



Empowering Financial Management in Educational Institutions: A Multi-Objective Decision-Making System using Intelligent Fuzzy Logic Algorithm and Digital Marketing

Qian Li^{1*} 

¹Economics and Trade Department, Shijiazhuang University of Applied Technology, Shijiazhuang 050081, HeBei, China liqian_vip@outlook.com

Corresponding author: Qian Li, liqian_vip@outlook.com

Abstract. Financial management and decision-making are core components of the management practices of education policymaking in colleges and universities. Therefore, the university uses the financial management system to attain ideal outcomes in formulating the financial plan, supporting financial control, and enhancing the effectiveness of financial management. Furthermore, the sustainability of the education industry is crucially related to the formulation and adoption of effective financial decisions. Hence, in this study, Fuzzy Comprehensive Evaluation based Financial Management System (FCE-FMS) has been suggested using Multi-Objective Decision Making (MODM) in educational institutions to enhance the efficiency of using funds and financial decision-making. The data are gathered from the Ed financial-related data for financial resource management in educational institutions. The MODM in higher education institutions contains the ability to achieve good performance and efficient service, and good financial management is paramount in managing the resources of the local government funds. Therefore, State or Government funding should continue to be an important and mandatory necessity for support of higher education. The main sources for financing higher education include government funds, funds of self-governing bodies, tuition fees, donations, scholarships, and educational cess. This article offers a model of support to the financial decision-making progression based on fuzzy notions, i.e., fuzzy expert systems and evaluation system that aids the financial decision-making process more successfully and realistically. The suggested FCM-FMS system achieves a great accuracy ratio of 98.7%, a decision-making ratio of 97.8%, an optimal fund allocation ratio of 96.5%, and an institution's performance of 95.1% compared to other existing techniques.

Keywords: Multi-objective decision-making, Financial management, Fuzzy logic, Educational institutions, Fuzzy Comprehensive Evaluation.

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1 INTRODUCTION

The continuous reform of the country's education system and the standardization and institutionalization of financial management are becoming increasingly important [13]. However, due to the system's historical imperfection, financial management problems are more prominent [10]. Financial management essentially means organizing, planning, controlling, and directing the financial activities in educational institutions to use financial resources efficiently and successfully [11]. In educational institutions, financial management oversees the funding for grounds and buildings, student programs, employee salaries, technology, and supplies [12]. A college's overseer or manager is responsible for assigning these funds and keeping precise documents or records related to these expenses [18]. The governmental fund is one of the components of instrumental input crucial for implementing quality education [17]. The spending on education funds indicates state financial efforts for investments in Human Resource (human capital) and demonstrates the priority scale amongst sectors in allocating state finances [2]. Educational accomplishments utilize funds allotted via budgeting or budget planning, so each work unit in the educational institution can utilize these funds as well as possible [5]. To guarantee that the limited resources provided to the sector have the greatest possible effect, cost recovery mechanisms must be employed, and governments, politicians, and civil society have all highlighted that developing nations must increase their investment in education. [3]. Therefore, the educational system should use both human and non-human resources to realize its goals and meet the educational requirements of its students and the wider society. [16]. Digital marketing provides cost-effective channels for promoting educational programs, attracting students, and engaging with the wider community. Online advertising, social media marketing, email marketing, and content marketing can reach a larger audience at a lower cost compared to traditional marketing methods. By optimizing digital marketing campaigns, educational institutions can maximize their return on investment and allocate resources efficiently.

