Best-value Selection Methods for Performance-based Roadway Maintenance Contracts

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Prepared By

Jubair Ahmed[1] and Nasir G. Gharaibeh[2]

(1) Construction Manager, ACE DFW Construction, 3575 North Belt Line Road, Ste.320, Irving, TX 75062 (formerly Graduate Research Assistant, Zachry Department of Civil Engineering, Texas A&M University)

[2] Corresponding Author; Assistant Professor, Texas A&M University, Zachry Department of Civil Engineering, 3136 TAMU, College Station, TX 77843
E-mail: ngharaibeh@civil.tamu.edu

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ABSTRACT

Performance-based maintenance contracts for roadways extend over multiple years and shift the responsibility of maintaining roadway assets at specific performance levels to contractors. Thus, it is important that contractors be selected based on best-value methods rather than the conventional low-bid method. Best-value bid selection considers both bid price and proposal technical aspects (such as contractor's qualifications, quality management plan, past experience, etc.). This paper describes and evaluates four best-value bid selection methods used by four different highway agencies in Florida, North Carolina, New Zealand, and the United Kingdom for procuring performance-based roadway maintenance contracts. A numerical analysis of these four methods indicates that best-value bid selection methods that use the adjusted price concept are balanced with respect to price and technical marks; methods that use direct price and technical weights favor low bids; and methods that consider the maximum technical quality offered by the bidders favor bids with high technical marks.

Key words: Maintenance Management, Performance-based Specifications, Best-value Bidding, Maintenance Quality Assurance.

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INTRODUCTION

With performance-based maintenance contracts (PBMCs), the agency (i.e., owner) specifies measurable performance standards, targets, and timeliness requirements for the roadway assets that the maintenance contractor is required to meet throughout the contract period. Several departments of transportation (DOTs) in the U.S. are using PBMCs, such as Virginia DOT (VDOT), Texas DOT (TxDOT), Florida DOT (FDOT), North Carolina DOT (NCDOT), and the District of Columbia DOT (DCDOT) *(1)*. PBMCs have also been used by highway agencies in Canada, Australia, South America, and Europe *(1, 2)*.

Because PBMCs extend over multiple years (usually 3-10 years) and shift the responsibility of maintaining roadway assets at specific performance levels to the contractor, it is important that contractors be selected based on best-value methods rather than the conventional low-bid method. Best-value bid selection methods consider both bid price and proposal technical aspects (such as contractor's qualifications, quality management plan, past experience, etc.).

Currently, highway agencies use various methods for determining the best-value bid for procuring PBMCs. The objective of this paper is to evaluate and understand the theoretical soundness and possible drawbacks of these methods by analyzing four best-value bid selection methods used by four different highway agencies in Florida, North Carolina, New Zealand, and the United Kingdom.

An overview of relevant literature is first presented and then the best-value bid selection methods of the four case studies are laid out. These methods are then analyzed and compared in terms of the agency's willingness to pay for quality and the neutrality of these methods with respect to lowest bid and highest quality. Finally, the study's findings and conclusions are presented.

OVERVIEW OF PREVIOUS WORK

Gransberg and Molenaar *(3)* defined best-value procurement as "the process which allows government contracting agencies to evaluate offers based on total procurement cost, technical solution, completion dates, and other criteria." Lo and Yan *(4)* concluded that the contractor's overly opportunistic bidding behavior can be avoided and quality be ensured if the contractor's past performance is carefully and closely examined and reflected in the bid evaluation process. Pakkala *(5)* suggested that the success of best-value and innovative PBMC procurement is contingent upon the extent of quality criteria taken into consideration instead of only price. The NCHRP Report 561 (Best-Value Procurement Methods for Highway Construction Projects) identified seven best-value award algorithms that define the steps that owners take to combine the parameters, evaluation criteria, and evaluation rating systems into a final award recommendation *(6)*. These algorithms include: meets technical criteria—low bid, adjusted bid, adjusted score, weighted criteria, quantitative cost—technical tradeoff, qualitative cost—technical tradeoff, and fixed price—best proposal. Vassallo *(7)* formulated an interesting idea based on microeconomic theory to identify the optimum bidder for infrastructure management services. Instead of using a fixed and pre-defined target level of service, the contractors are allowed to submit their best-value bid price along with best-value level of service they can achieve. The highway agency can then select the combination of price and level of service that maximizes the agency's net benefit. Minchin et al. *(8)* and Abdelrahman et al. *(9)* proposed best-value selection methods that take into consideration the contractor's performance in past projects.

While much of the previous research in best-value bidding focused on new construction projects, this paper focuses on methods used in roadway maintenance contracts.

CASE STUDIES

Four best-value bid selection methods that are in practice by the state transportation agencies in Florida, North Carolina, New Zealand, and United Kingdom were analyzed as case studies. In three of these case studies, the roadway maintenance contract has already been awarded by the highway agency, whereas the fourth one (the UK Highway Agency) is a model (or template) contract.

