01 Jan 2008

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Recommended Citation

M. Abdelrahman et al., "Rational Best-Value Model based on Expected Performance," *Transportation Research Record*, no. 2081, pp. 46-55, National Research Council (U.S.), Jan 2008.
The definitive version is available at https://doi.org/10.3141/2081-05

Rational Best-Value Model Based on Expected Performance

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The best-value procurement strategy is gaining interest from federal and state agencies. The term best value has many competing definitions in the industry. One of the suggested broad definitions is "a procurement process where price and other key factors are considered in the evaluation and selection process to enhance the long-term performance and value of construction" (*1*). This definition was disaggregated into four primary concepts: parameters, evaluation criteria, rating systems, and award algorithms. Based on the analysis of the literature, meetings, and case studies, it was determined that a best-value procurement, which is simple to implement and flexible in the selection of parameters and award algorithms, is the most effective approach in the context of a traditional bidding system.

The best-value procurement allows contracting agencies to evaluate offers based on total costs, technical solutions, completion dates, and other criteria to enhance the long-term performance of projects. When used correctly, the strategy obtains the optimum combination of price and technical solution for the public and rewards those who propose innovative concepts that enhance product quality or lower the price of quality. The inclusion of key parameters or evaluation factors, such as construction quality record, that match specific needs of a project guarantees the selection of the best contractor for a specific project. This happens when the agency adopting the system realizes the need, in each project, to use the best-value system as a unique case. The best-value system is viewed as a balance between fixed-price sealed bidding and sole source selection or between price and qualification considerations. The findings of the NCHRP 10-61 research study show a trend in the construction public sector toward the increased use of various best-value procurement methods and a long-standing concern expressed by public owners (*1*). However, a low-bid procurement system, while promoting competition and a fair playing field, may not result in the best value for dollars expended or the best performance during construction.

Literature indicates that a low-bid procurement system encourages contractors to implement cost-cutting measures instead of quality-enhancing measures and therefore makes it less likely that contracts will be awarded to the best-performing contractors who will deliver the highest-quality projects (*1*). However, state and federal sectors have moved aggressively toward the use of best-value procurement, have attempted to measure its relative success, and are convinced that it achieves better results than low-bid procurement because of the following reasons: (*a*) the low-bid method fails to serve the public interest because the lowest offer may not result in the lowest overall cost to the public; (*b*) the best-value procurement provides a reduction in cost growth from 5.7% to 2.5% and a reduction in claims and litigation by 86%; (*c*) a 1997 National Science Foundation study concluded that design–build contracts procured using the two-step best-value procurement procedure had the best cost and schedule growth performance, albeit representing only a small average improvement over the other procurement methods; and (*d*) the best-value procurement was emerging as a viable alternative to the traditional low-bid method in the public sector construction (*1–4*).

A key concept in best-value procurements is the focus on selecting the contractor with the offer "most advantageous to the government where price and other factors are considered." The factors other than price can vary, but they typically include technical and managerial merits, financial health, and past performance (*5–8*). Another key element in the success of innovative contracting techniques, including best value, is the communication between owners and contractors in two main areas: (*a*) the rationality in ranking the contractor qualification and (*b*) defining the owner expectations. Owners must think

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Transportation Research Record: Journal of the Transportation Research Board, No. 2081, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 46–55.
DOI: 10.3141/2081-05

carefully of what is valuable in the product and not just important or required in the selection process. The use of technical, managerial, or performance elements that are of indeterminate value, while important or required, simply clouds the decision. Owners should only base the best-value selection criteria on project elements that add measurable value to the project (*9*). It is also important that owners set standards for the procurement process. Owners must carefully define what is expected and communicate that with contractors. Earlier research (*10*) shows that agencies prequalify contractors using subjective values that may not follow a rational approach. A group of evaluators rate the contractor expected performance on several key areas such as staff, experience, project approach, schedule, and innovation. The use of subjective equations or rules introduces a different form of bias to the procurement process. Research indicates that most agencies do not define the expected level of contractor performance in low-bid procurement systems. The contractor is only required to secure the necessary bonds before submitting a bid. The prequalification process is different because the contractor's past performance has nothing to do with getting the next job, unless debarred. Even if a contractor fails miserably on an area, such as quality on one project, the contractor is able to bid the next project (*11*).

The number of agencies adopting innovation procurement techniques, such as A+B and design–build contracts, is increasing. In such cases, contractors submit both technical and price proposals. The technical proposal is based on announced expected levels of contractor performance, such as project time or lane rental requirements (*11*). Currently, many innovative procurement practices include an evaluation process that is conducted based on subjective criteria. In a low-bid procurement system, as in subjective criteria procurement systems, owners may introduce inappropriate biases into the selection process or add cost to the procurement. It is necessary for an agency implementing a best-value system to adopt a rational ranking system for contractor qualifications that is based on the agency's expected level of performance.

