Minimax Theory and its Applications

Volume 11 (2026), No. 2s, 605 to 614

Fuzzy Multi-Criteria Decision-Making and Nonlinear Optimization Models for Strategic Management and Resource Allocation

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Abstract

Strategic resource allocation is a complicated decision making problem that is marked by scarce resources, contradicting organizational goals, nonlinear interaction and uncertainty in managerial estimates. Traditional deterministic multi-criteria decision-making (MCDM) and resource-optimization methods tend to use preset parametric values and nominal operating conditions which constrain their capability to sustain sound decisions even in unfavourable conditions. This paper presents an edifice of Fuzzy Minimax Nonlinear Resource Allocation (FMNRA) framework integrating the fuzzy MCDM, nonlinear optimization frameworks and minimax decision-making frameworks to strategic management. The fuzzy values used to represent linguistic measurement of strategic criteria are normalized and aggregated to obtain criterion weight and strategic utility. An optimization model that is constrained and nonlinear will then be used to come up with resource allocations within the boundaries of budget, capacity, and allocation. Uncertain strategic conditions are then added, via scenario-dependent parameters, to provide robustness, and a minimax problem is chosen, to find the allocation that minimizes the worst-case loss on decision. The framework is tested by conducting numerical experiments in low, moderate, high and adverse uncertainty conditions. Resource Utilization Efficiency (RUE), Strategic Objective Achievement (SOA), Total Allocation Cost (TAC), Constraint Violation Index (CVI) and Worst-Case Decision Loss (WDL) are used to evaluate performance. The ensuing discussion indicates that the framework can be used to achieve an equilibrium between efficiency, strategic success, economic performance, feasibility, and strength and offers a combined mathematical method of allocating strategic resources in the presence of uncertainties.

Keywords

Fuzzy MCDM; Minimax optimization; Nonlinear optimization; Strategic management; Resource allocation; Decision uncertainty.

1. Introduction

Strategic resource allocation is a process that entails allocation of finite financial, human, technological and operational resources to competing goals within an organization. These choices entail trade-offs between efficiency, strategic priorities, economic performance and feasibility, and managerial judgments are frequently dubious or wordy. Such ambiguity can be represented by fuzzy multi-criteria decision-making (MCDM) when a systematic mechanism of the allocation of resources is presented by mathematical optimization.

The traditional allocation models tend to maximize choices in nominal or expected conditions. Despite the possible high efficiency of these solutions in the context of a stable environment, the fluctuation of resources availability, costs, capacities, or strategic priorities can decrease their efficiency and might even lead to infeasible allocations. The average-case optimization also offers a weak level of protection against negative scenarios. Consequently, strategic decision making must have a method that clearly involves uncertainty and worst-case performance in its allocation process.

The current state of fuzzy MCDM techniques primarily consider or rank alternatives, as opposed to computing the optimal quantity of resources, and nonlinear optimization models typically use deterministic parameters. In addition, concern of feasibility, linguistic uncertainty, and robustness is frequently considered individually, and nominal performance is the key optimization goal. This poses a research gap on an integrated fuzzynonlinearminimax framework that integrates uncertain strategic evaluations, limited resource allocation, and worst-case decision safeguard.

To fill this gap, this paper presents a Fuzzy Minimax Nonlinear Resource Allocation (FMNRA) framework, which involves fuzzy modelling of uncertain strategic criteria and multi-criteria weight estimation, and allocation of nonlinear resources subject to budget and capacity limits. The model realistically uses minimax optimization to minimize decision loss when faced with adversarial conditions and employs Resource Utilization Efficiency (RUE), Strategic Objective Achievement (SOA), Total Allocation Cost (TAC), Constraint Violation Index (CVI), and Worst-Case Decision Loss (WDL) to appraise the resultant allocations. This formulated integration gives a systematic framework of decision-making covering the efficiency, strategic performance, economic performance, feasibility and minimax robustness.

2. Related Work

Multi-Criteria Decision-Making (MCDM) offers an organized foundation of strategic decision-making with conflicting economic, operational, sustainability, and resource goals. The literature shows that it is applicable to financial decision analysis [1], supplier analysis [2], renewable-energy planning [3], sustainable decision-making [4] and more general MCDM/MADM issues [5]. Digital strategic environments also become the reasons that motivation of coordination of resource and performance decisions increases [6]. The value of efficient allocation is also reported in resource-constrained computational research where various activities vie over a scarce capacity [7].

