WORKING COMMISSION 55 • BUILDING ECONOMICS
INTERNATIONAL SYMPOSIUM ZAGREB 96

UDK 69.001.3:333.32

TENDERING THEORY 40 YEARS ON

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Abstract

This paper discusses the development of tendering theory from the publication of Friedman's paper on tendering in 1956. Forty years after it was published Friedman's proposition for how to tender for a specific project is still as relevant as it was then, but the subsequent extension of this method into a general theory of tendering has added little to our understanding of how prices are determined or contracts allocated in the industry. Key assumptions and predictions are inconsistent with empirical evidence and the proposed profit maximising behaviour applies only in exceptional circumstances.

Keywords: Tendering; tendering theory; pricing,

Teorija tendera nakon 40 godina

Sažetak

Članak se bavi razvojem teorije tendera, od objavljivanja Friedmanovog članka iz 1956. do danas. Četrdeset godina nakon objavljivanja, Fridmanov prijedlog o načinu prijavljivanja na određeni natječaj relevantan je kao i onda. Međutim, kasnije širenje te metode u opću teoriju o tenderima, malo je pridonijelo našem razumijevanju određivanja troškova i načinu dodjele ugovora u industriji. Ključne pretpostavke i predviđanja nisu u skladu s

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iskustvenim dokazima, a predloženo ponašanje postizanja maksimalnog profita primjenjivo je samo u izuzetnim okolnostima.

Ključne riječi: tendering, teorija tenderinga, određivanje troškova

1 Introduction

In 1956, Lawrence Friedman laid the foundation for tendering theory in *A Competitive Bidding Strategy* [1], a paper of great importance for the development of what is commonly known as building economics. Its real importance is not so much in what it said, but in the way it generated interest, research and publications. Already in 1969 a bibliography listed more than 100 papers on tendering [2], and it is now a well documented and established research area, although very little of the writings has been devoted to testing, verifying or analysing the theory itself.

The aim of this paper is to provide such a critical examination.

Friedman's paper is short and there is no discussion of previous work, indeed, there is not a single reference, ignoring totally both economic theory and the developments in game theory at the time. The message is equally simple and clear. To maximise the expected profit from a single tender where each of a set of competitors simultaneously submits one closed bid (tender) the bidder (tenderer) should select the mark-up on cost that maximises the expected value of the profit, ie the product of the mark-up and the probability of winning the contract. As Friedman [1; 3] points out, the problem lies in determining the probability of winning as a function of the mark-up. His solution is to study previous encounters with the competitors. Provided there has been a sufficient number of previous encounters, it is then possible to establish the probabilities of winning with different mark-ups against each competitor by calculating the ratio between each competitor's bids and the own cost estimate and through aggregation, against each possible combination of competitors.

However, before that is done, it is necessary to look at the cost estimate. Friedman is well aware that the estimated cost may be biased, and stresses the need to compare previous estimates and actual costs, so that any bias can be calculated and accounted for. "The true cost as a fraction of the estimated cost can then be obtained" [1, p 105].

The rest of the paper is devoted to alternative objectives, the estimate of number of competitors, the likely shapes of the probability density functions of the competitors' bids, how to deal with unknown competitors and the strategy when several bids must be submitted at the same time and there are restrictions on the total value of all bids.

The paper is clear, every assumption is clearly stated; it is simple and deals with a simple issue: how to approach a single bid. This, in hindsight, makes it difficult to understand fully why this strategy for a single bid or a single set of simultaneous bids, has been reinterpreted into a general, profit maximising pricing model for tendering - a clear distortion of the content, that took place over the next few years. This transition was completed in the next major paper on the topic published in 1967, Marvin Gates' *Bidding Strategies and Probabilities* [4]. Gates' paper is based on "real" tenders and it outlines a general theory of tendering. While Gates gives no acknowledgment to Friedman's paper in the development of his own model (apart from one oblique reference to "other investigators [sic]" [p 102]), there are similarities between the two papers. Like Friedman, Gates asserted that the probability of winning a bid could be estimated from previous encounters and that the appropriate strategy was to maximise the expected value of the profit of the bid. However, what for Friedman was a strategy for a single bid was for Gates *a general model, with general applicability.*