PROBLEM STATEMENT

The NCHRP 10-61 research study recommends a few basic strategies to implement in the area of best-value procurement from legislative guidelines and model specifications to the industry collaboration and pilot projects. There is a shortage of research on project characteristics, including evaluation criteria and parameter scores, which should be the foundation of the contractor selection process. There is a need for a rational system to represent the contractor performance in each of the selected best-value parameters. A rational scoring system requires the definition of the contractor's expected performance.

STUDY OBJECTIVES

The main objective of this study is to establish a rational and flexible scoring model to be used in the best-value system. The model will be capable of being tailored to the specific project need. This flexibility will be obvious in the selection of parameters to be included in the contractor selection process and in the determination of their weights. The model rationality will be achieved through relating all awarded scores to the agency's expected performance. The establishment of the best-value model uses the past record of the contractor's work for the agency as an indicator of qualification trend. This research incorporates prequalification as a first-level screening technique in selecting top contractor bids in the best-value procurement and then applies a rational scoring system in the final selection. Pilot projects, with the three lowest bidders for each project, are used to show the results of model application and to clarify the impact of the best-value system in the contractor selection process. Based on the results of this study, an evaluation of the best-value system versus the lowest-bid system is presented.

BEST-VALUE MODEL

The parameters and evaluation criteria of best value are first determined from the literature, survey, case studies, and meetings (*12*). Two facts should be kept in mind: a best-value model is easier to use with fewer evaluation criteria, and the probable lack of familiarity of department of transportation (DOT) officials and contractors with the best-value environment necessitates a gradual involvement with this new concept. A preliminary long list of evaluation criteria is prepared and the proposed measurements of each evaluation criterion are suggested. Based on previous applications of the best-value model within DOTs, it is suggested that evaluation criteria should be fewer in number and easy to obtain from project records. The research team discussed the possibility and validity of each evaluation criterion, included in the initial list, to be considered in a conceptual model. This process results in a second list of the evaluation criteria and suggested measurement factors as shown in Table 1.

The first parameter selected to be included in the model is bid price. This parameter was the most important parameter in selecting contractors using the traditional procurement system. For public agencies, lowest-bid selection is enforced by law even if there is no need. Contract time is used as a competitive parameter in contracts that require a fast track. This parameter represents the B part in the A+B bidding process, which yields from contract time multiplied by road user cost. The next parameter is lane rental, which reflects the impact of construction activities on the road users' time and money. Lane rental is equal to the percentage of lane closure cost divided by the total bid amount. Past quality parameter shows the quality of final product where it is evaluated by the percentage of rejected test specimens divided by the total test specimens.

Table 1 also shows examples of the expected performance (EP) of each parameter based on actual records. The EP can be defined in terms of engineering and design estimate or based on recoded data for similar projects. The EP is used as the baseline for comparing a contractor's performance in the best-value parameters. If no records are available, expected performance is estimated as the best submitted parameter values. In addition, the upper and lower reference limits (URL and LRL) of each parameter's best values are shown in Table 1. The details of the best-value parameters are listed in Equations 4 to 9 and are discussed later in the paper.

The general equation for the best value is shown in Equation 1:

$$\mathrm{BV}_j = \sum_{i=1}^{n} W_i \times S_i \tag{1}$$

where

BV_j = best value for contractor j,
n = number of parameters included in the best-value equation,
W_i = parameter i weight, and
S_i = parameter i score.

TABLE 1 Parameters of Best Value and Their URL and LRL

Evaluation Parameter	Definition	Example Expected Performance (EP)[a]	Upper and Lower Limits[b]	
			URL	LRL
BP = bid price	Bid amount as finally agreed upon with the owner	$9.9 million	Expected price or lowest bid	Highest bid
CT = contract time	Cost of contract time for current project	$0.9 million	Expected or lowest contract time * daily user cost	Highest contract time * daily user cost
UT = unauthorized time	Average unauthorized delay time that is recorded for past contractor performance	0.0%	Lowest percent delay in records	Highest percent delay in records
CL = rejected claims	Average rejected claims that is recorded for past contractor performance	15%	Lowest percent rejected claims	Highest percent rejected claims
PQ = quality	Average quality that is recorded for past contractor performance	1%	Lowest percent rejected testing	Highest percent rejected testing
LR = lane rental cost	Average recorded lane rental cost	2.5%	Lowest percent lane rental	Highest percent lane rental
TC = traffic control	Average recorded traffic control compliance for past contractor performance	0.04%	Lowest percent noncompliance of traffic control	Highest percent noncompliance of traffic control

[a]EP is estimated as the best submitted values of parameters of contractors' bids.
[b]These limits are set after the first screening or prequalification of contractors.

