contractor takes cost reducing effort, and again when the task is hard, if the contractor does not take cost reducing effort. We shall refer to this case where actual and signalled cost coincide as truthful signalling on the part of the contractor.

3.3. Equilibrium contracts and cost overruns

To get the reader acquainted with the underlying issues of the model, we shall first consider the special case where \( N = 1 \). The main ideas can be readily extended to the more general case.

Let \( P_i : (c, \bar{c}) \rightarrow \mathbb{R} \) denote the compensation function, where \( P_i(\alpha_i) \) is the payment the sponsor makes to the contractor upon completion of the task when the signalled cost is \( \alpha_i \). We proceed via backward induction. First, consider the cost reducing effort decision of the contractor given the

\(^{13}\) With \( 0 < a < \bar{c} - \bar{c} \).
pre-specified compensation scheme and given that the contractor has chosen to complete the project. Then, $c_1 = 1$ only if $P_1(c) - c^a(t_1, \bar{c}) \geq c^a(t_1, \bar{c})$. If we substitute for $c^a(.)$ into this expression when $t_1 = 1$, we have

$$P_1(c) \geq P_1(\bar{c}) - a. \quad (7)$$

When this inequality is violated the contractor has no incentive to take cost reducing effort. In the sequel we shall restrict attention to the case where $P_1(c) \leq P_1(\bar{c})$. Then, the contractor will not take cost reducing effort when $t_1 = H$. Moreover, we will assume that when task 1 is easy the contractor does indeed take cost reducing effort as long as (7) is satisfied. Given these additional assumptions we shall refer to (7) as a self-selection constraint since its verification induces truthful signalling.

Second, consider the contractor participation decision. Recall that if the contractor chooses to drop out she earns $\pi$. Then, the contractor will complete task 1 only if

$$\max_{a_1} P_1(a_1) - c^a(t_1, a_1) \geq \pi \quad (8)$$

Note that when $t_1 = H$, (8) reduces to

$$P_1(\bar{c}) \geq \bar{c} + \pi. \quad (9)$$

Substituting (9) into (7) yields

$$P_1(c) \geq c - a + \pi. \quad (10)$$
Evidently, if (10) holds then (8) does not bind when \( \alpha_1 = \xi \). In other words, if the sponsor induces participation by the contractor with a hard task and induces cost reducing effort by the contractor with an easy task then the contractor with an easy task earns a rent of at least \( \hat{c} - \xi - a \). The sponsor can extract this rent from the contractor with an easy task but only by inducing the contractor with a hard task to drop out. This is the trade-off the sponsor contemplates in choosing the compensation scheme.

Finally, we address the sponsor’s choice of the compensation scheme, \( P_1 \). Let \( Q_1 \in \{0, 1\} \) be an indicator variable. When \( Q_1 = 1 \) the sponsor allows the contractor to complete the task; when \( Q_1 = 0 \) the contractor drops out. We assume that the sponsor’s goal is to maximize the expected net benefit. Her problem can be written as

\[
\begin{align*}
\text{maximize } & (1-\theta) Q_1(\xi) \left[ B - P_1(c) \right] + \theta Q_1(\hat{c}) \left[ B - P_1(\hat{c}) \right] \\
\text{subject to: } &
Q_1(\alpha_1) \in \{0, 1\}, Q_1(\alpha_1) \left[ P_1(\alpha_1) - \alpha_1 - \pi \right] \geq 0, \text{ and } \\
(1 - Q_1(\alpha_1)) \left[ \pi - P_1(\alpha_1) + \alpha_1 \right] & \geq 0 \text{ for } \alpha_1 = \xi, \hat{c}; \text{ as well as (7).}
\end{align*}
\]

The solution to (10) is given in the following proposition.

---

14 In (10) we invoke the revelation principle, see Myerson (1979) or Harris and Townsend (1981), by asserting that there is an optimal compensation function which induces truthful signalling on the part of the contractor. That is why (7) is taken as a constraint and why we have omitted \( \xi \) as an argument of \( Q_1 \).

