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To bid or not to bid: a parametric solution

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One of the most important decisions that has to be made by construction companies/contractors is whether or not to bid for a new project when an invitation has been received. It would be of great help if a structured model could be developed that deals systematically with different bidding situations. A simple parametric solution for the 'bid/no bid' decision is reported in this paper. This solution is based on the findings of six semi-structured interviews and a formal questionnaire through which 38 factors that affect the bid/no bid decision were identified and ranked according to their importance to contractors operating in Syria. Only the most influential factors were considered in the development process. The model was optimized using data about 162 real bidding situations. Then the optimized model was tested using another 20 real projects. It proved 85% accurate in simulating the actual decisions. Although, the proposed model is based on data from the Syrian construction industry it could be modified very easily to suit other countries.

Keywords: Bid/No bid criteria, parametric bidding model, Syria

Introduction

For any construction company, being able to deal successfully with various bidding situations is of crucial importance, especially in today's highly competitive construction market. This is the reason behind the great volume of literature concerned with bidding strategies. Since Friedman's (1956) model the literature has been flooded with many bidding models. Most of these models remained in academic circles and did not find their way into the practical world. This could be traced back to many reasons, such as: the over simplicity of the models' assumptions made them unable to represent the real-world problem; (ii) most contractors are unwilling to struggle with sophisticated mathematical models. (Ahmad and Minkarah (1988) concluded that only 11.1% of top American contractors use some sort of mathematical model. They prefer to rely on their experience in dealing with bidding situations); and (iii) most of these bidding models neglected to take into account that contractors might have other objectives rather than maximizing the expected profit. These factors imply a need for other bidding approaches. Very few researchers approached the bidding problem practically, i.e. subjectively, rather than mathematically. The former approach is more acceptable in the construction industry.

This paper reports a parametric approach for modelling the 'bid/no bid' decision-making process. Six semi-structured interviews were conducted among expert contractors, who explained how they make the bid/no bid decision in practice. Through a questionnaire survey, the main factors that influence this decision were identified and ranked according to their importance to contractors operating in Syria. Only the most influential 17 factors were considered in the final model, which was tested against 182 real bidding situations and proved 92.8% accurate in simulating the contractors' decisions. This work is part of a study being carried out to build an integrated bidding model to help Syrian contractors in making both bid/no bid and mark up size decisions.

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Previous studies

The literature contains a great number of theoretical bidding models based on the works of Friedman (1956) and Gates (1967). All these mathematical models proved to be suitable for academia but not for practitioners. Very few qualitative approaches which study how the bidding decisions are made in practice have been carried out. Gates (1983) suggested a non-mathematical bidding strategy based on the Delphi technique, designated as the (expert subjective pragmatic estimate (ESPE)). In this model, the range and distribution of competitors' possible low bids will be estimated, and then another estimate made for the company's range and distribution of possible low bids. The two sets are then compared to select the most appropriate bid. This is done by a group of experts who, through an iterative process, will estimate the optimum bid.

Ahmad and Minkarah (1988) conducted a questionnaire survey to uncover the factors that characterize the bidding decision-making process in the United States. Subsequently, Ahmad (1990) proposed a bidding methodology based on the decision analysis technique for dealing with the bid/no bid problem. This model considers the bidding problem as a two-stage problem. One is a deterministic stage that concerns the bid/no bid decision. The important criteria considered in this stage are deterministic, i.e. certain, such as type of project and location. The second stage is probabilistic because the criteria considered in it are uncertain, such as competition and risks expected. The bidding problem is decomposed into four high level criteria and 13 lower level criteria. This model demands many inputs, some of which the bidder, especially those with limited experience, might not be able to provide. Also, it assumes that all factors contribute positively to the total worth, i.e. desirability, of the project under consideration. No distinction was made between some factors that count for the total worth, such as profitability, and others that count against the total worth, such as 'degree of hazard'. However, this approach is the most promising step on the road to modelling the bid/no bid decision.

Shash (1993) identified, through a modified version of the questionnaire used by Ahmad and Minkarah (1988), 55 factors that characterize bidding decisions in the UK. The need for work, number of competitors tendering and experience in similar projects were identified as the top three factors that affect the bid/no bid decision.

