Ranking e-Procurement Assessment Variables: A TOPSIS-Based MADM Approach for Bangladesh's Roads and Highways Department

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Abstract

In 2011, the Government of Bangladesh launched the e-procurement system based on the e-GP guidelines. Following successful pilot testing, all public procurement entities (PPEs) began adopting e-procurement for their tendering processes. This study aims to rank eight key variables that are involved in creating a conceptual e-procurement assessment model. The research focuses on eleven zones within the Roads and Highways Department (RHD), with a sample of 206 PE officers and 145 contractors. A survey was conducted, and the data were analyzed using SPSS software to develop a multiple linear regression model, testing eight hypotheses to form the proposed e-procurement implementation assessment model for RHD. All hypotheses were confirmed, validating the model. The eight variables were ranked using Python software and the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method, with transparency ranked highest. The study's findings will be valuable to academics, practitioners, researchers, and relevant authorities. The novel contribution of this study is its ranking of variables to develop a thematic framework for evaluating e-procurement implementation within Bangladesh's Roads and Highways Department.

Keywords: TOPSIS method, e-GP Guideline, Variables Ranking, e-Procurement Assessment Model

I. INTRODUCTION

Since 2011, Bangladesh has adopted an electronic procurement (e-procurement) system [1] for public sector procurement, developed and managed by the Central Procurement Technical Unit (CPTU) under the Ministry of Planning. Although the system is currently operational, both procurement entities (PEs) and bidders continue to face various challenges [2], [3]. This study aims to identify and prioritize the factors necessary for designing an effective e-procurement assessment model. The research focuses on Bangladesh's Road and Highways Department (RHD) [4]. Using the fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) [5] method to rank eight key variables identified through hypothesis testing. Multiple Criteria Decision Making (MCDM) is classified into two types: MODM and MADM. Again, the researcher focused on a Multi-Attribute Decision Making (MADM) method [6], using a fuzzy logic algorithm to rank variables in the study's hypothesis test. Some MADM methods are Simple Additive Weighing Method (SAW), Weighted Product Method (WPM), Analytical Hierarchy Process (AHP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

The TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method is a popular multi-criteria decision-making (MCDM) technique used to rank alternatives based on their proximity to an ideal solution. Hwang and Yoon developed it in 1981 [6], [7]. The method is based on the concept of finding a solution that is closest to the ideal (or best) alternative while being as far as possible from the worst alternative. TOPSIS is widely used because it is simple to implement and intuitively appeals to decision-makers [8]. It is beneficial in situations where multiple conflicting criteria need to be considered, as it provides a clear ranking of alternatives based on their distance to the ideal solution. It is commonly applied in various fields such as engineering, business, economics, and environmental management [9].

In this study, the researcher used this method for ranking variables, which suggests that multiple variables were evaluated, and the goal was to identify those closest to the ideal performance based on some criteria [10]. Briefly, the TOPSIS method [11] steps are defining criteria and alternatives, formulating a decision matrix, normalizing matrix, weighted normalize matrix, finding positive and negative ideal solutions, closeness coefficient, and ranking of alternatives. The multi-criteria decision analysis technique, TOPSIS [11] was employed to identify the optimal choice from a set of alternatives, comparing both positive and negative ideal solutions [12]. A dataset comprising eight dependent variables from the hypothesis test was used to determine the most suitable variable among the options. The findings demonstrate that TOPSIS is a reliable and effective method for multi-decision analysis, offering a robust strategy for ranking variables [13]. The study developed a proposed conceptual framework [14] for e-procurement assessment in RHD. To ensure a thorough and practical analysis,

the variables are categorized into dependent and independent variables. Eight variables are identified as dependent variables, which are treated as key factors in evaluating the implementation of e-procurement. These variables are (1) Accountability, (2) Procurement Governance, (3) Dematerialization, (4) Legal, Regulatory, and Policy Framework, (5) Process Improvement, (6) Efficiency, (7) Boosting Competition, and (8) Transparency. These variables served as the foundation for the assessment model, guiding the evaluation of e-procurement practices and their effectiveness [14], [15].

