A Novel Approach for Reducing Risk in Project Bidding Management

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ABSTRACT

Project bidding management is an important part of the engineering and building industries because it ensures that resources are used well, costs are kept low, and projects are finished on time. This process involves the solicitation of biddings from various contractors and vendors for a specific project and the subsequent evaluation and selection of the most suitable bidding. This article provides a comprehensive overview of project bidding management, encompassing key principles, methodologies, and best practices. It also highlights the significance of the integration of modern technologies and innovative approaches to enhance the efficiency and transparency of bidding processes. The paper also discusses challenges associated with project bidding and suggests potential solutions to mitigate risks and improve overall project outcomes. By delving into the intricacies of project bidding management, this research contributes valuable insights to practitioners, researchers, and stakeholders in the construction industry, fostering a deeper understanding of the critical factors that influence successful project bidding.

Keywords: Project Bidding, Risk Management, Project Management, Risk Analysis, BIM Technology

I. INTRODUCTION

In the realm of construction project execution, project bidding management is a pivotal and multifaceted process that significantly influences the success and efficiency of endeavors. Project bidding, as a critical phase in project development, involves the solicitation of competitive proposals from qualified contractors or vendors for the execution of specific tasks or the entire project. The intricacies involved in bid processes demand a comprehensive understanding of potential risks that may arise at

various stages. This paper aims to provide an extensive overview of the challenges associated with project bidding management and delineate strategic approaches to minimize inherent risks.

The urgency of understanding and refining project bidding management stems from its profound impact on project outcomes. A well-structured and efficient bidding process ensures the selection of competent contractors, optimal resource allocation, and adherence to project timelines and budgets. The importance of project bidding cannot be overstated, as it sets the stage for the entire project lifecycle. However, the current state of project bidding is characterized by a range of challenges, including procedural complexities, information asymmetry, and a lack of standardization, which often result in suboptimal project outcomes. As we navigate through the complexities of project bidding, it becomes apparent that a critical assessment of the existing practices is essential. The challenges inherent in the current system necessitate a reevaluation to formulate innovative processes that not only address current limitations but also enhance the overall effectiveness of project bidding.

This article endeavors to explore the multifaceted landscape of project bidding management, shedding light on the current challenges faced by industry stakeholders. Moreover, the study will propose a strategic framework for minimizing these risks, emphasizing the proactive measures that can be adopted by stakeholders. It aims to contribute to the ongoing discourse by presenting a holistic view of project bidding, examining its intricacies, and proposing potential solutions to optimize the bidding process. By synthesizing insights from industry experiences, best practices, and emerging trends, the author's goal is to present a framework that can serve as a foundation for more efficient and transparent project bidding practices. To show how useful the author's ideas are, we will look at the suggested framework, which is made up of five key steps: 1) The importance of project bidding in construction projects; 2) Problems in bidding agency; 3) Potential risk analysis of project bidding management; 4) Proposal to improve the project bidding management framework using BIM technology; 5) Call to action for the adoption of the proposed strategic plan in project bidding management.

In the subsequent sections, we will delve into specific aspects of project bidding management, examining its key components and challenges and proposing strategies for improvement. Through this exploration, we aspire to contribute to the advancement of project bidding practices, fostering a more effective and collaborative environment within the construction industry.

II. LITERATURE REVIEW OF PROJECT BIDDING MANAGEMENT

A. The importance of project bidding in construction projects

"Bidding" is a competitive process in which organizations or individuals submit proposals and cost estimates in order to have the opportunity to be selected as contractors for a specific project. During this process, participants compete by submitting bid documents, which include information about their capabilities, experience, and pricing related to the project at hand. The project bidding process typically involves the public announcement of project information, inviting bids from potential contractors, and subsequently collecting and reviewing their proposals. The project owner or organizing entity then selects the most suitable contractor based on criteria such as quality, cost, and the ability to execute the project. The project bidding process aims

to create a fair and competitive environment that benefits both the project owner and contractors, ensuring transparency and fairness in the selection of a contractor for a specific project.