Ahuja and Arunachalam (1984) proposed a model to aid contractors in evaluating systematically the risk due to the uncertainty of availability of the required resources before bidding on a new project. As argued by Ahuja and Arunachalam, it is vital for contractors to use their own resources optimally by procuring new projects to employ resources that will be released progressively from ongoing projects. A CPM summary network, with resource allocation, is required for this model. The model tries to help contractors balance resources owned, resources available from ongoing projects, and resources which must be procured. For each alternative, the model produces a duration and cost estimate for the project. In fact, this model could be viewed as a resource allocation model and not as a bid/no bid model. It does not have clear criteria to result in a bid or no bid recommendation. Resources, and risks related to them, are not the only criteria that affect the bid/no bid decision making process.

AbouRizk *et al.* (1993) proposed an expert system called 'BidExpert'. This model was integrated with a database management program, call 'BidTrak', that retrieved historical information from past bids submitted by the company and its competitors. The user was requested to provide information about the project and the company. The information provided by the user and derived from BidTrack was then passed to BidExpert, which is linked to two external programs: the 'fair and reasonable mark up pricing model' (FaRM) and a program to calculate the accuracy of the cost estimation. BidExpert processes the outcomes using its knowledge base, and provides the user with a bid/no bid recommendation. The necessity for historical information limits the applicability of this model. BidExpert has other drawbacks. For instance, the company capacity is evaluated by the number of projects the company has handled in the last five years and the number of the current projects, without any consideration of the projects' sizes.

Abdelrazig (1995) carried out a literature review and identified 37 factors that affect the bid/no bid decision. The analytical hierarchy process (AHP) was utilized and a computer program named 'Expert Choice' was develop to help contractors in Saudi Arabia in making their bid/no bid decisions.

Wanous *et al.* (1998) conducted a questionnaire survey among Syrian contractors to uncover the parameters that characterize their bid/no bid decision-making process. 38 parameters were ranked according to their relative importance in making the bid/no bid decision in Syria. It was concluded that fulfilling the to-tender conditions, financial capability of the client, and relation with/reputation of the client are the most important factors.

Methodology

To model the bid/no bid decision-making process it is necessary to identify the parameters that influence this decision. This task was performed by a formal questionnaire survey supported by six semi-structured interviews. The interviews were translated into a diagrammatic model that represents how a bid/no bid decision is made in practice. For each bidding factor, a set of parameters was extracted from the questionnaire findings. These parameters were used to produce a bidding index formula. Based upon this index, the model can recommend whether to bid on a new project or not. Data from 182 real bidding situations were collected and used to optimize, test and validate the proposed model.

Data collection

Six semi-structured interviews were conducted among interested and successful contractors who had considerable experience (19–31 years) in the Syrian construction industry. The main objective of these interviews was to gain an overall understanding of how contractors make their tendering decisions in practice. Certain open-ended aspects (e.g. please explain how you make the bid/no bid decision, and when is it recommended not to bid for a new project ?) were asked in the same order in each interview.

A formal questionnaire (questionnaire A) was designed to uncover the factors that characterize the bidding decisions in Syria and to find out how these factors affect the bid/no bid decision. When assessing a new bidding situation, high scores for some factors usually encourage contractors to bid, e.g. capital availability, experience in similar projects, etc. Such factors are referred to in this study as positive factors. On the other hand, high scores for some other factors usually encourage contractors not to bid, e.g. current workload, public objection, etc. Such factors are referred to as negative factors.

This classification of the bidding factors into two groups is artificial, and indicates simply that an increasing score in a positive factor strengthens the bid recommendation whereas the opposite is true for a negative factor. Depending on the scores assigned in a particular case, a negative factor may still have a positive effect on the Bid recommendation. Also, a positive factor may have a negative effect in a particular case (see later in Figure 2a, b). A simple statistical analysis of 162 real bidding situations confirmed that positive factors have significant positive correlation with the actual bidding decision, whereas negative factors have significant negative correlation with this decision. Nonetheless, it is acknowledged that this classification might not be true in all cases. High scores of some negative factors could be considered by some contractors in certain bidding circumstances as encouraging, and vice versa. This issue will be addressed in further work where another bid/no bid model is being developed using different techniques.

In questionnaire A, contractors were requested to provide the following subjective information.

- The importance of the listed factors in making the bidding decisions (as a score between 0 (extremely unimportant) and 6 (extremely important));
- Add any missing important factors;
- For each positive factor, a neutral score below which this factor will start to have a discouraging effect on the bid decision, and a kill-score below which this factor will be enough to cause a no bid decision; and,
- For each negative factor a neutral score above which this factor will start to have a discouraging effect on the bid decision, and a kill-score above which this factor will be enough to cause a no bid decision.

Part of the findings of the interviews and questionnaire (A) were reported in more detail in Wanous *et al.*(1998).

