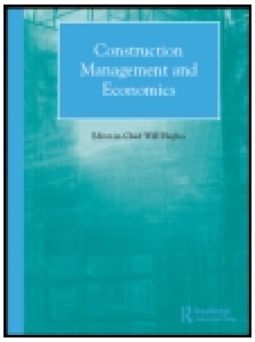

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Cost-plus and incentive contracting: Some false benefits and inherent drawbacks

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Two problems associated with cost-plus and incentive contracts in the construction industry are discussed: the financial costs of an earlier construction start through the use of a 'fast-tracked' design–build cycle, and the counterproductive effects of the 'adverse selection' of competing construction firms that must occur in a cost-plus or incentive contract environment. Though they stem from basic economic principles, these problems are often ignored in the conventional wisdom. The authors argue that the demonstration of these serious, commonly overlooked drawbacks should result in a decrease in the use of cost-plus or incentive contracts.

Keywords: Building procurement, contracts, cost-plus contracting, cash flow, project scheduling, uncertainty, adverse selection.

Introduction

One of the unique, characteristic features of the construction industry is the need for using formal written contracts to govern the transaction between the buyer (owner of the building) and the seller (contractor). This need arises from the nature of the product of the construction, which is generally immobile and unique to each sale, requires a long time to produce, and involves inherent risks and uncertainties. Though they are thus a necessary requirement, increasing stringent contractual arrangements have been blamed for being a major cause of the relatively poor productivity of the construction industry in recent decades. For example, the Business Roundtable Construction Industry Cost-Effectiveness Project (1982) estimated that a lack of careful attention to the effects of specific contractual arrangements adds about 5% to US construction costs, thereby wasting some US$6 billion per year.

This paper attempts to shed light on some micro- and macro-economic considerations and effects associated with a broad class of contracts prevalent in the construction industry, known as 'cost-plus' and 'incentive' contracts, characterized by the fact that the owner shares a greater or lesser part of the cost risks in the project with the contractor.

The well-known advantage of 'cost-plus' contracts is that they enable a 'fast-track' construction cycle to be adopted, because building specifications and drawings need not be completed prior to the start of construction. Another, less cited yet none the less important advantage of such contracts is that they put the owner and the contractor in a less 'adversarial' position, which smooths working relations during construction of the project and helps to reduce litigation costs. The primary disadvantage for the owner is that these

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contracts tend to increase construction costs, as they provide less motivation to the contractor to be efficient and minimize costs than do fixed-price contracts.

In this paper, we call attention to two hidden, less obvious problems in cost-plus and even in incentive contracting. One is the often unnoticed shift in the timing of expenditures in a fast-tracked design–build cycle, which drastically offsets its benefits. The other problem is a phenomenon called 'adverse selection', which is created by such contracts damaging productivity in the long run.

We regret the inconvenience that our strong conclusions may cause to the advocates – either in writing or in practice – of cost-plus and especially cost-plus-incentive contracts. We do realize that the two factors we highlight here are hidden and run counter to intuitive thinking; no wonder, therefore, that they have been overlooked by the professional literature. In fact, had it not been for the circumstance of the simultaneous stay of both authors at MIT – the first as a visting faculty member, the other as a PhD student – they also would probably never have arrived at discussing and formalizing such thinking, which seems to contradict accepted conventions.

We are not suggesting that our arguments should completely rule out cost-plus and incentive contracting, but rather that careful consideration should be given to the selection of the various contracting schemes available for any particular construction project.

The timing shift problem

The ability of cost-plus contracts to permit an earlier start to construction is often cited as *the* major benefit of such contracts from the point of view of the building owner. The following statement, from a construction management textbook, expresses this conventional wisdom well:

> [Cost-plus contracting] allows compression of the classical 'design-first-then-construct' sequence. Since time is literally money, every day gained in occupying the facility or putting it into operation represents a potentially large dollar saving. The cost of interest alone on the financing of a large hotel complex has run as high as $50 000 a day (Halpin and Woodhead, 1980).