Project management encompasses the systematic planning, organization, securing, and efficient utilization of resources with the aim of achieving specific objectives within a defined time frame. This discipline entails the adept application of knowledge, skills, tools, and techniques to effectively fulfill the project's requirements. Project management plays a crucial role in bidding processes as it ensures that the project is delivered on time, within budget, and with the expected quality. It involves defining the project scope, setting goals, creating a schedule, allocating resources, and managing risks. In the bidding process, project management helps in accurately estimating costs, determining timelines, and outlining deliverables to present a comprehensive and competitive bid. Effective project management practices in the bidding process contribute to building credibility, demonstrating competence, and increasing the likelihood of winning contracts, ultimately setting the stage for successful project implementation.

Project bidding management is a critical process in the world of business and construction. It involves the systematic approach to soliciting, evaluating, and awarding contracts to vendors or contractors for the execution of a project. This process is essential for ensuring that the project is completed on time, within budget, and to the required quality standards. As an example, Joseph M. Juran provides the method of Total Quality Management (TQM) in Bidding Management. TQM focuses on enhancing quality by integrating all elements of the project, including bidding management. [1] Quentin W. Fleming and Joel M. Koppelman analyzed specific aspects of

bidding management in the context of projects. [2] The first step in project bidding management is the identification of the need for a project. This could be a new construction project, a renovation, or the purchase of goods or services. Once the need has been identified, the next step is to prepare a detailed project scope that outlines the objectives, deliverables, timelines, and budget for the project. With the project scope in hand, the next step is to identify potential vendors or contractors who can fulfill the requirements of the project. This involves issuing a request for proposal (RFP) or a request for quotation (RFQ) to solicit bids from interested parties. The RFP or RFQ should clearly outline the project requirements and evaluation criteria to ensure that all bidders are on an equal footing. For example, Ballesteros-Pérez et al. [3] showed both an image and a mathematical calculation for figuring out a building bid. In later research [4], they improved a model that was originally made for capped bidding to come up with a quick way to spot bids that aren't normal or that are part of a scheme. Through a taxonomic review process [5, 6], the researchers also added to their work by making more than one scoring system, a wide range of Economic Scoring Formulas (ESF), and factors for prices that are too low in building tenders. They [7] used a multinomial model that works for both limited and open bidding to figure out how many new and returning bids there are in construction auctions. Once the bids have been received, the project bidding management team must evaluate them based on predefined criteria such as cost, technical capabilities, experience, and past performance. This evaluation process is critical for ensuring that the selected vendor or contractor has the necessary skills and resources to execute the project successfully.

Based on numbers, Banki et al. [8] looked at the relationship between the number of bidders and the

price of the bids for a project. A rise in the number of buyers causes the bid price to fall, according to their research. Hassanein and Hakam [9] suggested that contractors use a way of making decisions that are based on the multi-attribute utility theory. Contractors can use this method to help them decide if they want to take on a certain job. From the point of view of advisers, Gheorghe [10] created a unique Artificial Intelligence (AI) system for using Artificial Neural Networks (ANN) in consulting engineering management. This framework helps with the complicated and unorganized steps needed to choose bids for big projects and other expert engineering work.

Drew and Skidmore [11] looked at the competitiveness link between the size of the bidder and the size of the contract from the expert's point of view. After the evaluation process is complete, the project bidding management team must make a recommendation for awarding the contract. This recommendation should be based on a thorough analysis of the bids received and should take into account factors such as cost, quality, and schedule. The final decision on awarding the contract should be made in accordance with relevant bidding regulations and policies. Once the contract has been awarded, the project bidding management team must closely monitor the performance of the vendor or contractor to ensure that they are meeting their obligations as per the contract. This involves regular progress reviews, quality inspections, and financial audits to ensure that the project is progressing as planned. By following a systematic approach to soliciting, evaluating, and awarding contracts, organizations can ensure that their projects are delivered on time, within budget, and to the required quality standards.

Looking from a different perspective, Skitmore and Picken [12] delved into the accuracy of pre-tender cost estimation by scrutinizing data collected from the USA construction industry. Electronic bidding (EB) has been characterized by some scholars as an innovative approach to construction bidding, albeit with widespread acknowledgment that its efficient implementation remains a challenge. Nesan Lenin [13], for instance, put forth an online framework as a proposed solution to address this challenge. Furthermore, Idoro [14] carried out a comparative assessment contrasting the planning and execution of direct labor (DL) construction projects with design-bid-build (DBB) projects in Nigeria. The findings illuminated variations in the degrees of design and construction planning accomplished in DBB and DL projects, questioning the conventional public perspective and indicating potential areas for enhancement. Proficient project bidding management is imperative for the triumph of any project and holds substantial sway on an organization's comprehensive performance and standing.