15 Note that in (10) we could treat \( Q_1(\alpha_1) \) as a probability rather than as an indicator variable.
Proposition 2: Let $(P^*, Q^*)$ denote a solution to (10). Then:

(i) $P^*_1(c) \leq c + \pi$, $P^*_1(\bar{c}) \leq c + a + \pi$, and $Q^*_1 = 0$ if $B \leq c + \pi$;

(ii) $P^*_1(c) = c + \pi$, $P^*_1(\bar{c}) < c + a + \pi$, and $Q^*_1(c) = 1$, and $Q^*_1(\bar{c}) = 0$ if $c + \pi < B \leq \bar{c} + \pi$ or if $B \geq \bar{c} + \pi$ and $\Theta \leq (\bar{c} - c - a)/(B - c - a - \pi)$, and

(iii) $P^*_1(c) = \bar{c} - a + \pi$, $P^*_1(\bar{c}) + \bar{c} + \pi$, and $Q^*_1 = 1$ if $B \geq \bar{c} + \pi$ and $\Theta \geq (\bar{c} - c - a)/ (B - c - a - \pi)$.

Proof: See Appendix.

We now turn to the case where $N > 1$. Since we restrict attention to history independent compensation schemes the condition that governs the choice of cost reducing effort is the same as in the one period game. The substantive difference between this multiperiod game and the single period game lies in the participation decision for the contractor and the compensation function decision for the sponsor. Both of these decisions are influenced by the equilibrium play in periods closer to completion of the project.

To keep things as simple as possible we assume the contractor is risk neutral and, hence, acts as an expected profit maximizer. Let the expected rent earned by the contractor in the one period game, $R^*_1$, be defined by

$$R^*_1 = (1 - \theta) Q^*_1(c) [P^*_1(c) - c - \pi] + \theta Q^*_1(\bar{c}) [P^*_1(\bar{c}) - \bar{c} - \pi]. \quad (12)$$

Then, recursively define the expected rent earned by the contractor from period 1 till completion of the game, $R^*_1$, by
\[ R_i = (1 - \Theta) Q_i(\zeta) \{ R_{i-1} + P_i(\zeta) - \zeta - \pi \} + \Theta Q_i(\zeta) \{ R_{i-1} + P_i(\zeta) - \zeta - \pi \}. \]  

(13)

for \( i = 2, \ldots, N \). It follows that the contractor will continue to participate in the project in period \( i \) only if

\[ R_{i-1} + P_i(\alpha_i) - \alpha_i - \pi \geq 0. \]  

(14)

In a similar way let the expected net benefit earned by the sponsor in the equilibrium of the one period game, \( V_1 \), be defined by

\[ V_1 = (1 - \Theta) Q_1(\zeta) \{ B - P_1(\zeta) \} + \Theta Q_1(\zeta) \{ B - P_1(\zeta) \}. \]  

(15)

Then, recursively define the expected net benefit earned by the sponsor from period \( i \) till completion of the game, \( V_i \), by

\[ V_i = (1 - \Theta) Q_i(\zeta) \{ V_{i-1} - P_i(\zeta) \} + \Theta Q_i(\zeta) \{ V_{i-1} - P_i(\zeta) \}, \]  

(16)

for \( i = 2, \ldots, N \). The same reasoning as given in the proof of Proposition 2 determines the optimal compensation scheme in period \( i \). This result can be summarized in the following corollary.

\[ \text{Note that (14) is written under the assumption that truthful signalling is optimal for the contractor.} \]
Corollary 1: Let \( (\mathbf{P}_i, c_i^*) \) denote the equilibrium compensation scheme and contractor quit-stay function in period \( i \) for \( i = 2, \ldots, N \). Then

(i) \( P_i^*(c) < -R_{i-1} + c + \pi, \ P_i^*(\tilde{c}) < -R_{i-1} + \tilde{c} + a + \pi, \) and \( Q_i^* = 0 \) if \( V_{i-1} \geq c + \pi; \)

(ii) \( P_i^*(c) = -R_{i-1} + c + \pi, \ P_i^*(\tilde{c}) = -R_{i-1} + \tilde{c} + a + \pi, \ Q_i^*(c) = 1, \) and \( Q_i^*(\tilde{c}) = 0 \) if \( c + \pi \geq V_{i-1} \geq \tilde{c} + a + \pi \) or if \( V_{i-1} \geq \tilde{c} + a + \pi \) and \( \theta \leq (c - c - a)/(V_{i-1} - \tilde{c} - a - \pi - R_{i-1}); \)

