Game Theory Based Novel Integrated Decision Support System for Cost Analysis

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Abstract

Project-based industries have significant difficulties maintaining project costs under control and completing on budget. Effective cash flow management by businesses is an essential part of improved financial performance. For a business to persistence, effective cash flow management is essential. Considering the various financial risks and payment-related problems that exist in a wide range of worldwide organizations, effective cost analysis has become essential for projects and stakeholders. A particular stakeholder's perspective has been used to primarily analyze cash flow and payments in previous studies, this resulted in an imbalanced culture of cost analysis management, which is made asymmetry by the power imbalance in the process of making top-down payment decisions. To solve these issues, in this analysis, Game theory based novel Integrated Decision Support System for cost analysis is presented. The framework is made up of many modules for decision support, Earned Value Management (EVM), data collecting, payment simulation, analysis, and negotiation. It combines game theory, data envelopment analysis, and agent-based simulation to provide the forces of parties in payment discussions and to offer a multi-level analysis of project performance. Using the EVM, project managers show the ability to evaluate a project's current state, predict its future development, and make informed decisions that ensure projects. Cost growth, schedule growth, accuracy, flexibility, and efficiency are the parameters are used to evaluate this system's performance. This model will achieve better performance for effective project cost analysis

Keywords: Firms, Cost Analysis, Cash flow management, Payments, Earned Value Management and Game theory.

1. Introduction

A project is a planned work effort that might be small, medium, or large, with an aim of providing services to a group of people and achieving a specific goal. In an effort to complete a project successfully, many factors and considerations must be taken into consideration. When a project follows to the established standards, produces a high-quality end product or service, completed on time and within budget, it is considered to have done well [1]. Global economic disturbances have increasing concerns about high inflation, rising interest rates, supply chain disruptions, volatile energy prices, and labor shortages. Given the complicated and dynamic nature of the industry, considering that stakeholders (owners, contractors, and subcontractors) continue to face inefficiencies, cash flow problems, and difficult payment terms) frequently encounter, these situations can be difficult to work [2].

The implementation of sustainable projects may be affected by financial issues carried on poor cash flow management, an insufficient of financing and by economic instability. The most important resource for maintaining effective everyday activities is cash. Cash shortages during project development cause delays, penalties, and lost opportunities; these results such as financial standing of the organizations and projects as a direct reflection of project failure and business bankruptcy. In order to detect any financial issues and successfully complete high-performing projects, construction businesses must practice effective cash management [3]. Project managers can better predict, allocate, and control the project's costs with the support of cost analysis. It involves determining out and measuring all costs related to the projects, such as the labor, overhead, contingencies, equipment, and materials. Comparing actual costs to planned or budgeted costs and identifying any variations or variances that can have an impact on project performance is further benefits of cost analysis [4].

A cost-benefit analysis is a method used to evaluate the advantages of a decision or action minus the expenses involved. Measurable financial parameters, such as cash generated or costs avoided, are considered by a cost benefit analysis when deciding whether to proceed with a project [5]. The practice of timely and efficient payment is an essential factor to projects being completed successfully. Unfortunately, the complicated and lengthy payment procedure is a common cause of concern worldwide due to the dynamic nature of building projects and the number of stakeholders involved. Payment issues that frequently include underpayment, nonpayment, or delayed payment have been certified. This issue may be caused by disagreements over the way work is completed, insufficient documentation, funding problems, or additional significant variables. Furthermore, because of the adversarial connection and uneven power distribution among stakeholders, upper-tier stakeholders may establish unfair contractual payment conditions for their own financial benefit and interest [6].
Poor payment processes have negative effects that extend down the construction payment chain, affecting investment, employment, productivity, project performance, and stakeholder financial stability. The management of cash flow and forecasting techniques have been extensively studied in previous. However, in a decision-making process, they often included the analysis results, concentrating primarily on the cash flow analysis component from the perspective of a particular stakeholder [7].

For this purpose, a possible method is game theory. Situations involving strategic decision-making when multiple people's interests meet can be modeled and simplified into as games [8]. Economic game theory has been an important tool in this study. These games are especially useful for gaining insight into the way people behave when their own interests are at play [9]. One can take into consideration the performers varying levels of actors. Game theory's main objective is to use these models to produce action suggestions for all parties involved, or the players, in order to support decision-making in difficult situations [10].