The rapid development of Information and Communication Technology (ICT) in the business world in developing countries has yet to infuse other institutional functions, particularly financial management in educational institutions [23]. ICT has become valued for storing and examining financial management data in colleges or universities, including budgetary allocations, expenditures, student fees payment, and general accounting [1]. The combination of ICT and fuzzy aids to generate successful application and employment in finance management summary of the results of Fuzzy set theories in financial management [6]. Fuzzy set theory can resolve quantitative and qualitative model issues involving impression and vagueness [14]. Fuzzy expert systems support financial decision-making more successfully and realistically [21]. Given the inherent ambiguity and imprecision of the financial decision-making process [8]. Multi-Objective Decision-Making (MODM) is a methodical process to aid decision-makers facing competing values. [22]. The fuzzy set theory's representation of multi-objective selected problems with uncertain or vague goals is one of the theory's most valuable applications. [19]. Using a group of experts, a fuzzy MODM model evaluates potential options against predetermined standards. Fuzzy numbers are a linguistic representation of the values used to assess the acceptability of alternatives relative to criteria and the importance weights of criteria. [9]. Optimal financial planning is critical to keeping focus and on schedule; as educational institutions expand, new difficulties emerge, and unpredictability is the highest incidence. [4].

The main contribution of the paper is

- Designing the Fuzzy Comprehensive Evaluation based Financial Management System (FCE-FMS) in educational institutions to enhance the efficiency of using funds and financial decision-making.
- Evaluating the mathematical model of the Multi-Objective Decision Making (MODM) for better decision-making in government fund allocation for different purposes.
- The experimental outcomes demonstrate that the suggested FCE-FMS system increases the accuracy and decision-making ratio compared to existing models.

The remainder of the study is prearranged as follows: section 2 discusses the related study, section 3 suggests the FCE-FMS system, section 4 deliberates the findings and discussion, and Section 5 concludes the research article.

2 RELATED STUDY

Hui Jiang [7] proposed Data Mining Technology (DMT) for Intelligent Financial Management Systems in educational institutions. By combining conventional decision support systems and expert systems, AI has found a unique application in finance by creating smart financial decision support systems. A smart financial decision support system may greatly assist educational institutions in data classification, data processing, data analysis, and converting stale data into actionable intelligence for top-level administrators. To form an intelligent decision support system based on data mining, a data warehouse must be constructed on top of the existing intelligent decision support system, and the data stored there must be processed and analyzed using data mining tools to aid the decision-maker in making their decisions.

Maotao Lai [15] suggested Data Mining and Man-Machine Management (DM-MMM) for Smart Financial Management Systems. By analyzing and summarizing the algorithm, the author finds its shortcomings and suggest a new, better one to fix them in intelligent data mining. Next, similar mining tests were performed on the enhanced algorithm, demonstrating its benefits. The data-mining-based intelligent financial management was then thoroughly explored, the fundamental design framework for smart financial management was implemented, and data-mining models were applied in the decision-support systems through smart prediction financial management decisions.

Lu Liu [20] discussed the Dynamic Neuron Model (DNM) for Financial Accounting Quality in Colleges and Universities. The author proposed a neuronal model with dynamic components, developed a learning algorithm, and used it to assess the credibility of university budget figures. This study established a single-layer feedback network optimized for quick learning and adaptation. In terms of assessing the quality of financial accounting firms, this is important for educational institutions. However, there is theoretical validity in elevating the importance of financial management in higher education. Internal managers may benefit from the description of nonfinancial indicators in making financial choices, and external supervisors can benefit from having access to this information as a reference factor.

Tran Huong Xuan [24] deliberated the Purposive Sampling Technique (PST) for analyzing the impacts of financial management on innovation and efficiency of higher education. A cross-sectional survey with a purposive sample size of 200 was used for this research. Structural equation modeling is used to verify the validity of the study's hypotheses. According to the study's findings, employee financial literacy is positively and significantly related to innovation in financial management. Organizational liquidity and financial control are among the characteristics that contribute to effective financial management. A favorable and statistically significant correlation exists between financial management innovation and educational innovation. However, no proof exists that

introducing new ideas into universities improves student outcomes. Research like this suggests that the current approach to funding higher education needs to be rethought.