Yet while the ability to complete the project sooner is clearly a valuable economic benefit, the conventional wisdom is often unaware of the fact that this benefit is drastically reduced and often completely wiped out by the increase in effective cost due to the earlier start and usually longer duration of construction.

In-depth models of bid evaluation and the value of fast-tracking and 'design–build' have been presented by Warszawski (1979), Selinger (1983) and others. However, for the sake of clarity, we here prefer to make the point by presenting a simplified model, sufficient in its accuracy for our purpose.

In Fig. 1 we have adopted a basic diagram, taken from the Business Roundtable report on Contractual Arrangements (1982). The diagram presents, on a relative scale, typical indications for timing and duration of the construction phase under various contractual arrangements. We have inserted some notations in this diagram to illustrate the financial value of such time shifts by comparing a typical incentive-type contract with a common fixed-price one.

The fast-tracked cycle of cost-plus or incentive contracts enables construction to start ΔS

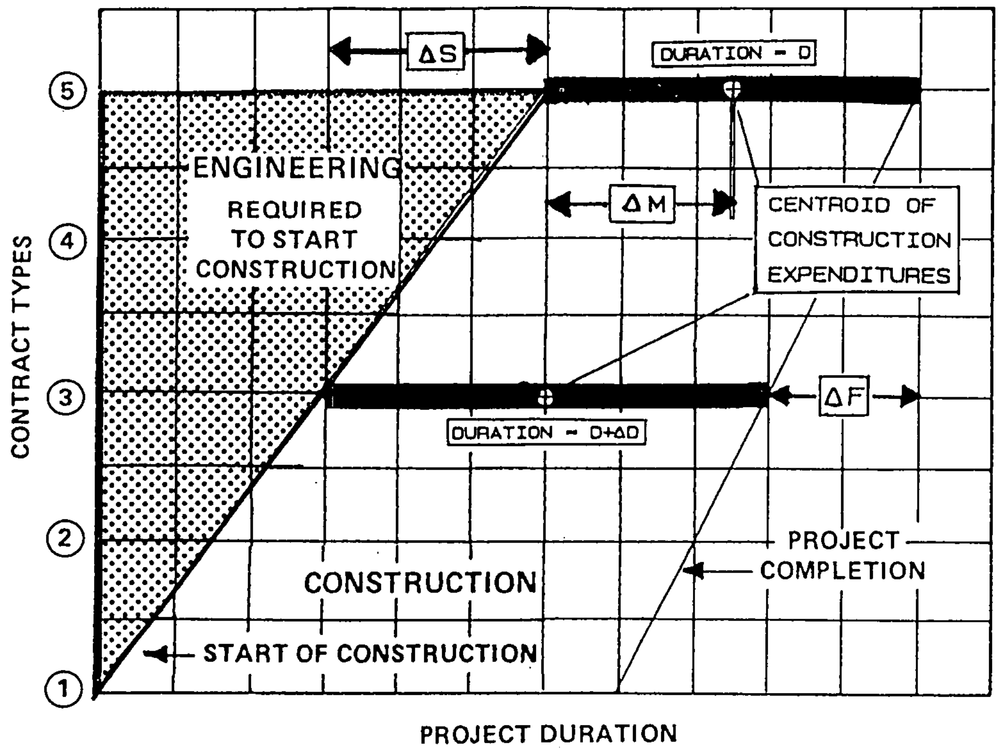

Fig. 1. Project schedule duration *vs* type of contract. 1, Cost reimbursable *W*/% fee; 2, cost reimbursable *W*/fixed fee; 3, target price; 4, guaranteed maximum price; 5, lump sum fixed price.

units of time earlier than the fixed-price alternative, but the incomplete design at the time construction start, usually results in a slower pace and longer duration of the construction phase, say by ΔD units of time. Thus the net savings in advancing the date of completion and putting the building into operation, ΔF, is:

$$\Delta F = \Delta S - \Delta D \tag{1}$$

Assuming that the building generates net operating cash flows at the rate of x dollars per unit of time (e.g. per month), the dollar value of the earlier completion is $\Delta F \cdot x$.

