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Journal of Addiction Research and Adolescent Behaviour

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Open Access

Review Article

Tender Evaluation Avoiding Weights

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Received date: January 06 2024; **Accepted date:** January 30 2024; **Published date:** March 06 2024

Citation: Satyendra Nath Chakrabarty, (2024), Tender Evaluation Avoiding Weights, *J. Addiction Research and Adolescent Behaviour*, 7(1)

DOI:10.31579/2688-7517/061

Abstract:

Evaluation of tenders often requires a composite index (CI) combining quoted price and technical qualification score to a single score by weighted sum for deciding award of tender. Methods followed to construct such CI result in different mathematical properties of the resultant CI and can result in different conclusions. The paper reviews various methods of tender evaluation with emphasis on problem areas in construction of CI with hypothetical examples relating to evaluation of single part and two parts tenders where rank of the bidders get changed with change in weights to price and non-price criteria. The proposed multiplicative aggregation of the indicators gives robust tender scores and unique rank to a bidder, avoiding subjective weights in evaluation of tenders. The proposed method solves the problem areas and thus, facilitates better decision making. The approach is simple to calculate and may be adopted to achieve value for money.

Key Words: tender; composite index; geometric mean; non-price criteria; bid evaluation; public procurement; JEL classification codes: H11, H57, R58

Introduction

A tender is a formal and structured invitation to bidders to submit competitive bids for construction or supplying products, services, etc. Major objectives of public procurement include among others reduction of cost by generating fair competition, transparent evaluation, better utilization of public funds, and elimination of corruptions [1]. Monetary values involved in public procureents for a country in a given year are significant depending on demand for total goods and services of a country [44]. and hence, public procurements, founded by the taxpayers' money are required to ensure the best utilization of money paid by the taxpayers [45]. Thus, procurement of commodities (goods and services) by public authorities has a direct effect on performance of a government [43].

Globally, expenditure on public procurement constituted about 18.42% of the gross domestic product (GDP) at global level [30]. and approximately 25% of gross GDP for developing countries [26]. Similarly, governments spending on public procurements are in the level of $11 trillion per annum [22]. In India, government procurements by the Centre and at the State levels including municipal and other local bodies, statutory corporations constitutes is about 30% of the GDP. Thus, proper decisions regarding public procurement can help significantly the economy of a country.

Success of a project depends significantly on the tender evaluation process since it strongly affects subsequent outcomes of the project [24]. Thus, the methods of tender evaluation and selection of the contractor can make or mar a project.

Despite different laws and regulations for public procurement process across countries and time, common goals are reduction of cost through competition in a transparent fashion, eliminating corruptions and safeguarding public funds. The organization floating a tender wants to procure one or more goods or services in a fair and transparent way by generating competitions. Tendering involves submission of bids in a structured format within a specified date and time satisfying the criteria indicated in the tender document. To maintain transparency and avoid favoritism, the bids are sealed in envelopes and are opened in front of the bidders at a pre-specified date and time which is communicated to the bidders. Bids submitted by the bidders are evaluated by a Tender Evaluation Committee formed for the purpose and the Committee assesses the bids with respect to the quoted price, time of completion, quality and other relevant details and gives recommendations on the award of contract.

Evaluation of tenders often requires a composite index (CI) which combines several variables in different units to a single (one-dimensional) score which is considered for deciding award of contract. For example, Tender Evaluation Committee may require combining cardinal variables like price and time estimate or quoted price and technical qualification score through a weighted sum. Methods followed to construct such CI result in different mathematical properties of the resultant CI and can result in different conclusions. If weights to price and technical qualification score are changed, ranks of the bidders may get changed. Thus, the tender evaluation method needs to be simple and help such Committee for evaluation of bids

on equal platforms to decide, following transparent procedures suggested in procurement regulations. Impact of different methods of contractor selection is a major area requiring further research [38].

The paper reviews strength and shortcomings of various methods of tender evaluations with emphasis on problem areas in construction of composite index as weighted sum with hypothetical examples relating to evaluation of single part and two parts tenders and suggests better method of obtaining robust tender ranks of the bidders avoiding weights.