Qi Jun et al. [25] suggested the Stochastic Hybrid Decision-Making based on Interval Type 2 Fuzzy Sets (SHDM-IT-2FS) for measuring the innovation abilities of financial institutions. This research aims to develop a multi-criteria decision-making strategy for assessing financial institutions' innovation ability. In this case, the criteria and dimensions are weighted using interval type 2 fuzzy DEMATELANP. Other interval types 2 fuzzy set-based ranking strategies studied include TOPSIS and VIKOR. The originality of this research is in proposing, with backing from the literature, a set of criteria and dimensions of innovation potential. Another innovative idea is combining IT-2FS with DEMATEL-ANP and offering integrated interval type 2 fuzzy stochastic decision-making and Monte Carlo simulation.

Based on the survey, there are numerous difficulties with the existing methodologies in achieving great accuracy and decision-making, such as Data Mining Technology (DMT), Data Mining and Man-Machine Management (DM-MMM), Dynamic Neuron Model (DNM), Purposive Sampling Technique (PST), Stochastic Hybrid Decision-Making based on Interval Type 2 Fuzzy Sets (SHDM-IT-2FS). Hence, this paper suggests a Fuzzy Comprehensive Evaluation based Financial Management System (FCE-FMS) in educational institutions to enhance the efficiency of using funds and financial decision-making.

3 FUZZY COMPREHENSIVE EVALUATION BASED FINANCIAL MANAGEMENT SYSTEM (FCE-FMS)

Finance plays a very critical role in the effective administration of higher education. Financial management in educational institutions is the administrative process of allocating, spending, and accounting for the institution's financial resources to support educational initiatives. Users of accounting data are becoming more concerned about the financial management of higher education institutions due to issues including the cost of higher education, the lack of uniformity in accounting processes across institutions, and the lack of transparency in reporting revenues and expenses. One of the numerous ways a good financial management system aids the educational industry is by streamlining payroll. A straightforward daily method for handling payroll, taxes, contributions, etc., is crucial to provide accurate outputs. Educative institutions can better safeguard their financial resources and demonstrate how to use them wisely if they establish a finance department with the right goals. The process can be managed more efficiently and expertly. Human resource management software facilitates effective administration and staff development for the college or university's teaching and non-teaching personnel. It facilitates the management of ancillary employment matters, such as time off, pay, proxies, etc. Human resources set salary ranges and depend on task responsibilities, experience required, and overall performance. The human resource management system ensures that all teaching and non-teaching personnel know their current compensation information. Staff upkeep includes promoting and relocating employees, inspiring them to do their best job, providing access to counseling and medical care, paying them on time, and keeping the workplace secure and free of hazards. Hence, this paper suggests a Fuzzy Comprehensive Evaluation based Financial Management System (FCE-FMS) in educational institutions to enhance the efficiency of using funds and financial decision-making. Fuzzy systems are believed, conceptually, to address non-linear problems in many domains, including categorization, modeling, management, and others. Designing a fuzzy rule-based system is an optimization issue for finding the most appropriate built-in parameters, variables, and rules. When faced with several options, the purpose of any decision-making process should be to zero in on the best one. The results show that the suggested FCE-FMS effectively improves the timeliness and accuracy of financial decision-making and promotes the incorporation of management and financial accounting.

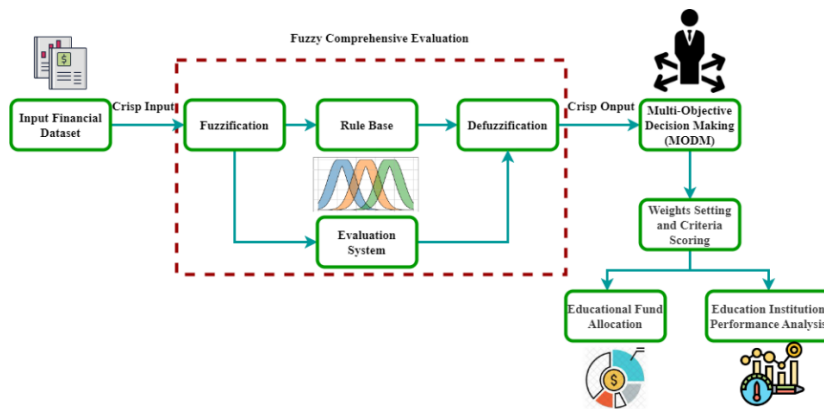


Figure 1: Proposed FCE-FMS system.