Parameter Weight (W_i)

The first step is to obtain the relative weights (W_i) for each included parameter in the best-value model. The total summation of the parameters' weight should equal 1. These weights are determined based on the opinion of DOT experts. Because most of the aforementioned parameters are subjective in nature, the analytic hierarchy process (AHP) technique is used to quantify the weight of these parameters. The AHP, which is an easy mature technique that attempts to simulate the human decision process (*13*), allows decision makers to incorporate both qualitative and quantitative considerations of human thought and intuition. The use of expert inputs in best-value modeling allows better consideration of the project-specific conditions and fulfills the agency requirements. Subjective inputs are just the starting point in best-value modeling and will be improved in the future implementation of the model. Several steps are required to model a problem using the AHP method as follows (*13, 14*):

1. A set of factors that contribute to problem solving should be identified. Then, these identified factors will be categorized within a hierarchy of various levels. In the best-value problem, the factors are listed in Table 1.
2. The relative weights of these factors are obtained using pairwise comparison matrices. These matrices are collected from district engineers from whom they grasp the engineers' opinion regarding the abovementioned factors (Table 1). By using mathematical processes (eigenvalue and vector), factors' weights can be determined. Each factor weight represents the relative importance of this factor among the others.
3. In order to consider the resulted weights from a pairwise comparison matrix, the logical consistency of weights has to be verified based on the matrix consistency ratio (CR). If the CR is more than 10%, then the results are inconsistent. Hence, the assigned priority values should be modified until the CR value is verified. The CR value can be determined by using Equations 2 and 3 as follows (*13–15*):

$$\mathrm{CI} = \frac{\lambda_{\max} - m}{m - 1} \tag{2}$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{3}$$

where

CI = matrix consistency index,
m = matrix size,
$\lambda_{\max}$ = maximum eigenvalue,
RI = random index [it has a value related to the matrix size (*14*)], and
CR = consistency ratio.

Best-Value Parameters

The parameters used in the developed best-value system are defined as follows:

Contract time:

$$\mathrm{CT} = \text{number of days bid} * \text{daily user cost} \tag{4}$$

Unauthorized time:

$$\mathrm{UT} = \left(\sum \frac{\text{unauthorized delay time}}{\text{total project duration}} \right)\% \tag{5}$$

or

$$\mathrm{UT} = \left(\sum \frac{\text{liquidated damage amount}}{\text{total \$ bid amount}} \right)\% \tag{6}$$

Quality:

$$PQ = \frac{\text{rejected test specimens}}{\text{total tested specimens}}\% \tag{7}$$

Lane rental cost:

$$LR = \left(\sum \frac{\text{lane rental rate} \times \text{hours bid}}{\text{total \$ million bids}}\right)\% \tag{8}$$

Traffic control:

$$TC = \left(\sum \frac{\text{\$ amount for noncompliance}}{\text{total \$ million bids}}\right)\% \tag{9}$$

Best-Value Determination

After determining the value of parameter weight (W_i) and score (S_i), both values are multiplied in order to determine the best-value for each parameter. Then Equation 1 will be implemented where the best-values of parameters are added to constitute the final score—best value—for each contractor. Contractors will be sorted based on the best value in which the contractor of the highest best-value score is the winner.

The concept implemented in this research is that both W_i and S_i reflect project specifics where both of them are sensitive to any project characteristics. The best-value parameters represent the key performance indicators for a specific project. The weights represent the significance of each parameter to a specific project. The parameter scores are given to each contractor and represent the compliance with the expected performance of the agency. For example, if lane rental is not included in a project, then the value of W_i and S_i is equal to zero. Then, for this parameter, the value of $BV_j = W_i * S_i$ is $0 * 0 = 0$.

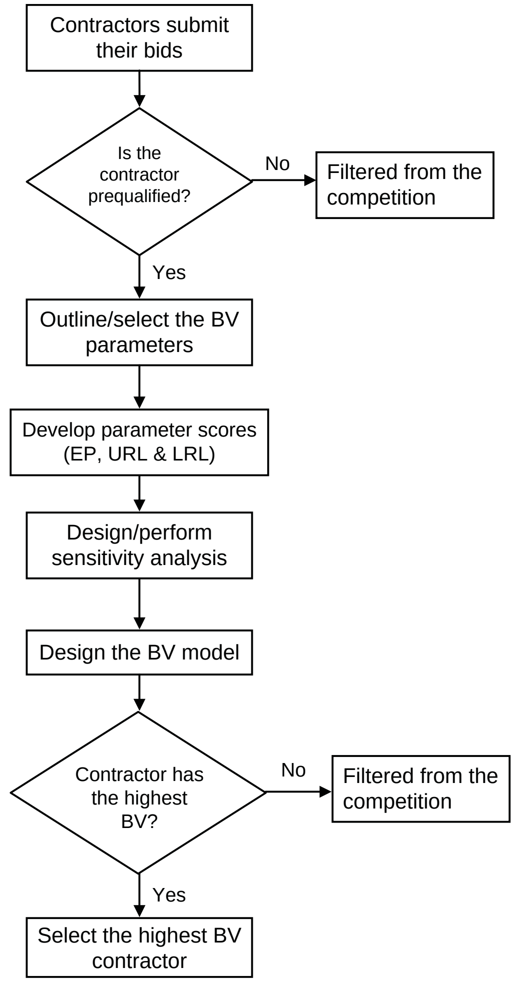


FIGURE 1 Research methodology.

