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Modelling contractor's bidding decision

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ABSTRACT

The authors aim to provide a set of tools to facilitate the main stages of the competitive bidding process for construction contractors. These involve 1) deciding whether to bid, 2) calculating the total price, and 3) breaking down the total price into the items of the bill of quantities or the schedule of payments to optimise contractor cash flows. To define factors that affect the decision to bid, the authors rely upon literature on the subject and put forward that multi-criteria methods are applied to calculate a single measure of contract attractiveness (utility value). An attractive contract implies that the contractor is likely to offer a lower price to increase chances of winning the competition. The total bid price is thus to be interpolated between the lowest acceptable and the highest justifiable price based on the contract attractiveness. With the total bid price established, the next step is to split it between the items of the schedule of payments. A linear programming model is proposed for this purpose. The application of the models is illustrated with a numerical example.

The model produces an economically justified bid price together with its breakdown, maintaining the logical proportion between unit prices of particular items of the schedule of payment. Contrary to most methods presented in the literature, the method does not focus on the trade-off between probability of winning and the price but is solely devoted to defining the most reasonable price under project-specific circumstances.

The approach proposed in the paper promotes a systematic approach to real-life bidding problems. It integrates practices observed in operation of construction enterprises and uses directly available input. It may facilitate establishing the contractor's in-house procedures and managerial decision support systems for the pricing process.

KEY WORDS

decision support; decision to bid; pricing strategy, contractor cash flows, linear programming

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Introduction

Tendering stays one of the most popular means of selecting contractors to carry out construction works. Any invitation to tender is an opportunity, and thus the contractor needs to decide if to explore it (use time and resources to prepare a bid) or decline it in search for better options. Several factors need to be considered in the process of decision-making. The contractor's experience and business intuition are not enough to ensure that the tender procedures entered by the contractor offer a good trade-off between costs (bid preparation costs including the opportunity cost of using the scarce time to prepare this bid and not the other) and benefits (winning a contract that is profitable, would maintain the contractor cash flows, or allow them to win a better market position).

With an invitation to tender accepted, a decision on the bid price needs to be taken. Apart from items defined in the tender documents, whose cost can be simply calculated, many components of the price are estimated based on a less tangible input; these are risks and profit. The bid price is expected to be high enough to guarantee that the contractor recovers all costs and earns a decent profit and, at the same time, low enough to beat the competition. Low bidding increases chances of winning the contract but reduces chances of making a profit. Therefore, the contractor's decisions whether to bid and later what price to offer, are complex and call for decision support tools. The paper puts forward models that facilitate rational decision-making in terms of bid/no-bid, unit rate pricing, and defining the overall price of a job. The focus of the models is on maximising the net present value of the project cash flows (excess of sums to be received from the client over cost). Application of the models is illustrated with a numerical example.

1. Literature review

1.1. Decision to bid

A contractor's bidding department can produce only a limited number of bids at the same time. A decision to assign resources to the analysis of one client's invitation to bid implies that other invitations are rejected. A quick selection of most promising invitations poses a practical problem, and, therefore, literature is rich in analyses of selection criteria and methods.

The first question, which is relatively simple to answer, is what criteria affect the contractor's decision to tender. Estimating and tendering handbooks provide guidelines on selection criteria based on the experience of their authors (among others, Brook, 2011, p. 96; Cartlidge, 2013, p. 3; Stevens, 2012, p. 93). Enquiries on factors affecting the bid/no bid decision were conducted in many countries: in Great Britain (Shash, 1993), Egypt (Hassanein, 1996), the United States (Ahmad & Minkarah, 1998), Syria (Wanous et al., 2000), Singapore (Chua & Li, 2000), Saudi Arabia (Bageis & Fortune, 2009), Poland (Leśniak & Plebankiewicz, 2015), Australia (Shokri-Ghasabeh & Chileshe, 2016), and Nigeria (Oyeyipo et al., 2016). As the authors drew from each other, the lists of initial criteria were rather consistent regardless of the country of origin. Criteria rankings presented in the literature varied considerably, although the most significant factors in the decision to bid usually include the client's reliability, the need for work, the expected number of competitors (chances to win the job), and experience with such projects. This may be attributable, on the one hand, to economic conditions varying strongly according to the location and the date of the survey. On the other hand, the profile and number of interviewees, as well as ranking methods, strongly affected the results. In the above-presented studies, the most popular methods of pointing to key criteria were based on average scores calculated according to individually adopted crisp or fuzzy scales, with a more or less rigorous approach to checking the consistency of opinions and the reliability of findings.