Figure 1 shows the Proposed FCE-FMS system. The data are taken from the dataset of for analyzing the financial data in educational institutions. Fuzzy comprehensive evaluation relies on the fuzzy operation found in fuzzy mathematics to carry out quantitative processes of the same non-linear assessment factors on the features of non-linear changes, allowing for a more precise and actionable decision based on the evaluation findings. Financial inputs may be transformed with the use of a module called "fuzzification," which takes a "crisp" number and changes it into "fuzzy" steps. Sensors provide the crisp numbers as inputs, and the control systems subsequently process the numbers via fuzzification. Experts' If-Then statements are used to direct decision-making systems, and the rule Base is a component used to store the rules. This new information or development helps reduce the total number of fuzzy rules. The inputs of a fuzzy set from the inference engine are processed by a defuzzification module or component, which ultimately outputs a discrete value. Ultimately, this is what a fuzzy logic system does. In contrast, user-accepted values are "crisp output."Therefore, because of the fuzzy comprehensive decision model, assessment criteria and indicators must be decomposed and confirmed in evaluating educational institutions' financial management systems. In addition, MODM has the anticipated elements of transparency and preserving auditing possibilities. Financial management is a multi-dimensional decision-making issue unrelatedly to which characterization is chosen. MODM involves the application of decision-making approaches by financial decision-makers in cases where it is essential to consider different inconsistent decision-making criteria. MODM comprises both the weighting of the criteria, based on their significance, employing the scoring function to the alternative concerning every criterion, and aggregating the results in the overall ranking for financial management.

A fuzzy set is a useful tool for addressing issues in uncertain environments. A triangle fuzzy number (TFN) \hat{T} is described by the membership function $\mu_{\hat{T}}(y)$ values in the range $[0,1]$.

$$\mu_{\hat{T}}(y) = \begin{cases} \frac{(y-r)}{(q-r)} & r \leq y \leq q \\ \frac{(p-y)}{(p-q)} & q \leq y \leq p \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Each degree of membership consists of the left and right parts of the TFN:

$$T = (T^l(x), T^r(x)) = r - (q - i)x, p(q - d)x, x[0,1] \quad (2)$$

Thus, fuzzy logic is integrated with classic MODM techniques to address humans' uncertainties and linguistic expressions. Besides, numerous people are involved in most decision-making studies, making the issue of group decision-making. Therefore, the geometric mean is employed for expert consensus.

$$M_{ji} = (k_{ji}, n_{ji}, v_{ji}) \quad (3)$$

$$k_{ji} = \min(A_{jil}) \quad (4)$$

$$n_{ji} = \sqrt[m]{\prod_{l=1}^m A_{jil}} \quad (5)$$

$$v_{ji} = \max(A_{jil}) \quad (6)$$

From Equation (3-6), according to fuzzy set theory, $k, n,$ and v are TFN,. A_{jil} signifies the score of l th experts for comparing the importance of $C_j - C_i$ criteria. The decision criteria system is a performance comprehensive evaluation index system of educational institutions, which contains nine sub-criteria, namely $\{C_1, C_2, \dots, C_9\}$. The linguistic parameters the expert panels provide can then be converted into fuzzy ratings depicted by TFN.