2. Types of Tenders:

Tenders are mainly classified into three major categories viz.

(1) Open tenders: An open tender is open for all. Anybody satisfying the minimum qualifications can bid. It provides greatest competition among the suppliers including opportunity to new or emerging firms to quote. An open tender may involve Single-stage or Two-stages

(2) Selective tenders: Quotations are invited only from a group of contractors who are pre-specified in the basis of satisfying certain specified pre-conditions. For example, price bids may be invited for construction as per the design given by consultants. Selective tenders can be categorized as Single-stage or Two-stage [15].

(3) Limited tenders: For small value of the products or to meet urgency, invitations are sent to a limited number of firms, which are on the list of approved contractors or suppliers.

(4) E-tender: To overcome inadequacy of traditional tender and to increase efficiency and scope of the potential bidders, e-tendering are used. Here, tenders are invited as a part of the online tender submission procedure. Usually, e-tender procedures are considered for open tenders. In India, different types of e-tendering portals are there where buyers can connect with suppliers.

Common methods of the tender process include

- ***Expression of Interest (EOI*)**: A screening process to shortlist interested vendors before asking for detailed quotations. EOI helps to estimate the ability of a market to supply before issuing formal tenders.
- ***Request for Information (RFI*)**: An initial document primarily to understand project requirements and capabilities of vendors.
- ***Request for Proposal (RFP):*** A solution-based response to fulfill its requirements, used in situations where no clear solutions or specifications are available, and a number of innovations and options could be possible, like professional services where defining the best solution is difficult. Thus, RFP gives creative freedom to the vendors for innovative solutions.
- ***Request for Quotation (RFQ)*:** More specific document for procurement of physical products like laptops or non-physical items like software, etc. with exact specifications and the vendors quote their prices to supply the products accordingly. Thus, RFQ has no scope for innovations.

3. Regulations governing Tenders:

A public procurement is a regulated, open process for which a number of guidelines, laws, rules and regulations exist, which vary across countries. In India, public procurement needs to adhere to the following major rules and guidelines:

(i) General Financial Rules **(GFR),** 2017 compiles rules and orders of the Government of India (GOI) relating to matters involving public finances and are required to be followed by all Organizations and Departments under the Government and specified Bodies (excluding those provided for in these Rules). GFR rules indicating concepts of Total Cost of Ownership, Life Cycle Cost, Whole-of-Life cost, etc. are treated as executive instructions on administrative rules, directives on financial management and procedures for government procurement.

(ii) Guidelines for purchase of goods and the Delegation of Financial Powers Rules, 1978 (**DFPR) are provided in the** Manual for Procurement of Goods, 2017 (**MPG**) and indicates financial powers to different ministries and authorities. These are supplemented by policies and guidelines regarding procurement by individual ministries/departments like defence and railways and Directorate General of Supplies and Disposals (DGS&D), the central purchase organization which helps other ministries/departments which may lack requisite expertise of public procurement.

(iii) Manuals and rules of relevant ministry regarding Sector-specific procurements.

(iv) State-specific legislation on transparency in procurement.

4. Literature survey

The stage of evaluation of bids comes after satisfactory completion of pre-qualification stage with the assumption that the pre-qualification exercise eliminates all incompetent contractors and each pre-qualified bidder will be able to execute the project successfully and thus, tender- decision goes in favour of the lowest bidder.

4.1 Lowest bidder approach:

Consideration of lowest bidder ignoring other factors like number of years in business, performances in previous projects, project management capabilities, company nationality and records of company trade union, qualification and experience of contractors' key persons, time of execution, relation with sub-contractors etc. along with cost of operation, maintenance, spare parts, may give rise to cost and time overruns [6]. Questions have been raised regarding appropriateness of pre-qualification exercise where bidders face increasing competition and client expectations get widened especially in terms of number of non-financial factors [3]. The process of decision-making considering price quotations along with non-priced qualifications could be ill-structured, since there is no minimum standards of experience and knowledge of the decision maker to evaluate the bids of a specific project. Often, evaluations are performed in subjective fashion ignoring some of the other factors which can influence the decision and may not represent the lowest project cost after completion [38]. Total expenditure over the entire duration of the product (life-cycle cost), may consider net present value (NPV) of costs of procurement, installation, operation and maintenance over a long period and can be used as an alternative to Lowest quoted price.