With the criteria at hand, numerous methods were proposed to compare invitations to bid to find those potentially most promising. Some authors aimed at creating models based on records on qualities of previously selected invitations to tender allowing the user to assess a particular invitation as worth or not worth considering. These models were either parametric, such as logistic regression (Lowe & Parvar, 2004; Hwang & Kim, 2016), or non-parametric, for instance, based on artificial neural networks (Wanous et al., 2003). Complex knowledge-based expert systems can also be found in the literature (Egemen & Mohamed, 2008).

Other authors applied multi-criteria analyses to provide a ranking within a set of options. The methods range from the simplest additive scoring models (Stevens, 2012), to allowing for the imprecise and subjective character of input by using fuzzy logic (Lin & Chen, 2004; Tan et al., 2010). With the wide selection of multi-criteria methods constantly developed (Saaty, 2000; Triantaphyllou, 2000; Köksalan et al., 2011), these examples present but a small fraction of research on the subject.

1.2. Defining the bid price when cheapest bid wins

According to Mochtar and Arditi (2000), construction pricing strategies can be divided into two groups: cost-based pricing and market-based pricing. Most models presented in the literature assume that the definition of the price is a two-stage process that comprises "first the calculation by the estimator of the true commercial cost to the contractor/subcontractor, followed by the adjudication or settlement process…" (Cartlidge, 2013, p. 221). The latter consist of adding allowances for cost-affecting risks and uncertainties, company overheads and profit to obtain the bid figure (Mochtar & Arditi, 2000). This traditional approach to costing is suitable in traditional procurement routes, where the contractor has little influence on materials and construction methods, i.e. the factors that determine most construction costs.

Another group of models uses the concept of market-based pricing (Best, 1997) or target costing (Cooper & Slagmulder, 1997), where the price is prompted by the demand side of the market and objectively corresponds to the client's perceived value of the job. If this can be established, the contractor (or, in fact, the whole value chain that cooperates to satisfy the client) strives to "engineer" the cost of providing the service, at the same time, sell for this market price, and reach the profit targets. From the viewpoint of a construction contractor, it is impossible to apply target costing to traditionally procured projects as the product (a built facility) is made to detailed specifications prepared in advance by other entities. However, schemes with a higher level of integration of design, construction and ongoing maintenance of the built facility are a perfect object of target costing (Sobotka & Czarnigowska, 2007; Potts, 2008; Kaka et al., 2008).

Models within the first group facilitate the decision on the mark-up level by maximising the expected value of contractor's profit while bearing in mind the probability of winning the contract, which drops with the increase in the price and the intensity of the competition (number of bidders). Early models of this kind, based on the probability theory and statistical patterns observed in bidding by the competitors were proposed by Friedman (1956) and Gates (1967), and were later verified, modified, expanded or criticised by many researchers (among others, Benjamin et al., 1979; Carr, 1982; Ioannou, 1988; Mielec et al., 2009). These models assume that a detailed knowledge of competitors (their number in the bidding procedure, historical records of their prices) is available and that behaviour of competitors is going to be repeatable, as keeping to the pattern of the bid price and the cost probability distribution assessed based on historical data.