(iii) \( P_i^*(c) = -R_{i-1} + \tilde{c} - a + \pi, \ P_i^*(\tilde{c}) = -R_{i-1} + \tilde{c} + \pi, \ Q_i^* = 1 \) if \( V_{i-1} \geq \tilde{c} + \pi \) and \( \theta \geq (\tilde{c} - c - a)/(V_{i-1} - \tilde{c} - a + \pi + R_{i-1}). \)

By substituting the results from Corollary 1 into (13) it follows that \( R_i = 0 \) if either case (i) or case (ii) holds and that \( R_i = (1-\theta)(\tilde{c} - c - a) \) if case (iii) holds. This limits the possible compensation schemes over time to a manageable number. Since the sponsor can always induce contractor drop-out by making the compensation function sufficiently low, it follows that \( V_i \geq 0 \). Then (16) implies that \( V_i \) is nonincreasing in \( i \) and is decreasing in \( i \) as long as \( V_i > 0 \). It follows that if case (iii) holds in period \( i \) then it will necessarily hold in period \( i - 1 \). In other words, the equilibrium contract may entail an interval near completion where the sponsor is locked in to complete the project regardless of costs. Prior to this lock-in phase the sponsor funds the project only if the task proves to be easy. With exception of the phase just before lock-in, there are no future rents to be earned by the contractor in this initial phase and, consequently, the payment made to the contractor in this initial phase equals project cost plus opportunity cost. During lock-in the sponsor...

17 In Arvan and Leite, we observe that prior to lock-in, the expected cost, conditional on continuation of the project, is increasing as the number of remaining tasks decreases. During lock-in, the distribution of cost, conditional on continuation of the project is constant. This shift in the cost distribution over time offers a possible explanation for cost overruns. Furthermore, lock-in payments are higher than pre-lock-in payments. This shift in payments over time offers a second possible explanation for cost overruns.
Corollary 2: There exists two nonnegative integers, $L$ and $\sigma$, $\sigma \geq L + 1$, such that $L \geq 1$ and if $L \geq 1$ then:

(i) $P^*_1(c) = c - a + \pi$, $P^*_2(c) = c + \pi$, and $Q^*_1 = 1$;
(ii) $P^*_1(c) = \theta \left( c - a \right) + (1-\theta) \cdot c + a + \pi$, $P^*_2(c) = \theta \cdot c + (1-\theta) \cdot (c + a) + \pi$, and $Q^*_1 = 1$ for $1 = 2, \ldots, L-1$;
(iii) $P^*_L(c) = \theta \left( c - a \right) + (1-\theta) \cdot c + a - (1-\theta) \cdot (c - a) + \pi$, $Q^*_L(c) = 1$; $Q^*_L(c) = 0$; while for all values of $L$,
(iv) $P^*_1(c) = c + \pi$, $P^*_2(c) < c + a + \pi$, $Q^*_1(c) = 1$, and $Q^*_1(c) = 0$ for $1 = L + 1$, \ldots, $\sigma - 1$; and
(v) $P^*_1(c) < c + \pi$, $P^*_2(c) < c + a + \pi$, and $Q^*_1 = 0$ for $1 \geq \sigma$.

Notice that if $L = 0$ and $N < \sigma$ the payment scheme is flat. That is, there will not be any cost overruns. If $L \geq 2$ and $N < \sigma$ there is a tilting of the compensation scheme: payments are higher during lock-in than they are during the initial phase of the project. Since the initial phase is characterized by cost plus compensation the lock-in phase can reasonably be interpreted as the occurrence of cost overruns.

3.4. Additional remarks

This model shows that in a dynamic context an explanation for cost overruns can be provided simply by assuming that the sponsor cannot precommit to the compensation paid to the contractor when the contractor has some private cost information. Since actual compensation functions can almost always be written on a cost plus basis this model can be interpreted as predicting cost overruns as equilibrium outcomes only when contractors
can falsely upward their reported costs with little effect on their actual costs. The model implies that the sponsor goes along with such falsification, even though the sponsor is well aware of the truth, because such falsification is the only way to attain the equilibrium level of compensation.\footnote{If such falsification is highly costly to the contractor then the model suggests that actual, cost plus compensation functions are not optimal and may then suggest that contractors do not take the appropriate cost reducing effort in actuality. We prefer the first interpretation though we recognize that this second interpretation also has its merits.}

In the model we have presented we interpret the tilt in the compensation scheme as cost overruns.\footnote{As mentioned in footnote 9, Arvan and Leite interpret the twofold effect of an unfavorable shift in the cost distribution and the tilt in the compensation scheme as cost overruns. The first effect does not appear in the current version of the model.} This, of course, cannot be the sole explanation for cost overruns. Undeniably, sponsor learning about project costs and bargaining over the split of quasirents are also important sources of cost overruns and were not considered in the model. Furthermore, it happens that, given the structure of the model, this tilt can be anticipated \textit{ex ante}. Therefore, it can be argued that in a strict statistical sense there are no cost overruns. This particular problem motivated the approach presented in the following section.