For the sake of accuracy, let us exclude the effect of the land price from our calculations, taking P to be what the owner pays for construction alone, and x the owner's share of the cash flow due to the building alone (i.e. the total cash flow less the cash flow for the land alone). The building's net cash flow, x, can be expressed as the yield or payout rate of the building, p, times the cost, P, of the building to the owner, namely $x = P \cdot p$. The gross cash value of the earlier completion, G, thus becomes:

$$G = P \cdot p \cdot \Delta F \tag{2}$$

While this benefit of earlier completion is emphasized by most writers on contracting in construction, they somehow fail to charge, against this gross benefit, the higher effective cost of an earlier start and longer duration of construction. In order to arrive at the true net benefits of the fast-tracked cycle, suppose, for the sake of simplicity, that the construction costs to the owner, P, would be the same regardless of whether the construction is fast-tracked or not. (This assumption is quite conservative, because in reality it is likely that the fast-tracked construction would cost more, if for no other reason than that the longer duration of the construction phase necessarily leads to higher overhead costs.)

Let us further assume, again for simplicity and without changing the substance of our analysis, that all the construction payments will be made by the owner at one time, namely the 'centroid' of the duration of the construction phase. (This approximation is sufficient for the purpose of our analysis, although construction expenditures may not be uniform over time.) By the previous definitions, the fast-tracking construction will cause this centroid to occur approximately ΔM units of time earlier than it would without fast-tracking. Figure 1 reveals that:

$$\Delta M = \Delta S - \Delta D/2 = \Delta F + \Delta D/2 \tag{3}$$

Finally, suppose that the owner finances the entire construction cost with a perpetual loan that he takes out on the day he has to pay the construction contractor, namely the 'centroid' of the construction phase in our model. The loan is at an interest rate, i, charged to the amount P, taken to start at the centroid of the construction phase. It is a fact that in the fast-tracked case this centroid occurs earlier, so that the additional interest charges, I, cause a direct increase in effective construction costs:

$$I = P \cdot i \cdot \Delta M \tag{4}$$

Thus, the net benefit of fast-tracking, labelled N, is given approximately by:

$$\begin{aligned} N &= G - I \\ &= P \cdot p \cdot \Delta F - P \cdot i \cdot \Delta M \\ &= P(p \cdot \Delta F - i \cdot \Delta M) \end{aligned} \tag{5}$$

To gain an idea of the typical magnitude of these net benefits and how they differ from the gross benefits, let us use Fig. 1 for illustration, assuming that each division on the horizontal axis equals 2 months. Thus:

$$\Delta F = 4 \text{ months}$$

$$\Delta M = 5 \text{ months}$$

Inserting some typical values for i and p (e.g. according to Miles and McCue, 1982):

$$i = 0.8\% \text{ per month } (\approx 10.0\% \text{ per year})$$

$$p = 1.2\% \text{ per month } (\approx 15.4\% \text{ per year})$$

and substituting them into equations (2), (4) and (5), gives:

Gross benefit: $G = P \cdot p \cdot \Delta F = P \cdot 1.2\% \cdot 4 = P \cdot 4.8\%$

Interest charge: $I = P \cdot i \cdot \Delta M = P \cdot 0.8\% \cdot 5 = P \cdot 4.0\%$

Net benefit: $N = G - i = P(4.8\% - 4.0\%) = P \cdot 0.8\%$

In this example, a gross benefit of 4.8% on P, due to the earlier start of operation of the building, has been reduced to less than 1% in net benefits.