There were other differences as well. Most noticed in the subsequent discussion was the difference in how the probability of winning over more than one competitor was estimated [5; 6; 7; 8; 9; 10; 11; 12]. Friedman treated the probabilities of winning against each competitor as independent events, aggregated as a set of conditional probabilities. Gates, on the other hand assumes that the probabilities are dependent. This difference appears to be derived from the differences in the assumptions regarding the estimated cost. For Friedman the estimated cost is "corrected" to the "true" cost, while Gates works with "uncorrected" cost data and the estimated probability density functions incorporate also systematic differences in cost estimates.

However, the attention has concentrated on this single aspect of the two papers and there has been a number of empirical and theoretical tests of the comparative appropriateness of the two methods of aggregating probabilities, among others [5; 6; 7; 8; 9; 10; 11; 12; 13]. The far more important transformation from a strategy for a single event in Friedman's paper to a general strategy in Gates' paper has been totally ignored.

1.1 How tendering theory relates to game theory and decision rules

Before progressing any further, it may be appropriate to establish that despite talk of maximising strategies and Gates references to game theory and to von Neumann and Morgenstern's theoretical work, tendering theory is not about game theory but is, in fact, a theory of price formation, a special case of full cost pricing theory.

1.1.1 Game theory

Game theory is the analysis of problems involving the interactions of rational agents. In a zero sum game such as tendering, where the winner takes all, this assumes that the competitors adopt the most profitable counter-strategy, and the selection of the "best" defensive measures [14 p 438] and that game theory applies when "the outcome of the behaviour of firms and individuals does not depend on their own actions alone nor those combined by chance, but also on the actions of others who sometimes oppose, sometimes fortify, those of the former". The basic assumption in game theory is that "each player is assumed to have a known payoff function, which depends on the strategy selected by that player and the strategy selected by the other players" [15 p 427], and "conscious conflict" is an absolute requirement for game theory to apply [16 p 309]. Fudenberg and Tirole [17] in one of the more formal recent statements of game theory state that it is based on "the assumption that his opponents are themselves rational, and are thus trying to make their own predictions and to maximise their own payoffs" and that "any predictions that are inconsistent with this presumed but vaguely specified rationality are rejected" [p 261-64]

Certainly, game theory requires that all players consider their respective strategies and select the most appropriate strategy, assuming that all other players do the same. It does not apply to situations where one player alone is allowed to adopt a preferred strategy without any attempt from other players to modify their strategies in response. The assumption in tendering theory that there is no response, no modification of the behaviour of other players violates the most fundamental assumption of game theory.

On a more philosophical basis, there are also problems with the applicability of game theory for the kind of complex problems tendering theory represents. Arrow [18 p 5] points out that each firm depends on a conjecture of other firms' actions, when there is no reason to believe that these actions should be consistent while Schmalensee [19 p 675] points out that "The assumption that boundedly rational humans can solve the much more complex games they face in real life seems to push the rationality assumption very far indeed. (Chess is solvable in theory, for instance, but not in practice.) Nor is it clear, ... how to deal in general with models possessing multiple perfect Baysian-Nash equilibria". Arguments about learning during games do not improve the situation. Allowing for rational learning simply requires the formulation of successive new and more complex games as behaviour changes [20].

It can also be demonstrated that if the mark-up is regarded as a continuous variable, infinitely divisible so that it represents an infinite number of possible strategies while the payoff is discontinuous as in either winning or not winning, then there is no pure strategy equilibrium [17 pp 270-1]. Hence, tendering theory cannot represent an optimum game strategy. However, in a non-game situation where there is no conflict and therefore no competing strategies, such as tendering, it may serve as a decision rule

While it is outside the scope of this discussion to pursue the domain of game theory, it is quite clear that for all of these reasons, whatever the terminology in Gates' original paper, tendering theory cannot be classified as a game theory. Rather, as expressed by Gates - and also as explicitly stated by Friedman - tendering theory is a theory of pricing although there is no indication in either of their papers that this is intentional or fully understood (despite Friedman's note that "pricing of products can be conceived of as bidding for customers' dollars" [1 p 104]). As a theory of pricing, the bid has two components: the estimated cost of executing the project and, with some qualifications, a constant mark-up, virtually identical to full cost pricing theory, but clearly developed independent of the economic theory that proceeded tendering theory.