MODELING BEST-VALUE PARAMETERS

The procedure of developing the best-value model includes the main steps shown in Figure 1:

1. Use the prequalification screening to select the appropriate contractors.
2. Outline the various parameters that have to be included in the best-value determination.
3. Perform sensitivity analysis in order to test the minimum reference limit of each parameter's score and build its functions.
4. Design the best-value model.
5. Select the highest best-value for bid award.

A computer software program, MnCAST, has been developed to model rationally the best-value following the aforementioned steps (*16*).

The parameter scores for each contractor are calculated and normalized on a scale of up to 100. A bonus score is possible if the contractor qualifications exceed the expected performance of the agency. The following steps are used to perform this normalization process:

1. Determine the best and worst score values for each parameter from among the available contractor values. These scores will be compared with the EP of the project.
2. Assign a parameter score ranging from upper reference limit to lower reference limit for each contractor. The URL is represented by EP (100%) if the contractor achieves the expected performance. However, the URL might be higher than 100% if the best qualification is better than the EP, higher-quality parameter, or lower bid price, for example. In other words, for bid price parameter, the URL is the lowest bid price or expected engineering estimate (i.e., performance). For quality parameter, the URL is the highest quality or expected quality performance. If the URL is higher than 100%, it represents a bonus to the contractor of being better than the EP as shown in Figure 2. The EP will be assigned a 100% value in the normalized scale. However, the LRL represents the worst value in a specified parameter. In other words, it is the highest value for bid price parameter and the lowest value for quality parameter. The contractor with the worst parameter value has S_i = LRL. The normalized value that will be assigned to the LRL [minimum (min)] is discussed in the following paragraphs. The contractor of intermediate score (S_i) will be assigned a value in between the URL and LRL based on a linear relation assumption as shown in Figure 2. The relation assumed is a linear scoring function based on the sensitivity analysis results discussed later in the paper. Future research will further examine this assumption through investigating the parameter combinations affecting the best-value scoring. The straight line slope is ascending

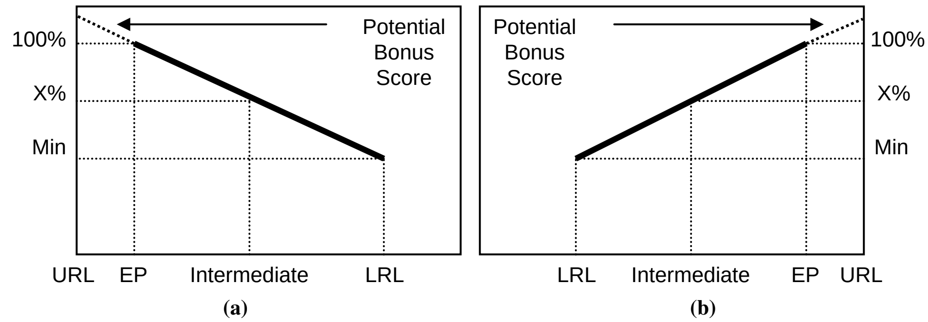


FIGURE 2 Score of normalized scale for various parameters: (*a*) descending slope and (*b*) ascending slope.

and descending based on the nature of the parameter. For example, it is descending in Figure 2*a* because the URL represents the lowest bid value as in the case of bid price, lane rental, traffic control, rejected claims, and contract time parameters. It is, however, ascending in Figure 2*b* for quality parameter because the URL reflects the highest value (i.e., quality). The corresponding percentage to the intermediate score can be determined using the model in Equation 10 as follows:

$$X(\%) = (\text{URL} - \text{min})\frac{\text{intermediate} - \text{min}}{\text{URL} - \text{min}} + \text{min} \quad (10)$$

3. Sensitivity analysis is performed in order to examine the effect of the bid price weight and to assign a percent for the LRL (min value). Because bid price was the only parameter that was used to select the awarded bidder, it was recognized by practitioners as the dominant parameter in the best-value calculation. However, a previous study revealed, based on practitioner opinions, that bid price had a weight of 10% to 15% relative to the rest of parameters that affected the best-value index (*12*). In order to accommodate both opinions (i.e., practitioners and previous results) and to test the effect of bid price weight on the best-value calculation, sensitivity analysis is performed by assigning the weight of bid price parameter to 10%, 50%, 70%, 80%, and 90%. The weight of other parameters changes according to their relative importance and the previous percentages of bid price.