In other situations, where the rates of i and p are closer to each other and/or ΔF and ΔM are farther apart, the net benefit may go down to well below zero, being sensitive not to the absolute magnitude of either variable, but only to the proportion between these two sets:

$$N > 0 \text{ as long as } p/i > \Delta M/\Delta F \tag{6a}$$

$$N < 0 \text{ as long as } p/i < \Delta M/\Delta F \tag{6b}$$

In addition to these simple arithmetic calculations, it must be borne in mind that equation (5) tends to overstate the net benefit in three aspects:

1. The assumption that P remains unchanged, no matter what contracting scheme is used, is very conservative because, as we shall prove, cost-reimbursable contracts (with or without incentive) always tend to cost the owner more than fixed-price contracts. That greater cost may cancel any small net benefit that may be expected on the basis of equation (5). Furthermore, the longer duration of construction, and the closer cost control the owner must maintain in such contracts, are likely to increase his overhead costs.
2. In equation (5), we did not convert the benefit and the cost of fast-tracked construction to present values. Because the benefit occurs later than the cost, the net benefit is somewhat overstated.
3. A further slight overstatement, of the calculated gross benefit derived from an earlier completion of the building, stems from the fact that we did not subtract from it the present value of its expected earlier deterioration by the same amount of time.

While the first aspect deals with a substantial amount (several per cent of P), the second and third aspects are almost negligible compared with the major variables of equation (5).

To summarize this section, let us return to the title of this paper. We have revealed in this section the ostensible benefits of fast-tracking associated with cost-plus and incentive contracts. Our point was to call attention to the fact that the conventional wisdom and much of the current literature seems to focus only on the gross value of fast-tracking, whereas its net benefit is considerably smaller. The following section focuses on some very real drawbacks of reimbursable contracts.

The adverse selection problem

Our primary argument in this section is that not only cost-plus, but also cost-plus-incentive contracts, lessen the motivation of contractors to minimize construction costs and lead to a productivity-dampening adverse selection phenomenon on both the micro and the macro levels of the industry. 'Adverse selection' is encountered in industries in which imperfect information results in an asymmetry of knowledge between buyers and sellers, that knowledge affecting the value of the relevant product. The asymmetry referred to causes buyers and/or sellers in the marketplace to be selected in a manner that affects prices undesirably and reduces efficiency in the market.

An often cited example of adverse selection is the used-car market, where the seller knows more than the buyer about how good the car is (Ackerlof, 1970). Buyers discount the prices they are willing to pay for used cars in order to reflect the probability that cars in the market are 'lemons'. This low (lemon-probability-discounted) price in the used-car market encourages owners of good used cars not to sell in that market (e.g. by holding on to their good used cars longer than they otherwise would), which causes the used cars on offer in the market to have a higher probability of being 'lemons' than the average car of the same type and vintage on the road. The cars in the used-car market are thus subject to adverse selection, and this causes the used-car market to be less efficient than it would otherwise be, in that sellers of good or even average quality used cars face a market price that undervalues their cars. They therefore hold on to their cars longer than would be socially optimal, namely, longer than would maximize buyers' and sellers' welfare, if all could have perfect information about car quality.

The used-car market example shows how adverse selection can apply to the quality of the product and can lead to a direct relationship between quality and price in the market. Of course, when price becomes a proxy or 'signal' for quality, it is difficult for price also to signal a firm's efficiency or productivity. This type of quality-oriented adverse selection probably also occurs in the construction market. In such markets, the seller's reputation becomes extremely important as the major non-price signal to the buyer. Careful and educated buyers may be able to control sellers' quality fairly well, especially with the aid of legal mechanisms, such as contracts that define quality standards by technical and performance specifications.

Can adverse selection affect price or cost as well as quality, even in the absence of a quality dimension? Indeed, this can be seen in the insurance industry to which the term 'adverse selection' was originally applied. Consider the life insurance market, where buyers of insurance are likely to know more about their own health and prospects for a long life than the company selling life insurance. At any given price, therefore, life insurance will be a better deal for a person of worse than average health than for one of better than average health. Buyers of life insurance policies will thus tend, on average, to be in worse health than the average person of the same outwardly observable actuarial characteristics. To the extent that this adverse selection problem arises, the price insurance companies must charge for life insurance is driven up, beyond the efficient level – namely, the level that would apply in a competitive market with perfect information. In this example, adverse selection affects the cost that everyone must pay for insurance. Like the insurance industry, the construction industry is also characterized by uncertainty and imperfect information.