Florida Case Study

This case study consists of FDOT's asset maintenance contract #E5N05 for maintenance of primary highways in Brevard, Osceola, and portions of Orange and Volusia Counties in Florida. The contract period is from July 1, 2009 to June 30, 2016, for a total of 7 years, with a provision for possible renewal once or twice with mutual agreement of both parties.

The flowchart in Figure 1 illustrates the bid selection process. The minimum technical score required is 70 points. Price and Technical proposals are given 30 and 70 percent of weights. The contractor with the highest total proposal score (i.e., weighted sum of technical and price scores) is identified as the best-value bid and wins the contract.

Each bid proposal is evaluated based on predefined project-specific technical criteria (see Table 1) to determine the Total Technical Mark (TTM). Proposals with TTM less than 70 are rejected. A Technical Score (TS), Price Score (PS), and Total Proposal Score (TPS) are computed for the remaining proposals, as follows:

$$TS = TTM \times 0.7 \quad (1)$$

$$PS = \frac{P_L}{P} \times 30 \quad (2)$$

$$TPS = TS + PS \quad (3)$$

where P_L is the lowest bid price, and P is the Proposer's bid price.

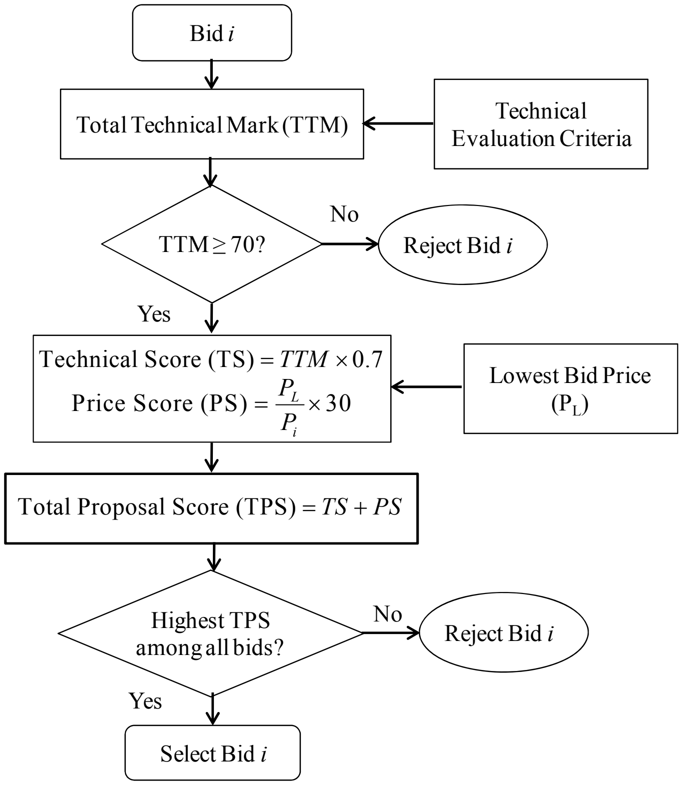


FIGURE 1 Bid Evaluation Process for Florida Case Study.

TABLE 1 Technical Evaluation Criteria for Florida Case Study

Technical Item & Subitem	Max. Mark
Executive Summary	5
Administrative Plan	25
a. Identification of Key Personnel, Organization Structure, Coordination, Communication (Max Mark = 10)	
b. Contractor Experience (Max Mark = 10)	
c. DBE/Respect/Agency Participation (Max Mark = 2)	
d. Proposed Facilities Capabilities (Max Mark = 3)	
Management and Technical Plan	25
a. Plan to Achieve and Maintain Maintenance Rating Program (Max Mark = 15)	
b. Permit Processing Plan (Max Mark = NA)	
c. Bridge Inspection (Max Mark = NA)	
d. Customer Service Resolution Plan (Max Mark = 10)	
Operation Plan	35
a. Incident Response Operations (Max Mark = 10)	
b. Routine/Periodic Maintenance Operations (Max Mark = 25)	
c. Bridge Maintenance Operations (Max Mark = NA)	
d. Rest Area Maintenance Operations (Max Mark = NA)	
Plan for Compliance with Standards	10
a. Compliance with Current Department Procedures, FL Statutes, and FL Administrative Code (Max Mark = 5)	
b. Compliance with Current Department Manuals, Guides, and Handbook (Max Mark = 5)	

North Carolina Case Study

The NCDOT case study consists of an interstate maintenance contract for 131 centerline miles on I-77, I-85, I-485, and I-277 in Mecklenburg, Gaston, Cabarrus, and Cleveland counties. The contract extends from May 2007 to April 2012. The final Request for Proposal required that the contractor submits technical and financial offers separately, and the best-value bid was identified based on both price and technical evaluations.