4.2 Combination of indicators:

Instead of a single indicator, a combination of indicators is likely to give better solution of an objective [16]. Methods for evaluation of bids require

aggregation of multidimensional criteria and may suffer from substitution effect i.e. high value of non-monetary criteria may compensate the price difference [9]. The award process may be influenced by number of bidders participating in a bid or by tactical variants [33]. The problem of tender evaluation involves determining the evaluation criteria and weights for each chosen criterion [11]. and developing methods for the evaluation of bids [27]. to decide the award. This approach assigns an evaluation score as a weighted sum to each bidder. However, it is common to decide weights to the attributes by subjective judgments of the experts where the set of chosen weights may not be optimal [13]. Tender evaluation become complex when responses of bidders to the criteria are in different units or the pertinent data are difficult to be quantified [41].

Weighted sum approaches often involve assigning weights to the criteria. Different methods of selection of weights may affect the evaluation differently. Methods of Composite Index (CI) as weighted sum do not discuss about variance of the weighted sum and correlation of CI and the chosen indicators. Thus, it is desirable to construct CI without considering weighted sum.

4.3 Objective evaluation:

In addition to CI as weighted sum, researchers have adopted multi-criteria decision making (MCDM) approaches like multi-attribute analysis (MAA), Analytical Hierarchy Process (AHP), Analytic Network Process (ANP), Multi-Attribute Utility Theory (MAUT), Data Envelope Analysis (DEA), etc. For example, [34]. compared traditional 'lowest bidder' method with MAA and AHP and suggested against use of AHP due to minor influence on the final ranking of the short-listed bidders. However, to shortlist the bidders for high-valued government projects [19]. used AHP despite rank conservation being unrealistic for AHP. [4]. showed that independence between clusters is not satisfied by AHP and used ANP to minimize risk of main activities of an urban bridge project. However, ANP uses subjective ratings to assess alternatives according to their contributions to the goal. Ranks of bidders based on traditional 'lowest bidder' criterion differed with ranks obtained from MMA and AHP.

4.3.1 Major shortcomings of MCDM approaches:

MCDM approach in tender evaluation considers quoted price (cost), time quoted, and other aspects like, performance and qualifications, quality management, design alternates, etc. MCDM methods have been criticized as complex, ad-hoc in nature, may not provide efficient way for managerial decision-making in case of high number of alternatives [31]. All the attributes may not be quantified in objective fashions in MAA. Weights could be selected based on factors like practitioner experience, consensus opinion of the group, survey from a sample, etc. Unified aggregate score (AC) of the j-th contractor (UAC_j) is achieved as ratio

$$UAC_j = \frac{AC_j}{Max.\ AC_j}. \text{ Clearly } 0 \leq UAC_j \leq 1$$

However, derivation of essential variable/attribute scores and corresponding weights need to be investigated further with respect to factors like nature of work, form of procurement options, location of project, etc. and MAA could be extended to Multi-Attribute Utility Theory (MAUT) considering 'utility' covering both tangible (e.g. safety record) and intangible (e.g. contractor image) to quantify the subjective components of MAA [20]. But, the concept of MAUT can be complex with respect to both models and derivation of utility weights.

Instead of finding relative importance or weights, AHP uses pair-wise comparisons of criteria by a group of experts and allows checking the logical consistency of the priority setting exercise in terms of eigenvalues of the comparison matrix. The principal eigenvector is normalized to give the vector of weights. Major disadvantages of AHP are:

- Requires complex calculations and expert knowledge.
- Calculations of eigenvector and eigenvalues are not possible from small data of shortlisted bidders.
- Takes longer time especially in number of criteria is large [49].
- May produce wrong results if the underlying principles are overlooked [5].

While [7]. used AHP for tender evaluation, decision support system based on the ANP was favoured by [21]. A decision support system based on group method of data handling model for scoring of tenders was proposed by [32]. where the seven inputs were based on literature survey and subjective experts' opinions.