The key issue is that no previous research in RHD had been conducted in the context of ranking variables that influence the e-procurement assessment model. Different criteria and weights must be considered when ranking the eight variables obtained from the research gap analysis. The level of interest in this study topic is initially approached when ranking the eight dependent variables used in the hypothesis test to obtain the closeness index. The contributions of this study are threefold: First, a conceptual framework is proposed, outlining eight dependent variables and 33 independent variables for designing an e-procurement implementation assessment model specific to RHD. Second, eight hypotheses are formulated and tested through a multiple linear regression (MLR) model, confirming the validity of the proposed framework. Finally, the TOPSIS method is employed to rank the eight variables of the e-procurement assessment model, helping to prioritize their contributions within the conceptual framework [16]. To evaluate the e-GP platform, which was launched in 2011 [1], a more comprehensive e-procurement assessment model can be developed. As a result, the central research question for this study was: What are the different factors that influence the adoption of the e-procurement implementation assessment model in RHD? The corresponding research objective was to predict the significant effects of different factors that influence adopting the e-procurement implementation assessment model in RHD development project procurement.

II. METHOD

The Roads and Highways Department (RHD) was chosen as the focus of this study due to its pivotal role in Bangladesh's e-Government Procurement (e-GP) system, which has been actively utilized for public procurement processes since its introduction in 2011 [17]. To comprehensively evaluate the effectiveness and challenges of e-procurement implementation within the RHD, the study employed a quantitative research approach using structured survey questionnaires. These questionnaires targeted two key respondent groups: procurement entity (PE) officials within the RHD and registered contractors involved in public procurement projects. Data collection was conducted through direct visits to various RHD PE offices located throughout the country, ensuring geographic representation across 11 zones, 31 circles, and 70 divisions. The sample consisted of 145 contractors and 206 PE officials, providing a robust dataset for analysis. With prior approval from the PhD supervisor, the researcher personally administered the surveys to maintain consistency and data integrity. To prioritize and rank the eight dependent variables selected for hypothesis testing, the study employed the fuzzy logic-based Multi-Attribute Decision Making (MADM) Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method [6]. The outputs from the Multiple Linear Regression (MLR) coefficient table were used as inputs for the TOPSIS analysis, allowing for a nuanced evaluation of variable importance. The entire data analysis process, including the implementation of the TOPSIS algorithm, was conducted using Python software, which facilitated accurate, efficient, and reproducible results [18].

III. RESULTS AND DISCUSSION

The hypothesis testing in this study is conducted using the Multiple Linear Regression (MLR) method to evaluate the influence of various independent variables on the eight identified dependent variables that define the proposed e-procurement assessment model. This analysis is performed using SPSS software and is based on field data collected through surveys from RHD procurement officials and contractors. The MLR generates a set of coefficients (B values) that represent the strength and direction of the relationship between each independent variable and the dependent variables in the model. The obtained coefficients can be seen in Table 1, indicating that most independent variables positively influence the dependent variables, except for one that shows a slightly negative impact (-0.012). The corresponding standard errors reflect the variability and precision of the coefficient estimates. These regression outputs serve as the input values for the fuzzy logic-based Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) analysis. The integration of MLR results into the TOPSIS method allows the study to systematically rank and prioritize the eight dependent variables, offering a structured, data-driven approach to assess the implementation and effectiveness of e-procurement practices within Bangladesh's Roads and Highways Department.

Table 1 Dependency Test Result Summary

Sl #	Dependent Variable	Coefficients B (Constant)	Std. Err
1	Accountability	.822	.374
2	Procurement governance	.353	.186
3	Dematerialization	.205	.093
4	Legal, regulatory, and policy framework	.390	.154
5	Process improvement	-.012	.159
6	Efficiency	.529	.203
7	Boosting competition	.225	.120
8	Transparency	.707	.378

Table 1 presents the summary of dependency test results using Multiple Linear Regression (MLR), which evaluates the strength and direction of the relationship between independent variables and eight identified dependent variables central to assessing e-procurement effectiveness in the Roads and Highways Department (RHD). Each dependent variable is associated with a regression coefficient (B) and a corresponding standard error (Std. Err), indicating the magnitude and reliability of its relationship with the predictors. The coefficients reflect how much the dependent variable is expected to change for a one-unit increase in the independent variables, holding all other variables constant.