As shown in Figure 2, the bid evaluation process for this case study is based on the concept of quality credit. NCDOT assigned a quality credit (*QC*) for each proposal based on its TTM, where TTM is determined based on the technical evaluation criteria shown in Table 2. The maximum quality credit for this particular case study was 20; meaning that a proposal with a TTM of 100 (i.e., full technical marks) receives a quality credit of 20 percent of its bid price. The quality credit is reduced linearly as a function of TTM. Thus, a proposal with a TTM of 80 or below receives no quality credit. A quality value (*QV*) is computed based on the quality credit as follows:

$$QV = QC \times P \quad (4)$$

where *QC* is quality credit, and *P* is the Proposer's bid price. Each bid price is then adjusted based on its quality value, as follows:

$$AP = P - QV \quad (5)$$

where *AP* is adjusted bid price. The bid with the lowest adjusted bid price is identified as the best-value bid.

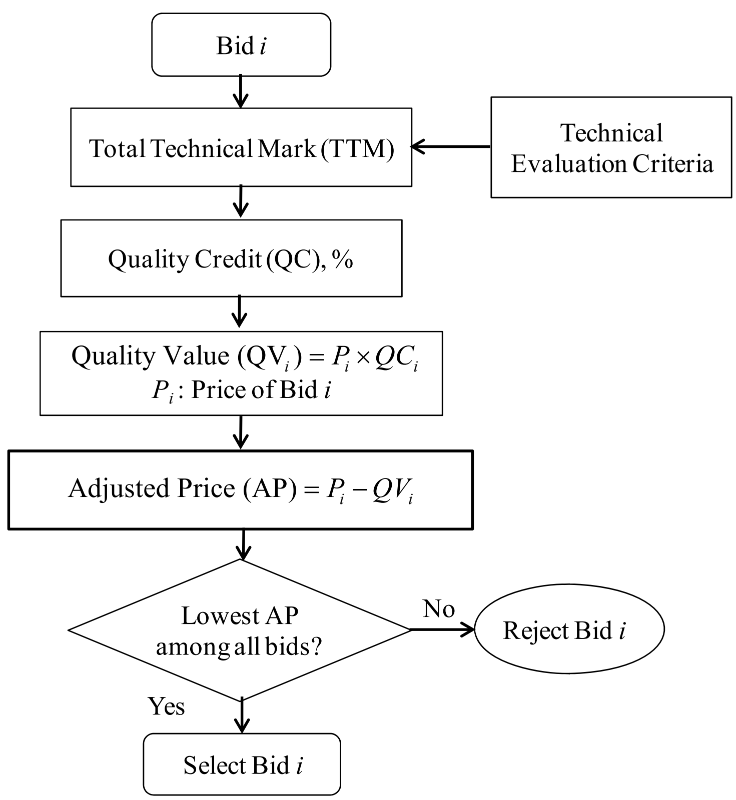


FIGURE 2 Bid Evaluation Method for the North Carolina Case Study.

TABLE 2 Technical Evaluation Criteria for the North Carolina Case Study

Technical Item	Max. Mark
1. Management	20
2. Responsiveness to Request for Proposal a. General (Max. Mark = 15) b. Quality Management (Max. Mark = 15) c. Minority and Women's Business Enterprise and Small Business (Max. Mark = 5) d. Natural Environmental Responsibility (Max. Mark = 5)	40
3. Maintenance of Traffic and Safety Plan	20
4. Timeliness Requirements and Tracking	15
5. Oral Interview	5

Table 3 provides a hypothetical example to illustrate the North Carolina method. In this example, Contractor C has a total technical score of 90 and a quality credit of 10 percent. This leads to an adjusted bid price of $2,520,000 (using Equations 6 and 7). Since Contractor C has the lowest adjusted price, contractor C is selected as the best-value bid.

TABLE 3 Identification of Best-Value Bid using the North Carolina Method (Demonstration Example)

Proposal	TS	Quality Credit (%)	Price Proposal ($)	Quality Value ($)	Adjusted Price ($)
A	95	15	3,000,000	450,000	2,550,000
B	90	10	2,900,000	290,000	2,610,000
C*	90	10	2,800,000	280,000	2,520,000*
D	80	0	2,700,000	0	2,700,000
E	70	0	2,600,000	0	2,600,000

*Best-value Bid

New Zealand Case Study

The New Zealand Transport Agency (NZTA) awarded the Westcoast and Canterbury region highway maintenance contract for a 5-year period (2009 to 2014). The bid evaluation procedure follows the Price Quality Method (PQM), which is described in Figure 3. Bid prices are adjusted by subtracting the supplier quality premium (SQP) from the submitted bid price.

This bid evaluation method is described through an example. This hypothetical example consists of four bidders with different quality attributes and prices. As shown in Table 4, a weighted sum index is computed for each bidder based on several technical attributes (relevant experience, track record, technical skills, resources, management skills, and methodology). Each individual index is computed as the product of an assessed mark and an attribute weight. The weights are pre-defined by NZTA, and the marks are determined by the agency's evaluators.