Another data form (questionnaire B) was designed to capture real bidding situations as subjective assessments of these situations combined with the bid/no bid decision made by contractors. 300 copies were sent to 30 contractors (10 copies each) who had a minimum experience of five years. The contractors were requested to fill in a form for each new project. 182 responses were received, i.e. the response rate was 60.66%. Only 26 factors that have a moderate to high importance in making bid/no bid and mark up selection were included in the questionnaire. The following information was requested.

- General information on the project in hand (approximate size, duration and type).
- Assessing the bidding situation by scoring 26 factors between 0 and 6, where 0 represents no importance and 6 represent extreme importance.
- The main expected risks.
- The importance of visiting the intended project site before submitting a bid.
- The decision made: bid or no bid.
- Type of procurement system adopted.
- The estimated direct cost, indirect cost, the markup size, and the final price.
- The net profit.
- After the appointed opening day: first bid, second bid, third bid and number of bidders.
- Any additional notes related to the bidding situation and the decisions taken.

A simple statistical analysis of the contractors responses confirmed that positive bidding factors have significant positive correlation with the actual bidding decision. Conversely, the negative factors have significant negative correlation with this decision.

Factors influencing the bid/no bid decision

In previous work (Wanous *et al.*, 1998), 38 factors that characterize the bidding decisions were identified and ranked according to their importance to contractors operating in Syria. To avoid double counting, two of these factors (availability of qualified staff and degree of hazard) were omitted because it appears that contractors in Syria do not differentiate between them and two other factors (availability of skilled labour and risks expected). Also, the 'project geological study' factor was considered to be included in the 'risks expected' factor.

Table 1 presents the remaining 35 factors along with the importance index in making the bid/no bid decision (Ib). Factors that have less than moderate importance, i.e. Ib < 50%, in making the bid/no bid decision were discarded. The remaining factors with moderate to high importance are considered in the development of the model and are identified with an asterisk in column three of Table 1.

Table 2 presents the positive factors ranked in descending order of importance, each along with two parameters, B_i and NB_i where B_i is a neutral score below which the factor F_i will have a discouraging effect on the bid recommendation, and NB_i is a kill value below which this factor will be enough to cause a no bid recommendation. Similarly, Table 3 presents the negative factors ranked in descending order of importance each along with two parameters, B_j and NB_j, where B_j is a neutral score above which the

Table 1 Bidding factors that are considered in developing the proposed model

Bid/no bid criteria	Ib	Factors considered to have moderate to high importance
Fulfilling the to-tender conditions imposed by the client	89.88%	*
Financial capability of the client	77.67%	*
Relations with and reputation of the client	76.83%	*
Project size	73.17%	*
Availability of time for tendering	70.83%	*
Availability of capital required	68.33%	*
Site clearance of obstructions	68.00%	*
Public objection	67.83%	*
Availability of materials required	66.33%	*
Current work load	65.83%	*
Experience in similar projects	64.00%	*
Availability of equipment required	64.00%	*
Method of construction (manually, mechanically)	64.00%	*
Availability of skilled labour	58.00%	*
Original project duration	55.5%	*
Site accessibility	53.83%	*
Risks expected	52.17%	*
Rigidity of specifications	50.00%	*
Expected project cash flow	47.00%	
Degree of buildability	47.00%	
Availability of other projects	46.17%	
Confidence in the cost estimate	45.33%	
Project location	31.67%	
Original price estimated by the client	28.50%	
Past profit in similar projects	26.50%	
Expected date of commencing	24.67%	
Availability of equipment owned by the contractor	22.17%	
Expected number of competitors (degree of competition)	17.83%	
Local climate	17.50%	
Specific features that provide competitive advantage	16.33%	
Fluctuation in labour/materials price	15.00%	
Competence of the expected competitors	12.50%	
Relations with other contractors and suppliers	10.33%	
Proportions to be subcontracted	5.50%	
Local customs	4.17%	

Table 2 Parameters of the positive bidding factors

i	Positive bidding factors	B_i	NB_i
1.	Fulfilling the to-tender conditions imposed by the client	5.84	5
2.	Financial capability of the client	3.48	2
3.	Relations with and reputation of the client	3.84	2
4.	Availability of time for tendering	2.54	0
5.	Availability of capital required	3.41	2
6.	Site clearance of obstructions	3.64	0
7.	Availability of materials required	3.56	2
8.	Experience in similar projects	3.61	2
9.	Availability of equipment required	3.40	0
10.	Method of construction (manually, mechanically)	3.05	0
11.	Availability of skilled labour	3.25	0
12.	Original project duration	3.02	0
13.	Site accessibility	3.00	0