Among the eight dependent variables, Accountability shows the highest positive coefficient value of 0.822 with a standard error of 0.374, suggesting a strong and statistically meaningful relationship with the independent variables. This result implies that improvements in the influencing factors are likely to lead to significant gains in accountability within the e-procurement framework. Similarly, Transparency records a high coefficient value of 0.707 and a standard error of 0.378, reinforcing its crucial role in shaping the effectiveness of e-procurement systems. Both variables are consistent with theoretical and empirical expectations in public procurement literature, where transparency and accountability are fundamental to improving integrity, public trust, and compliance.

Efficiency and Legal, Regulatory, and Policy Framework also demonstrate moderately strong coefficients of 0.529 and 0.390, with standard errors of 0.203 and 0.154, respectively. These results indicate that both variables contribute meaningfully to the model and are influenced by the conditions set by the independent variables. Procurement Governance (B = 0.353, Std. Err = 0.186) and Boosting Competition (B = 0.225, Std. Err = 0.120) follow, both showing moderate associations, suggesting they play supportive roles in the overall performance of e-procurement implementation. These values underscore the necessity of establishing robust institutional frameworks and promoting competitive bidding processes to enhance procurement outcomes.

Interestingly, Process Improvement registers a slightly negative coefficient (-0.012) with a standard error of 0.159, indicating a very weak and potentially inverse relationship in the context of this model. While this may reflect limitations in current process optimization efforts or inconsistencies in their implementation, further investigation is needed to understand its underlying causes. Lastly, Dematerialization—which refers to the digitization of procurement procedures—has a lower coefficient of 0.205 and the smallest standard error (0.093), suggesting a statistically stable but modest impact on procurement performance. Overall, these MLR results offer empirical insights into the relative influence of each variable, providing a robust foundation for further analysis through ranking methods such as TOPSIS, and contributing to the evidence-based refinement of e-procurement strategies in Bangladesh's public sector.

Following the TOPSIS solution, the results obtained are presented in Table 2. Table 2 discovers the final ranking of the eight dependent variables used in the hypothesis testing, based on their Closeness Index values generated through the fuzzy logic-based TOPSIS analysis. This ranking reflects the relative importance of each variable in assessing the effectiveness of e-procurement implementation within the Roads and Highways Department (RHD). The variable transparency ranks highest with a Closeness Index of 0.8561, indicating its critical role in the success of e-procurement. Following closely are accountability and process improvement, ranked second and third, respectively. Other variables such as procurement governance, efficiency, and legal, regulatory, and policy framework also show strong relevance, while boosting competition and dematerialization receive lower rankings. These results provide a prioritized view of the variables, guiding policymakers and stakeholders in focusing their efforts on the most impactful aspects of e-procurement reform.

Table 2 Hypothesis Test Variables Ranking

Hypothesis	Variables	Closeness Index value	Ranking
H1	Transparency	0.8561497432385287	1
H2	Accountability	0.8328183758583159	2
H3	Process improvement	0.8131768788506507	3
H4	Procurement governance	0.8112754022672461	4
H5	Efficiency	0.8046808844955613	5
H6	Legal regulatory and policy framework	0.7850116770449888	6
H7	Boosting competition	0.7741189612344201	7
H8	Dematerialization	0.757377596127159	8

The results generated from the fuzzy logic-based TOPSIS algorithm reveal that transparency ranks as the most significant variable among the eight selected for the proposed e-procurement assessment model in the Roads and Highways Department (RHD) [19], [20]. This high ranking highlights the critical role transparency plays in fostering trust, reducing corruption, and ensuring fairness in public procurement systems. Closely following transparency is accountability, which secures the second rank [19]. These two variables align closely with the national objectives of public procurement reforms in Bangladesh, where enhancing transparency and accountability are primary goals outlined in regulatory frameworks and policy documents [19], [21]. The findings of this study strongly support these goals, reinforcing the importance of institutional mechanisms that uphold openness and responsibility in procurement practices [22].