A structured framework for mathematically describing and representing multiple-agent decision problems is provided by game theory. This theory offers a framework for analyzing various agents' strategies and identifying the best choices they can make [11]. But game theory can also be used to predict behavior and explain events that are observed. As a result, cost analysis and game theory have similar objectives. Cost analysis provides purchasers with practical recommendations cost estimates and evaluations to help in their decision-making [12]. Establishing precise data collection procedures, creating strategies to measure intangible benefits, and project managers should prioritize eliminating any biases in the decision-making process, decision-makers, and stakeholders [13]. This research aims to create a cost

management and decision support framework for various stakeholders, including owners, contractors, and subcontractors, in projects. In this analysis, Game theory based novel Integrated Decision Support System for cost analysis is presented. The work is set up in the following manner: In Section II, the literature Survey is described. In section III, presents Game theory based novel Integrated Decision Support System for cost analysis. In section IV, the results and discussion are discussed. The conclusion represents the end of section V.

2. Literature Survey

V., Stehel, T., Kliestik, M., Vochozka and V Bakes, et. al., [14] explains the use of game theory to the economic analysis of the Vendor Management Inventory (VMI) model. The matrix is examined in the first phase from the perspective of the game's meaning and its limit parameters. The economic realities are taken into consideration when setting the limit parameters. The results that are produced can be applied to practical management, enabling managers to determine the true costs and probability of system introduction. At the same time, they are able to determine which factors are susceptible to their influence and track the effect of those parameters on the shift in the probability of the system introduction.

Q. Tong and D. Zhou et. al., [15] discusses research on using cooperative game theory to allocate transmission fixed costs. In this paper, different cooperative game models, game algorithms, and their transmission fixed cost allocation properties were thoroughly examined. It first analyzing traditional cost allocation methods and then carefully explaining the advantages of allocating transmission fixed costs through a cooperative game algorithm.

Pasquale Lucio Scandizzo et. al., [16] explains A unified approach to impact and cost-benefit analysis. The approach for combining effect evaluation based on social accounting matrix-computable general equilibrium (SAM-CGE) and cost-benefit analysis is presented in this research. There is growing agreement, since their economic evaluation, the two methods of analysis which have developed concurrently and without a clear connection should be combined for complex investment projects.

P. Vaidehi Nirmal, W. Nitin Ingole, B. Ashish Ugale et. al., [17] discusses cash-flow management in construction projects involving buildings. To show the cash flow and outflow in a construction company as the profit at the project's conclusion, a sample cash flow was also created. Additionally, the main sources of capital loans were determined. A set of questionnaires was created in order to determine the factors listed above. A total of fifty-six contractor replies were gathered, from which the expected results and conclusions were obtained. According to the questionnaire's results, most contractors who encountered problems with their annually project contracts did not do cash flow analysis before submitting bids for projects, which can be attributed to poor cash flow management and forecasting.

Premi L., Massari G., Reghenzani F., and Fornaciari W. et. al., [18] Describes Work-in-Progress: An Approach to Heterogeneous Resource Management Based on Game Theory. In order to distribute heterogeneous resources among applications with an emphasis on performance, power, and energy requirements, a game theory approach was provided. A cost function has been created and the game congestion model has been chosen. An initial experimental evaluation is then conducted to evaluate the suggested allocation technique.

H. Zhang, J. Han, J. Zhang and J. Wang et. al., [19] Using game theory for information system security, the paper offers a Security risk evaluation model based on the complete information

static game (SRE-CSG). The approach is able to compute the payoff more accurately since it considers both the cost and benefit factors. A security risk value evaluation technique is developed by examining the information security game's Nash equilibrium approach. Based on the equilibrium approach of attackers and defenders, the algorithm and SRE-CSG model theoretically offer effective information systems security protection. The model and algorithm's effectiveness are demonstrated by the analysis.