4. SELECTION BIAS AND COST OVERRUNS

4.1. The argument

Gaspar and Leite argue that neither Lewis nor Arvan and Leite succeed at providing a comparison between benchmark cost expectations and realized costs and that this is a more natural way for analyzing cost overruns. They develop a model where, given optimal procurement rules regarding project...
selection, cost overruns are expected to occur. In their model, the sponsor receives a noisy though unbiased estimate of project costs from a prespecified number of potential contractors and then selects the contractor whose signal is the least ex ante expected cost. Although the estimates constitute ex ante unbiased estimators of the true project costs, when the sponsor uses the initial estimates to predict the costs of completing the project, it will underestimate them on average. The intuition behind this result is that the chance of a given contractor being selected is an increasing function of how much the original signal underestimates the true cost. In fact, given the selection mechanism, the sponsor will choose the signal which underestimates the true cost the most, in an expected value sense. This is the phenomenon which is identified with cost overruns.

Furthermore, this model provides an additional explanation for the pervasiveness of cost overruns in long-term projects. Besides their nature, these projects typically involve less reliable cost estimates than projects in ordinary business. This aspect can easily be captured in the model since it is easy to establish, within its simple framework, a positive relationship between greater uncertainty and larger cost overruns.

20 By optimal they mean a rule ensuring cost minimization given the available information.

21 This argument resembles the winner's curse phenomenon in the auctions literature, e.g., Capen, Clapp and Campbell (1971), Milgrom (1981), Milgrom and Weber (1982).

22 Quirk and Terasawa (1986) provide an explanation for cost overruns in "pioneer" or "first of a kind projects". Their framework is substantially different from Gaspar and Leite's in two ways. First, they rely on the maximization of the expected utility from the project while Gaspar and Leite focus on cost minimization. Second, they consider the decision to undertake a pre-specified project, given an ex ante unbiased cost estimate, while Gaspar and Leite address the selection between a finite number of potential contractors. Both explanations are compatible and complementary. Furthermore it is possible to integrate them in a unified framework.
4.2. The model

Consider the relationship between a sponsor and a contractor regarding the construction of a project. Initially the sponsor receives $n$ unbiased signals: $y_i$, $i=1,2,...,n$, concerning the cost of the project from $n$ potential contractors. The signals may be provided to the sponsor by an independent expert whose only task is to evaluate potential contractor's costs. These signals are assumed to be the sum of an idiosyncratic cost component, $c_i$, unobserved by the sponsor and a measurement error, $e_i$, $i=1,2,...,n$. $c_i$ is assumed to be normally distributed with mean $\mu$ and variance $\sigma^2_c$, i.e., $c_i \sim N(\mu, \sigma^2_c)$. The measurement error is also a normally distributed random variable with zero mean and variance $\sigma^2_e$, $e_i \sim N(0, \sigma^2_e)$.  

$c_i$ and $e_i$ are assumed to be independent random variables. Also let $f$ denote the signal's probability density function and $F$ the corresponding distribution function. Since $y_i = c_i + e_i$, $f$ is a normal density function with mean $\mu$ and variance $\sigma^2_c + \sigma^2_e$.

In order to maximize the expected value of her net benefits the sponsor selects the contractor whose costs are evaluated by the expert as being the lowest. 

Let $y^* = \min (y_1, y_2, ..., y_n)$ where $(y_1, y_2, ..., y_n)$ is an $n$-dimensional sample drawn from $f$. Define $\Psi(y^*)$ as the probability density function of $y^*$. $\Psi(y^*)$ is given by:

$$\Psi(y^*) = \text{pdf}(\min (y_1, y_2, ..., y_n)) = n f(y^*) (1 - F(y^*))^{n-1}. \quad (17)$$

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23 In Gaspar and Leite the normality assumption is dropped and it is considered that the joint distribution of $c_i$ and $e_i$ belongs to the family of symmetric elliptical distributions.