Once the weighted sum (WS) is computed, then a Weighted Sum Margin (WSM) is calculated for each bidder by subtracting the weighted sum of the contractor from the lowest weighted sum of all bidders. A supplier quality premium (*SQP*) is then computed as follows:

$$SQP = P_A \times \left(\frac{WSM}{W_p} \right) \tag{6}$$

where P_A is the agency's estimate of bid price, and W_P is the agency-specified price weight. In this hypothetical example, the agency's estimated price for this project is \$1,000,000, and the price weight is 70. Thus, *SQP* is computed as $SQP = 1000000 \times (WSM/70)$. Each bid price is then adjusted based on its *SQP*, as follows:

$$AP = P - SQP \tag{7}$$

where *AP* is adjusted bid price, and P is submitted bid price. The bid with the lowest adjusted bid price is identified as the best-value bid (see Table 5).

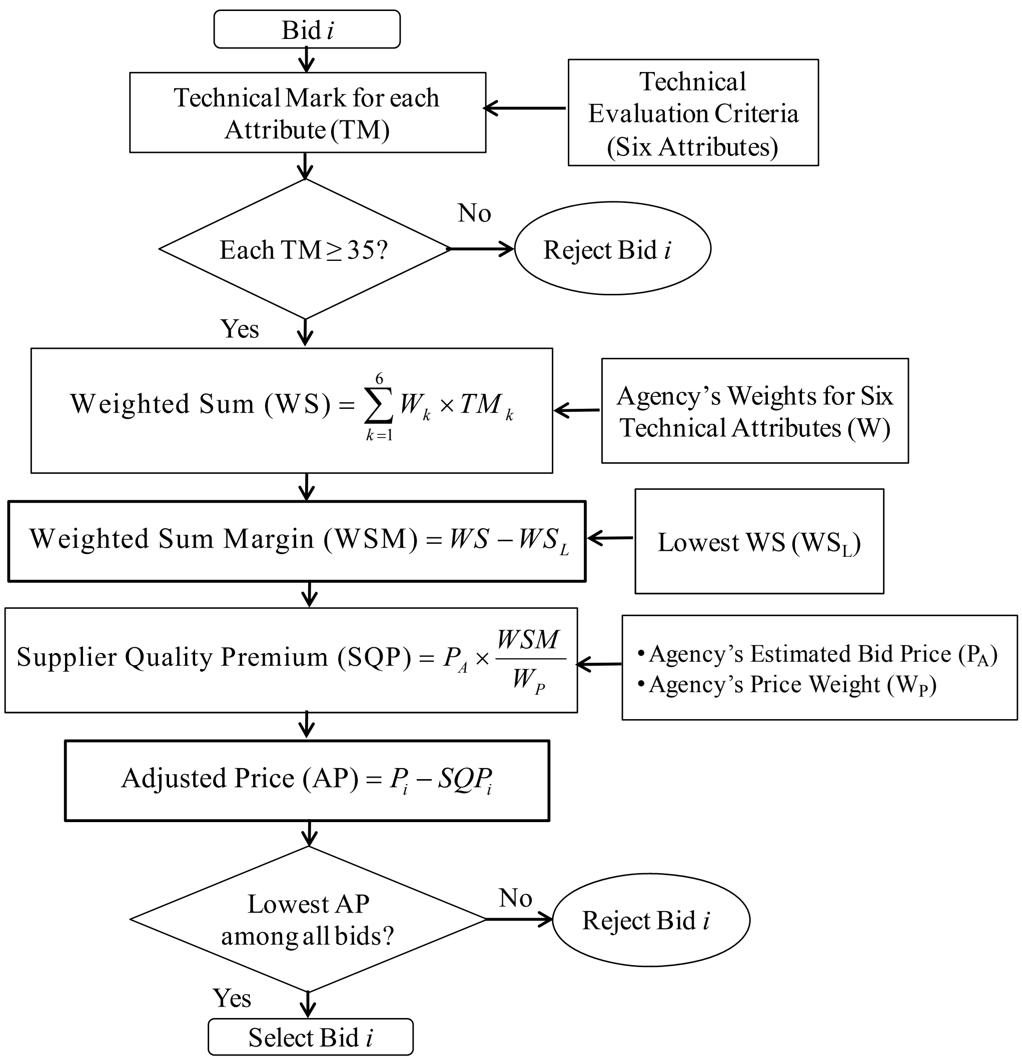


FIGURE 3 Bid Evaluation Method for the New Zealand Case Study.