In the case of bids related to complex projects of unique scope, the price is the result of elaborate calculations of direct and indirect costs that allow for fluctuations in resource prices. Other factors that affect the contract's attractiveness from the contractor's point of view need to be accounted for. They may provide justification for reducing mark-up to improve chances for getting an attractive job (big, prestigious, or just badly needed in the times of recession). They may also provide justification for inflated mark-up that reduces the probability of winning the contract to compensate for additional related risks, e.g. with undefined scope in fixed price contracts, or just to use the opportunity. Thus, current objectives may not be convergent with the long-term aims of maximising the expected value of profit, and statistical methods may be not enough to depict such complex relationships. Therefore, many authors refer to artificial intelligence techniques that capture relationships between contract properties and mark-up value, consider more criteria than just profit maximisation, and allow for the uncertainty of input using, e.g., fuzzy logic. Tools based on Artificial Neural Network have been proposed by, among others, Moselhi et al. (1993), Li and Love (1999), or Leśniak and Plebankiewicz (2013). Wang et al. (2007) integrated cost model and multicriteria evaluation to provide a more flexible way of defining the bid price.

In general, the authors of most pricing models meant for typical construction tendering problems (sealed auction, lowest bid wins) agree that:

- the decision whether to bid is an individual and multi-criteria problem;
- the bid price should be economically justified, and this means different things in different circumstances (another multicriteria problem).

2. Research methods

The authors propose to calculate the aggregated score O of the overall desirability of the contract (approach put forward by, among others, Lin & Chen, 2004) according to the arbitrarily assumed set of criteria. The set of criteria is likely to be individually decided by the contractor, according to the type of project and economic circumstances, and, therefore, the authors refrain from proposing a fixed list of criteria. The aggregate score O, a single value, is to be compared with an arbitrary threshold – the lowest score that supports the decision to bid.

To calculate the total desirability score, the authors decided to use simple additive weighting method:

$$O = \sum_{i=1}^{n} o_i \cdot w_i, \quad \sum_{i=1}^{n} w_i = 1, \quad o_i \subset \langle 0,1 \rangle, \qquad (1)$$

where:
o_i – represents the normalised score, and
w_i – the weight of a particular criterion i of n criteria used for analysis.

Considering the findings on bid/no bid decision criteria presented in the literature, the criteria can be divided into three to four groups, each with a set of specific sub-criteria. The assumption is, the sub-criteria scores are to be given by an expert, and scores are to be expressed in the intuitive linear scale between 0 (worse) and 1 (best). The value of 0.5 means that, according to this criterion, there is a minimum justification for accepting the invitation. Thus, the aggregated score $O = 0.5$ is the lowest score that supports the decision to bid.

Values of criteria weights w_i are to be established by means of the Analytic Hierarchy Process (Saaty, 2000), again using the expert opinion of the managers. The Analytic Hierarchy Process (AHP) is a popular decision-making method where variants are evaluated using both quantitative and qualitative criteria, suitable for determining relative weights of compared alternatives. It is easier for a decision maker to define relative dominance than to provide the direct value of weight.

In AHP, the main goal, criteria, and sub-criteria create a multi-level hierarchical structure (which corresponds well with the idea of using bid/no bid sub-criteria that form generic groups). The decision -making process was replaced by a consecutive sub-problem solving, defined at the same level. Calculations on each level of the hierarchy are repeated according to the same rules of the pair-wise comparison with respect to the element in the immediate upper level. Decomposition of the problem implies that a relatively small number of comparisons is to be made on each level. The method also provides measures of judgment consistency, so results can be verified (Saaty, 2000; Kou et al., 2013).

For the next step of the analysis, determining the bid price, the authors assume that the bid price, C, is a function of the project attractiveness, O (Fig. 1). The score of the overall attractiveness of the invitation to tender is to be used for interpolation of the contract price between two predefined values: the maximum total bid price C_{max} and the minimum total bid price, C_{min}.