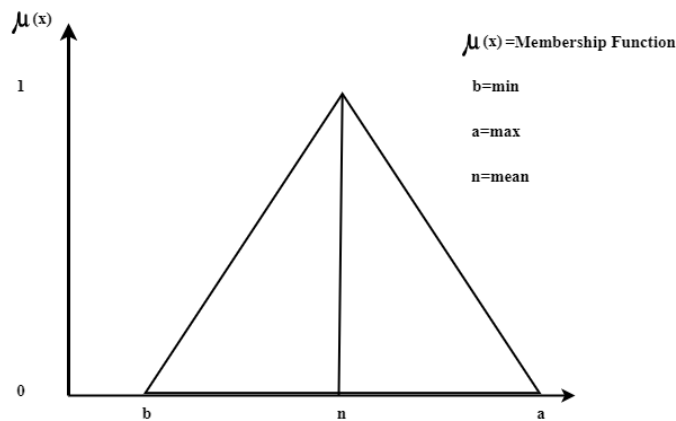


Figure 2: Triangular Fuzzy Numbers (TFNs).

Figure 2 shows the triangular fuzzy numbers. It is a fuzzy number signified with three points as follows. This depiction is interpreted as a membership function and holds the subsequent condition. (i) b to a is increasing functions, (ii) n to decreasing functions, (iii) $b \leq n \leq a$. This representation is interpreted as a membership function $\mu(x)$. The collective opinions are characterized by a triangular fuzzy number whose construction is based on the possible distribution of the grading progression. Fuzzy numbers' modes and spreads are assessed using a weight determination method. The efficacy of the suggested system is shown in a group decision-making issue, including multiple assessment criteria.

The fuzzy comparison matrix can be determined by

$$B = \begin{bmatrix} C_1 \\ C_2 \\ \vdots \\ C_m \end{bmatrix} \begin{bmatrix} \tilde{b}_{11} & \tilde{b}_{12} & \cdots & \tilde{b}_{1m} \\ \tilde{b}_{21} & \tilde{b}_{22} & \cdots & \tilde{b}_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{b}_{m1} & \tilde{b}_{m2} & \cdots & \tilde{b}_{mm} \end{bmatrix} \quad (7)$$

As discussed in equation (7), where \tilde{b}_{ji} denotes the relative fuzzy preference of criterion j to criterion i , and TFNs.

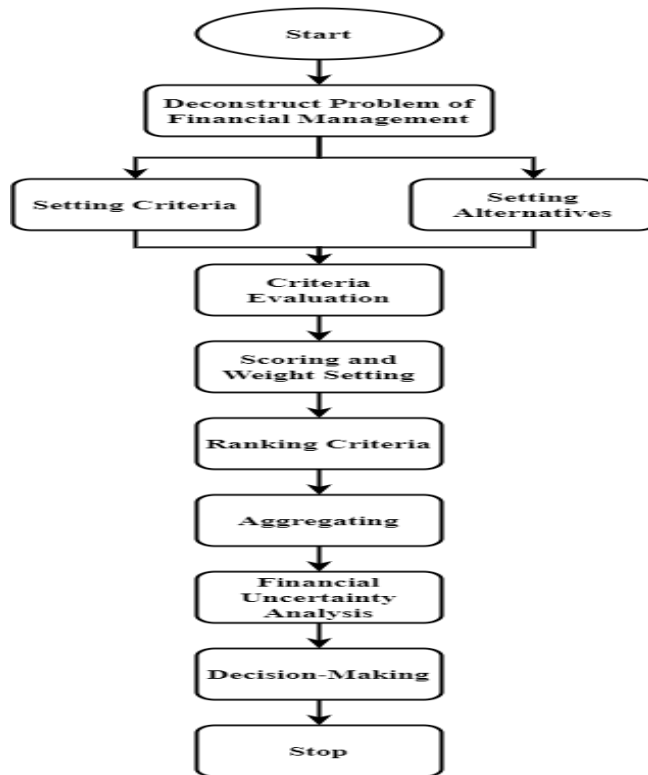


Figure 3: MODM technique in financial management system.