TABLE 4 Weighted Sum Calculations (Demonstration Example)

Attribute / Bidder	Relevant Experience (Weight=3%)		Track Record (Weight=3%)		Technical Skills (Weight=4%)		Resources (Weight=7%)		Management Skills (Weight=4%)		Methodology (Weight=9%)		Weighted Sum (WS)
	Mark	Index*	Mark	Index*	Mark	Index*	Mark	Index*	Mark	Index*	Mark	Index*	
A	69	2.07	83	2.49	83	3.32	78	5.46	82	3.28	55	4.95	21.57
B	75	2.25	87	2.61	87	3.48	87	6.09	84	3.36	80	7.20	24.99
C	68	2.04	84	2.52	80	3.20	76	5.32	79	3.16	57	5.13	21.37
D	75	2.25	85	2.55	87	3.48	85	5.95	82	3.28	60	5.40	22.91
Lowest Weighted Sum =													21.37

*Index = Weight x Mark

TABLE 5 Identification of Best-Value Bid using the New Zealand Method (Demonstration Example)

Bidder	WS	WSM (WS – Min. WS)	SQP, $ (1,000,000×(WSM/70))	Original Bid Price, $	Adjusted Bid Price, $
A	21.57	0.2	2,857.14	1,250,240	1,247,382
B*	24.99	3.62	51,714.29	1,117,030	1,065,315*
C	21.37	0	0	1,109,470	1,109,470
D	22.91	1.54	22,000	1,182,970	1,160,970

*Best-value Bid

United Kingdom Case Study

Figure 4 illustrates the bid evaluation process used by the United Kingdom Highway Agency (UKHA) for roadway maintenance contracts. Quality marks are assigned for project specific criteria (pre-defined by the agency) based on the contractor's approach to meet these criteria. The bidder's proposed approach is verified through supporting evidence from past performance records. Table 6 shows the assessment criteria along with example marks (for a hypothetical bidder). It can be seen that the technical marks are assigned as the minimum of two marks: 1) Part A mark for proposed approach, and 2) Part B mark for evidence provided by the bidder to show past performance. A total technical mark (TTM) is computed as the sum of all technical marks. Part A mark is determined based on the agency's assessment of how well the proposal demonstrates an understanding of the project objectives and addresses the main management and technical risks relating to the project. Part B mark is determined based on the agency's assessment of how well the evidence from previous projects provides confidence that the proposed approach is likely to be delivered successfully.

The bidder with the highest TTM is assigned a technical score (TS) of 100. The remaining bidders receive a deduction of one quality mark for each full percentage point below the highest TTM. A price score (PS) is determined in a similar manner. The lowest bidder receives a price score of 100, and the remaining bidders receive a deduction of one price mark for each full percentage point above the lowest bid. A total proposal score (TPS) is computed for each bidder, as follows:

$$TPS = 0.7 \times TS + 0.3 \times PS \quad (8)$$

The bidder with highest TPS is determined as the Leading Bidder (or best-value bid). This process is described through the hypothetical example shown in Table 7. In this example, contractor D has the highest TPS and thus is identified as the best-value bidder. Thus, the best bid is neither the lowest bid nor the highest technical bid; it is a bid that balances both price and technical attributes.