C_{max}, understood as the highest justifiable price, is to be calculated on the basis of maximum resource prices and highest mark-ups (overhead and profit) reported in the market. Input for the calculation of

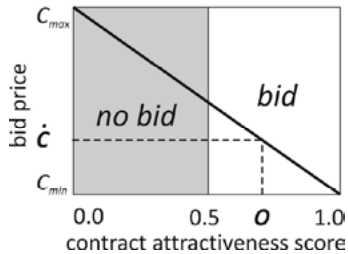

Fig. 1. Bid price interpolation

C_{max} may come from construction price books; historical rates should be adjusted for time according to expected trends in construction prices.

The minimum total bid price C_{min}, is considered the lowest sum to cover all project costs estimated according to the most probable scenario for the development of construction prices. Formulas (2)–(7) represent the linear programming model proposed for determining C_{min}, and distributing it among items of the schedule of payments by defining unit prices of items, c_j, in a way that makes the contractor's discounted surplus non-negative. This way, the authors decide to use the cost-based approach to pricing, assume that "suicide bidding" is not to be considered, and that it is possible to objectively calculate the cost.

To calculate C_{min}, one needs to prepare a schedule of payments and a schedule of works to define the amounts to be received and to be paid in each unit of time, l, out of t units of time in the time for completion.

Formula (2) is the objective function minimising the total price being the sum of products of unit prices of the bill of quantity items, c_j, and their predefined quantities, q_j:

$$\min C:\ C = \sum_{j=1}^{m} c_j q_j \,. \qquad (2)$$

Condition (3) is to assure that the service is not offered below the cost, so the net present value of the contractor's surplus of money received R_{jl} and money paid P_{lj} is non-negative:

$$NPV = \sum_{j=1}^{m}\sum_{l=1}^{t} d^{l}(R_{lj} - P_{lj}) \geq 0 \,, \qquad (3)$$

In Formula (3), d is a discounting factor introduced to allow for the opportunity cost. The amount to be received in return for the item j at the unit of time l, is the product of the unit price of the item, c_j, and the quantity to be paid for by the client at the time unit l. This quantity is expressed as $q_j s_{jl}$, where q_j

is the total quantity of the work j, and s_{jl} is the fraction of the total quantity of the work to be paid, according to contract conditions, by the client at the unit of time l:

$$R_{lj} = q_j s_{lj} c_j . \quad (4)$$

The cost related to the item j payable by the contractor at the unit of time l, is a product of unit cost of the item, k_j, and the quantity of the item completed in this unit of time, $q_j p_{jl}$, where p_{jl} is the share of the total quantity of the item whose costs are to be paid by the contractor at the time unit l:

$$P_{lj} = q_j p_{lj} k_j . \quad (5)$$

The authors assume that all costs are contractor's payments at the unit of time they have been incurred, whereas the amount payable by the client may be based on different quantities, for instance, the client may pay only for items that are totally completed, with a certain delay from their physical completion, or retentions that are agreed in the contract. For this reason, s_{lj} and p_{lj} may be different.

Condition (6) ensures that unit prices for particular works are not too low or high in comparison to market prices: $c_j^{\min}$ and $c_j^{\max}$ are, respectively, minimum and maximum unit prices of the item j calculated on the basis of construction price books or individual market surveys, adjusted for the most probable scenario of construction price changes:

$$c_j^{\min} \le c_j \le c_j^{\max}, \ \forall j \in Q . \quad (6)$$

Condition (7) is to guarantee that unit prices of items stay in some logical relationship: if the cost of item v is naturally greater than the cost of the item u, their prices should reflect this fact. For instance, the unit price of mechanical excavation in heavy cohesive soil is naturally greater than the unit price of excavation in the light granular soil. In Condition (7), A represents a set of pairs of items whose unit prices are related this way:

$$c_u \le c_v , \ \forall (u,v) \in A . \quad (7)$$

Apart from quoting the total bid price, the contractor is usually required to submit a schedule of payments with values assigned to particular items defined in the client's breakdown structure, with special care to include all components of the rate according to the client's specification. Another linear programming model, described by Formulas (8) to (13), very similar to the previous one, is put forward for calculating the optimum unit prices, $\dot{c}_j$ of items.