L., Zhao, J. I. C., Mbachu and N Domingo, et. al., [20] explains an improved modeling and evaluation of the key factors affecting the cost performance of building projects: New Zealand's Case. This study aims to identify, evaluate, and analyze the impact of the influencing elements on a project's cost. A survey using questionnaires was conducted with a particular group of developers and clients. Techniques for structural equation modeling were used to examine the information gathered. The results indicate that the building project costs are significantly affected by four constructs: the external economic environment, building and construction regulations, market conditions, and the influence of key stakeholders. To ensure the success of the project, these factors in a cost management scenario should be properly monitored and controlled.

Qian, Xiaoduo, Liu, Wei, and Yang, Jiaquan et. al., [21] discusses the use of game theory to the analysis of supply chain pricing and adoption timing in the context of asymmetric Nash equilibrium. This strategy developed a supply chain with two manufacturing enterprises and one technology supplier. The provider gives enterprises access to enhanced versions of a certain type of industrial technology can make products. The system looks at each business should purchase an improved version of production machinery and compares the costs of two different product types, and decides whether or not to purchase this type of production technology. These results demonstrate that the asymmetric Nash Equilbrium can help avoid the technology investment prisoner's dilemma while maximizing the goals of the social welfare system, which consists of consumers and technology-supplying manufacturing enterprises.

3. Integrated Decision Support System for Cost Analysis

In this analysis, game theory based novel integrated decision support system for cost analysis is presented. Figure 1 displays the block diagram for the method is provided. This system includes different modules like Data Acquisition, Earned Value Management, Payment simulation and Payment Negotiation.

The information gathered from various sources to capture the details of the project under study is represented by the data acquisition module. The foundation's first module, the data acquisition module, serves as the source of input data for a number of different areas of the construction payment system, such as project specifics, cost and schedule information, performance indicators and progress data, payment agreements and legislation, contract specifics, and stakeholder financials. According to the project stage, the type, availability, sources, collection technique, and usage of the input data may change.

A wide range of data sources and types divide into several categories, such as project documentation and communications, work progress data gathered by various reality capture techniques, and work-related data tracked by an as-planned BIM (Building Information Modeling) model.

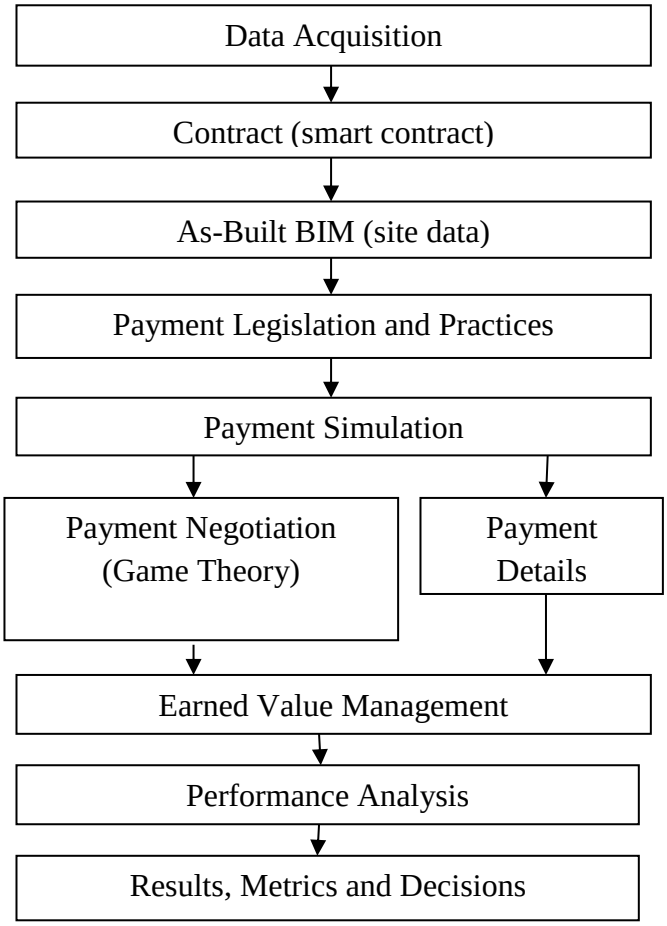

Figure 1. Block Diagram of Game theory based novel Integrated Decision Support System

Using the information gathered from the data gathering module, the sub-module focused to payment simulation models and simulates the project, concentrating on stakeholder interactions, payment agreements, and the cash flow process while the project is being implemented. The goal of the payment simulation and negotiation module is to integrate game theory, Data Envelop Analysis (DEA), and financial transaction analysis and payment arrangement analysis using Agent-Based Modeling and Simulation (ABMS).