In line with methods used in multi-attribute decision making, several aggregating methods have been proposed in evaluation of tenders for public procurement, recognizing the inter-relationships (dependencies) among competitive factors [40]. For example, delivery time and liquidated damages clause are mutually dependent, since there is a common driver in terms of perceived risk of the contractors.[3]. suggested managing the dependencies among the competitive factors in different ways including use of techniques for dependence analysis within an AHP framework.

Multivariate decision-making approaches with pre-defined objectives and restrictions can be solved by Data Envelope Analysis (DEA) where Technical Efficiency (TE) value of a decision-making unit (DMU) is computed and only technically efficient tenders are considered [33]. However, selection of inputs and outputs can change DEA results. The method does not consider effect of exogenous variables and performing statistical tests are difficult. Derivations of TE, scale efficiency vary for Constant return to scale (CRS) and Variable return to scale (VRS). However, DEA with advantages and disadvantages is best suited at short-listing stage [48] where weights to the attributes are usually decided by subjective judgments of the experts and thus, choice of weights may not be optimal [13].

4.4 Weighted sum:

Weighted sum for combining n-indicators involves finding positive weights $w_1, w_2, w_3, \ldots \ldots, w_n$
where $\sum_{i=1}^{n} w_i = 1$.
However, there is no best way to find weights and no weighting system is above criticism [18].
Hence, need is felt to have better method to evaluate bids avoiding weights and considering bids of only the pre-qualified bidders.
The following points merit consideration in the context of evaluation of bids:

- Variables to be combined in tender evaluation are in different units. While the quoted price is in terms of a currency of the country, time is in weeks or months.
- Distributions of the variables are not known.
- Normalization or standardization of the variables may not be possible with small sample size of the pre-qualified bidders relating to a particular tender.

- Transformation of variables will have effects on CI depending on nature of transformation.

- Weighted sum appears to be feasible in combining the selected variables.

The weighted criteria for tender evaluation usually involve:

1. Non-price selection criteria of the project like relevant experience; past performance; appreciations of the tasks completed; availability of management and technical skills; availability of resources; methodology proposed, etc.
2. Finding or deciding weights to reflect the perceived relative importance of the selection criteria
3. Deciding formula to find tender score for each bidder in a uniform fashion based on bid information.

Each non-price criterion is evaluated individually by experts usually in a scale ranging from 1(Poor) to 10 (Excellent). All intermediate offers are interpolated linearly. This is a subjective method. Sum of non-price scores for each bid is normalized to 10 by linear interpolation using

$$Score = \left(\frac{Sum\ of\ non{-}price\ score\ for\ each\ bidder}{Highest\ sum\ of\ non{-}price\ scores}\right) \times 10$$

Overall weighted non-price score is obtained as Normalized non-price score multiplied by total weighting of non-price criterion.

Scoring of Price: A score of 10 is given to the lowest price bid and others are ranked accordingly. Here, lowers the price, higher the score. Normalized price score may be obtained as $\left(\frac{Lowest\ quoted\ price}{Bidder's price}\right) \times 10$.

Final score is taken as (Normalized price) × (Total weighting price)

5. Problem areas of Tender evaluation:

Many problems associated with traditional system of evaluation of tenders are avoided with implementation of e-Procurement system with high level of automation.

5.1 Traditional tender vs. e-procurement:

- Under the traditional system, bidders to physically put bids in sealed cover to Tender Box or submit their bids by post/courier and thus, disclosing their identities, which may result into undesirable practices including formation of cartel.
- In e-Procurement, a bidder can submit and modify his bids from any place for any number of times within the stipulated time frame. Enough protections are maintained to see that bid documents are not affected by hacking and illegal access and the integrity of the file is maintained.
- e-Procurement gives wide publicity of tenders and ensures high level of transparency of tender related information. The portal can be visited by all potential bidders. Interested bidders need to be enrolled on the e-Procurement portal and receive system generated e-mail and SMS depending on their enrolled preference.
- Tender Inviting Authorities can see the rates quoted by different bidders
- The system provides automatic refund of EMD to the unsuccessful bidders within a reasonable time.
- Bidders can seek clarifications of the tenders during the bidding process, without disclosing their identities.