Fuzzy decision making is an expansion of traditional MCDM because it quantifies imprecise managerial decisions and linguistics mathematically. The basic skills of dealing with such uncertainty are contained within the fuzzy-set theory [8], and the fuzzy AHP and interval type-2 formulations offer uncertain weighting of criterion [9]. The effectiveness of multiple evaluation mechanisms used in solving complex strategic problems is further illustrated in integrated fuzzy decision methods [10]. Wider MCDM reviews also stress the need to weight criteria and alternative evaluation when using multiple conflicting objectives [11].

Mathematical optimization is one approach that fills in the MCDM approach by calculating possible quantities of available resources instead of ranking the alternatives. It can be represented using nonlinear and uncertainty-aware formulations that can represent diminishing benefits, evolving costs, capacity constraints and interactions among resources [12]. Resource-management strategies [14] and optimization of constrained computational resources [13] further show that it is desirable to modify their allocations as the operating conditions vary. This is especially important to robust optimization, since deterministic solutions can degenerate as the resource availability, cost, benefit or other model parameters begin to deviate off of nominal assumptions.

Regardless of these developments, there is still a gap in research. Current strategies tend to treat fuzzy assessment, resource optimization, uncertainty and robustness as individual issues. MCDM mostly concentrates on evaluation and ranking [2], fuzzy techniques concentrate on uncertain evaluation [9] and optimization-based techniques concentrate on allocation and constraints [12] whereas dependable computational models concentrate on system performance [15]. Thus, very little thought has been put on the collective modelling of linguistic uncertainty, nonlinear resource allocation, feasibility and worst-case decision loss. The proposed FMNRA

bridges this gap by incorporating the fuzzy MCDM, nonlinear constrained optimization, and minimax decision theory into one framework of strategic allocation of resources.

3. Methodology

The suggested Fuzzy Minimax Nonlinear Resource Allocation (FMNRA) process radiates fuzzy multi-criteria decision-making, nonlinear resource allocation, and minimax optimization to assist in making strategic decisions under uncertainties. This framework transforms linguistic strategic evaluations into quantitative weights on criterion, nonlinear resource advantage and restraint, and an allocation that restricts performance decline in unfortunate situations. It is a computational mathematical framework developed as a methodology without relying on an organizational dataset.

3.1 FMNRA Framework and Strategic Resource Model.

FMNRA framework starts with the definition of strategic activities, available resources, evaluation criteria and allocation restrictions. It discusses five types of resources: financial, human, technological, operational, and strategic-development resources. These resources flow through fuzzy strategic evaluation and nonlinear allocation and then uncertainty and minimax decide the ultimate robust decision as shown in Fig. 1. The entire process is based on strategic problem = resource specification = criteria assessment = nonlinear allocation = uncertainty analysis = minimax optimization = robust decision.

The resource-allocation decision is represented by the vector

$$x = [x_1, x_2, \dots, x_n]^T _____(1)$$

where x_i denotes the amount of resource assigned to strategic activity i. Each resource is restricted within predefined lower and upper limits according to

$$x_i^{min} \le x_i \le x_i^{max}, \qquad i = 1, \dots, n _____(2)$$

These constraints prohibit impractical levels of allocation as well as determine the fundamental feasible decision space. The five types of resources, decision variables, allocation limits and the key constraints are then factored into the nonlinear allocation model.