Primary and secondary agents made up the project's division in the suggested simulation model. Throughout the payment procedure, the primary agents represent for the project work items and important stakeholders. The primary agent types stakeholders possess characteristics that are representative of the payment process, such as maximum overdraft, profits, interest rates, advance payments, quantities received and paid, retention, and so on. The information provided show the financial standing of the parties involved any payment procedure bottlenecks. The suggested framework for evaluating each key agent's or stakeholder's efficiency under the examined payment and financing policies scenarios includes DEA.

The characteristics of each secondary agents include the submission and due dates, the work items contained, the amount of money is required interest costs for delays, etc. This makes it easier to decide the amount to pay for each application individually rather than implementing

set choices for everyone. Modeling building projects are the parties involved under different payment policies and conditions is made possible by the ABMS component. Subsequently, the efficiency levels and stakeholder payoffs under the studied strategies are calculated using the DEA analysis component. To achieve a symmetric and balanced payment choice, the game theory component is also used to represent stakeholder payment negotiations.

As mathematical models that represent strategic situations involving several decision-making entities, or players, have been developed, game theory provides an integrated method by allowing individuals to communicate and choose an approach of action based on their individual and rational abilities to make decisions, so that each entity's choice affects the results of the other parties. A key concept of game theory is rationality, which holds that players are aware of their options and choose the ones that would maximize their payoffs. Understanding player interactions and predicting their results while taking into consideration their unique behaviors and goals is made easier by analyzing and solving games.

The participants in the strategic problem, their plans, and the payoffs they have earned, and the rules unique to the game are the essential elements of a game model. A game-frame in strategic form is a list of four items$< I, (S_1, S_2, \dots., S_n), O, f >$ where:

$I = 1,2, \dots, n$ is a set of players$(n \geq 2)$. $(S_1, S_2, \dots., S_n)$ is a list of sets, one for each player? The set of strategies of player i for each player$i \in I$ is denoted by S_i. The collection of strategy profiles These sets Cartesian product indicates S: As a result, a list with the elements $S = S_1, S_2, \dots., S_n$, constitutes one element of S. So, s = (s_i, s_{-i}) can be used to write a strategy profile s. A collection of player outcomes are represented by O, where πi stands for player i's payoffs. f: A function known as $f: S \to O$ links a result $f(s) \in O$ to each strategy profile s.

Using the Earned value management (EVM) methodology, which is an objective framework to evaluate project performance project costs and schedules, is the most popular approach to cost analysis estimates at completion (EAC). The Earned value (EV), Planned value (PV), and Actual cost (AC) are the project costs that form the basis of the method is are used as a proxy to monitor the performance and progress of the activities. As a result, the EVM may be applied to any type of project. The equation (1) defines the forecast of Estimates at Completion (EAC) as follows:

$$\text{fEAC} = \left[\text{AC} + \frac{1-\text{WP}}{\text{CPI}}\right] / \text{BAC} \quad (1)$$

In this case, AC denotes the actual cost in Time Period (TP) with a value range of 0 to rEAC, normalized by BAC (Budget at Completion). The CPI means Cost Performance Indexes. This project completion cost normalized by BAC is referred to as rEAC.

Managers can evaluate how much value is achieved in comparison to the planned value and if the project is on time or behind by using the Earned Value. Strong cost control techniques are provided through earned value analysis. Through the process of comparing the Planned Budget (PV) with the Actual Costs (AC) and discovering variances in costs, project managers may efficiently monitor and control the project's costs. This helps in cost overruns and controlling expenses. The EVM offers several advantages for cost control, including monitoring performance and progress against the baseline, evaluating the effectiveness of resources used, projecting completion and cost data, and informing stakeholders of the situation and results. The EVM provides invaluable insight on schedule management, cost containment, and project

success. Project managers may evaluate their work, predict future performance, and make well-informed decisions to maintain projects on track by using EVM, which integrates project scope, schedule, and cost data.