The rise in global population and the expansion of societies throughout the last century, coupled with the necessity for infrastructure development, have intensified the spotlight on the construction industry, resulting in increased funding and investment in construction projects [15, 16]. Consequently, a higher volume of construction projects gives rise to a broader spectrum of problems and challenges within this sector [17, 18]. One of the most formidable challenges faced by the construction industry is the matter of bidding [19]. The multi-stage process of construction bidding holds significant importance in the project lifecycle, enabling owners to identify the best teams for the construction job at the most competitive prices. Effective bid management becomes crucial for contractors to prevent time

wastage and optimize the efficiency of each bid, particularly when multiple projects are simultaneously underway with various tender processes [20].

Beyond its technical aspects, construction bidding encompasses economic, legal, and managerial dimensions, playing a pivotal role in the successful implementation of construction projects [21, 22]. The examination of bidding can be independently approached from the perspectives of the client, contractor, or consultant. You can choose the best building plan and material sources for engineering jobs using the bidding method. Therefore, the basic rules of bidding in a fair, just, and open way can fully support the growth of the construction industry, and the competition model can fully support the growth of building technology. The bidding method is a very important part of figuring out how much a project will cost, the speed at which it is built, and the quality of the finished product. Controlling and directing engineering projects still comes with a very big risk because the projects cover too much ground. As a result of the high risk, the bidding method also causes a lot of problems with the project. Although the real building time of winning projects isn't very long, there is a lot of work to do. Some projects even need to be looked into while they're being built, which results in poor quality. As people's living standards rise and more practical needs are met by buildings, new technology is used in the area of construction engineering. This makes the plan easier to understand but harder to implement. As a result of the short time available for planning during the bidding process, it has become more difficult to calculate the bill of quantities. However, doing the calculations by hand has not been able to guarantee the accuracy of the amount requirement. Some problems have to be solved urgently in the bidding stage of construction projects; otherwise, it will restrict the development of the construction industry [23].

Managing risks during the bidding process for construction projects is crucial in mitigating potential issues that may arise in the course of the project, impacting aspects such as quality, cost, and duration. The ultimate goal is to enhance economic and social benefits, bolster the competitiveness of construction engineering enterprises, and contribute to the overall improvement of the market economic system. Effectively addressing risks in project bidding not only ensures the successful and smooth execution of construction projects but also plays a pivotal role in advancing economic and social advantages, ultimately strengthening the competitive position of construction enterprises. This comprehensive approach to bidding management serves as a prerequisite, laying the foundation for the seamless progress of construction projects and furthering the overall development of economic and social benefits, as well as the competitiveness of the construction industry within the market economy [24]. The global building business spent $12 trillion in 2019. By 2035, it's expected to have spent $19.2 trillion. Investments, project bids, project completion, and the use of technology have all changed the business a lot. These ongoing changes and spending patterns intensify competition among contractors. Bidding on construction projects is an important part of the competition process. There are different ways to bid, such as open bidding, agreed selection, and qualification-based selection. Despite abundant information on construction conflicts, insufficient knowledge exists about disputes occurring in the bidding process. Moreover, prevailing models frequently overlook the influence of real-world factors on bidding decisions. The paper outlines a plan for enhancing the usefulness of future

studies in assisting stakeholders with decision-making [25].

The findings indicate that in preparing a bid list, consultants should have access to specific technical data, including details on the "size of bidders," "preferences of bidders," and the "recent experience of bidders in similar projects with comparable type and contract value." A contemporary perspective on bidding, recognizing its complexity among stakeholders, introduces Building Information Modeling (BIM) as an Information Technology (IT) tool. BIM serves to organize reciprocal interdependencies among diverse stakeholders, facilitating effective bidding process management in construction projects [26]. Leveraging BIM technology allows construction corporations to showcase the project's design scheme, mitigating the need for engineering changes and subsequently reducing associated costs. Integrating BIM into bidding management enhances overall enterprise profitability, leading to more rational construction project management practices and fostering the broader adoption of BIM technology throughout the project lifecycle.