Table 3 Parameters of the negative bidding factors

j	Negative bidding factors	B_j	NB_j
1.	Project size	3.69	5
2.	Public objection	2.15	4
3.	Current work load	2.90	6
4.	Risks expected	3.12	6
5.	Rigidity of specifications	3.66	6

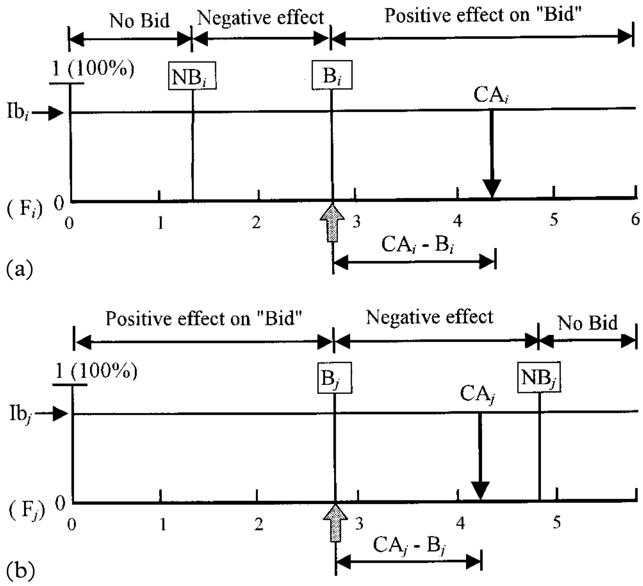


Figure 1 A parametric model for (a) a positive factor and (b) a negative factor, where F_i, F_j are positive, negative bidding factors, IB_i, IB_j are importance indexes in making the bid/no bid decision, NB_i, NB_j are kill scores of factors, F_i, F_j, B_i, B_j are neutral scores for factors, F_i, F_j, and CA_i, CA_j, are the contractor's assessment of the bidding situation regarding factors F_i and F_j.

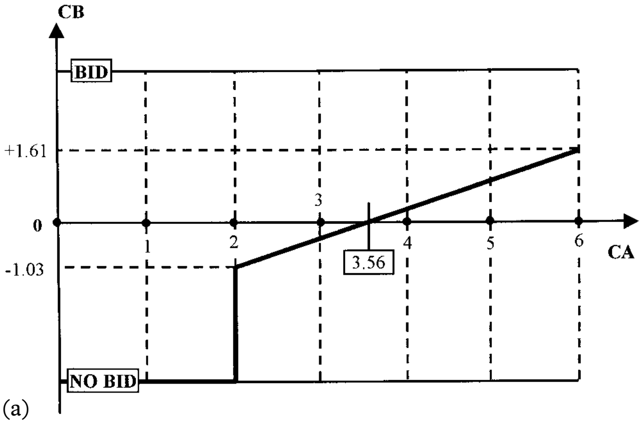
factor F_j will have a discouraging effect on the bid recommendation; and, NB_j is a kill value above which this factor will be enough to cause no bid recommendation. The parameters B_i, NB_i, B_j, and NB_j were selected through statistical analysis of questionnaire A and the six semi-structured interviews conducted among Syrian contractors.

The modelling process

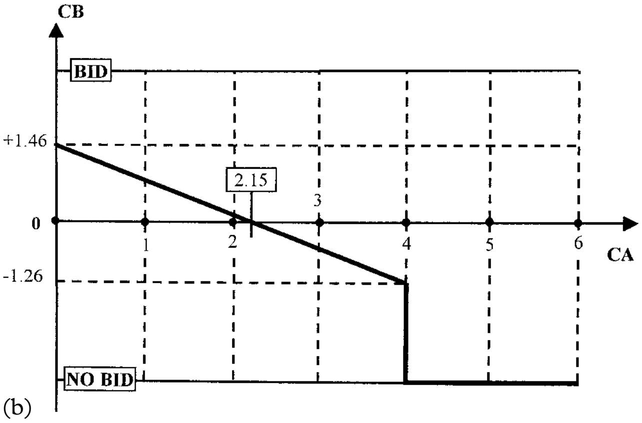
The bid/no bid decision-making process explained by expert Syrian contractors was translated into a systematic bidding model. First of all, a simple parametric scale was developed for each positive factor (F_i in Table 2) as illustrated in Figure 1a, that explains how a positive factor affects the bid/no bid recommendation. Also, a parametric scale was developed for each negative bidding factor (F_j in Table 3) as illustrated in Figure 1b, that explains how a negative factor affects this recommendation. Here, F_i is a positive bidding factor; I_i is the importance index of factor F_i; CA*i* is the contractor's assessment (score between 0 and 6) given to F_i when considering a new bidding situation; F_j is a negative bidding factor; I_j is the importance index of factor F_j; and, CA_j is the contractor's assessment (score between 0 and 6) given to F_j when considering a new bidding situation.