24 As shown in Gaspar and Leite, this decision rule is optimal in the sense that a cost minimizing sponsor will choose the minimum signal.
In this structure, despite the \textit{ex ante} unbiasedness of signals, the sponsor, on average, underestimates the true cost of the selected project by using the expert’s cost estimate for the selected contractor. This result constitutes Proposition 3.

\textit{Proposition 3: The use of the above-mentioned selection mechanism leads to an underestimation of project costs on average, i.e.:}

\[
\int_{\Omega} E(c|y^*) \psi(y^*) \, dy^* > \int_{\Omega} y^* \psi(y^*) \, dy^*, \text{ with } \Omega = [1-an, +\infty].
\]

\textit{Proof: See Gaspar and Leite.}

Note that, in this formulation of the procurement process, the sponsor is choosing the minimum of \( n \) noisy estimates of project costs. It may pick a particular estimate either because it reflects a low idiosyncratic cost or because it reflects a low realization of the error term. Proposition 3 simply formalizes the intuitive idea that the minimum signal in a sample of size \( n \) is expected to contain a negative error term.

Within this framework we can also establish another result relating signal accuracy to the extent of cost overruns. In order to do so suppose we had two samples of cost signals of size \( n \) drawn from two normal distributions, \( f^1 \) and \( f^2 \), with the same mean \( \mu \), and variances \( \sigma^2 = \sigma_c^2 + \sigma_{e_1}^2 \) and \( \sigma^2 = \sigma_c^2 + \sigma_{e_2}^2 \) with \( \sigma_{e_1}^2 < \sigma_{e_2}^2 \). Let \( y^* = \min (y^1_1, y^1_2, \ldots, y^1_n) \), where \((y^1_1, y^1_2, \ldots, y^1_n)\) is a sample of size \( n \) drawn from \( f^1 \). Similarly, let \( y^*_2 = \min (y^2_1, y^2_2, \ldots, y^2_n) \), where \((y^2_1, y^2_2, \ldots, y^2_n)\) is a sample of size \( n \) drawn from \( f^2 \). Define \( \psi(y^*_1) \) and \( \psi(y^*_2) \) as the probability density functions of \( y^*_1 \) and \( y^*_2 \), respectively. We are now in conditions to establish Proposition 4, indicating that a less accurate signal leads to larger cost overruns, on
Proposition 4:

\[
\int \frac{E(c|\mathcal{F}_2^n)}{\mathcal{F}_2^n} \psi^2(\mathcal{F}_2^n) \, d\mathcal{F}_2^n - \int \frac{E(c|\mathcal{F}_1^n)}{\mathcal{F}_1^n} \psi^2(\mathcal{F}_1^n) \, d\mathcal{F}_1^n > 0
\]

Proof: See Gaspar and Leite.

This proposition implies that, on average, we should expect larger cost overruns when the cost signal is less accurate. Therefore, cost overruns are more likely to occur in large-scale, long-term projects in which costs are less accurately predictable.

5. COMPETING OR COMPLEMENTARY EXPLANATIONS?

We have presented three papers aimed at explaining why cost overruns are so pervasive in long-term government sponsored procurement. In both Lewis, and Arvan and Leite, the notion of cost overruns appears to be identified with the occurrence of unfavorable shifts in the distribution of realized costs as a project nears completion. In the first model, cost overruns are the result of a bilateral relationship between a sponsor and a contractor, where a contractor with an unfavorable cost distribution initially exerts substantial effort, which is reduced as the project nears completion. Towards the end of the project minimum acceptable performance levels for the contractor are lowered, and hence the contractor has lesser incentives to engage in cost reducing effort. As a result, cost performance deteriorates in the final periods of construction and cost overruns are
equilibrium outcomes of the model.