B. Problems in bidding agency

Within the scope of bidding agency responsibilities, a pertinent bidding agency undertakes the owner's entrusted tasks, adhering to the fundamental principles of fairness, impartiality, and transparency. Additionally, the bidding agency offers relevant professional services to fulfill the owner's requirements. Particularly in new tenders, the bidding agency acts as a facilitator between the tender company and potential bidders. In the context of construction project bidding processes, the government employs bidding agencies to standardize and regulate the bidding procedures [27].

1) Lack of standardization of bidding agency

Concerning the practical responsibilities of a bidding agency, it is essential to deliver services based on the fundamental principles of fairness, impartiality, and openness. However, many bidding agencies exhibit deficiencies in standardizing their processes and services, indicating a need for prioritized attention [28]. Presently, to secure tenders, some agencies resort to opportunistic practices during the bidding process, being willing to accommodate unreasonable demands from the tender owner, potentially violating laws and regulations. Instances arise where bidding agencies, in violation of legal standards, engage in opaque operations, predetermining the winning bidder. In such situations, even if a bidding enterprise fails to meet construction conditions, it can illegitimately secure the bid or tender, jeopardizing the construction project's quality and posing risks to safety [29]. Chotibhongs and Arditi [30] proposed a systematic method for identifying irregularities in bidding using data from a public agency. Porter and Zona [31] focused on strategies for detecting bid rigging in auctions, specifically in the context of highway construction contracts.

2) Lack of professional bidding agency talent support

To fulfill the specific requirements of a construction project bidder agency, it is imperative for the agency to ensure excellence in bidding qualifications, bolster the expertise of its personnel, and cultivate a proficient bidding agency team [32]. Nonetheless, the current state of construction project bidding agencies reveals certain shortcomings, including inadequate internal personnel professionalism, a low level of professional cultural knowledge, and a deficiency in overall professional quality, potentially hampering the service quality of these agencies [33]. Some existing personnel within bidding agencies lack systematic professional knowledge, training, and education related to the bidding process. They

exhibit a limited understanding of bidding procedures and legal provisions, with narrow knowledge scopes and relatively weak professional abilities, resulting in a notable lack of objectivity in the bidding process [34]. Certain bidding agencies lack strict management, neglecting rigorous reviews of the qualifications, quality, and skills of bidding personnel. This laxity can compromise the fairness of the bidding process, affecting equitable competition among construction enterprises [35].

A professional bidding agency should meticulously devise schemes for construction timelines, progress, milestones, and other factors based on the project's actual conditions. Bidding agency personnel should possess a comprehensive understanding of the construction process, construction period estimates, and other fundamentals to ensure the effective realization of bidding period objectives. Proposed contract terms must be rigorously and carefully signed, and the construction period should be reasonable to alleviate concerns for the tender's owner.

3) Budget preparation is not scientific

Within construction project management, cost management proves susceptible to numerous influencing factors, contributing to its high complexity and challenging estimation. Particularly in the midst of a complex economic environment characterized by significant market fluctuations, accurately gauging and managing costs becomes even more intricate. The construction project bidding stage, spanning an extended period and subject to inevitable material price fluctuations, adds an element of unpredictability, posing a continual risk of project costs exceeding the initial budget estimates [36].

During the budget preparation phase, personnel within the bidding agency lacking professional skills

and experience or neglecting on-site research may struggle to grasp the entirety of the situation. Consequently, they may overlook factors influencing project costs, leading to inaccurate budget estimations [37]. A proficient bidding agency must ensure the precision, accuracy, and comprehensiveness of bidding document terms, project costs, and associated expenses. Rigorous reviews of the cost control strategy's rationality should be conducted to maintain project investment within reasonable bounds.

C. Potential risk analysis of bidding

Effectively managing bidding risks constitutes a crucial aspect of bidding management. Project bidding activities exert influence on project cost, schedule development, and quality standards, assuming a guiding, regulatory, and restraining role. According to Cui Fengli, the application of risk management can lead to a reduction in economic losses within the project's operational plan, gradually achieving the dual objectives of cost minimization and benefit maximization in construction projects [38].