The score of bid price parameter is calculated, based on Table 1, assuming that URL = EP = 100%. This is due to the lack of EP estimation by the owner. The LRL will be assigned the values 50%, 70%, and 90% in order to check the effect of this change on the decision among contractors. In addition, this change might lead the research to select the minimum score (LRL value) for various parameters. The number of sensitivity analysis combinations is calculated to be 1,134.

DATA COLLECTION AND CASE STUDIES

Two case studies of different pavement projects have been used to show the calculation results for the model and to investigate how the model works. The Minnesota DOT (MnDOT) suggested the two cases and provided the project details as part of the Minnesota best-value development effort.

TH-113 Project

The primary purpose of this project was to reclaim state highway TH-113 (Mahnomen County, Minnesota) from the junction of TH-32 to the Norman–Mahnomen County line. District 4 out of Detroit Lakes added a 1.5-in. overlay from the Norman–Mahnomen County line to the city of Waubun (Mahnomen County is in District 4). This contract was awarded in January 2006 with 35 working days and a bid price of $2,155,015.

TH-494 Project

This project involved a new Valley Creek Road interchange with interstate TH-494 in Woodbury, Minnesota. The project included grading, concrete and bituminous surfacing, and signal system. This contract was awarded in April 2006 with 145 working days and a bid price of $9,932,277.

Questionnaire

A questionnaire was sent to district engineers in order to encompass their subjective opinions regarding the parameters' weights. The engineers were asked to evaluate the significance of parameters using a scale from 1 to 5, where 1 represents maximum significance and 5 represents not significant. The collected data from these questionnaires were used to develop the parameters' weights. Fourteen groups of district engineers were asked to answer the questions. Each group consisted of the district engineer and the other engineers in his or her office. All groups answered the questionnaire with a 100% response rate.

MODEL IMPLEMENTATION

To show how the developed best-value model works, real-world data were collected. These data include a group of two pilot projects (two case studies) to be used in the test-drive process of the model. The chosen group represents two different project scenarios in order to test values resulting from model application. Both are different in volume, location, scope, preferences, and work type. The lowest three bidders were selected after the prequalification stage for each pilot project. Calculations were made for the lowest three bidders through the following stages:

1. Determination of parameter weight (weights may be determined before the bidding process to ensure fairness and transparency),
2. Determination of parameter score, and
3. Determination of best value.

Data for case studies were collected from the MnDOT. In addition, subjective data were collected from the district engineers through the questionnaire.

Stage 1. Determination of Parameter Weight

The relative weights (W_i) for each included parameter in the best-value model was determined where the total summation of the parameters' weights should be equal to 1. These weights were determined based on the opinion of DOT experts. The above mentioned steps of applying the AHP technique were carried out in order to generate the parameters' weights. Pairwise comparison matrices were analyzed. The matrices' dimensions are 6×6 and 8×8 for TH-113 and TH-494 projects, respectively. The CR values of the pairwise comparison matrices of TH-113 and TH-494 projects are 0.021 and 0.0192 (less than 0.1), which are acceptable and consistent. The weights for best-value parameters using the AHP technique are shown in Table 2, column 1. It is noted that contract time and unauthorized time have the highest weight (0.178) and rejected claims have the lowest weight of 0.118. Table 2 shows the weights of each parameter based on assigned values for the weight of bid price parameter. Discussions with the MnDOT personnel indicate that bid price can be the most decisive parameter in best-value procurement. This is particularly true in the early stages of best-value implementation. However, AHP questionnaires indicate that bid price weight can be significantly lower than 50% (*12*). To ensure proper coverage of different scenarios, the weight of bid price parameter was assigned to values of 10%, 50%, 70%, 80%, and 90%, as shown in Table 2. Based on the AHP technique, the weight of other parameters was calculated in which the summation was equal to one.

Stage 2. Determination of Parameter Score

Based on the above mentioned procedure, the EP, URL, and LRL values were calculated for each parameter in the case study project. In this implementation example, the URL value was estimated to be equal to EP = 100%, which reflects the best performance of the contractor in each parameter. This is because most agencies do not include an EP estimate in their bids. However, the LRL value estimate is tricky because assigning a value of zero to the LRL will reduce the chances of this contractor being able to compete with others. Conversely, assigning a 90% value to the LRL will not serve the purpose of best value, which is supposed to distinguish clearly between the competitors. Therefore, it was decided to perform a sensitivity analysis to test the effect of changing the LRL, from 50% to 90%, on the best-value index. This process serves two purposes: (*a*) it facilitates the selection of a LRL that will not dominate the decision and (*b*) it tests the effect of changing the parameter scores on the best-value index.