A valuable literature has focused on optimal bidding in the construction industry, including considerations of uncertainty, and has recently expanded existing bidding models to include considerations of opportunity costs (Carr, 1982, 1987). However, this optimal bidding strand of the construction management literature has focused on the fixed-price contract environment and has therefore missed the adverse selection problem raised by incentive and cost-plus contracting. Stuckhart's (1984) review of NASA and defence industry literature focused on the issue of risk allocation between the contractor and the owner but did not consider the implications of asymmetrical information. In the remainder of this section, we shall show how the cost-oriented type of the adverse selection problem, described for the insurance industry, may also affect the construction industry, when it uses cost-plus and incentive contracts. We shall also show that adverse selection could help to explain lagging productivity growth in the construction industry relative to other industries, and how it could cause incentive contracting to result in, contrary to intuitive thinking, negative consequences for the building owner or developer. For clarity of presentation, numerical examples are used in this section to describe and illustrate the problem. Nevertheless, the key conclusions presented here are entirely general and independent of the particular illustrative numbers employed. The generality of adverse selection in incentive contracting is demonstrated by McCall (1970) through an algebraic treatment of the problem.

To see how cost-oriented adverse selection can occur with incentive contracting in construction, consider the following numerical example. Suppose a developer has to choose between two competing contractors, X and Y, to build a certain fast-tracked project, estimated by him to cost around US$1 million. To simplify the analysis, suppose further that the developer can control the quality so that firms X and Y are equal on the quality dimension, and only the question remains which firm will be the most efficient or productive in carrying out the job. To try to obtain the most efficient construction, the developer does not offer a simple cost-plus, but a cost-plus-incentive contract. He will pay the construction firm its target or bid cost estimate plus 5% of that amount as profit, plus or minus 40% of the difference between what the actual cost turns out to be and the bid target.

Algebraically, let P be the actual cost to the owner, which is equal to the revenue to the construction firm, B the bid or target cost stated by the contractor, and C the actual cost borne by the contractor. The above-described incentive contract can then be represented by:

$$P = B + 0.05B + 0.40(C - B), \quad \text{or}$$

$$P = 0.65B + 0.40C \tag{7}$$

The contractor's profit, V, will just be $P - C$, or:

$$V = 0.65B - 0.60C \tag{8}$$

Because each contractor knows that the developer will choose between firms X and Y at least partly on the basis of the lower bid (target cost), B, he must try to offer as low a target cost as possible. But, how low is he willing to go, since his profits will be a direct function of B? Certainly, the answer to this question would be expected to depend on the contractor's knowledge of what his own costs, C, will actually be. Let us therefore suppose that contractor X knows that the actual cost of the project to him (i.e. his expenditures or outlays) will be US$800 000, and that contractor Y, who is less efficient than X, knows that the costs to him will be US$950 000.

The developer, of course, does not know beforehand, when selecting his contractor, what the contractor's actual cost, C, will eventually be, or that X is more efficient than Y. However, one would hope that contractor X *could and should* offer a lower target cost bid than Y, reflecting X's higher productivity. In this way, and other things being equal (which we assume they are, such as quality of construction), the developer would be led to select the more efficient construction firm.

However, this project is not the only one in town, and contractors usually have limited resources. Suppose that other projects of similar type and size are available, for both contractors X and Y, at an average price, P, of US\$1 050 000. That is, the resources or inputs which either contractor would use on this particular job, could instead be employed on another one, where the revenue earned would be US\$1 050 000. Thus while the two contractors face different actual outlays, C, for the job because of their different efficiencies or productivity, they still face the same 'opportunity revenue', because they are both in the same market. That 'opportunity revenue' is US\$1 050 000 for both. Thus contractor X, who estimates his cost at US\$800 000, will demand a profit of at least US\$250 000 on the incentive contract project, while contractor Y, who estimates his cost at US\$950 000, will demand a profit of at least US\$100 000. If these profits are unattainable, each firm would do better by just concentrating all their resources on the alternative jobs available. So both contractors' bids on the incentive contracts are set to equate their profit, as expressed by equation (8), to their opportunity profit, which could be theirs on the other, similar jobs:

$$\text{For firm X:}\quad 0.65B-0.60(800\,000)=250\,000$$

$$\rightarrow B=730\,000/0.65=1\,123\,077 \tag{9}$$

$$\text{For firm Y:}\quad 0.65B-0.6(950\,000)=100\,000$$

$$\rightarrow B=670\,000/0.65=1\,030\,769 \tag{10}$$

In this rational, profit-maximizing bidding strategy, the less efficient contractor, Y, will bid the lower target cost, even though he takes full account of his own higher cost. The asymmetry of information destroys the ability of the target cost bid, B, correctly to signal the relative efficiency of the competing firms under the incentive contract (or under a purely cost-plus contract). This perverse relationship between the bid or target cost and the efficiency of the bidder, destroys the usual ability of the pricing mechanism in a competitive market to maximize efficiency, and it results in adverse selection, in which less efficient firms will tend to be selected over more efficient firms, because their target bids are lower.

The graph in Fig. 2 describes the profit-maximizing bids, B, and the effective price, P, to the owner, as functions of the construction firm's cost, C, over the region where these costs are less than the average market price for similar jobs, i.e. US\$1 050 000.

The irony is that, in this case, it appears not to matter to the developer which contractor he selects, because his costs, P, will end up being the same and equal to the going price, or 'opportunity cost', for such works in the fixed-price construction market:

$$\text{For X:}\quad P=0.65(1\,123\,077)+0.40(800\,000)=1\,050\,000 \tag{11}$$

$$\text{For Y:}\quad P=0.65(1\,030\,769)+0.40(950\,000)=1\,050\,000 \tag{12}$$

Thus, the developer gains no advantage from the incentive contract, but he obviously does not realize this, or he would not use that type of contract in the first place. The only one in this example who gains from the use of the incentive contract is contractor Y, the inefficient firm, because he wins the job.

While, by equation (7), it does not matter to the developer in this specific project why,

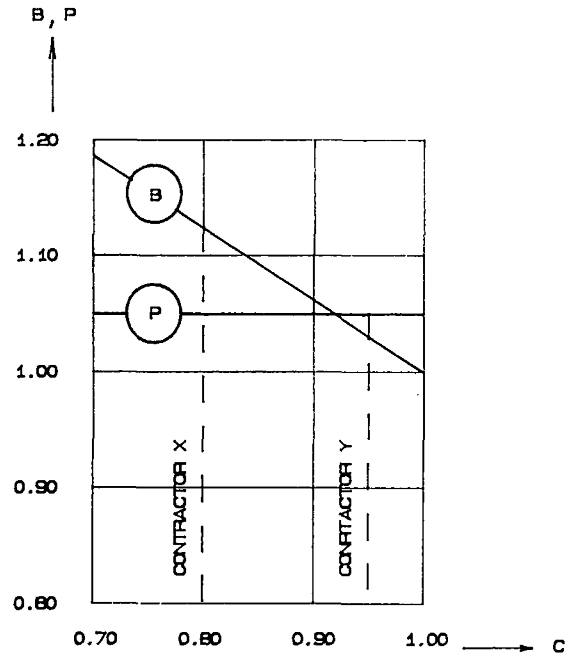

Fig. 2. Bid and final price of contractors X and Y. *C*, contractor's own cost (US$ millions); *B*, contractor's bid or target cost (US$ millions); *P*, final price paid to the contractor (US$ millions).

despite contractor Y's inefficiency, he is able to win jobs against more efficient competitors, it does matter to the construction industry as a whole and, in the long run, to developers as purchasers of construction services. This type of adverse selection in the construction market is bound to cause the construction industry to be less efficient, less productive, and operating at higher cost than it could. Less efficient firms are not weeded out as effectively as they are in other industries, which raises the prices in the construction market. The worst situation of adverse selection, however, is yet to come, as demonstrated by the fact that it even enables construction firms whose costs exceed the average market price, to continue to exist and avoid losing money if sufficient cost-plus or incentive contract jobs are around for them to compete for. For demonstration, suppose that a third firm, contractor Z, is also competing for the job offered by the developer. While X is quite efficient and Y has mediocre productivity, let us assume that Z's productivity is really poor, with costs exceeding the average market price on this type of job. To be specific, suppose Z's costs are US$1 100 000, i.e. almost 5% above the average market price of US$1 050 000, while X's and Y's costs are as given before. Suppose further that Z, knowing that his costs are higher than the average winning bid on such jobs, deliberately bids at cost, setting his expected profit equal to zero. According to equation (7), Z will bid US$1 015 385 and still not incur a loss, because:

$$P = 0.65(1\ 015\ 385) + 0.4(1\ 100\ 000) = 1\ 100\ 000 = C \tag{13}$$

If the developer makes his selection on the basis of the lowest bid, as he often does, he will pick contractor Z. Yet in this case, clearly, the developer will end up worse off if he does that, because he will, finally, have to pay US$1 100 000 instead of US$1 050 000. Moreover, Z could even insert a small profit into his bid and still underbid both X and Y. In this case, the developer would finally pay more than US$1 100 000 for his 'rational' selection.

This situation is illustrated in Fig. 3, which extends Fig. 2 to contractors whose costs

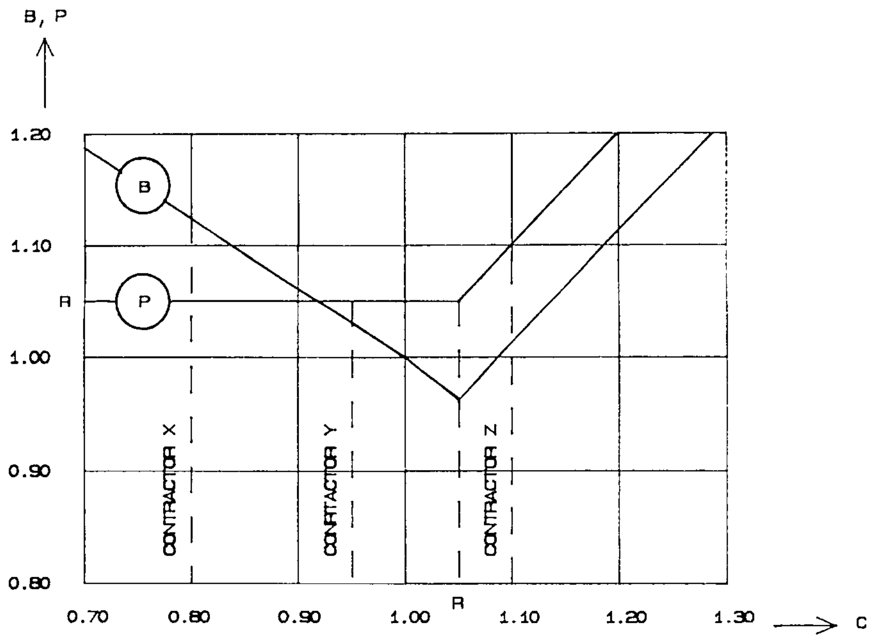

Fig. 3. Bid and final price of each contractor as a function of his own cost. *C*, contractor's own cost (US$ millions); *B*, contractor's bid or target cost (US$ millions); *P*, final price paid to the contractor (US$ millions).

exceed the average market price. Note that with contractors whose costs are less than, or equal to, the average market price, the developer ends up paying the average market price, or 'opportunity cost', no matter what the contractor's costs are. But for contractors whose costs exceed the average market price, the developer in the end pays more than the opportunity cost for his job.