Liu Li underscores the comprehensive implementation of bidding work in construction projects, emphasizing its pivotal role in influencing construction progress in later project stages. In severe cases, neglecting bidding work can even result in work suspension [39]. Therefore, integrating risk management into the bidding process and formulating countermeasures for construction project risks stand as indispensable components of successful project management. This entails commencing an assessment of potential risks linked to bidding and tendering, scrutinizing the risks in bidding, bid opening, bid evaluation, bid award, and contract performance. The risk management process in bidding covers business management, internal

management, and supervision and management, with the goal of offering a comprehensive analysis and proposing countermeasures.

1) Functional theory of the concept of bidding

Fu Yu asserts that bidding serves as a market transaction, promoting open market activities for goods and engineering contracting. It is a manifestation of market economy development, fostering fair competition and allocating rights, obligations, and responsibilities reasonably among bidding parties [24]. Open tendering and invitational tendering are the two main methods, each contributing to the selection of suppliers and contractors but differing in their procedures.

Both methods require detailed solicitation documents, including bidding requirements, technical specifications, method of quotation, and criteria for bid evaluation. Suppliers or contractors prepare and submit bids to the purchaser, who evaluates them and selects suitable partners for cooperation. These bidding methods significantly enhance project transparency, reducing costs and improving efficiency. The three types of tendering methods are open, invited, and negotiated, with the aim of achieving quality pairing of price and construction while maintaining project quality [24]. Bidding exhibits characteristics of risk, policy, technology, continuity, and dynamics, where bidding risks directly impact projects.

2) Bidding risk analysis

Wang Ruinian asserts that bidding, when influenced by market turbulence, economic policy adjustments, and changes in management concepts, can detrimentally impact the overall benefits of a construction project. Additionally, it may affect the project's quality and deviate from the initially estimated standards [40]. This highlights the critical role of risk management for bidding companies as a scientific safeguard to ensure seamless.

3) Bid opening, bid evaluation, and bid winning risk analysis

In the bidding process, potential risks emerge during bid opening, evaluation, and the awarding of bids. Major and minor deviations, often caused by staff errors, pose significant risks. Major deviations may include bid guarantee defects, omission of authorized representative signatures, non-compliance with technical standards, extension of bid completion deadlines, and inadequate inspection standards. Minor deviations involve omissions or missing data in files. The bid evaluation committee is susceptible to unfair practices such as corruption, bribery, subjective evaluation, biased bidding, and improper competitive behaviors. Unfair actions can impact bid opening fairness. Instances of missing bidding documents or bribery can lead to significant deviations in bid quotations, affecting final evaluation results. Corporate dishonesty, like false quotations and delayed delivery, may occur during the bidding process. Financial problems can lead to a broken capital chain for the winning company, hindering project completion. Similarly, financial issues mid-project can halt work due to the inability to pay for materials and labor, resulting in extended construction periods and substantial economic losses.

4) Signing and performance risk analysis

Teng Rongqian contends that considering the macro-environment, the business conduct in the construction market mirrors the characteristics of futures trading, where contracts are signed before organizing production. Construction companies encounter the task of fulfilling diverse contract criteria, encompassing construction period, quality, safety, and cost. Various challenges may emerge during contract execution, including unforeseen risks. Especially in the case of extensive large-scale

projects with stringent timelines, elevated quality standards, distinctive structures, varied shapes, and other specialized needs, heightened risk factors frequently affect project performance capabilities [19]. The execution of a construction project entails meeting the stipulations of the agreement, with both parties upholding their rights and obligations as specified in the contract. Risk management in contract signing and performance has direct or indirect implications on construction schedules, costs, workforce deployment, subcontracting, project planning, technical support, and more. This underscores the essential nature of conducting risk analysis during the bidding process for contract signing and performance.

The goal of managing project bidding risks is to recognize, assess, and regulate potential risks linked to bidding, along with developing appropriate response strategies. Yin Xueqin recommends that, for enhanced risk control in construction project bidding, bidders should carefully consider their specific requirements and characteristics while establishing evaluation standards and choosing methods [41]. Paul Erikson and Don Howard emphasize the evaluation and management of risks during the bidding process to ensure project success [42]. Kenneth K. Humphreys proposes synchronizing the bidding process with other project activities for optimal performance [43].