The influence of the 'Availability of materials' factor on the bid recommendation is presented graphically in Figure 2a as an example to clarify the usual effect of the classified positive factors. It is clear that this positive factor still has a negative effect if the contractor's assessment was CA$<$ 3.56 (the neutral score) and that it will cause a no bid recommendation when CA$<$ 2 (the 'kill' score). Also, the influence of the 'public objection' factor is illustrated in Figure 2b as an example of the negative factors. This figure shows that the 'public objection' factor still has a positive effect when CA$<$ 2.15 (the neutral score). B_i, NB_i, I_i, B_j, NB_j and I_j were derived from information supplied by expert contractors operating in Syria, and some features of the Syrian construction industry will be reflected in these values. Therefore, this model might be of greater help to new contractors who do not have considerable experience in dealing with bidding problems. However, expert contractors can modify these values to suit their own bidding policies. Also, the basic modelling approach of the proposed model can be applied to other international industries.

It is worth mentioning that the subjective assessments CA_i and CA_j will be influenced by the bidder's attitude towards risk and uncertainty.



(a)



(b)

Figure 2 Contribution of (a) 'availability of materials' factor and (b), 'public objections' factor in the Bid recommendation, where CA is the contractor's assessment and CB is the contribution to the bid recommendation

The following formula has been used to produce a bidding index (BI_k) for a certain project k.

$$BI_k = \sum_{i=1}^{m} Ib_i(CA_i - B_i) - \sum_{j=1}^{n} Ib_j(CA_j - B_j) \qquad (1)$$

BI_k indicates the degree of desirability of bidding on project k. The additivity adopted in formula 1 is justified by the small correlation between bidding attributes. This additivity has been defended by others (Ahmad, 1990).

For $CA_i = B_i$ and $CA_j = B_j$, the bidding index will be $BI_k = 0$. That represents the mid-point case scenario where there are neither positive nor negative effects on the bid decision, i.e. the strengths of both bid and no bid decisions are equal. If $BI_k > 0$, that indicates a more positive effect on the bid decision, and thus, the proposed model will recommend the bid decision when $BI_k = 0$ and the no bid decision when $BI_k < 0$.

The proposed bid/ no bid model is illustrated diagrammatically in Figure 3 and can be explained as follows

1. The user is requested to describe the bidding situation by assigning subjectively a suitable score between 0 (extremely low) and 6 (extremely high) to each positive bidding factor. In the case of any one of these factors violating its kill value, the no bid decision will be recommended. This decision could be accepted or rejected by the user.
2. Step 1 repeated for the negative factors.
3. Having all the required inputs, the model produces the bidding index (BI_k).
4. If $BI_k \geqslant 0$ then the bid decision is recommended.
   If $BI_k < 0$ then the no bid decision is recommended.
5. This process could be repeated for other new projects or for what-if analysis on a single project.
6. All the projects examined can be ranked in descending order according to the bidding index. This indicates which project is most suitable for the user.

To demonstrate the application of this model a case study is provided later in this paper using a real-life bidding situation.

Sensitivity analyses

An attempt was made to simplify the proposed bidding model by reducing the number of inputs required. This should be done without affecting the model accuracy significantly. Theoretically, the least important factors should be considered for omission first. However, this strategy could be invalid because the degrees of importance of the bidding factors might not be exactly the same in real life as suggested by contractors. Also, as well as the importance index (Ib), there are other parameters (B_i and B_j) that affect the bidding index (BI). To overcome this problem, a sensitivity index was developed for each bidding factor. For each factor, two values of the bidding index (BI_0 and BI_6) were produced for two values of the contractor's assessment (AC=0 and AC=6), while setting the other factors to the mid-case scenario (where BI=0). A sensitivity index (SI_i) of a bidding factor F_i is defined by

$$SI_i = |BI_{0i} - BI_{6i}| \qquad (2)$$

Table 4 represents BI_0, BI_6 and SI for each bidding factor, and the sensitivity of the model to changes in individual factors is illustrated in Figure 4. Factor F_{18} has the lowest SI. Thus, the model was tested with factor F_{18} being eliminated by using the model to produce bidding indices for 162 real bidding situations