5.2Ambiguity in tender document:

Tender documents may contain ambiguous terms or clauses which can be interpreted differently and leads to conflicts, litigations, etc. For example, bimonthly payment to contractor may refers to a pay schedule wherein contractor is paid twice per month i.e. 24 payments per year. It may also mean one payment on every two months. If the tender document mentions bimonthly payment, it is binding on the organization to pay the agreed price at agreed time i.e. bimonthly to the contractor, once the tender is accepted. But the successful contractor may object after a few months against receipt of payment on every two months since it affects the cash flows of the bidder and may give rise to litigations. A few examples/Case studies (without giving details of Executing Agencies (EA) and Bidders) in this context are as follows:

5.2.1 Eligibility: Bid documents for ADB-financed contracts often involve eligibility in terms of nationality of the bidder (ADB member countries) and the country of manufacture of the goods to be supplied by a bidder need to be a member country of the ADB.

5.2.2 Conflict of interests: Two bidders with same head office address submitted their bids for a contract in India. Companies of the bidders were separate and had different names, but the owners were brothers, with a common residential address.

The Bid Document had mentioned that bidders will be taken to have a conflict of interest if they *"have a relationship with each other, directly or through common third parties, that puts them in a position to have access to information about or influence on the Bid of another Bidder"*.

The evaluation authority (EA) rejected both the bids in the ground of having conflict of interest. **5.2.3 Bid evaluation criteria not specified in the tender documents**: The tender document gave specifications for both asbestos cement pipe or steel pipe and bidders were free to bid for either any type of pipes satisfying the prescribed specifications. Two of the three bidders quoted for steel pipes and the third bidder quoted for asbestos cement pipes. Quoted price for asbestos cement pipes exceeded the prices quoted for steel pipes.

EA realized that steel pipes are likely to get corrosion and can be avoided by cathodic protection. So, price bids for steel pipes were adjusted by adding cost of providing the cathodic protection to the offered price, since the bidding documents stated that *determination of the lowest responsive bid, will consider operation and maintenance costs also.* The award went in favour of the party who offered asbestos cement pipes.

5.2.4 Deviations: Normally, bids with "minor" deviations are not rejected. But bids with major deviations are rejected. However, method of determining whether a deviation is major or minor, different EAs follow different approaches, despite general agreement that features of Minor deviations:

- Do not affect validity of the bid
- Do not change the quoted price, quality, delivery of the goods, services offered
- Do not change the commercial terms or technical specifications as given in the bid documents
- Amounts to less than 10% of the bid price.

5.2.5 Selection of weights: Two examples of problems of deciding weights:

Example – 1: **Non-Invariant properties of Composite Index**

Copnsider a single-bid limited tender where quotations are:

Bidder A: Time - 8 weeks and price - $8,000.

Bidder B: Time – 5 weeks and price - $10,000

The decision to be based on distance from the hypothetical Ideal Point (0, 0) i.e. Zero time with Zero price. Quotations of bidder "A" is a point with co-ordinates (8, 8) and the same for the bidder "B" as (5, 10) in the (Weeks) – (thousand $) space.

Here, square of distance between the point A (8 weeks, $.8 thousand) and origin ($D_A{}^2$) = 128 and the same for point B (5 weeks, $ 10 thousand), $D_B{}^2 = 125$. So, distance of the party B < distance for party A and thus, party B could be preferred due to closeness with the Ideal point or most desired point.

However, in the (Week - $) Space, then $D_A{}^2$ =64,000,064 and $D_B{}^2$ =1000, 00,025 which indicates party A is preferred over party B.

The example shows that simple change of scale in one criterion variable changed the decision. This is because of the Euclidian distance is not invariant under change of scale.

Example – 2: Subjective weights

Consider a hypothetical Two-part Tender, where each bidder submitted Technical Proposal and Cost Proposal and evaluation considered Combined Qualification cum Cost Based System (CQCCBS) as follows:

i) Financial proposals will be converted to Evaluated Cost (EC) by assigning 100 to the lowest cost bid and financial scores of other bids are inversely proportional to their quoted price.

ii) Evaluation by weighted sum of Technical Proposal score and EC.

iii) The Proposal with highest Total Score to be marked as H_1 and will be selected.