Therefore, creating comprehensive response strategies for risks related to technology, law, finance, and the market involves crafting an inclusive bidding risk list. The utilization of probabilities and engineering impacts enables both qualitative and quantitative assessments of potential bidding risks. Tools such as risk matrices and risk indexes can be applied to prioritize and manage project bidding risks effectively. A thorough technical evaluation of the

bidding company during project bidding, scrutinizing the feasibility of the bidder's construction technology and the company's dependency relationships, is imperative. The establishment of backup technologies and suppliers contributes to mitigating project risks. Bidding risk management plays a pivotal role in ensuring the fairness, transparency, and effectiveness of the bidding process [44].

From the contractor's perspective, various research initiatives concentrate on bidding strategy models, particularly Bid/No-Bid and Mark-Up decisions. For example, Friedman [45] introduced the pioneering bidding strategy model addressing mark-up decision-making, representing an innovative approach at the time. Subsequently, numerous scholars introduced creative models for mark-up decision-making [46-48]. Researchers also explored Bid/No-Bid decision modeling, with Wanous et al. [49] and Dias and Weerasinghe [50] presenting novel models employing the artificial neural network (ANN) technique, a subset of artificial intelligence (AI). Ahmad [51] and Baggies and Fortune [52] conducted analogous studies. Lin and Chen's [53] significant research introduced the Bid/No-Bid decision as a pivotal contractor action, proposing a fuzzy linguistic approach for a more efficient decision-making process.

Risk control plays a vital role in enhancing the scientific and systemic aspects of the project [54]. In the context of a comprehensive construction project, considering both engineering and project management perspectives, the control of bidding risks is imperative and should not be underestimated. The effectiveness of bidding risk control in construction projects is intricately linked to the quality and progress of the project, ensuring seamless

project advancement through rigorous standardization of promotional procedures.

III. APPLYING BIM TECHNOLOGY IN PROJECT BIDDING MANAGEMENT

Bidding is a pivotal phase in construction projects, serving as a crucial factor for owners in selecting the optimal construction plan and optimizing project costs. For construction corporations, it represents a vital opportunity to showcase their construction technology, thereby enhancing their chances of winning bids. A fair, just, and open bidding process fosters competition, promotes the development of the construction industry, and advances construction technology. However, due to the compact timeline of bidding project construction, the workload is substantial, potentially resulting in substandard quality [55-56].

The preparation stage of bidding projects is relatively short, and manual calculations of the bill of quantities become complex, making it challenging to ensure accuracy. To address these issues, modern technology management should be introduced. Building Information Modeling (BIM) technology has become crucial in bidding management, garnering attention globally. Governments worldwide have introduced policies mandating the application of BIM technology in the bidding process, signifying its importance for technological development [57].

Compared to traditional graphic design, BIM technology better expresses designs, facilitating a more accurate understanding of construction drawings. Through 3D modeling, architectural design functions are analyzed, forming the basis for comprehensive design optimization. BIM technology, integrated into bidding management, allows for effective control of project costs, stages, and overall processes. It enhances operational and management work, addressing construction bidding challenges and playing a vital role in quantity bill calculations. BIM's application comprehensively improves bidding rationality and management levels, significantly impacting the future of bidding management [58-59].

In the context of smart building projects, accurate engineering information collection during the bidding phase is crucial for determining engineering cost quality. BIM technology accelerates the determination of cost indices, aiding in the efficient development of accurate investment budgets. By building a virtual model through BIM, relevant information can be extracted to evaluate project investment feasibility. Integration of project cost and financial parameters allows for the evaluation of investment program benefits, making construction projects more economical and improving the effectiveness of project bidding management [60].

With the continuous improvement of information levels across industries, the construction industry is increasingly applying informatization methods to enhance management and economic performance. BIM, as a carrier of project information, spans all construction process stages, supporting project understanding, reducing errors, and aiding decision-making. The practical significance of BIM lies in its ability to apply data for multiple purposes, serving as a foundation for investment assessment, bill of quantities, bidding, contract signing, estimation, and budget audits. Despite the challenges in integrating BIM into traditional project bidding management processes, its application is expected to grow, offering valuable contributions to the construction industry's development [61-62].