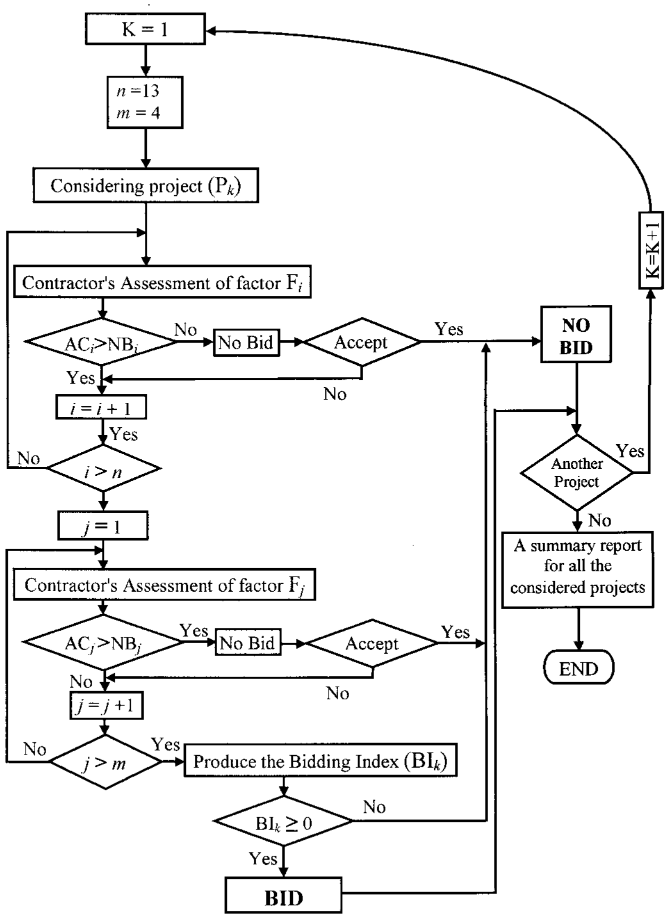


Figure 3 Systematic model for bid/no bid decision, where K is the code of the project considered, n is the number of factors (F_i), m is the number of negative factors (F_j), CA_i is the contractor's assessment of the bidding situation regarding factors F_i, NB_i is the kill-score of factor F_i, CA_j is the contractor's assessment of the bidding situation regarding factor F_j, and NB_j is the kill-score of factor F_j.

Table 4 Sensitivity of the bid/no bid decision to changes in individual factors

i	Positive bidding factors	BI_0	BI_6	SI $\lvert BI_0–BI_6 \rvert$
1.	Fulfilling the to-tender conditions	–5.25	+0.14	5.39
2.	Financial capability of the client	–2.70	+1.95	4.65
3.	Relation with/reputation of the client	–2.95	+1.66	4.61
4.	Project size	+2.70	–1.69	4.39
5.	Availability of time for tendering	–1.80	+2.45	4.25
6.	Availability of capital required	–2.33	+1.77	4.10
7.	Site clearance of obstructions	–2.48	+1.60	4.08
8.	Public objection	+1.46	–2.61	4.07
9.	Availability of materials required	–2.36	+1.62	3.98
10.	Current workload	+1.91	–2.04	3.95
11.	Experience in similar projects	–2.31	+1.53	3.84
12.	Availability of equipment required	–2.18	+1.66	3.84
13.	Proportion that could be constructed mechanically	–1.95	+1.89	3.84
14.	Availability of skilled labour	–1.89	+1.60	3.49
15.	Sufficiency of the project duration	–1.68	+1.68	3.36
16.	Site accessibility	–1.63	+1.60	3.23
17.	Risks expected	+1.63	–1.50	3.13
18.	Rigidity of specifications	+1.83	–1.17	3.00

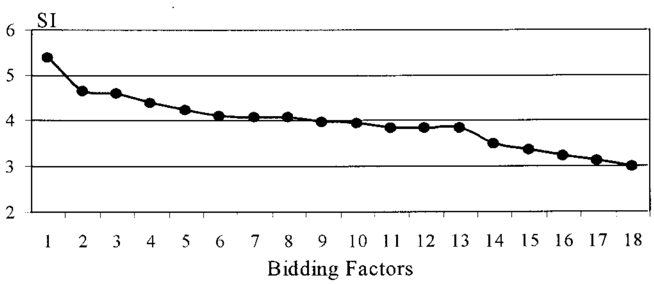


Figure 4 Sensitivity of the bidding index to changes in individual factors, with SI the sensitivity index