Evaluation of bids received from the three bidders and different weights for Technical

Qualification and Financial proposals are shown in Table 1, 2 and 3.

Tables - Tender Evaluation Avoiding Weights

Bidder	Tech. Qualification marks	Evaluated Score (EC)	$\frac{LEC}{EC} \times 100$	Combined Score
A	90	120	$\frac{100}{120} \times 100$ =83.33	90(0.7) + 83.33(0.3) = 87.999 Highest combined score H_1
B	75	100	100	52.5+30=82.5 (H_3)
C	80	110	91	56+27.3=83.3 (H_2)

Table 1: (Tech. Qualification: 70% & Fin. Proposal: 30%)

So, if weights for Tech. Qualification and Fin. Proposal are 70% and 30% respectively, the bidder A gets selected with the highest score. The bidder C and the bidder B become H_2 and H_3 respectively.

In case weights are changed to 60% for Tech. Qualification and 40% for Fin. Proposal, the situation is shown in Table 2

Bidder	Tech, Qualification marks	Evaluated Score (EC)	$\frac{LEC}{EC} \times 100$	Combined Score
A	90	120	83	90(0.6) + 83(0.4) = 87.2 (H_1)
B	75	100	100	45+40=85 (H_2)
C	80	110	91	48+36.4=84.4 (H_3)

Table 2: (Tech. Qualification: 60% & Fin Proposal: 40%)

Under this situation, A is still H_1 but ranks of bidders B and C got changed with change in weights though all others conditions are kept unchanged. Consider change of weights as Tech. Qualification: Fin. Proposal = 40% and 60% which is given in Table 3

Bidder	Tech, Qualification marks	Evaluated Score (EC)	$\frac{LEC}{EC} \times 100$	Combined Score
A	90	120	83	36 + 49.8 = 85.8 (H_3)
B	75	100	100	30+60=90 (H_1)
C	80	110	91	32 + 54.6 = 86.6 (H_2)

Table 3: (Tech. Qualification: 40% & Fin. Proposal: 60%)

Here, the bidder B gets selected and the Bidder C and A are H_2 and H_3 respectively.

The example clearly indicates that any bidder could be selected depending on chosen weights to Technical qualification and Financial Proposals, keeping the condition of sum of weights is equal to one. Thus, subjective weights may lead to different decisions. Convex property of measurement will be violated if sum of weights is different from one and mathematical properties of the combined scores will be in dark.

6. Proposed method:

For *n*-variables, consider bids of party A as a vector $\boldsymbol{X_A} = (X_{1A}, X_{2A}, \ldots\ldots, X_{nA})^T$ and the same for party B as $\boldsymbol{X_B} = (X_{1B}, X_{2B}, \ldots\ldots, X_{nB})^T$ and so on. Let the desired or target vector be $\boldsymbol{X_0} = (X_{10}, X_{20}, \ldots\ldots, X_{n0})^T$.

For negatively related variable like price, where lower value is desirable, consider reciprocal of ratio $\frac{X_{it}}{X_{i0}}$ i.e. instead of $\frac{X_{it}}{X_{i0}}$, take $\frac{X_{i0}}{X_{it}}$ for t = A, B, C, etc.

After making adjustments for each negatively related variable, define score of Party- A as geometric mean i.e. $Score_A = \sqrt[n]{\frac{X_{1A}, X_{2A}, \ldots\ldots, X_{nA}}{X_{10}\, X_{20}\, \ldots\ldots X_{n0}}}$ or by avoiding the n-th root,

$$Score_A = \frac{X_{1A}, X_{2A}, \ldots\ldots, X_{nA}}{X_{10}\, X_{20}\, \ldots\ldots X_{n0}} \qquad (1)$$

Score of each bidder party can be computed accordingly.

Score given by equation (1) reflects multi-dimensional score of a bidder considering target values of all variables under consideration for evaluation of bids.