Ranked third is process improvement, which reflects the significance of continuously refining procurement procedures to enhance efficiency, accuracy, and responsiveness. This ranking is further supported by observations collected through focus group discussions with RHD stakeholders, which emphasized the need for process optimization as a way to streamline operations and improve outcomes [21]. The fourth-ranked variable, procurement governance, highlights the importance of effective oversight structures and decision-making processes in ensuring procurement integrity and compliance [23]. The position of governance in the ranking confirms existing literature that argues strong governance is a prerequisite for successful e-procurement implementation [24]. Without clear rules, responsibilities, and accountability structures, even technologically advanced systems may fail to deliver intended results.

In fifth place is efficiency, which reflects the extent to which the e-procurement system reduces time, cost, and administrative burdens in procurement activities [24]. While not at the top of the ranking, efficiency remains a critical operational goal and a key indicator of the system's performance. Following efficiency, the legal, regulatory, and policy framework occupies the sixth position. This result suggests that while a supportive legal environment is essential, it may serve more as an enabling factor than a direct driver of e-procurement success [23]. In seventh place is boosting competition, which indicates that although encouraging broader supplier participation is beneficial, it may not have as immediate or visible an impact as transparency or process improvements in the current RHD context [25].

Lastly, dematerialization, which refers to the digital transformation of procurement processes, is ranked eighth [26]. Although it plays an essential role in enabling e-procurement, its lower ranking suggests that stakeholders may perceive it as a foundational component rather than a differentiating factor in performance. Importantly, the Closeness Index values for all eight variables are relatively close, indicating a balanced contribution of each factor and lending credibility to the conceptual framework proposed in this study. This relatively uniform distribution of values supports the robustness and practical applicability of the model, reinforcing its relevance for assessing and guiding e-procurement implementation in the RHD. Furthermore, the reliance on field data ensures that the model is grounded in real-world practices and perceptions, making it a reliable tool for both evaluation and policy formulation.

The results from Table 1, which summarizes the dependency test using Multiple Linear Regression (MLR), provide insight into how significantly each dependent variable is influenced by the independent factors within the proposed e-procurement assessment model for the Roads and Highways Department (RHD). Among the eight variables, Accountability has the highest regression coefficient (B = 0.822), suggesting it is most strongly influenced by the predictors, followed by Transparency (B = 0.707), Efficiency (B = 0.529), and Legal, Regulatory, and Policy Framework (B = 0.390). These values reflect a solid alignment with the goals of e-Government Procurement (e-GP) systems, where transparent and accountable processes are essential for fostering trust and efficiency. Meanwhile, Process Improvement has a near-zero and slightly negative coefficient (B = -0.012), indicating an insignificant or inverse relationship within the context of the current model—this may suggest a gap between intended improvements and practical outcomes.

Complementing this analysis, Table 2 presents the rankings of the same variables using the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method, which measures the relative importance of each variable based on a multicriteria decision-making framework. Transparency ranks first with the highest Closeness Index value (0.856), reaffirming its critical role in effective e-procurement, followed closely by Accountability (0.833) and Process Improvement (0.813). Interestingly, despite its low regression coefficient in the MLR results, Process Improvement ranks third, highlighting that stakeholders may perceive it as essential in practice, even if it does not statistically emerge as a strong dependent outcome in the model. Conversely, Dematerialization, while demonstrating statistical stability in the MLR (with the lowest standard error), ranks last in TOPSIS, implying a lower perceived impact among the variables. Together, these findings illustrate the multidimensional nature of e-procurement assessment, where both statistical relationships and practical stakeholder evaluations contribute to a holistic understanding of performance effectiveness.

IV. CONCLUSION

This study focused on data collected from the RHD population in Bangladesh, utilizing survey questionnaires and hypotheses tailored to the study's objectives. Data was gathered from eleven RHD zones across the country, and eight variables were tested through hypothesis testing, all of which were validated. The TOPSIS method was then employed to rank these variables within the context of the e-procurement assessment model. The results highlighted a clear preference order, with the variable scoring 0.8561 ranked highest, followed by those with scores of 0.8328, 0.8132, and so on. Transparency emerged as the highest-ranking variable. The study's findings not only validate the proposed framework but also contribute valuable insights for both theory and practice in the realm of e-procurement. The application of the TOPSIS method proved to be a practical approach for the first-time assessment and ranking of key variables relevant to e-procurement performance.

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