The basis for this stage of analysis is the total bid price, $\dot{C}$, calculated previously according to the idea presented in Figure 1. With $\dot{C}$ defined, one can calculate the unit price $\dot{c}_j$ of each particular item in a way that maximises the contractor's cash flows:

$$\max NPV: \ NPV = \sum_{j=1}^{m} \sum_{l=1}^{t} d^l (\dot{R}_{lj} - P_{lj}) , \quad (8)$$

$$\dot{R}_{lj} = q_j s_{lj} \dot{c}_j . \quad (9)$$

$$P_{lj} = q_j p_{lj} k_j . \quad (10)$$

$$\dot{C} = \sum_{j=1}^{m} \dot{c}_j q_j , \quad (11)$$

$$c_j^{\min} \le \dot{c}_j \le c_j^{\max}, \ \forall j \in Q , \quad (12)$$

$$\dot{c}_u \le \dot{c}_v , \ \forall (u,v) \in A . \quad (13)$$

Both these models can be solved by means of popular solvers, e.g. GAMS, LINGO, AIMMS, Lp_Solve.

3. Illustration of the method's application

The method proposed above was applied to a notional case of a construction project to build a six-storey office building. Table 1 lists sub-criteria, divided into four generic groups (project conditions, risk, contract conditions, contractor's standing), that were used as a basis for the bid/no bid decision. The criteria list was compiled arbitrarily based on literature review. Criteria scores, on the scale between 0 and 1, were defined during an interview with one expert based on the analysis of tender documents. Criteria weights were calculated by means of the Analytic Hierarchy Process using the pair-wise comparisons provided by the same expert.

The schedule of works is presented in Table 2. Payment conditions assume that the contractor shall be paid on a monthly basis for each completed element. There are no retentions in the contract.

The total cost of the project, as calculated by the contractor, was EUR 1,125,525.42. The maximum total price C_{max}, calculated based on maximum unit prices from price books, was EUR 1,390,876.33. The minimum total price, C_{min}, was calculated by solving

Tab. 1. Multi-attribute assessment of job attractiveness – justification for entering the competition

Criterion	Weight, w_i	Score, o_i (0÷1)	Weighted score, $w_i \cdot o_i$
1. Project conditions	0.2124		0.1153
– conditions to enter the procedure	0.0525	0.7	0.0367
– expected number and type of competitors	0.0280	0.4	0.0112
– relationship with the design team and the client team	0.0090	0.4	0.0036
– location	0.0117	0.7	0.0082
– time for completion	0.0195	0.5	0.0097
– profit earned in similar projects	0.0918	0.5	0.0459
2. Risk	0.1633		0.0929
– job uncertainty	0.0358	0.4	0.0143
– owner reputation	0.0071	0.6	0.0043
– owner financial standing	0.0652	0.7	0.0456
– quality of the bid documents	0.0266	0.4	0.0106
– technical difficulty	0.0204	0.6	0.0122
– availability of qualified subcontractors	0.0083	0.7	0.0058
3. Contract conditions	0.0655		0.0295
– duration and cost of bid preparation	0.0027	0.6	0.0016
– contract type	0.0029	0.4	0.0012
– term of payment	0.0270	0.4	0.0108
– warranty terms	0.0159	0.5	0.0080
– penalty conditions	0.0054	0.4	0.0022
– claim solution	0.0116	0.5	0.0058
4. Contractor's standing	0.5588		0.3841
– experience in similar project	0.2308	0.8	0.1846
– percentage of work to be subcontracted	0.0247	0.6	0.0148
– need for work	0.1390	0.7	0.0973
– qualified technical and managerial staff	0.0887	0.5	0.0443
– availability of resources	0.0507	0.7	0.0355
– financial statement	0.0249	0.3	0.0075
Total	1.0000		0.6217