The presented research in this paper shows the implementation of the best-value concept to one of the pilot projects because both projects depict close results. Table 3 shows the implementation of such a process. For example, when the weight of bid price parameter is 50% and the minimum score is 50%, the URL will be 100% for Contractor A (100%), the LRL will be 50% for Contractor C, and the intermediate score will be 62.07% for Contractor B, which is calculated using the model in Equation 10. Similarly, these score values were calculated for the other minimum score values of bid price parameter (70% and 90%). This process was repeated for other weight values of bid price parameter as shown in Table 3.

Typically after the prequalification screening, contractors who are available in the competition will be very competitive and the differences among them will be minimal. Therefore, assigning a low value to the LRL, such as 0% or even 50%, will be detrimental to such a contractor and might put him or her out of the competition. Similarly, assigning a high value for LRL, such as 90%, will not show any distinction among contractors, as shown in Figure 3. Based on sensitivity analysis, it is noted that when the LRL equals 70%, the distinction between contractors is clear (i.e., there is a significant difference between them) and the contractors' rank might not be affected, which will be reasonable for all project parties.

Stage 3. Determination of Best Value

The best value is calculated, using the AHP method, for the TH-494 project as shown in Tables 3 and 4. The numbers in Tables 3 and 4 are calculated by using the corresponding weight values in Table 2 for all bidders. When the weight of the bid price parameter and the minimum scores of all parameters are 50%, Bidder A has the highest best value of 90.46, as shown in Table 4.

Sensitivity of the Best-Value Index

Table 3 shows samples of the sensitivity analysis results for determining the LRL score. The values presented are the individual parameter scores and are presented as URL, LRL, or intermediate. Contractor ranking, within the same parameter, is constant and is not affected by either the parameter weight or the LRL value. Obviously, contractor ranking will vary from one parameter to another because the awarded score depends on the qualification input, for example, bid price.

Table 4 shows samples of the sensitivity analysis for the selection process. The presented values represent the best-value scores for all parameters. As shown, contractor ranking is not constant for all combinations of bid price weight and LRL values. LRL value has an effect on the best-value ranking at specific combinations of bid price weights and LRL values for all parameters. LRL has no effect on the best-value ranking at bid price weight of 80% and 90% and LRL values of 70%. Therefore, LRL = 70% is selected for all parameters. The results of the sensitivity analysis also confirm that the assumption of a linear scoring function as the starting point is acceptable until

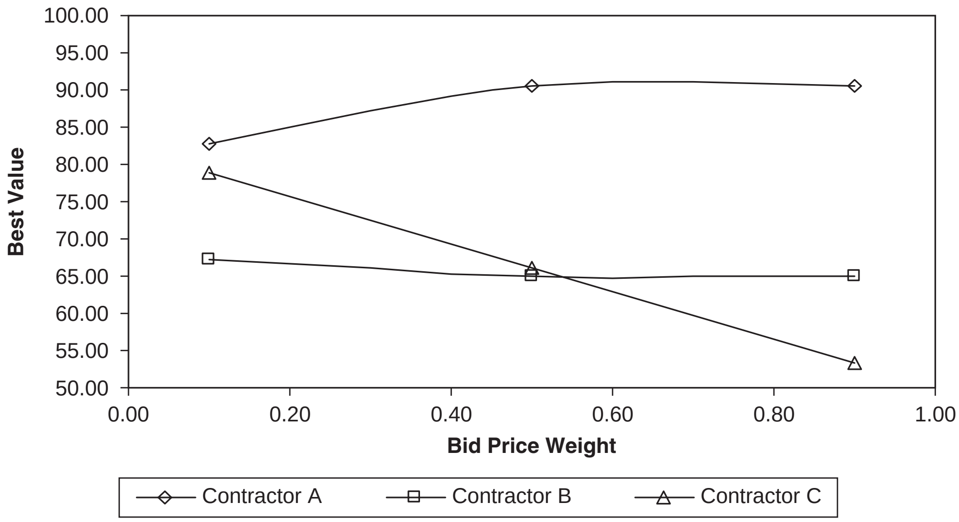
TABLE 2 Weights of Parameters Corresponding to Various Bid Price Weights (TH-494)

	Weight Analysis				
Parameter	(1)	(2)	(3)	(4)	(5)
BP = bid price	0.100	0.500	0.700	0.800	0.900
CT = contract time	0.178	0.099	0.059	0.039	0.020
UT = unauthorized time	0.178	0.099	0.059	0.039	0.020
RC = rejected claims	0.118	0.066	0.039	0.026	0.013
PQ = quality	0.154	0.086	0.051	0.034	0.017
LR = lane rental cost	0.142	0.079	0.047	0.032	0.016
TC = traffic control	0.130	0.072	0.043	0.029	0.014
Sum	1.00	1.00	1.00	1.00	1.00