Figure 3 shows the MODM technique in a financial management system. The objective of MODM is to find the optimal solution values of more than one desired goal. The proposed MODM is to construct portfolios that are best diversified on a subset of assets and are globally optimal with an appropriate performance measure in educational institutions. Then, to explicitly incorporate more than one evaluation criterion into a decision problem in education institutions' financial management. The first step in the MODM procedure is to define the decision-making issue and the critical outcomes that must be attained. The next step in making a multi-criteria decision is problem structuring, which involves identifying the types of selections to be made and the criteria that will be used to rank them. Next, optimal selection is determined by weighing both optimal and suboptimal options. Finally, the value is calculated by evaluating every selection against the best possible. The primary

benefits of the MODM principle in financial decision-making are the following: the application of qualitative and quantitative criteria in the analysis progression; the likelihood of transparency of assessment; the introduction of enhanced, universal, and practical academic approaches; and the capacity to structure complex assessment tasks that permit for well-founded financial decisions. When applying the model to new instances, those predictions are weighted by their similarity to the input instance. In addition, the original data is transformed into membership scores ranging from 0 to 1 to calibrate the antecedent and outcome variables. The fundamental advantage of this set over traditional fuzzy sets is that it provides a more practical means of dealing with uncertainty in decision-making. Combining many goals into a single one or selecting one target and using the others as constraints are two strategies for solving multi-objective issues. Value at risk (VaR) and conditional VaR provide quantitative measures of risk and uncertainty, respectively, whereas reducing transaction costs and maximizing return are two examples of such goals. The suggested FCM-FMS system achieves a high accuracy ratio, decision-making ratio, optimal fund allocation ratio, and institution performance ratio.

4 RESULTS AND DISCUSSION

The purpose of a financial analysis of a college or university is to get regular knowledge of the economic operations and career growth of the students and institution by systematically analyzing, comparing, and evaluating the institution's financial situation over a certain period. An essential element of college budgeting is doing a thorough financial analysis. To encourage the growth of higher education, its guiding concept is to prioritize efficiency, thoroughly enhance financial management, increase financial management, maximize income and decrease spending, and make the most of available resources while minimizing waste. This study uses FCE-FMS to build a model for managing the performance of a university's financial budget execution. To encourage the steady growth of the higher education sector, this article examines the day-to-day financial activities of colleges and universities, identifies frequent issues with university financial management, and proposes solutions. The data are taken from the dataset of [26] for analyzing the financial data in colleges or universities. Data includes revenue by source, expenditure by function and object, indebtedness, and cash and investments for all state and district college systems. Uses demographic and financial data from the Private School Survey (PSS) and Common Core of Data (CCD) to build customized tables/charts for school-, district-, and state-level systems. The performance of the FCE-FMS system is examined based on the metrics such as accuracy ratio, decision-making ratio, optimal fund allocation ratio, and institution performance ratio.

4.1 Accuracy Ratio of Proposed Fcm-Fms System (%)

Payment of university tuition fees should follow the departmental budgets to successfully complete, and in practitioners, some completely inadequate recognition of the university budget for career education, often due to budget preparation time being too short or the budgetary control accountability to creates such as the financial plan not being accurate enough or not having enough extensive coverage. Financial management requires effort to further enhance the company's level, and to do a good job of financial management of school staff, because the number of institutions of higher learning further tend to teach the staff of a line, and economical personnel has fewer opportunities for in-service training. In addition to societal advancements, students, faculty, and staff may participate in the decision analysis that goes into college and university budgeting. This mandate from the FCE-FMS and MODM in college and university financial planning to management and financial professionals encourages the provision of accurate financial information for management decision-making and the promotion of the healthy and uninterrupted development of various endeavors in colleges and universities. In equation (2), the accuracy ratio has been calculated. Figure 4 shows the accuracy ratio.