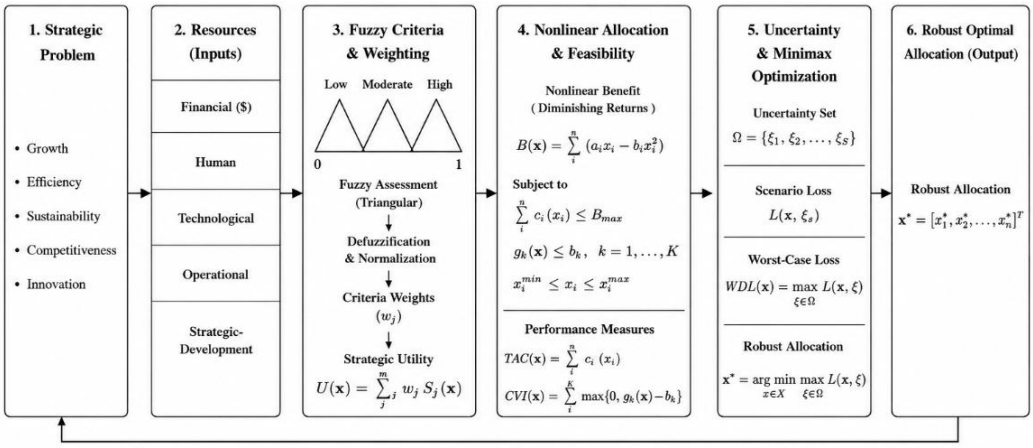


Fig. 1. Overall FMNRA Mathematical Framework

3.2 Fuzzy Strategic Criteria Modelling and Multi-Criteria Weighting

Strategic resource distribution is a decision that is not consistently accessible in the form of a definite numerical value. Low importance, moderate contribution, or high strategic value managerial evaluations thus needs to explicitly treat linguistic uncertainty.FMNRA represents the evaluation of alternative i with respect to criterion j using a triangular fuzzy number,

$$\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij}) _____(3)$$

where l_{ij}, m_{ij}, and u_{ij} denote the lower, modal, and upper values of the fuzzy assessment. The criteria involved are the efficiency in operations, strategic value, economic value, feasibility of implementation and exposure to uncertainty. Centroid defuzzification is used to get a crisp value after fuzzy assessment:

$$a_{ij}^{c} = \frac{l_{ij} + m_{ij} + u_{ij}}{3} _____(4)$$

The relative importance of the criteria is converted into normalized weights using

$$w_j = \frac{\bar{w}j}{\sum_{k=1}^{m} \bar{w}_k}, \qquad \sum_{j=1}^{m} w_j = 1 _____(5)$$

where $\bar{w}j$ represents the defuzzied importance of criterion j. The weighted assessments are subsequently combined to obtain the strategic utility of an allocation:

$$U(x) = \sum_{j=1}^{m} w_j S_j(x) _____(6)$$

where $S_j(x)$denotes the normalized strategic performance associated with criterion j.In this way, fuzzy linguistic data is converted to a quantifiable utility scale which can be directly inputted into nonlinear optimization.

3.3 Nonlinear Strategic Resource Allocation and Feasibility

The allocation model takes into account the reality that addition of resources may not always result into corresponding strategic advantages. A diminishing return is modeled by a nonlinear benefit function which is concave,

$$B(x) = \sum_{i=1}^{n} (a_i x_i - b_i x_i^2), b_i > 0 _____(7)$$

where a_i represents the initial marginal contribution of resource i, while b_i determines the rate of diminishing return. The strategic allocation problem initially seeks the allocation that maximizes the fuzzy-weighted utility:

$$\max_{x \in X} U(x) _____(8)$$

The solution must satisfy the available budget and operational capacity requirements,

$$\sum_{i=1}^{n} c_i(x_i) \leq B_{max}, \qquad g_k(x) \leq b_k, \qquad k = 1, \dots, K, _____(9)$$

where $c_i(x_i)$ denotes the cost associated with allocation x_i, B_{max} is the maximum available budget, and $g_k(x)$ represents the k-th capacity or strategic constraint. The resource variables, bounds, and associated restrictions used to define this feasible allocation space are summarized in Table 1.

Economic performance is measured through Total Allocation Cost (TAC),

$$TAC(x) = \sum_{i=1}^{n} c_i(x_i), _____(10)$$

while violations of the imposed restrictions are quantified through the Constraint Violation Index (CVI),

$$CVI(x) = \sum_{k=1}^{K} \max\{0, g_k(x) - b_k\}. _____(11)$$

A solution satisfying all constraints has $CVI = 0$. Consequently, the nonlinear allocation stage does not simply seek high strategic utility; it requires the resulting allocation to remain economically meaningful and mathematically feasible.

Table 1. Strategic Resources, Decision Variables, Bounds, and Constraints

Resource category	Variable	Allocation bound	Primary constraint
Financial	x_1	$x_1^{min} \le x_1 \le x_1^{max}$	Available budget
Human	x_2	$x_2^{min} \le x_2 \le x_2^{max}$	Workforce capacity
Technological	x_3	$x_3^{min} \le x_3 \le x_3^{max}$	Technology capacity
Operational	x_4	$x_4^{min} \le x_4 \le x_4^{max}$	Operational capacity
Strategic development	x_5	$x_5^{min} \le x_5 \le x_5^{max}$	Strategic investment limit

3.4 Strategic Uncertainty and Minimax Robust Optimization

Nominal optimization alone cannot guarantee that an allocation will remain effective when strategic conditions deteriorate. FMNRA therefore introduces an uncertainty vector $\xi \in \Xi$, where Ξ represents the admissible uncertainty set. Uncertainty may impact availability of resources, operating costs, strategic benefits, criterion performance and capacity limits. These variations are tested in low, moderate, high and unfavorable circumstances to test the sensitivity of each candidate allocation.