the model with the objective function defined by Formula (2) and constraints (3) to (7). The discounting rate to calculate the discounting factor d was set to 1% per month. As for constraint (7), it was assumed that the unit prices of floor slabs and walls in the substructure should be greater than the unit price of floor slabs and floors of the superstructure because of differences in their design. The result, which is the minimum bid C_{min}, is EUR 1,241,260.32 and is considered to ensure that all costs (including opportunity cost) are recovered by the contractor. In the next step, the total bid price $\dot{C}$ was interpolated according to the idea presented in Figure 1 to the amount of EUR 1,297,855.81.

The unit prices of particular items of the bill of quantities, $\dot{c}_j$, were calculated by solving the model defined by Formulas (8) to (13).

Table 3 presents the bill of quantities with information on unit costs k_j (direct and indirect) of each item, and unit prices:

- minimum c_{jmin} (directly from price books adjusted for expected changes over time), maximum c_{jmax} (directly from price books adjusted for expected changes over time), as required for Condition (6) and (12);
- calculated unit prices for the bid, $\dot{c}_j$, found by solving the model (8)–(13), with results rounded to two numbers after the decimal point.

4. Discussion of the results

Considering the results of the illustrative example presented in Section 3, the model, as expected, assigns the highest possible unit prices to the items that are to be completed by the beginning of the project to maximise the contractor's net present value. Unit prices of the items scheduled by the end of the project are close to the minimum prices.

Tab. 2. Schedule of works

No. (J)	Element	Percentage of work completed [%]															
		Month															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	Earthworks	0.9		0.1													
2.	Footing	1															
3.	Substructure walls		1														
4.	Substructure insulation and waterproofing			1													
5.	Substructure slabs & stairs		0.55	0.45													
6.	Superstructure walls			0.16	0.14	0.18	0.14	0.13	0.08	0.17							
7.	Superstructure slabs & stairs			0.02	0.14	0.17	0.17	0.16	0.17	0.17							
8.	Partitions									0.95	0.05						
9.	Roof – RC structure									0.34	0.66						
10.	Roof – timber structure									0.25	0.75						
11.	Roof drainage										1						
12.	Roof cladding										1						
13.	Screeds													0.43	0.57		
14.	Plasters										0.04	0.28	0.32	0.28	0.08		
15.	Interior tiling													0.12	0.56	0.32	
16.	Metal fixtures									0.1	0.15	0.1	0.2	0.2	0.25		
17.	Painting														0.52	0.41	0.07
18.	Flooring															0.83	0.17
19.	Windows & external doors										0.25	0.75					
20.	Internal doors																1
21.	Façade plasters											0.53	0.47				
22.	Façade cladding												0.78	0.22			
23.	Heat source														1		
24.	Heating system									0.15	0.22	0.24	0.19		0.05	0.15	
25.	Disposal system									0.22	0.09	0.09	0.1		0.25	0.25	
26.	Water system									0.25	0.08	0.09	0.18		0.26	0.14	
27.	Ventilation									0.25	0.12	0.12	0.21		0.09	0.21	
28.	Electrical									0.4	0.11	0.11	0.13		0.17	0.08	
29.	Communication									0.3	0.17	0.06	0.27		0.15	0.05	
30.	Lifts														1		

The model corresponds well to the logic of price calculation. However, it is not universal as based on several assumptions that may seriously reduce the practical applicability:

- The best bid is the cheapest bid (the model is not directly applicable to the tendering procedure with multiple criteria). The lowest price tenders remain one of the most popular approaches, especially in the case of subcontractor selection, but with currently observed trends of the clients searching for best value, it is certainly not the only one;