The study seeks to leverage advanced technologies, specifically employing machine learning (ML) algorithms and analysis methods, to conduct man-hour estimates in BIM projects during the bidding stage. Machine learning, a subset of artificial intelligence (AI), is dedicated to constructing systems that learn from the data they process. This investigation will specifically apply regression analysis within the Supervised Learning category of ML to scrutinize man-hour estimates for BIM projects during the bidding stage. The ultimate goal is to improve accuracy and efficiency in project estimation [63].

In the domain of statistical modeling, regression analysis comprises a collection of statistical techniques utilized to estimate the relationships between a dependent variable (commonly referred to as the 'outcome' or 'response' variable, or a 'label' in machine learning) and one or more independent variables (referred to as 'predictors,' 'covariates,' 'explanatory variables,' or 'features'). Linear regression, the most prevalent form of regression analysis, entails identifying the line (or a more intricate linear combination) that best aligns with the data based on a specific mathematical criterion. The various types of regression analysis are summarized in Table I [64].

TYPES OF REGRESSION ANALYSIS TECHNIQUES [64]

Number	Types of Regression Analysis Techniques
1	Linear Regression
2	Logistic Regression
3	Polynomial Regression
4	Quantile Regression
5	Ridge Regression
6	Lasso Regression
7	Elastic Net Regression
8	Principal Components Regression (PCR)
9	Partial Least Squares (PLS) Regression
10	Support Vector Regression
11	Ordinal Regression
12	Poisson Regression
13	Negative Binomial Regression
14	Quasi Poisson Regression
15	Cox Regression
16	Tobit Regression

This study does not encompass all types of analysis. To outline the research, the initial phase involved soliciting information for man-hour analysis from entities and individuals experienced in BIM projects. The outcome of this effort was the compilation of project information from 16 completed projects. Subsequently, in Section 2, the gathered information was transformed into a dataset and processed through regression analysis algorithms using Jupyter Notebook (Python format). Within the algorithm, the dataset, now in matrix form, underwent an internal analysis, evaluating the consistency of parameters. In the third section of the study, man-hour estimates were conducted and graphically presented across various parameters using the linear regression algorithm.
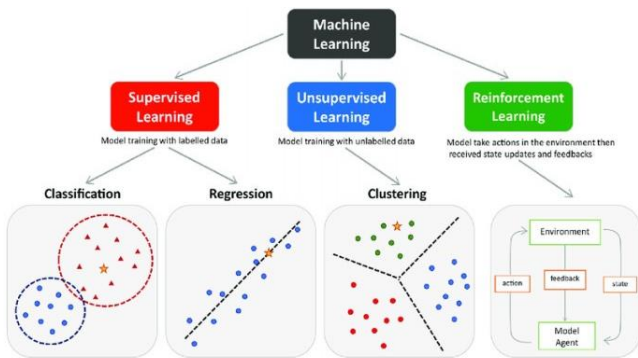

FIG.1 TYPES OF MACHINE LEARNING [64]

TABLE I

Scholarly works in building project management have traditionally emphasized conventional methods. The recent introduction of BIM has revolutionized global work practices, influencing the evolution of project management styles and systems. Planning and proposal bidding are crucial stages in project development, involving accurate cost estimation and man-hour assessment. While numerous studies exist on manpower analysis, there is a notable scarcity of research focusing on man-hour analysis for BIM projects. The recent integration of AI apps and machine learning in such studies holds promise for more efficient estimates and mitigating errors. Regression analyses, including simple and multiple linear regression, were employed in this study to explore machine learning applications. Privacy regulations hindered extensive data collection, but realistic results were obtained from current projects. The study concludes that leveraging AI tools in research significantly enhances operational efficiency.

IV. DISCUSSION

Project Bidding Management plays a crucial role in the successful execution of projects. One of the primary objectives of project bidding management is to strategically plan and organize the bidding process. This involves assessing project requirements, defining scope, and determining the optimal approach for successful project completion. A well-structured bidding management process ensures that organizations align their resources and capabilities with the project's demands, leading to a more efficient and cost-effective execution. Accurate cost estimation is a critical component of project bidding management. Through meticulous analysis of project requirements, organizations can develop realistic budget proposals that consider all relevant factors, including materials, labor, and overhead costs. A well-structured budget not only attracts potential clients but also ensures that the project remains financially viable throughout its lifecycle.