1.1.2 Tendering theory as decision theory

Both Friedman [1 p 104] and Gates [4 p 75] refer to tendering theory as a strategy of bidding. Consequently, tendering theory is often seen as simply a prescriptive or normative theory rather than as descriptive or positive. The same argument is frequently used also about micro-economics and other social sciences. Such theories, according to this argument are no more than bodies of rules about how to be rational. Hence if rationality is taken to be a normative concept rather than an axiom, tendering theory, economic theory and a great many other social science theories would be essentially irrelevant to the explanation of actual behaviour [21].

However, in a normative theory, "ought to" also implies "being able to". Tendering theory is not only about how tendering "ought to" be performed, but also explains achievable rationality in tendering. Rationality, whether aimed for or postulated as an axiom, is about outcomes [22 p 99], which if achieved, will have implications that at least in principle can be observed, tested and falsified. Hence, the *a priori* argument that theories that can be formulated normatively cannot also be descriptive or positive is invalid. This argument must be empirically derived which it has not yet been..

It is also widely accepted [23 p 1] that there are sanctions that apply for the violation of rational behaviour. Only rational behaviour can survive in business [24] or in a more general form: irrational behaviour can not be afforded [23]. In other words, if tendering theory works, the market will assure that it is universally applied.

2 A theory of pricing for unique objects

To justify the concept of tendering theory as a theory of pricing, there must be a market and a product for sale in that market. Here, there is a conceptual problem based on the traditional way of looking at the output of the building industry. Certainly, if we look at each project as a design, a location, a time and a set of building materials, each project is unique. However, we must look away from the obvious differences in different buildings because builders do not sell buildings. Builders sell the management skills necessary to combine manpower, machinery and material into new buildings.

We have different markets because the skills for different types of projects are different. On the other hand we have distinct markets for each type of project. There is for instance virtually no difference between the skills required to manage the construction of different single family dwellings and any participant in that market can produce any of the services traded in that market. The same is true for the market for driveways or the market for high rise office blocks. The building firm is selling services, and within each market, the services being sold are virtually identical.

If we have an identical product for sale, a tendering process that communicates to the buyer who is willing to sell and for what price, we have a market and a market price, even if the product is traded in bundles of different sizes each time.

A characteristic of tendering theory as a pricing model is that the mark-up is constant, over time and in practice, from tender to tender. While Friedman assumed "that each competitor is likely to bid as he has done in the past" [1, p 107], in later versions of the model [eg 25] this *ceteris paribus* condition is removed, and Gates' approach substituted instead. Friedman uses the probability estimates as a "best guess", not reality but sufficiently close to guide the bidder, but Gates clearly implies that his technique to establish the probability density functions of success is a *correspondence rule*, removing any possibility of there being a *ceteris paribus* condition. The established probabilities are also, in both papers, extended to situations where the competitors are not known but analysed through the use of "the typical bidder", an average of bidders encountered in the past.

The assumption that probabilities can be assigned to bids means not only that the distributions do not change over time, but also that all variations in tenders originate in unsystematic or random variations in the competitors' and/or own cost estimates and/or mark-ups. In particular, *this means that market conditions or capacity utilisations do not influence the behaviour of any competitors* or their probability density functions[1]. Another obvious consequence of these assumptions is that competitors do not modify their behaviour in response to the strategy developed by another competitor. This, as indicated above, is the crucial difference between tendering theory and game theory.

If these assumptions are accepted, the optimum mark-up will remain constant for the typical case with *n* typical competitors, changing only in response to changes in the number of competitors or to the presence of specific competitors. However if any of these assumptions is violated, the probability distribution for each tender process would be unique.