Table 5 Sensitivity to omitting some factors

Factors omitted	No. of wrong recommendations
None	17
F_{18}	17
F_{18}+ F_{17}	**16**
F_{18}+ F_{17}+ F_{16}	19
F_{18}+ F_{17}+ F_{16}+ F_{15}	19
F_{18}+ F_{17}+ F_{16}+ F_{15}+ F_{14}	21

and comparing the model recommendations with the actual decisions. The model predicted the 'wrong' decision 17 cases out of 162 cases. The same process was repeated for omitting factors F_{18}+F_{17}, F_{18}+ F_{17} +F_{16}, F_{18}+F_{17}+F_{16}+F_{15} and F_{18}+F_{17}+F_{16}+F_{15}+ F_{14}. Table 5 summarizes the test results. The model accuracy in simulating the actual decisions was improved marginally when omitting factors F_{18}+ F_{17} ('risks expected' and ' rigidity of specifications'). This indicates that these two factors are not important in practice. Therefore, these two factors were discarded. It is not necessary to discard more factors as those remaining can be assessed by the user very easily.

Model optimization and validation

This model is based on subjective opinions elicited from Syrian contractors (through questionnaire A) and on personal experience with the Syrian construction industry. Also, some assumptions were made to facilitate the modelling process, e.g. classification of bidding factors into positive and negative. Thus, it was believed that it is necessary to optimize this model using real bidding situations.

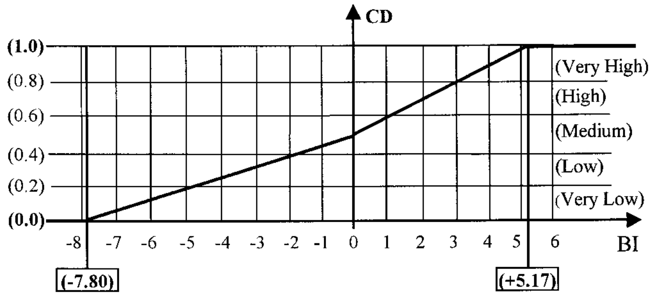


Figure 5 Degree of confidence based on the bidding index, with BI the bidding index and CD the degree of confidence

The same 162 real bidding situations were used to optimize the proposed model and to improve the quality of its recommendations.

Initially, BI = 0 was considered as the cutoff point between bid and no bid recommendations. However, zero might not be the optimum value (X). Therefore, the model recommendations were tested against the actual decisions for different values of X, and the test results are presented in Table 6. X = 0 corresponds to the minimum number of unsuccessful recommendations indicating that it is not necessary to change the initial cutoff point (BI = 0). Two other cutoff points are required to improve the quality of the model output. These are X_1 and X_2 where: X_1 is the bidding index above which the model will be confident 100% in recommending to bid (or 0% in no bid), and X_2 is the bidding index below which the model will recommend not to bid with 100% confidence (or 0% in bid).

Based on the bidding indices produced for the previously mentioned real bidding situations, X_1 and X_2 were selected as follows: X_1 is the maximum bidding index below which all contractors decided not to bid (X_1 = –7.80); and X_2 is the minimum bidding index above which all contractors decided to bid (X_2 = +5.17). Using these values, a simple model was developed to produce the degree of confidence based on the bidding index, as illustrated in Figure 5, that can be explained as follows.

If BI $\geq$5.17, then bid recommendation with degree of confidence CDb = 100%.
If 0 $\leq$BI < 5.17, then bid with degree of confidence CDb (%) = 50 + 9.7 BI.
If -7.80 < BI < 0, then 'no bid' with CDnb (%) = 50 – 6.41BI.

Table 6 The optimum cutoff point between bid and no bid

X	–0.15	–0.10	–0.05	0	+0.05	+0.10	+0.15
No. of unsuccessful recommendations	17	17	16	16	16	16	17

If BI ≤−7.80, then no bid with CDnb = 100%.
CDb = 100 − CDnb.

Here, CDn is the degree of confidence in a bid recommendation and CDnb is the degree of confidence in a no bid recommendation.