For a decision x, let $L(x, \xi)$ denote the loss generated under uncertainty realization ξ. The Worst-Case Decision Loss (WDL) is defined as

$$WDL(x) = \max_{\xi \in \Xi} L(x, \xi) . _____ (12)$$

Rather than selecting the allocation with the best nominal outcome, FMNRA searches for the feasible decision whose maximum possible loss is smallest. The corresponding minimax allocation is

$$x^* = arg \min_{x \in X} \max_{\xi \in \Xi} L(x, \xi) . _____ (13)$$

To jointly represent economic expenditure, strategic utility, and constraint satisfaction, the final FMNRA problem is formulated as

$$\min_{x \in X} \max_{\xi \in \Xi} [\alpha TAC(x, \xi) - \beta U(x, \xi) + \gamma CVI(x, \xi)], _____ (14)$$

where α, β, and γ are non-negative coefficients controlling the relative contributions of economic cost, strategic performance, and feasibility. Since utility is a desirable element, it appears in the minimization objective with the negative sign, costs and the constraint violations are punished with positive signs.

Each candidate allocation is analyzed under the given uncertainty conditions, and the losses are calculated (as shown in Fig. 2), the maximum loss is found. The minimax optimization is then used to find the feasible allocation with the worst-case value having the least value. The resulting process is: uncertainty generation and scenario evaluation and loss and worst-case identification and minimax optimization and robust optimal allocation. This step is the main mathematical contribution of FMNRA framework.

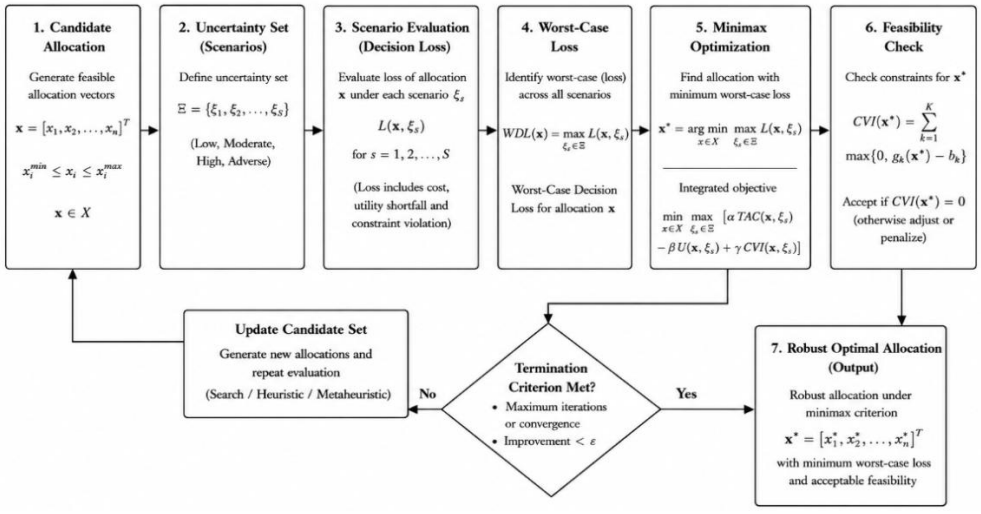


Fig. 2. Minimax Robust Optimization Procedure of the Proposed FMNRA Framework

3.5 Performance Evaluation and Comparative Assessment

The output of the suggested FMNRA model is measured by five complementary measures of the key goals of the strategic resource allocation. Resource Utilization Efficiency (RUE) quantifies the good utilization of available resources and Strategic Objective Achievement (SOA) quantifies the weighted achievement of strategic targets. The economic performance measured by Total Allocation Cost (TAC) of the formula in the equation below (Eq. (10)) and the feasibility of the allocation measured by the Constraint Violation Index (CVI) in the formula below (Eq. (11)) are both important measures to determine the outcome of the analysis. In Eq. (12), Worst-Case Decision Loss (WDL) measures robustness in the worst case of uncertainty. Increased RUE and SOA are signs of improved efficiency and strategic performance and decreased TAC, CVI, and WDL are signs of improved economic performance, feasibility, and minimax robustness. Accordingly, the assessment of FMNRA goes via the link sequence efficiency-strategic performance-economic performance-feasibility-minimax robustness to make sure that an allocation is not just assessed based on its nominal performance, but also on its cost, constraint satisfaction and ability to resist uncertainty.