By using the results of payment simulation and negotiation to modify payment arrangements are offer suggestions for better performance, the EVM ultimately establishes the foundation for decision-making and support. A data-oriented, non-parametric programming technique called Data envelope analysis, or DEA is used to compare the effectiveness of a group of entities, or Decision-making units (DMUs), that take in many inputs and provide different outputs. Equation (2) states that a DMU's efficiency was the weighted sum of its inputs divided by the weighted sum of its outputs.

$$\text{Efficiency} = \frac{\text{Weighted sum of outputs}}{\text{Weighted sum of inputs}} \tag{2}$$

As a result, the goal of efficiency is to maximize results while minimizing the use of input resources. Typically, the goal of DEA is to evaluate each DMU under study to determine its level of efficiency, identify possible inefficiencies, and calculate the relative efficiency of each DMU. The DMUs can any number of entities, supporting a wide application of DEA.

Efficiency, flexibility, schedule growth, and cost growth are the parameters used to evaluate this system's performance. The cost growth is expressed as in equation (3):

$$\text{cost growth}(\%) = \frac{\text{final project cost} - \text{initial PMB budget}}{\text{initial PMB budget}} \tag{3}$$

Where, PMB is Performance measurement baseline budget. The schedule growth is expressed as in equation (4) as follows:

$$\text{schedule growth}(\%) = \frac{\text{final project duration} - \text{initial baseline duration}}{\text{initial baseline duration}} \times 100 \tag{4}$$

The accuracy parameter is used to evaluate how accurately this system takes the decisions as per the project situations.

4. Result Analysis

In this analysis, Game theory based novel integrated decision support system for cost analysis is presented. The results and discussion of presented model are discussed here. This system's performance is evaluated in terms of efficiency, accuracy, flexibility, cost growth, and schedule growth. The performance of schedule growth and cost growth is displayed in Table 1.

Table 1. Statistics comparison

Metrics/statistics	Mean	Median	Standard deviation
Cost growth (%)	+60.1	+13.5	125.6
Schedule growth (%)	+20.2	+2.4	48.4

From the results, it is clear that this approach has improved cost growth and schedule growth. Through changing important model parameters, each stakeholder will be able to reproduce cash flow situations under different financing and payment scenarios, enabling them to evaluate that different contract conditions may impact project cash flows and weight their advantages and disadvantages.

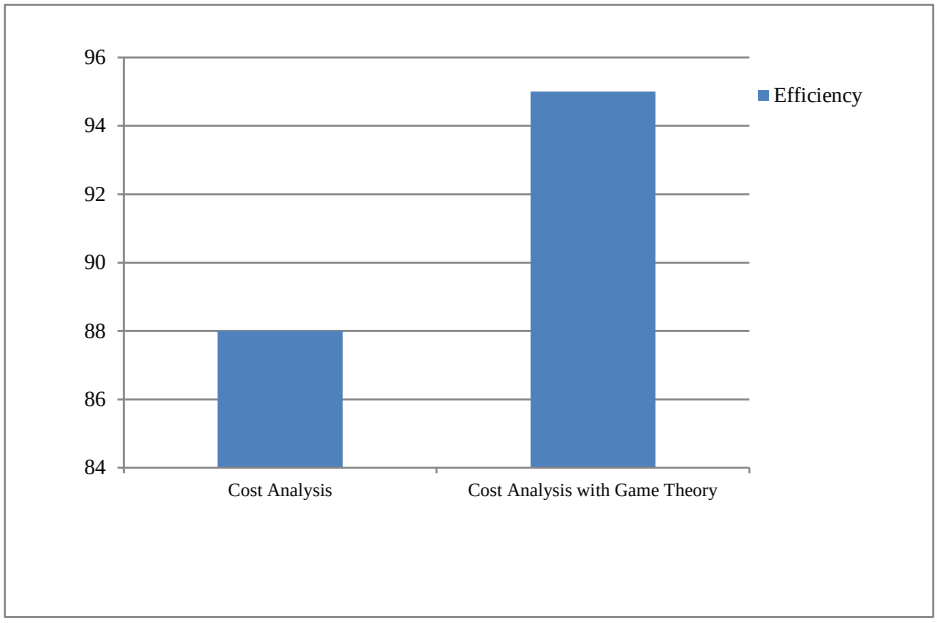

Figure 2. Efficiency Comparison

In order to demonstrate the flexibility and efficiency of the suggested framework, it was implemented under numerous situations concerning the interest rate, advance payment, work productivity, payment cycle status. The Figure 2 shows the efficiency performance comparison.