Arvan and Leite also analyze cost overruns in the context of a long-term relationship between a sponsor and a contractor. However, contractor’s reputation building in the early stages of the project no longer plays a visible role in explaining cost overruns. Instead, Arvan and Leite take up one of the major weaknesses of Lewis’s model. In Lewis’s model the sharing rule by which the contractor is compensated is taken to be parametric. Arvan and Leite wonder whether Lewis’s results would be maintained if this sharing rule was endogenously determined, since in Lewis’s model the incentive to exert cost reducing effort is provided by expected future rents and is not clear why these rents should be present. Then, instead of taking exogenously the compensation scheme which determines contractor’s payments in the course of the project, the authors focus on contract design. That is, in their model the compensation scheme is endogenous to the model and its shape results from sponsor’s optimization given the structure of the model. As in Lewis, they show, in the published version of their model, the occurrence of unfavorable shifts in the distribution of realized costs as the project nears completion. However, they also show that the optimal per period compensation scheme rises towards the end of construction. This tilt in the compensation scheme arises from the fact that, as the project approaches its final stages, the sponsor becomes locked in to finishing the project and optimally decides to fund the project regardless of cost realizations.

Neither Lewis nor Arvan and Leite created the impression that they addressed what, in their view, was the sole explanation for cost overruns. Note, for instance, that even in the context of possible equilibria in long-term relationships between a sponsor and a contractor, some aspects which are probable sources of cost overruns were totally dismissed from both
frameworks of analysis. Arvan and Leite, for instance, do not consider
sponsor learning about project costs and bargaining over the split of the
quasi-rents, which can be argued also to be sources of cost overruns.
Nevertheless, the inclusion of such aspects would make the model hardly
tractable, and would probably only amplify their results.

Gaspar and Leite took a rather different approach to provide a
plausible explanation for the occurrence of cost overruns. They started out
by noticing that neither of the previous two stories provides a comparison
between benchmark cost expectations and realized costs. This was to be
expected since both Lewis, and Arvan and Leite omitted the problem of
contractor selection in the face of contractor's ex ante cost estimates. As
Gaspar and Leite have noticed, in most cases contractors are selected on the
basis of their ex ante cost estimates. In fact, there is widespread
evidence that many times sponsors choose the contractor presenting the
lowest ex ante cost estimate, i.e., sponsors will choose the signal which
underestimates the true cost the most, in an expected value sense. Cost
overruns are then inevitable. Since there is extensive evidence of use of
this type of selection rules in military procurement, we should expect cost
overruns in many defence projects. In fact, evidence pertaining to
procurement practices by the U.S. Department of Defense and government
agencies in Western Europe uncovers the existence of procurement directives
implying the use of the minimum bid to determine which contractor will
undertake the project.

The results provided by Gaspar and Leite do not seem to be incompatible
with those of Lewis, and Arvan and Leite. Gaspar and Leite simply point out
that, given the nature of the other two models, the shifts in the cost
distribution which occurs in both Lewis and Arvan and Leite and the tilt in
the compensation function occurring in the latter model, can all be
anticipated ex ante. Therefore, it is also relevant to identify commonly used selection mechanisms as a source of downward bias in estimating project costs. That is, Gaspar and Leite are able to explain cost overruns without considering the long-term nature of the contractual relationships involved in long-term procurement. This does not mean that we have learnt nothing from Lewis and Arvan and Leite, but simply that they have not uncovered the whole story: cost overruns can be explained without requiring the existence of incentive problems, but these are certainly important in explaining their occurrence and pervasiveness.
APPENDIX

Proof of Proposition 2: First note that if \( B = \bar{\alpha}_{I} + \pi \) then it is optimal for the sponsor to cancel the project when the actual cost is \( s_{I} \). In our formulation, the sponsor cancels the project by inducing the contractor to drop out. This is accomplished by violating the voluntary participation constraint (8), in which case \( Q_{I}(\alpha_{I}) = 0 \). If \( Q_{I}(\alpha_{I}) > 0 \) at the optimum then the objective function is decreasing in \( \mathcal{P}(\alpha_{I}) \). Hence, either the voluntary participation or the self-selection constraint must bind. If \( B > \bar{c} + \pi \) then it is always optimal to induce the contractor with an easy task to complete the project, i.e., \( Q(c) = 1 \) is optimal, since inducing the low cost contractor to quit implies that the project will never be built. Finally suppose, \( B > \bar{c} + \pi \). If \( Q_{I}(c) = 1 \) and \( Q_{I}(c) < 0 \), then the maximum value the objective takes on is \( (1 - \Theta)(B - \bar{c} - \pi) \). If \( Q_{I} = 1 \), then the maximum value the objective takes on is \( B - \bar{c} - \pi + (1 - \Theta) \alpha \). The former exceeds the latter iff \( \Theta < (\bar{c} - c - a) / (B - \bar{c} - a - \pi) \). \( \square \)
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