Bidding management allows for a thorough evaluation of potential risks associated with a project. By conducting a comprehensive risk assessment during the bidding phase, organizations can develop effective risk mitigation strategies. Identifying and addressing potential challenges early in the process enhances the likelihood of project success and prevents unexpected setbacks during project execution. Effective bidding management provides organizations with a competitive edge in the marketplace. By understanding client needs and tailoring bids accordingly, companies can differentiate themselves from competitors. Utilizing innovative solutions and demonstrating a deep understanding of project intricacies can elevate a bid, increasing the likelihood of winning contracts and fostering long-term client relationships. Project bidding management necessitates strong communication and collaboration among internal teams. Departments such as sales, finance, and project management must work cohesively to develop a bid that meets client expectations and aligns with the organization's capabilities. Open communication channels facilitate the exchange of critical information, ensuring that all stakeholders are on the same page throughout the bidding process.

The integration of technology in project bidding management has become increasingly important. Advanced software tools and platforms streamline the bidding process, making it more efficient and reducing the likelihood of errors. The application of BIM technology in Project Bidding Management represents a significant advancement that can revolutionize the construction industry. BIM supports the entire project lifecycle, from

conceptualization to facility management. This continuity ensures that the information generated during the bidding phase is seamlessly transferred to subsequent project stages. The integration of BIM in project bidding management establishes a foundation for a more streamlined and efficient project delivery process, ultimately leading to better project outcomes and client satisfaction. Organizations that embrace BIM in project bidding management gain a competitive advantage by showcasing their technological capabilities and commitment to innovation. Bidders who leverage BIM technology are better positioned to stand out in a competitive market, attracting clients who prioritize advanced project management practices. The application of BIM technology in Project Bidding Management brings transformative benefits by improving collaboration, visualization, and accuracy in the bidding process. As the construction industry continues to embrace digital innovation, integrating BIM into bidding management practices is becoming a key differentiator for successful and forward-thinking organizations.

Project Bidding Management is a multifaceted process that goes beyond the mere submission of proposals. It involves strategic planning, risk assessment, cost estimation, and effective communication. Organizations that prioritize and excel in bidding management are better positioned to secure projects, optimize resources, and achieve long-term success in a competitive business environment.

V. CONCLUSIONS AND RECOMMENDATIONS

Project Bidding Management stands as a strategic imperative for organizations aiming for project success. The integration of technology, observed in modern bidding management, enhances efficiency by automating tasks and reducing errors. Organizations that leverage technology effectively can streamline processes, allowing for a more focused and strategic decision-making approach.

Organizations should invest in robust technological infrastructure, including advanced software tools and platforms, to streamline bidding processes. Automation can significantly reduce the time and effort required for tasks such as document generation and data analysis. Training programs focusing on risk management should be prioritized for project bidding teams. Equip team members with the skills to identify, assess, and mitigate risks effectively, fostering a proactive approach to project challenges. Organizations should prioritize enhancing collaboration among different departments involved in the bidding process, such as sales, finance, and project management. This ensures a cohesive and well-informed approach, improving the overall quality of bids. Bidding teams should stay abreast of industry trends, market dynamics, and regulatory changes. Regular training sessions and knowledge-sharing forums can help teams adapt to evolving industry standards and enhance the competitiveness of their bids. Given the increasing importance of sustainability in project execution, organizations should integrate environmental and social considerations into their bidding strategies. Demonstrating a commitment to sustainable practices can enhance the appeal of bids to environmentally conscious clients.

BIM should be integrated seamlessly into the organization's standard operating procedures. The exploration of the application of BIM technology in Project Bidding Management reveals a transformative potential for the construction industry. BIM can be utilized to analyze and

optimize sustainable design elements, aligning bids with the growing emphasis on environmentally conscious construction practices. The application of BIM technology in Project Bidding Management introduces a paradigm shift in the construction industry. The transformative potential of BIM needs to be highlighted, while the recommendations provide a roadmap for organizations to harness this technology effectively, ensuring a competitive edge and successful project outcomes.

Project Bidding Management is a dynamic and multifaceted process that requires strategic planning, effective communication, and technological integration. Organizations that embrace these principles, along with the recommended strategies, are better positioned to navigate the complexities of project bidding, secure contracts, and achieve long-term success in the competitive business landscape.

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