Compared to Normal Cost Analysis model, cost analysis with Game theory has better efficiency. The Figure 3 shows flexibility comparison.

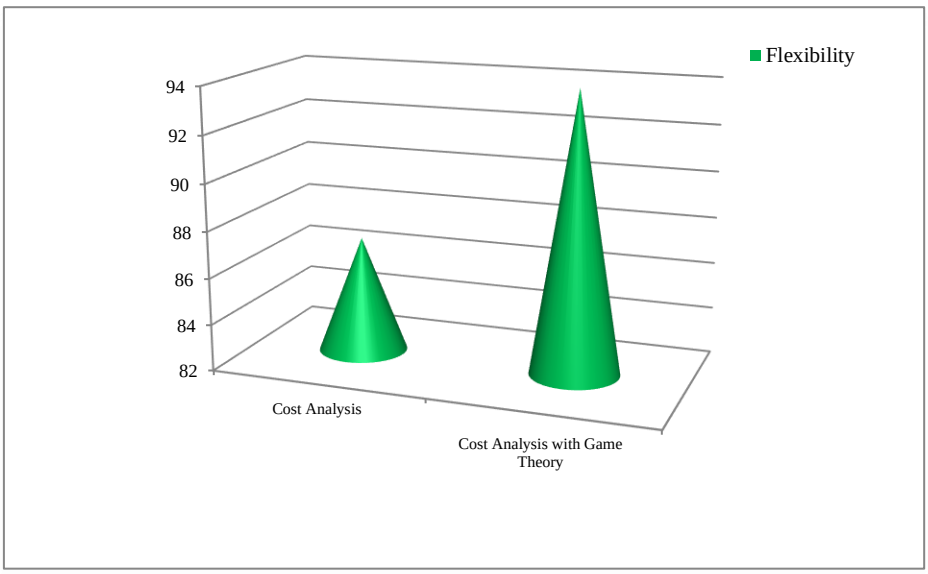

Figure 3. Flexibility Comparison

Presented cots analysis with Game theory has better flexibility than normal cost analysis model. The Figure 4 shows the Accuracy Comparative Graph.