The price, set by the winning tender, is based on the cost plus a mark-up from a given probability density function, and differences in the prices offered between different bidders will reflect random differences alone. *If it is assumed that all bidders behave in the same way, they will all apply a given mark-up consistent with the number of competing bidders, and all differences in bids are the result of differences in the original cost estimate.* The result of these assumptions is very much consistent with the full cost pricing theory. The price is calculated in the same way as costs plus a constant mark-up, determined without reference to market conditions and with little regards to the activities and strategies of competitors. Any differences arise from the necessity to estimate the cost prior to the execution of the contract rather than the more conventional method of selling the product after the cost is known. Hence, from both a theoretical and empirical point of view, it would seem desirable also to examine the outcome of the tendering - the price level.

3 Tendering and the theory of auctions.

One potential method of analysing tendering is through auction theory. Auction theory comes in many models, distinguished by number of bidders and/or sellers, by symmetric or asymmetric information between bidders and seller or between bidders, information available, type of auction, type of bidding, single or sequential auctions, finite or infinite sequences, equal or individual-private valuations of the item auctioned, cooperative or non-cooperative bidding, with or without reserve price, with or without commitment to accept the resulting bid, acceptance of risk and so on. The type of auction applicable to tendering for building contracts is a non-cooperative, simultaneous, single sealed bid type with individual-private valuations, with, if not perfect at least extensive public information, a large number of bidders for an infinite or long sequence of auctions.

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[1] If there are systematic changes in bidding behaviour, in response to changes in economic conditions, the mark-ups are no longer random and representing the bids as random is theoretically and logically invalid. The only interpretation of the probability distributions that is internally consistent and logical is that they are constant and unchanging. The frequency distribution of tenders that differ systematically in different markets and in response to changing market conditions is no more a probability distribution for a specific tender than a set of daily temperature readings from different Australian weather stations over a year is a probability distribution for the temperature in Darwin on new year's eve.

According to tendering theory, the significance of a single bid is that this bid must express both the valuation of the contract and the strategy employed to achieve success [26]. However, the significance of this is questionable. The Revenue-Equivalence Theorem suggests that the single sealed bid auction on average yields the same price as for instance the English auction [26; 27; 28; 29; 30; 31] with no room for strategy.

Applying auction theory to the tendering in the building industry, we also need to know what happens in repeated auctions. Auctions is an area where experimental results are available, so that we have replication without violating the *ceteris paribus* conditions, and can therefore test the theorems. An evaluation of these experimental results, [32 p 1006] concludes that "One of the striking and by now well known results from that literature is that ...traders converge to competitive equilibrium, in repeated markets with relatively few traders, often in relatively few periods, as traders gain experience, through repetition, with the parameters of the market". Similarly, McAfee and McMillan [33 p 733] suggest that experiments show that provided there are many bidders and provided information is dispersed among the bidders, the price equals the item's true value

It is quite obvious that the tendering process tends towards a competitive equilibrium. Indeed auctions is the answer to Arrow's criticism that neo-classical economic theory does not provide a mechanism for the process of price adjustments. Auction theory provides an explicit model of how prices adjust to the competitive equilibrium level, avoiding the bargaining process in a disequilibrium, where, in Arrow's words "the market [temporarily] consists of a number of monopolists facing a number of monopsonists" [34 p 47]. Hence, the theory of auctions provides strong support for the applicability of neo-classical micro-economic theory in tendering, while giving no support to the core assumption in tendering theory that the bid incorporates a specific strategy. Tendering theory is therefore logically inconsistent with both a games theory equilibrium and an auction theory competitive equlibrium

4 Later developments in tendering theory

Most of the discussion of tendering theory has concerned the aggregation of the probabilities of being successful against other builders individually [1; 5; 6; 8; 9; 10; 13; 25; 35; 36; 37]. Several writers have reformulated the problem to the more obvious of being successful against the lowest competitor only, avoiding the problem altogether without changing the essential assumption of constant probability density functions [11; 12; 38; 39]. Others have introduced economic concepts into the models by suggesting the maximisation of expected utility rather than expected value [40], introduced the possibility of capacity constraints [41; 42] or opportunity costs rather than nominal costs [43], developed a more complex utility function including risk and continuity of work as well as profit [39] or examined the consequences of approaching the capacity limit where the Marginal Cost equals Marginal Revenue [44].