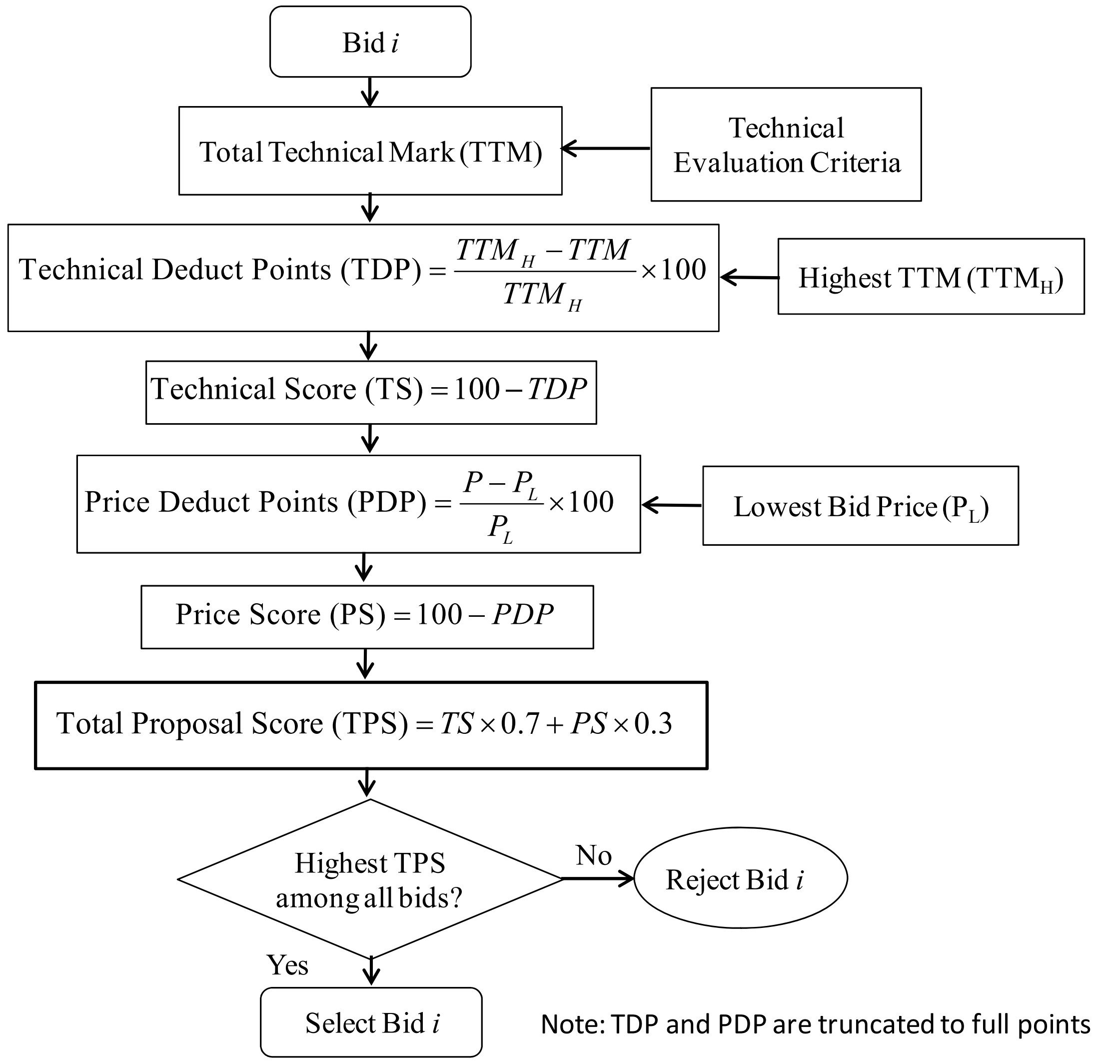


FIGURE 4 Bid Evaluation Method used by UKHA.

TABLE 6 Technical Evaluation Criteria Used by UKHA for an Example PBMC Bidder

Assessment Criteria	Part A Marks: Proposed Approach (1-10)	Part B Marks: Evidence from Past Projects (1-10)	Lowest of Marks A and B
Maintaining Network Value	8	7	7
Enabling Network Use	8	8	8
Reducing Congestion	9	8	8
High Quality Customer Service	8	7	7
Improving Efficiency	9	8	8
Effective Management	9	7	7
Control of Quality	9	9	9
Reliability of Cost Estimates	9	8	8
Reliability of Time Estimates	9	8	8
Improvement of Safety	9	9	9
		Total Technical Mark (TTM) =	79

TABLE 7 Identification of Best-Value Bid using the UK Method (Demonstration Example)

Bidder	Quality Mark	Bid Price, $M	% Below Highest Quality Mark	Tech Deduct Points (TDP)	TS	% Above Lowest Price	Price Deduct Points (PDP)	PS	TPS
A	68	52	13.9%	13	87	23.8%	23	77	84.0
B	61	42	22.8%	22	78	0%	0	100	84.6
C	79	55	0.0%	0	100	30.9%	30	70	91.0
D	75	47	5.1%	5	95	11.9%	11	89	93.2*
E	65	44	17.7%	17	83	4.8%	4	96	86.9

*Best-value Bid

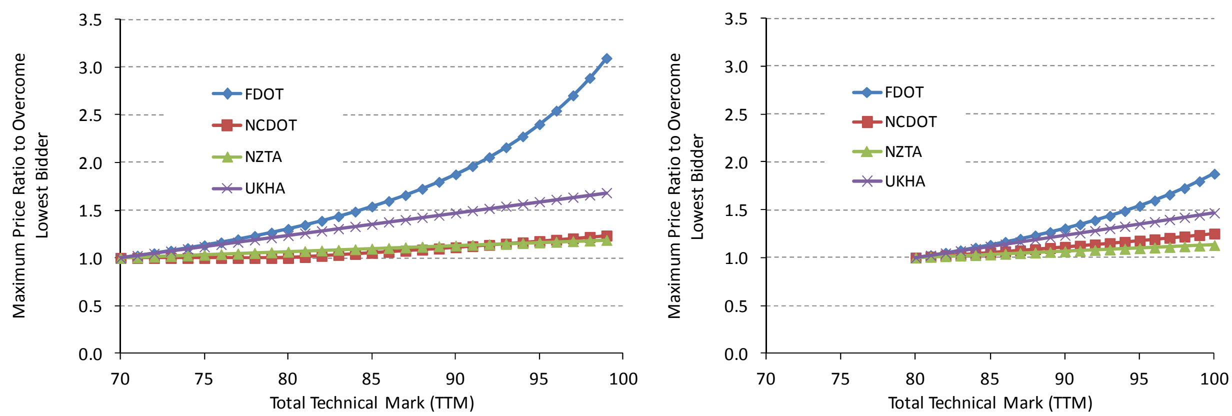
EVALUATION OF CASE STUDIES

The best-value bid selection methods discussed earlier are evaluated in terms the agency's willingness to pay for quality and the neutrality of these methods with respect to lowest bid and highest quality, as discussed in the following sections.