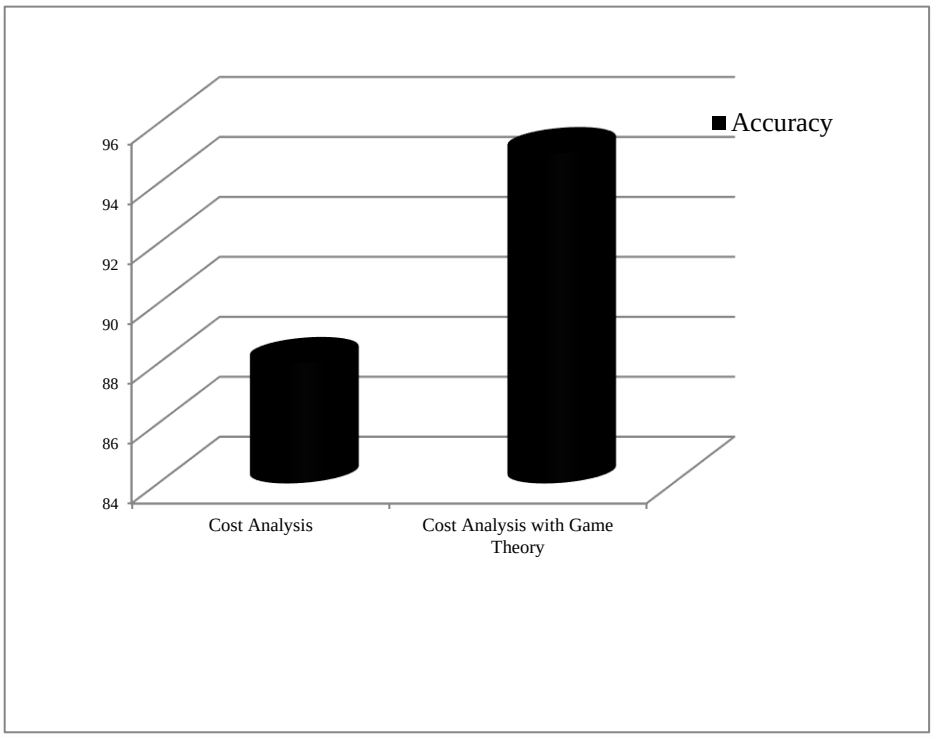

Figure 4. Accuracy Comparison

Compared to general cost analysis model, presented cost analysis model with game theory has shown better accuracy for making accurate decisions as per the project requirement and cost analysis. The results showed that a culture of trust, honesty, transparency, communication, and shared values, along with contractor support for EVM, contractor experience, and contractor qualification in EVM, are the three most critical features. Additionally, by supporting stakeholders in identifying the essential and highly significant environment components of EVMS, this research improves the project's performance.

The chosen work items and agents, which can be used for specific activities, work packages, or milestones, can be seen as reflections of this model. For example, the framework for the analysis and simulation can be used by the owner and subcontractors to examine possible approaches and expected outcomes. The processes of analysis, negotiation, governmental and legislative bodies, research groups, and contractors can all profit from simulations that are necessary for decision-making. This technique can be applied by a wide range of target users, based on their requirements and perspectives regarding the payment process, such as the owner, contractor, subcontractor, governmental/legislative groups, and research entities.

5. Conclusion

In this analysis, Game theory based novel Integrated Decision Support System for cost analysis is presented. The systems offered an integrated and adaptive decision support framework that combines game theory, data envelopment analysis, simulation for managing and simulating construction cash flow payment arrangements during planning and execution, as discrete event

and agent-based modeling and simulation. Under various payment arrangements, finance policies, negotiation techniques, project is external circumstances, the framework structure makes it easier to analyze performance at several levels for projects, stakeholders, work items, and resources. The technique of measuring project physical, financial, and time progress known as Earned Value Management (EVM) shows projected and actual performance, and estimates of the project's ultimate cost and duration. The framework structure allows for a quantitative analysis of cash flow and payment process by ensuring individual representation of all stakeholders involved. Efficiency, accuracy, flexibility, increase in schedule, and cost are all considered while evaluating the performance of the system that is being provided. Compared to previous cost analysis models, presented model has shown significant performance.

References

1. Bichang'a, L. C., & Kimutai, G, "Project Cost Control Techniques and Performance of Water Projects in Kericho County, Kenya," vol. 10, no.4, pp 569 – 592, doi: 10.61426/sjbcm. v10i4.2776
2. Dorrah, Dalia H., and Brenda McCabe, "Integrated Agent-Based Simulation and Game Theory Decision Support Framework for Cash Flow and Payment Management in Construction Projects," Sustainability, vol. 16, no. 1, pp. 1-25, 2024, doi:10.3390/su16010244
3. Yoon, Jong Han, and Pardis Pishdad-Bozorgi, "Game Theory-Based Framework for Analyzing the Collaborative Dynamic of Tacit Knowledge Sharing and the Choice of Procurement and Contract Types in Mega Construction Projects," Buildings, vol. 12, no. 3, pp. 1-20, 2022, doi:10.3390/buildings12030305
4. Ruhago GM, Kapologwe NA, Ngalesoni FN, Kengia JT, Kibusi SM, Kalolo A, Kitali EJ, Mtatifikolo JD, Masuha SR, Kikula A and Mtei G, "Cost-Efficiency Analysis of the Improved Web-Based Planning, Budgeting, and Reporting System (PlanRep) in Tanzania," Front. Health Serv. vol. 1, no. 787894, pp. 1-8, 2021, doi: 10.3389/frhs.2021.787894
5. Laghari F, Ahmed F, Lo´pez Garcı´a MdlN, "Cash flow management and its effect on firm performance: Empirical evidence on nonfinancial firms of China," PLoS ONE, vol. 18, no. 6, pp. 1-26, 2023, doi: 10.1371/journal.pone.0287135
6. Avinash T. Shingar, Omkar S, Nigade, Varsha N. Nagtilak, Anand C. Nagarale, Divya S. Ovhal, "The Study and Analysis of Cash-Flow on Project Cash Finance," 2023 IJCRT, vol. 11, no. 5, pp. 1780-1785, May 2023, doi: https://ijcrt.org/papers/IJCRT23A5399.pdf
7. K Koopman and R Cumberlege, "Cash flow management by contractors," The ASOCSA 14th Built Environment Conference, vol. 654, pp. 1-9, 2021, doi:10.1088/1755-1315/654/1/012028
8. D. Smirnov and A. Golkar, "Design Optimization Using Game Theory," in IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 51, no. 2, pp. 1302-1312, Feb. 2021, doi: 10.1109/TSMC.2019.2897086.
9. Capraro V, Di Paolo R, PercM, Pizziol V, "Language-based game theory in the age of artificial intelligence," J. R. Soc. Interface, vol. 21, pp. 1-9, 2024, doi:10.1098/rsif.2023.0720
10. Ove Granstrand, "A cooperative game theory systems approach to the value analysis of (innovation) ecosystems," Technovation, vol. 130, pp. 1-17, 2024, doi: 10.1016/j.technovation.2023.102926