Such modifications may be justified and also consistent with the core of tendering theory: the assumption that variations in the competitors' bidding are the results of unsystematic variations of cost estimates and/or mark-ups, or the central behavioural assumption that the preferable strategy is to maximise the expected value, in money or utility, of each bid, but none of these modifications has been generally accepted to the extent of being incorporated in the most recent restatement of the theory [25].

More radical reformulations include smoothing [45], ie to assign a higher weight to the most recent events when calculating the probability density function, suggesting effectively that the theory is fundamentally flawed for determining the winning tender, but by dropping the central assumption of constant probabilities, the technique for assessing the probabilities developed by Friedman and Gates, can be used as a simple "naive" forecasting model where existing trends may be extrapolated. Changes in the competitiveness have been recognised and solved by including "managerial judgement" as a variable [46]. Apart from the problem of formulating this variable so that it becomes meaningful and quantifiable, it is a small improvement on using managerial judgement without going to the trouble of calculating the frequency distributions in advance. Again, it rejects the central core of the theory without apparently noticing.

5 Tendering theory and profit maximisation

In conventional economic theory the seller maximises profit (or minimises loss) when the addition to costs (the marginal cost) of producing the last unit equals the addition to total revenue (the marginal revenue) of that unit. Since the marginal cost is dependent on the degree of capacity utilisation, this automatically includes all the factors relevant for the level of profit: price per unit, cost per unit and volume of output, all determined by supply and demand. The firm does not set, but accepts the price and adjusts output to the optimal level. This maximises the return to the productive resources of the firm.

According to tendering theory, the strategy for maximising profit is to maximise the expected value of each bid. This strategy, the maximisation of the expected value of each event is an appropriate strategy for a game of poker or betting on horses or any other game for money, where the cost of each event must be balanced against the gains and the best way of doing so is to seek the most favourable combination of probability of success and value of pay-out. The problem with tendering is that it is not a game of odds for money. The aim is not to maximise the expected value of a set of potential tenders, but *to maximise the return to a given productive capacity.* The error of logic should be apparent. The two aims give the same result only if there is a predetermined number of contracts that the firm must bid for and there is no penalty for not reaching or exceeding optimum work load. This would seldom be the case. In reality there is a choice of contracts to bid for or not to bid for and winning a contract means that this part of the firm's resources are locked up for the duration of the contract so that the firm is unable to compete for potentially more profitable contracts. Loosing a tender, on the other hand, may mean only that the firm can tender for any number of other contracts, but it may, in other circumstances mean that the firm's resources may be unutilised at high costs for a period of time [47; 48]

6 Empirical testing of core assumptions

One of the characteristics of the markets for building and construction services is rapid substantial changes in effective demand. According to tendering theory, a change in demand will not change the winning tender price, as a systematic change in strategy is excluded by assumption [49]. The probability density functions of all known competitors and the average competitor are constant and given. Tender prices will change only if costs or the composition or number of competitors change, but there is nothing in the model to suggest that this will happen as a result of any change in demand. Similarly, profit, for the typical case with n typical competitors is a function of n and will therefore change only if the number of competitors changes.

There has been extensive testing of the movements of prices, and they have been found to change with the number of competitors, as predicted by tendering theory, but also to change systematically with market conditions [40]. It has been demonstrated that the tender price changes much more than does cost when the demand changes [50] and that price changes systematically with changes in demand and utilisation of capacity in the industry [51].. In one investigation of a single market, systematic price changes of more than plus/minus 20 per cent were reported in response to changes in the level of activity, even when the number of competitors was held constant [52]. In this study 85 per cent of the price changes could be explained by changes in market conditions while the number of competitors had a minor impact only. A study covering several different, non-competing markets, found the same relationship but much weaker [53]. This tendency is also often reflected in the so called Tender Price Indices that are now compiled in an increasing number of countries, sometimes with different indices for different types of construction and different regions. Such indices occasionally move at different rates or in a different direction to each other and to input cost indices.

Unfortunately price changes cannot, on their own, conclusively verify or falsify any theory of pricing. In tendering theory, the price level as such is not an issue, as it is concerned only with mark-ups. The price will change if costs change. In a neo-classical partial equilibrium analysis, price changes appear to result exclusively from a movement along the supply curve, as such analyses do not show price changes that occur industry wide in response to increased demand, but only those internal to the firm. However in a general equilibrium analysis, it is obvious that the overall cost structure also changes.