Clearly, $\frac{X_{it}}{X_{i0}} > 1$ indicates improvement by t-th bidder in the i-th variable and $\frac{X_{it}}{X_{i0}} < 1$ indicates that the t-th bidder failed to achieve target value for the i-th variable. If $Score_A$ in equation (1) is multiplied by 100, it will reflect percentage changes. CI > 1 implies overall improvement from the target vector. In the context of bid evaluation, CI for Bidder A can be taken as

$$CI_A = \prod_i \frac{Quote\ given\ by\ A\ in\ i-th\ non-price\ variabl}{Max.quote\ for\ i-th\ non-price\ variable} * \frac{Max.quoted\ price}{Price\ quoted\ by\ A} \qquad (2)$$

In the Example 1; consideration of Case 1: (Weeks – Thousand $) space and Case 2: (Weeks – $) space, reversed the decision, despite every element of bid vector and target vector is positive. CI for A and B are shown in Table 4 separately for Case 1 and Case 2

Bidder	Case 1	Case 2	Remarks
A	$\frac{8*10}{8*8} = 1.25$	$\frac{8*10000}{8*8000} = 1.25$	Bidder A is preferred in each case
B	$\frac{5*10}{8*10} = 0.625$	$\frac{5*10000}{8*10000} = 0.625$	

Table 4: Evaluation of bids avoiding weights- Example 1

Clearly, Bidder A is preferred in each case and thus, avoids the problem of non-invariant property.

Similarly, Example – 2 could be solved if CI_A is taken as

$$CI_A = \frac{Tech\ qualification\ mark\ of\ A}{Max.Tech\ qualification\ mark} * \frac{Max.quoted\ price}{Price\ quoted\ by\ A}$$

CI of each bidder is shown in Table 5.

Bidder	Tech. Qualification mark	Price quoted	Composite Index	Remarks
A	90	120	$\frac{90}{90} * \frac{120}{120} = 1.00$	Bidder A is preferred in each case
B	75	100	$\frac{75}{90} * \frac{120}{100} = 0.999996$	
C	80	110	$\frac{80}{90} * \frac{120}{110} = 0.969697$	

Figure 5: Evaluation of bids avoiding weights- Example 2

Bidder A is preferred in each case. Thus, the proposed method of evaluation avoiding weights gave robust result.

7. Limitations:

The proposed method fails if X_{i0} for i= 1, 2, …, n. So, zero value for any target cannot be taken. In that case, choose a very small value say 10^{-K} where K is large.

8. Discussion and Conclusion:

Models used for tender evaluations like DEA, AHP, ANP, etc. with different sets of assumptions and limitations are primarily suitable for shortlisting of bidders. For the evaluation stage, the paper proposes construction of composite index by multiplicative aggregation (function of geometric mean) avoiding scaling and weights to the indicators or variables. In usual method of evaluation of two-stage tender, any bidder could be selected by changing weights to Technical qualification and Financial Proposals. The proposed approach, applied in evaluation of tenders could solve the problem and assign robust ranking of the bidders. The approach could be well used to evaluate bids with wider scope of evaluation covering non-monetary criteria like environmental, social, innovative aspects viz. energy consumption or generation of hazardous waste, etc. emerging from sustainable development goals (SDGs) in the World Economic Forum [2017]. In addition, cost of ownership may be better reflected by Life cycle cost (LCC) in public procurement, requiring appropriate aggregation of multidimensional criteria to a scalar scoring index. The proposed approach avoiding weights may be adopted to achieve value for money by identifying the most appropriate bidder and may be considered as a guideline in tender evaluation after rigorous investigations.

Declarations:

Acknowledgement: Nil

Conflicting Interests: The author declares no potential conflicts of interest.

Funding: No financial support received for the research, authorship and/or publication of this article.

Data Availability: No data, models, or code were generated or used during the study.

Highlights:

- Problem areas in tender evaluation as weighted sum described with examples.
- Suggest better method of obtaining robust tender scores using of geometric aggregation and avoiding weights.
- Assumptions free proposed method provides integrated, coherent and consistent evaluation of tenders.
- Proposed approach leads to unique ranks of the bidders and unambiguous tender decision.

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DOI: 10.31579/2688-7517/061