Tab. 3. Bill of quantities with unit cost and unit prices

No. (j)	Element	Unit of measure	q_j	k_j, EUR/unit	c_{jmin}, EUR/unit	c_{jmax}, EUR/unit	$\dot{c}_j$, EUR/unit
1.	Earthworks	m³	2364.60	34.02	36.22	41.50	41.50
2.	Footing	m³	154.50	244.37	263.29	296.88	296.88
3.	Substructure walls	m³	171.20	250.13	274.62	314.93	314.93
4.	Substructure insulation and waterproofing	m²	1945.52	5.43	5.84	6.77	6.77
5.	Substructure slabs & stairs	m²	322.30	55.73	59.24	71.10	71.10
6.	Superstructure walls	m³	1082.70	188.93	203.83	228.24	228.24
7.	Superstructure slabs & stairs	m²	1755.80	52.35	56.83	64.69	64.69
8.	Partitions	m²	2058.30	12.92	13.88	15.48	15.48
9.	Roof — RC structure	m²	177.20	35.99	39.56	43.71	43.71
10.	Roof — timber structure	m²	251.50	16.02	17.57	19.40	19.40
11.	Roof drainage	m²	428.70	7.32	8.05	8.98	8.98
12.	Roof cladding	m²	428.70	28.82	31.20	34.70	34.70
13.	Screeds	m²	2035.80	0.92	1.00	1.15	1.00
14.	Plasters	m²	8610.90	4.07	4.44	4.92	4.44
15.	Interior tiling	m²	1560.40	36.05	38.70	45.02	38.70
16.	Metal fixtures	kg	4755.40	3.08	3.35	3.90	3.35
17.	Painting	m²	8602.80	1.35	1.45	1.67	1.45
18.	Flooring	m²	2268.30	50.03	54.00	64.03	54.00
19.	Windows & external doors	m²	191.20	237.21	258.99	294.01	284.75
20.	Internal doors	m²	206.00	54.88	59.89	69.08	59.89
21.	Façade plasters	m²	913.90	32.36	35.58	41.05	35.58
22.	Façade cladding	m²	268.60	38.38	40.99	47.95	40.99
23.	Heat source	szt	1.00	60090.00	65959.00	77179.30	65959.00
24.	Heating system	m² UFA	1716.00	15.08	16.14	18.63	16.14
25.	Disposal system	m² UFA	1716.00	7.22	7.67	8.77	7.67
26.	Water system	m² UFA	1716.00	11.83	12.61	14.26	12.61
27.	Ventilation	m² UFA	1716.00	22.13	23.82	26.65	23.82
28.	Electrical	m² UFA	1716.00	23.49	25.48	29.96	25.48
29.	Communication	m² UFA	1716.00	17.82	19.27	21.57	19.27
30.	Lifts	pcs.	1.00	30037.00	31965.00	36191.10	31965.00

- The contractor can accurately schedule the work and assess costs prior to tender, and no major changes to the schedule are to be expected. In this model, risks and uncertainties are allowed for only in the form of cost allowances arbitrarily spread over the items of the schedule of payment and included in kj rates;
- The model does not provide any measure of the probability of winning the job. Instead, it focuses on defining a "reasonable price" corresponding to the perceived desirability of the work;
- The bid/no bid threshold of the contract attractiveness was set arbitrarily.
- The contract desirability remains in the linear relationship to the bid price (as in Fig. 1). This relationship was intuitively assumed by the authors and is not supported by hard evidence.

Further research, including contractor opinion surveys, is planned to support these assumptions.

Conclusions

Decisions whether to bid and what price to offer directly affect the economic efficiency of a contractor. They should not be based solely on intuition and experience. To avoid losses, the potential bidder should analyse acceptable solutions by means of reliable methods and using credible input. The approach proposed in the paper may facilitate establishing the contractor's in-house procedures and managerial decision support systems for pricing process. It enables the estimators to consider many factors (some of them of purely qualitative character) that affect both the chance of winning a contract and capacities to deliver and satisfy the client. However, the presented approach for modelling bidding decisions is a concept and needs validation.

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