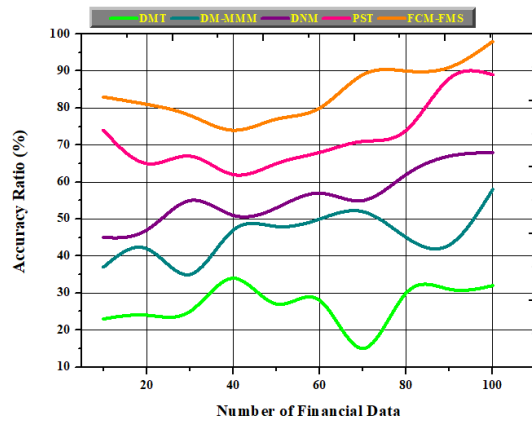


Figure 4: Accuracy Ratio.

4.2 Decision-Making Ratio (%)

The scope of decision-making has three dimensions; budget, personnel, and curriculum. The MODM approach to budgeting for educational goals requires yearly budgeting within the context of longer-term strategic management in which education is integrated into the planning for organizational growth. A budget is an FCE-FMS framework that allows for planning, implementing, documenting, and reporting decisions about an organization's financial input, outflow, and real-estate expenses. Documenting, monitoring, and adjusting income and cost inflows and outflows are collectively called "financial control." These processes are carried out to ensure that the budget is handled ethically, productively, and efficiently. Integrity in financial matters is the basic minimum need, followed by good housekeeping. Controlling finances to help ensure that educational goals are met efficiently and effectively. When educational institutions adopt a budget to keep track of managerial finances, educational financial institutions are obligated to record all revenue inputs and payment outflows in the budget. Compared to the budget's function as a plan, the budget's record-keeping and reporting functions emphasize the document's retrospective nature. In equation (2), the decision-making ratio has been calculated. Figure 5 demonstrates the decision-making ratio.

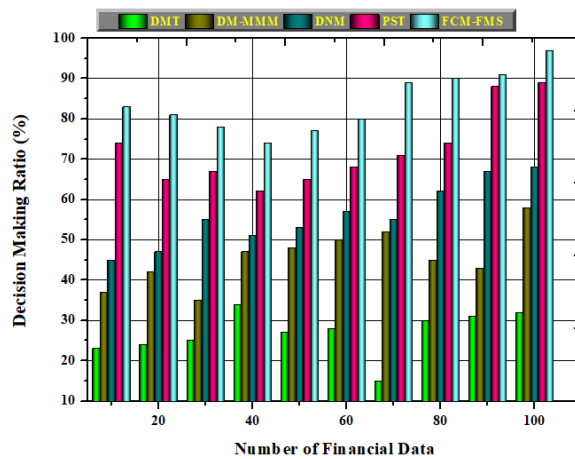


Figure 5: Decision-Making Ratio.

4.3 Optimal Fund Allocation Ratio (%)

The primary revenue sources for higher education institutions' budgets come from financial allocations and the social resource provided by the institution's self-financing component. Currently, this is the first choice made to distribute resources in higher education. The achievement of the first optimization of resource allocations relied on the secondary improvement of the productive assets of higher education; this step belongs to the micro decision-making process of the optimum resource allocations. The appropriate educational departments are in charge of controlling the sources of funding and expenses. Additionally, each college's budget estimate must be submitted to the college for approval. After finishing the budget at the school level, the school will next send that budget to the state government and apply for budget allocation. There are three principal sources of funding for educational institutions: (1) student fees, (2) government, and (3) donation containing foreign aid. The funds from the government are direct funding to colleges or universities, assigned via the Directorate General of Higher Education (DGHE) as routine and growth budget allocation. The routine budget covers personnel maintenance and salaries, while the growth budget covers capital investments (building and equipments) and operational maintenance and facility (OMF). In equation (1), the optimal fund allocation ratio has been calculated. Figure 6 displays the optimal fund allocation ratio.