The final optimized model was tested against 20 real-life bidding situations that were excluded randomly from the optimization cases. The model failed to predict the actual decisions in three cases, which means the accuracy of the proposed model in simulating the actual decisions is 85%. However, to assess the reliability of this model in recommending the 'right' decisions it is necessary to know the real outcome (e.g. the actual profitability) of the real projects that were used in developing and validating it. It is intended to investigate this issue in future work.

Cases studied

A real-life bidding situation is used to demonstrate the application of this model. The project, valued at Syrian pounds 166 million (about $4.50m) was for student accommodation. Table 7 presents the contractor's assessment of the bidding situation in terms of the aforementioned factors. Each factor was assessed using a score from 0 to 6 where 0 is extremely low and 6 is extremely high.

The model starts by examining the individual bidding factors. The 'to-tender conditions' factor is fully met, as indicated by $AC_1 = 6$. Thus, no bid is not recommended at this stage because this factor does not violates its kill value, i.e. $AC_1 = 6 > NB_1 = 4$. The same process is repeated for all the positive factors, and if any one of them is scored at less than its kill value (NB_i), then the model recommends a no bid decision, but the contractor can reject the recommendation and continue.

In this bidding situation, all the positive factors were scored higher than their NB_i. Therefore, the model starts examining the negative factors. The first one 'project size' was scored $AC_1 = 4$, which means the size of this project is high compared with the average size the contractor deals with usually. However, this score is not higher than its kill value ($NB_1 = 5$, i.e. very high). The other negative factors are examined in the same process. None exceeded its NBj. Finally, the model produces a bidding index (BI) for the project under consideration. In this case, the bidding index was greater than zero (BI = 4.78). Therefore, the model suggests to bid for this project. The degree of confidence in this recommendation is CD = 96% (refer to Figure 5). In real life, the contractor submitted a bid for this project and won the contract.

Table 7 Contractor's assessment of the bidding situation

Positive factors		Negative factors
CA_1=6	CA_8=3	CA_1=4
CA_2=4	CA_9=3	CA_2=2
CA_3=4	CA_{10}=5	CA_3=4
CA_4=4	CA_{11}=4	
CA_5=2	CA_{12}=5	
CA_6=4	CA_{13}=4	
CA_7=6		

Conclusion

A systematic solution for one of the most critical problems faced by construction companies/contractors is presented. An overview of previous, similar models is provided as a foundation for the proposed new model. This bidding model is based on the findings of a formal questionnaire survey supported by six semi-structured interviews and optimized using 162 real bidding situations. The model was tested against another 20 real-life projects and proved 85% accurate in simulating the actual decisions. Some bidding experience that was provided by expert Syrian contractors is embedded in this model, which could be very beneficial to new contractors who do not have considerable experience in dealing with new bidding problems. This is not offered by any other bidding models. The proposed model will be extended to make possible a recommended mark up percentage for those projects which the user decides to bid on. Although, the proposed model is based on data from the Syrian construction industry the general approach can be viewed as a universal 'shell' that can be applied to other countries.

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References

Abdelrazig, A.A. (1995) MSc dissertation, King Fahd University of Petroleum and Minerals, Saudi Arabia, unpublished.

AbouRizk, S.M., Dozzi, S.P. and Sawhney, A. (1993) BidExpert—an expert system for strategic bidding, Annual Conference of the Canadian Society of Civil Engineering, Frederichton, NB, Canada, pp. 39–48.

Ahmad, I. (1990) Decision-support system for modelling the bid/no bid decision problem. *Journal of Construction Engineering and Management*, **116**(4), 595–607.

Ahmad, I. and Minkarah, I.A. (1988) Questionnaire survey on bidding on construction, *Journal of Management in Engineering ASCE*, **4**(3), 229–243.

Ahuja, H.N. and Arunachalam, V. (1984) A simulation to aid in bid/no bid decision, in 4th I*nternational Symposium on Organisation and Management of Construction*, pp. 323–332.

Friedman, L. (1956) A competitive bidding strategy. *Operational Research*, **4**, 104–12.

Gates, M. (1967) Bidding strategies and probabilities *Journal of the Construction Division*, *ASCE*, **93**(1), 75–103.

Gates, M. (1983) A bidding strategy based on ESPE. *Cost Engineering*, **25(**6), 27–35.

Shash, A. (1993) Factors considered in tendering decisions by top UK contractors. *Construction Management and Economics*, **11**(2) 111–18.

Wanous, M., Boussabaine, A.H. and Lewis, J. (1998) Tendering factors considered by Syrian contractors, in *Proceedings of the 14th Annual ARCOM Conference*, Vol. 2, ARCOM, Oxford, p. 535.