Willingness to Pay for Bid Technical Quality

A best-value bidding system represents the agency's willingness to pay for bid quality. The agency's willingness to pay for any given increment in technical score over the technical score of the lowest bidder is evaluated using the concept of equivalent bid. Suppose that the lowest bidder has a bid price P_L, total technical mark of TTM_L, and a technical score of TS_L. For any other bidder (with a bid price of P and total technical mark of TTM) to be equivalent to the lowest bidder, their total technical mark must be greater than TTM_L, so that their total proposal score (*TPS*) becomes equal to the *TPS* of the lowest bidder (TPS_L). The agency's willingness to pay for technical attributes can then be measured using a curve that represents the relationship between technical mark and bid price ratio (R). R is computed as $R = P/P_L$, where P_L is the lowest bid price and *P* is the proposer's bid price. These curves are referred to here as Willingness-to-Pay (WTP) curves. Figure 5 shows the WTP curves for the case studies, assuming TTM_L values of 70 and 80 points (out of a perfect TTM of 100 points). For example, suppose that the TTM values for Bid X and the lowest bidder are 90 and 70, respectively. Using FDOT method (see Figure 5a), Bid X can have an R value up to 1.2 (i.e., Bid X's price can be up to 1.2 times the lowest bid price) and still beats the lowest bidder. Note that the WTP curves shift to the right or left, depending on the value of the TTM_L (see Figure 5).

For the specific parameters used in these case studies, agencies that use the price and technical weights concept (i.e., Florida's method) appear to be more willing to pay for bid quality than those that use the adjusted price concept (i.e., North Carolina's and New Zealand's methods). The UK method, which is the only one among the studied methods that considers the highest quality offered by the bidders, is influenced by the quality of the highest bidder and the price of the lowest bidder. Finally, Figure 5 shows that none of these methods has a point of diminishing willingness to pay for bid quality.



(a) WTP Curves for TTM_L=70 (b) WTP Curves for TTM_L=80

FIGURE 5 WTP Curves for Case Studies.

Neutrality in Best-Value Bid Evaluation Methods

To assess the neutrality of the studied bid evaluation methods with respect to technical attributes and price, a Monte Carlo simulation of four hypothetical bids (A through D) with different bid prices and technical marks was carried out. In this analysis, the following assumptions are made:

- The bidders will choose their prices with prior knowledge of the bid evaluation method.
- The lowest bidder has a total technical mark of 70 point s(out of 100 points) and a bid price of $6.0 million (i.e., TTM_L=70 and P_L=$6.0 million).
- The bidders will design their bids (i.e., select their bid price and technical capabilities) according to the WTP curves (see Figure 5a). This assumption ensures that they overcome the lowest bidder using the maximum possible bid price.

Table 8 shows the ranges of the total technical mark and bid price for these hypothetical bids. For each best-value bid evaluation method, Monte Carlo simulation was used to generate 3,000 bidding scenarios (i.e., simulation iteration) from the TTM and corresponding bid price ranges shown in Table 8. In each iteration, TTM and bid price values were randomly selected from normal distributions that correspond to these ranges; and then a best-value bid (out of the four bidders) was identified using each bid selection method. The probability of being selected as the best-value bid was then computed as follows:

$$\Pr = \frac{N_D}{N_T} \times 100 \quad (9)$$

where P_r is the probability of being selected as best-value bid; N_D is the number of times (i.e., number of simulation iterations) for which the bid is selected as best-value bid; and N_T is the total number of simulation iterations (i.e., 3,000 iterations in this analysis).

TABLE 8 Bid Price Ranges and Technical Mark Ranges used in Simulation Process

Bidder	TTM Range	Bid Price Range, $ million			
		Florida	North Carolina	UK	New Zealand
A	86–90	9.2–10.8	7.1–7.4	8.1–8.7	6.6–6.8
B	81–85	7.8–8.9	6.7–7.0	7.4–8.0	6.4–6.6
C	76–80	6.8–7.6	6.3–6.6	6.7–7.26	6.2–6.4
D	70–75	6.0–6.6	6.0–6.3	6.0–6.56	6.0–6.2

Since the bid prices were determined according the WTP curves, the behavior of the analyzed methods can be classified as follows:

- Balanced: all bids have approximately equal probability of being identified as best-value bid since any increase in bid price is balanced by an increase in the TTM according to the WTP.
- Favors Technical Attributes: bids with higher total technical mark have higher probability of being identified as best-value bid.
- Favors Low Bid Price: bids with low bid price have higher probability of being identified as best-value bid.