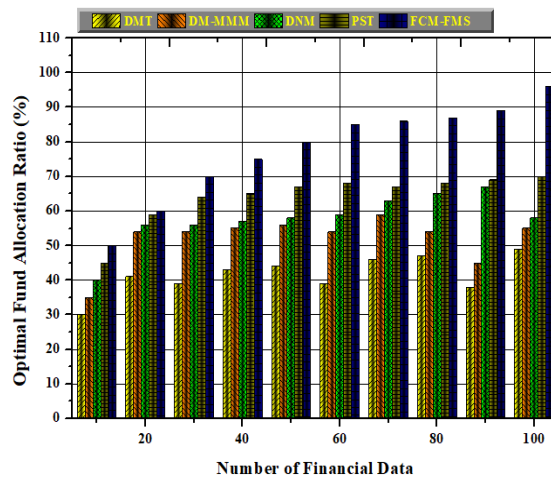


Figure 6: Optimal Fund Allocation Ratio.

4.4 Educational Institution Performance Ratio Based on the Proposed Fcm-Fms System

Our proposed FCE-FMS-based financial performance management is a realistic financial assessment indicator, and the construction of fair assessment standards and scientific criteria are all prerequisites for the university's financial budget performance assessment system. This paper's FCE-FMS and MODM assessment technique is to review the progression and outcomes of the development and execution of the financial budget of the university and award commensurate rewards or penalties. Enhancing the study on the performance assessment of the budget allocation of higher education institutions based on the MODM of higher education can play a crucial role in supporting the growth of educational institutions. In equation (7), the institution performance ratio has been calculated. Figure 7 illustrates the institution's performance ratio.

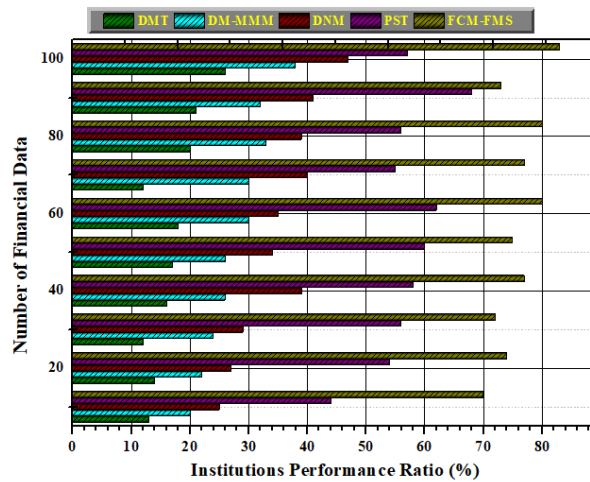


Figure 7: Institution Performance Ratio.

5 CONCLUSION

The paper utilizes FCE-FMS and Multi-Objective Decision Making (MODM) to design the assessment of the financial budget execution achievement management system, and model effect authentication was carried out. This paper makes use of these two methodologies. The FCE-FMS of higher education can scientifically assess the use of resources, thereby enhancing resource usage efficiency. Furthermore, the findings from the assessment can be utilized by the administration and other venture capitalists to make decisions regarding the operating condition of the college, and it is beneficial for the education system itself to comprehend the financial expenditure of the university and the campus and to keep improving its own expansion. In addition, the administration and other investors can use the evaluation results to make decisions regarding the operating condition of the university. According to the findings, the method described in this study may significantly enhance the efficacy of college financial budgets by playing an essential role in the educational institution's performance assessment of the financial budget employment at higher education institutions. The suggested FCM-FMS system achieves a great accuracy ratio of 98.7%, a decision-making ratio of 97.8%, an optimal fund allocation ratio of 96.5%, and an institution's performance ratio of 95.1% compared to other existing approaches. The limitation of the suggested MODM-based fuzzy evaluation method for imbalanced learning methods can make up for the shortfall of single criteria assessment. Therefore, future research should be analyzed from a multi-level and multi-dimensional point of view so that the dynamics and complexity of high financial performance can be completely, profoundly, and entirely understood.

Qian Li, <https://orcid.org/0009-0002-1394-1742>

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