11. Saadatfar, Hamid, Hamid Gholampour Ahangar, and Javad Hassannataj Joloudari. 2024. "A New Dynamic Game-Based Pricing Model for Cloud Environment" Future Internet, vol. 16, no. 2, pp. 1-19, 2024, doi:10.3390/fi16020049
12. Bodendorf, F., Hollweck, B. & Franke, J, "Information Asymmetry in Business-to-Business Negotiations: A Game Theoretical Approach to Support Purchasing Decisions with Suppliers," Group Decis Negot, vol. 31, pp. 723–745, 2022, doi:10.1007/s10726-022-09780-3
13. Ernest Whitman, Henry A. Brown, and Patricia N. Meyer, "Cost-Benefit Analysis and Project Performance," Journal of Project Management Studies, vol.1, no. 1, pp 1 – 12, 2023, doi: 10.58425/jpms. v1i1.183
14. Stehel, V., Vochozka, M., Kliestik, T., & Bakes, V, "Economic analysis of implementing VMI model using game theory," Oeconomia Copernicana, vol.10, no. 2, pp. 253–272, 2019, doi:10.24136/oc.2019.013
15. Q. Tong and D. Zhou, "Research on Allocation of Transmission Fixed Cost by Cooperate Game Theory," 2020 IEEE 4th Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), Chongqing, China, 2020, pp. 380-383, doi: 10.1109/ITNEC48623.2020.9084990
16. Pasquale Lucio Scandizzo, "Impact and cost–benefit analysis: a unifying Approach," Journal of Economic Structures, vol 10, no. 10, 2021, doi:10.1186/s40008-021-00240-w
17. Vaidehi P. Nirmal, Nitin W. Ingole, Ashish B. Ugale, "Cash-Flow Management in Building Construction Project," International Journal of Research in Engineering, Science and Management, vol. 2, no. 5, pp. 744-750, May-2019, ISSN (Online): 2581-5792,
18. L. Premi, F. Reghenzani, G. Massari and W. Fornaciari, "A Game Theory Approach to Heterogeneous Resource Management: Work-in-Progress," *2020 International Conference on Embedded Software (EMSOFT)*, Shanghai, China, 2020, pp. 25-27, doi: 10.1109/EMSOFT51651.2020.9244046.
19. H. Zhang, J. Han, J. Zhang and J. Wang, "Security Risk Evaluation of Information Systems Based on Game Theory," 2013 5th International Conference on Intelligent Human-Machine Systems and Cybernetics, Hangzhou, China, 2013, pp. 46-49, doi: 10.1109/IHMSC.2013.18.
20. Zhao, L., Mbachu, J. I. C., & Domingo, N, "A Better Modelling and Assessment of Key Factors Affecting Cost Performance of Building Projects: The Case of New Zealand," International Journal of Construction Engineering and Management, 2017, vol. 6, no. 5, pp. 187-196, 2017, doi: 10.5923/j.ijcem.20170605.01
21. Qian, Xiaoduo, Liu, Wei, and Yang, Jiaquan. "Game Theory Analysis of Technology Adoption Timing and Pricing Decision in Supply Chain System Under Asymmetric Nash Equilibrium," vol. 35, no. 3, pp. 3101–3111, January 2018, doi:10.3233/IJFS-169664