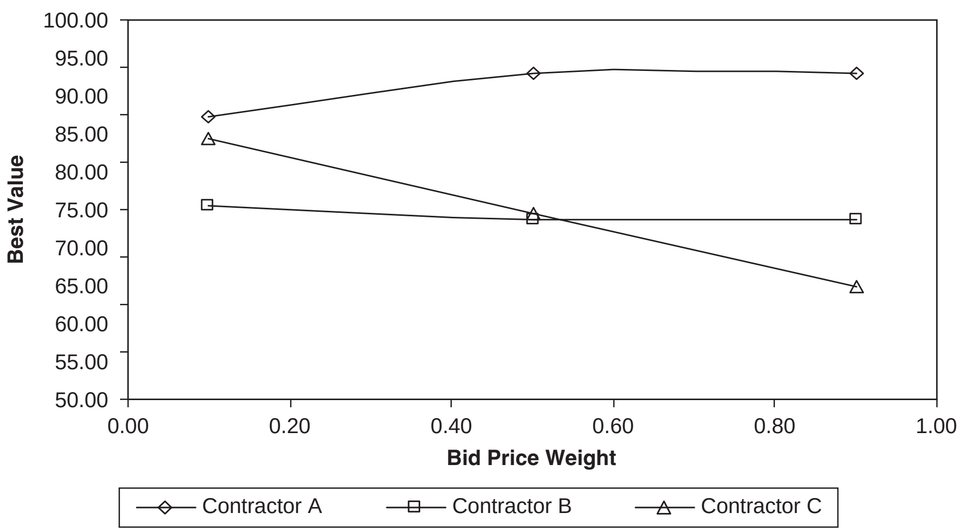
TABLE 3 Samples of Sensitivity Analysis Results for Selected Cases

		Bid Price			Contract Time			Unauthorized Time		
		URL	Inter	LRL	Inter	URL	LRL	Inter	LRL	URL
		Contractor								
	LRL	A	B	C	A	B	C	A	B	C
Bid price weight = 50%	LRL = 50	100	62.07	50	88.89	100	50	75	50	100
	LRL = 70	100	77.24	70	93.33	100	70	85	70	100
	LRL = 90	100	92.41	90	97.78	100	90	95	90	100
Bid price weight = 90%	LRL = 50	100	62.07	50	88.89	100	50	75	50	100
	LRL = 70	100	77.24	70	93.33	100	70	85	70	100
	LRL = 90	100	92.41	90	97.78	100	90	95	90	100

NOTE: Inter = intermediate.



(a)



(b)

FIGURE 3 Lower reference limit values: (*a*) LRL = 50% for all parameters, bid price LRL = 50%, and LRL for other parameters = 50%; (*b*) LRL = 70% for all parameters, bid price LRL = 70%, and LRL for other parameters = 70%.

(continued)

Rejected Claims			Quality			Lane Rental			Traffic Control		
Inter	LRL	URL	Inter	LRL	URL	Inter	URL	LRL	Inter	LRL	URL
A	B	C	A	B	C	A	B	C	A	B	C
77.27	50	100	75	50	100	81.82	100	50	87.5	50	100
86.36	70	100	85	70	100	89.09	100	70	92.5	70	100
95.45	90	100	95	90	100	96.36	100	90	97.5	90	100
77.27	50	100	75	50	100	81.82	100	50	87.5	50	100
86.36	70	100	85	70	100	89.09	100	70	92.5	70	100
95.45	90	100	95	90	100	96.36	100	90	97.5	90	100

further research investigates the parameter combinations affecting the best-value scoring.

SUMMARY AND CONCLUSIONS

The best-value contracting strategy aims at using price and other key factors in the evaluation and selection process to enhance the long-term performance of projects. The inclusion of model parameters as key factors that match the specific needs of a specific project guarantees that the selected contractor is the best to construct the facility. Previous attempts to implement best-value contracting strategy did not consider the unique characteristics of each construction project in which they based the selection criteria on subjective methods. Unlike previous studies, this study deals with each project as a unique case and includes the appropriate parameters in the contractor selection process. The study uses a rational approach in calculating the contractor scores based on the agency expected performance. The aim is to establish a flexible but rational model capable of being tailored to specific needs of the project. This flexibility is obvious in the selection of parameters to be included in the contractor selection process and in the determination of parameter weights. The model rationality is achieved through relating all awarded scores to the agency's expected performance. The establishment of the best-value model uses the past record of the contractor's work for the agency as an indicator of the contractor's qualification trend. This research incorporates prequalification as a first-level screening technique in selecting top contractor bids in best-value procurement and then applies a rational scoring system in the final selection. Data were collected from groups of experts in the MnDOT and processed through the AHP to establish the parameter weights. A sensitivity analysis was conducted to verify the model scale and calculation methods. The analysis shows reasonable differences in the parameter scores reflecting the differences in the contractor qualifications.