An empirical testing of tendering theory must therefore examine the process of price formation rather than using the traditional, positivist method of examining the outcome of an event, in this case movements in the price level as a result of changes in demand. As the process cannot be observed in the equivalent way to the outcome, this raises undeniable doubts about the results of any testing. Motives and intentions can not be measured but only inferred. However, several studies have reported that mark-ups are not constant but respond to changes in demand [44; 45; 46; 50; 54; 55; 56; 57; 58]. Another study found a highly significant relationship between market conditions and actual profit on individual projects, far greater than anything attributable to different numbers of tenderers alone with the most likely determinant being differences in mark-up strategies during different levels of activity in the industry [59].

As discussed above, an essential assumption of tendering theory that the probability density function of the differences in the ratio between the competitors' tenders and the own cost estimates is constant. That requires that price differences originate either in random mark-ups and/or random errors in all cost estimates, ie random variations rather than systematic variations, and this has also been subject to empirical testing. Technically, it is possible to have random variations in the costs that are not the results of errors and/or mark-ups, but the theoretical implications of such an assumption: monopoly powers to each tenderer for his/her own specialty, but over-lapping markets - are so complex as to render any theory based on these premises virtually inoperable.

Hence, in the literature, there are constant references to unexplained variations in tenders as "ever present" mistakes [60], or of tendering as a game of darts [61] or "the game of the greater fool". While tendering seems to be perceived by theorists as not substantially different from a lottery or a game of chance, this is not, in my understanding, the view of people actually involved in tendering. There is, no doubt an element of chance, but the degree of uncertainty appears much less to practitioners than to academics. Part of this difference in attitude may be because tendering is not such a random process as assumed in academic literature.

There are other indications that this is so. McCaffer [62] reports that tenderers gradually reduce their bids relative to their competitors when they are unsuccessful until they win a contract. However, after a tenderer has been successful the next bid increases sharply in relative terms, and a new cycle of gradual decrease starts. In one study, 84 per cent of winning tenders were preceeded by at least two consecutive decreases in relative price, and in 65 per cent of the cases, there was a sequence of five or more consecutive decreases before a successful tender [p 133]. This work has been duplicated for subcontractors with exactly the same findings [63]. *These results strongly indicate that there is very little randomness in tendering.*

This, of course poses two questions: (i) if tenders are known not to be competitive, why are they submitted; and (ii) if tenderers can estimate with a high degree of accuracy, why are there such variations in tenders? The answer to the first question is quite simple. All projects are unique in terms of the exact quantities of building management services required. Therefore, the only reliable method to obtain information about current market conditions and how they affect the price level is to complete an estimate of what is required and compare that to the winning tender. Only by participating and tendering on a continuing basis, can a tenderer keep abreast of what is happening in the market.

The answer to the second question is that tenderers start with a high mark-up that is systematically reduced to make the tenders more competitive as the need for new work becomes more urgent. Also, economic theory suggests that the cost of production is a function of output. When production increases, productivity decreases so that the cost of production depends on the bidder's capacity utilisation [44]. A conceptual problem with tendering theory is that there is no allowance for continuity in the theory. It is not that the theory is static, it is that it is central to the theory that the outcome of one tender process is not affected by the outcome of previous events nor does it affect subsequent tender processes. Hence, there is no market, no price level, no change in behaviour and certainly no learning. This is presumably justified by the uniqueness of each project and the failure to consider the firm rather than the project as the appropriate unit of analysis.

7 Conclusions

Forty years after it was written, Friedman' proposition for how to tender for a specific project is still as relevant as it was then. However, as has been demonstrated in this short discussion, the subsequent extension of this method into a general theory of tendering has added little or nothing to our understanding of how prices are determined or contracts allocated in the building industry. Contrary to the predictions of tendering theory, the tendering process results in a competitive equlibrium price, and the theory requires a behaviour that is inconsistent with empirical evidence. Furthermore, the maximising behaviour proposed in the theory will not maximise profit other than in exceptional circumstances.

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