Figure 6 illustrates the results of this simulation process. It can be seen that, using the Florida method, Bid D (lowest bidder and lowest TTM) has the highest probability of being selected as the best-value bid, whereas Bid A (highest bidder and highest TTM) has the lowest probability of being selected. This indicates that this method is sensitive to any deviation from the WTP curve. Since the bidders do not know the price and TTM of the lowest bidder with certainty, an underestimation of these parameters can mislead other bidders to raise their prices and consequently lose to the lowest bidder. Thus, this method appears to favor low bid prices. At the opposite end, using the UK method, Bid A (highest bidder and highest TTM) has the highest probability of being selected as the best-value bid, whereas Bid D (lowest bidder and lowest TTM) has the lowest probability of being selected. Thus, this method appears to favor high-quality bids. Using the North Carolina and New Zealand methods, all bids have similar chances of being selected as the best-value bid. Thus, these two methods are described as balanced (i.e., the process is not overly sensitive to accurately predicting the price and TTM of the lowest bidder, and bidders who follow the WTP curve have equal chances of being selected).

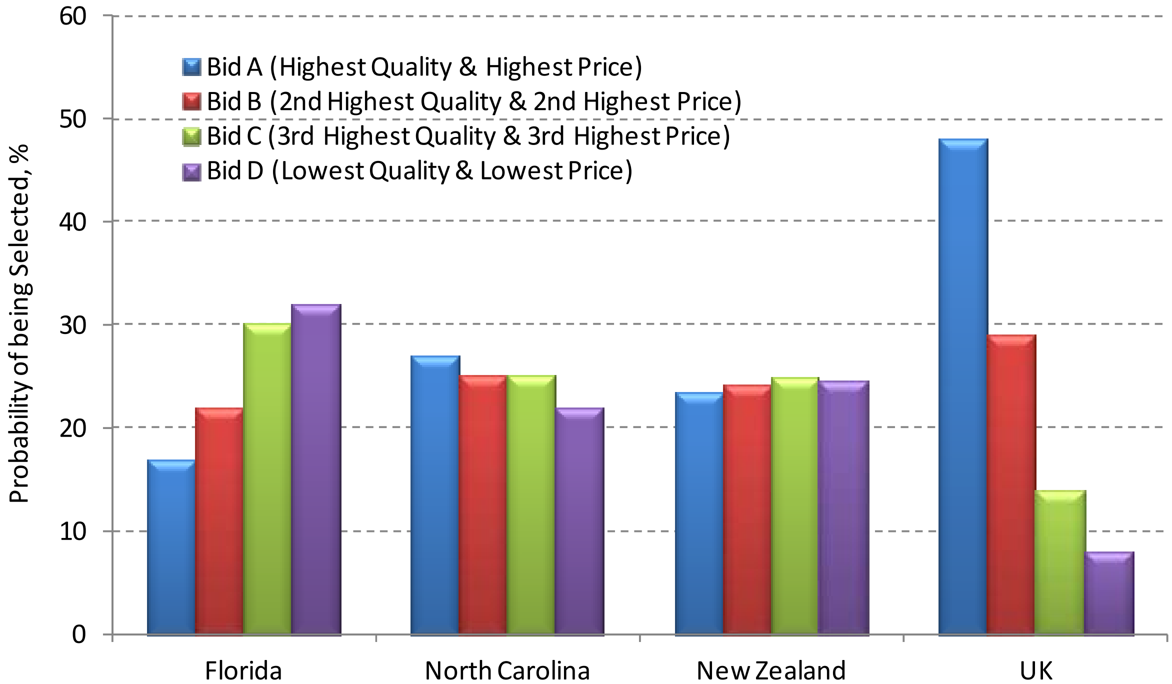


FIGURE 6 Best-value Bid Simulation Results.

SUMMARY AND CONCLUSIONS

Because PBMCs extend over multiple years and shift the responsibility of maintaining roadway assets at specific performance levels to the contractor, it is important that contractors be selected based on best-value methods rather than the conventional low-bid method. Best-value bid selection methods consider both bid price and proposal technical aspects.

Four best-value bid selection methods that are already in practice by the transportation agencies in Florida, North Carolina, New Zealand, and the United Kingdom were analyzed as case studies. These four methods were evaluated in terms of the agency's willingness to pay for quality and the neutrality of these methods to lowest price and highest quality bids. The following conclusions are made based on the results of a simulation-based numerical analysis of these methods:

- Methods that use the adjusted price concept (i.e., the North Carolina and New Zealand methods) are balanced with respect to price and technical marks.
- Methods that use direct price and technical weights (i.e., the Florida method) favor low bids.
- Methods that consider the maximum technical quality offered by the bidders (i.e., the United Kingdom method) favor bids with high technical marks over bids with low price.

Further research would be needed to understand the practical aspects of implementing the studied bid selection methods, such as how certain factors (e.g. bid size, project location, contract duration, etc.) influence the agency's willingness to pay for bid quality, point of diminishing willingness to pay for bid quality, and broader implications of using these bid selection methods.

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