Pilot projects were used during model implementation to clarify the impact of the best-value system in the contractor selection process. Results of model implementation show the significant turnover from the lowest bid strategy to the choice of the best contractor based

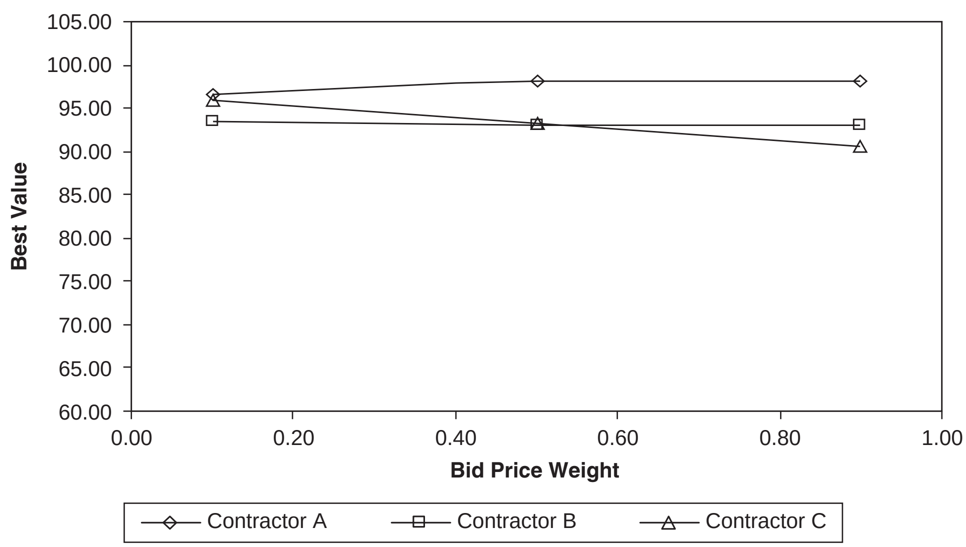


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FIGURE 3 *(continued)* **Lower reference limit values: (*c*) LRL = 90% for all parameters, bid price LRL = 90%, and LRL for other parameters = 90%.**

TABLE 4 Sensitivity Analysis for Decision Selection

	Min. Score of Bid Price Parameter					
	50%		70%		90%	
LRL	Ranked Contractor	BV	Ranked Contractor	BV	Ranked Contractor	BV
At 50% Weight of "Bid Price" Parameter						
50%	A	90.5	A	90.5	A	90.46
	C	66.1	C	76.1	C	86.12
	B	64.9	B	72.5	B	80.09
70%	A	94.3	A	94.3	A	94.28
	B	71.4	C	79.7	C	89.67
	C	69.7	B	79	B	86.54
90%	A	98.1	A	98.1	A	98.09
	B	77.8	B	85.4	C	93.22
	C	73.2	C	83.2	B	92.98
At 70% Weight of "Bid Price" Parameter						
50%	A	90.5	A	90.5	A	90.5
	B	64.9	C	73.7	C	87.7
	C	59.7	B	72.5	B	80.1
70%	A	94.3	A	94.3	A	94.3
	B	71.4	B	79.0	C	89.8
	C	61.8	C	75.8	B	86.5
90%	A	98.1	A	98.1	A	98.1
	B	77.8	B	85.4	B	93.0
	C	63.9	C	77.9	C	91.9
At 80% Weight of "Bid Price" Parameter						
50%	A	90.5	A	90.5	A	90.5
	B	64.9	B	72.5	C	88.5
	C	56.5	C	72.5	B	80.1
70%	A	94.3	A	94.3	A	94.3
	B	71.4	B	79.0	C	89.9
	C	57.9	C	73.9	B	86.5
90%	A	98.1	A	98.1	A	98.1
	B	77.8	B	85.4	B	93.0
	C	59.3	C	75.3	C	91.3
At 90% Weight of "Bid Price" Parameter						
50%	A	90.5	A	90.5	A	90.5
	B	64.9	B	72.5	C	89.2
	C	53.2	C	71.2	B	80.1
70%	A	94.3	A	94.3	A	94.3
	B	71.4	B	79.0	C	89.9
	C	53.9	C	71.9	B	86.5
90%	A	98.1	A	98.1	A	98.1
	B	77.8	B	85.4	B	93.0
	C	54.6	C	72.6	C	90.6

NOTE: BV = best value.

on past contractor performance. The maximum value of best value for these pilot projects has gone to a contractor other than the lowest bidder. This result shows the significance of including other parameters than just the lowest bid.

ACKNOWLEDGMENT

The authors gratefully acknowledge the Minnesota Department of Transportation for its support in conducting this research.

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The Construction Management Committee sponsored publication of this paper.