Although shown here to apply to specific numerical examples, the pattern of Fig. 3 is generally valid for any case of cost-plus or incentive contracting. As long as a contractor's own cost, *C*, is below the average market price, *R*, for similar jobs, he is expected to price his bid, *B*, so that his final takings (including incentive), *P*, will equal *R*. Inefficient contractors, however, with own cost, *C*, higher than *R*, will merely try to cover their costs. They will deliberately set their target price or bid, *B*, below their own cost, but will, in the end, get their final cost. A developer or owner who offers a cost-plus or an incentive contract, must be prepared to pay more than the market price for similar jobs. He may finally pay either the market price, *R*, or more, but he can never expect to pay less. The cost-plus and incentive contracts market, which exists side-by-side with the fixed-price market, mainly attracts inefficient contractors who, with their own high costs, cannot compete in the fixed-price market; but in the cost-plus and incentive contracts market they can deliberately submit low bids. Knowingly or unknowingly, they fully utilize the adverse selection phenomenon. In the lower zone of B in Fig. 3 are found only 'mediocre' or worse contractors, whose own costs are around R. Efficient contractors, such as X, are located on the left side of the graph and have a very small chance of winning a job in the cost-plus and incentive contract market.

Summary and conclusions

We realize that our assumptions somewhat simplify and abstract the real world of construction contracting. In that real world, contractors' costs are not known for certain in advance, even to the contractors themselves, nor are the 'opportunity revenues' in terms of average market prices. More importantly, owners do not make their selection among competing bidders solely on the basis of lower bid or target cost, and experienced developers have at least some familiarity with construction firms and their reputations regarding both quality and cost.

Nevertheless, we believe that our basic conclusions are not merely theoretically valid, but also important and applicable in the real world. These conclusions are:

1. At the micro level of specific construction projects, cost-plus and incentive contracting can have perverse and unexpected results for owners and developers buying construction services via such contracts.
2. At the macro level of the construction industry as a whole, the widespread use of incentive and cost-plus contracting tends (on average and over time) to contribute to an adverse selection phenomenon. It lowers the pressures and blunts the incentives for production efficiency on the part of construction firms, and in time leads to higher costs and prices in the industry. This adverse selection problem as created by cost-plus and incentive contracting should be considered seriously before the type of contract is chosen. The major incentive inherent in such contracts goes to help 'mediocre' and very bad contractors, like Y and Z in our example, to win jobs against efficient contractors, like X.
3. We further showed, in the first part of the paper, that what is often perceived as a major benefit of cost-plus and incentive contracting, namely that it allows a so-called 'fast-track' design–build cycle, is of a much smaller value than it appears to be. The benefit of earlier completion is usually more than half offset by the cost of the consequent shift in the timing of construction expenditures. In some circumstances, the earlier expenditures and the longer duration of the construction phase will completely wipe out any benefit gained by an earlier start of profitable operation of the building; it may even lead to the accumulation of losses.

For an initial exposure of our ideas, which seem to run counter to intuitive thinking, we have chosen to explain them in basic terms and by numerical examples. If they arouse any debate, we shall gladly present a more detailed mathematical and algebraic treatment of both arguments in order to validate their generality. We believe that, with or without debate, the great weaknesses we pointed out should limit the use of cost-plus and incentive-type contracts in construction to truly exceptional, rare situations.

Notations

The following symbols are used in this paper:

B = Bid or 'target cost' presented by a contractor to the owner prior to the latter's selection of the contractor.
C = Contractor's cost (per job), known before the start of work only by the contractor, but unknown to the owner.
D = Duration of the construction phase.
ΔD = Difference in duration between cost-plus-incentive and fixed-priced projects.
ΔF = Difference between the time of completion of a cost-plus-incentive and a fixed-price project.
G = Gross benefit of earlier completion of the project.
I = Interest or financing charges due to an earlier 'centroid' of the project.
i = Rate of interest for construction financing.
ΔM = Time shift in centroid of construction expenditures.
N = Net benefits of fast-tracking the design–build cycle.
P = Construction price (or cost) to owner, which equals the revenues of the contractor.
p = Rate of payback to the owner on his investment P.
R = Opportunity cost to the owner, equals the average opportunity revenue to the contractor for a similar job.
ΔS = Amount of time by which the construction phase starts sooner under a fast-track cycle.
V = Contractor's profit on job.
x = Net cash flow from the building upon its completion.
X = Name label of the most efficient contractor in the examples.
Y = Name label of the mediocre contractor in the examples.
Z = Name label of the least efficient contractor in the examples.

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