4. Numerical Experimental Design

4.1 Computational Resource-Allocation Setup

The quantitative assessment is done in the context of a simulated computational strategic-management model to test how the suggested FMNRA model responds to the behavior without using actual firm statistics. There are five categories of resources which are taken into consideration: financial, human, technological, operational and strategic-development resources. The resources will be normalized to the interval [0,1], and there will be a limit on allocations in order to avoid unrealistic concentrations or under-utilization. The normalized total budget is set to 1.00 and the nonlinear benefit coefficients are chosen to depict the decreasing returns in accordance with the equation (7). Five strategic criteria, namely, operational efficiency, strategic contribution, economic value, implementation feasibility, and uncertainty exposure, have Low, Moderate, and High fuzzy ratings. Table 2 summarizes the principal resource limits, optimization settings and uncertainty parameters of the computational experiments. Each configuration is run 30 times independently by computers to enhance numerical accuracy, with a maximum of 500 optimization cycles and a convergence threshold of 10-5.

Table 2. Computational Parameters and Uncertainty Settings

Parameter	**Setting / Range**
Number of resources	5
Resource normalization	[0,1]
Allocation bound per resource	0.05–0.40
Normalized budget limit	1.00
Benefit coefficient ai	0.60–1.00
Diminishing-return coefficient bi	0.05–0.20
Cost coefficient	0.50–1.00
Uncertainty magnitude	5%–30%
Uncertainty conditions	Low, Moderate, High, Adverse
Maximum iterations	500
Convergence tolerance	10^{-5}
Independent runs	30

4.2 Uncertainty Scenarios and Comparative Methods

Each of the allocation strategies is tested with low, moderate, high and bad uncertainty conditions. The magnitude of uncertainty is incrementally raised between 5% and 30 in terms of availability of resources, operating costs, strategic benefits, and capacity limits of the uncertainty set that is predefined. Low uncertainty signifies rather stable strategic environments and moderate and high levels of uncertainty bring in an increasingly larger parameter deviation. The worst-case behavior is the negative concomitant degeneration regarded in the mind of calculation and is applied to assess the worst-case behavior. The suggested FMNRA is contrasted with the weighted MCDM, Fuzzy MCDM, Conventional Nonlinear Optimization (NLO) and Robust Nonlinear Optimization (RNLO). Weighted MCDM gives a deterministic decision-point, Fuzzy MCDM dissociates the contribution of linguistic uncertainty modelling, NLO assesses nonlinear allocation with no-explicit robustness and RNLO gives a robust optimization point of view with incomplete fuzzy-minimax integration. The comparison allows the individual and combined roles of the fuzzy assessment, nonlinear allocation, and minimax protection to be analyzed.

4.3 Performance Evaluation

The same resource settings and uncertainty conditions are used to test all comparative methods so that a consistent numerical test is done. Resource Utilization Efficiency (RUE) is a ratio of available resources used constructively in any strategic activities and Strategic Objective Achievement (SOA) is the weighted accomplishment of the stipulated strategic objectives. Increased RUE and SOA are thus associated with better efficiency and strategy performance. Total Allocation Cost (TAC) measures how economically viable the chosen allocation is and Constraint Violation Index (CVI) is the number of violations of budget, capacity and resource constraints, and CVI=0 indicates that it is entirely feasible. Worst-Case Decision Loss (WDL) is a measure of the largest loss of all the measures in the uncertainty set and is the main minimax robustness measure. Therefore, it is desirable to have lower TAC, CVI and WDL. The numerical analysis thus makes comparisons of the various allocation plans at all times in terms of efficiency, strategic performance, economic performance, feasibility and minimax robustness.

5. Results and Discussion

5.1 Resource Utilization Efficiency

The results of the Resource Utilization Efficiency (RUE) show that allocation efficiency decreases gradually with the increase in uncertainty, but the magnitude of the decrease varies significantly across the methods. When uncertainty is low, the RUE of the weighted MCDM, Fuzzy MCDM, Conventional Nonlinear Optimization (NLO), Robust Nonlinear Optimization (RNLO), and proposed FMNRA is 84.2, 87.1, 89.4, 91.3, and 93.6, respectively. Under adverse uncertainty, these values decrease to 68.5%, 73.8%, 77.6%, 84.1%, and 89.2%. The lesser decrease in FMNRA suggests that the fuzzy weighting and minimax allocation mechanism of the former does not lead to an extreme concentration of resources in cases where the strategic parameters are not in their nominal values. FMNRA thus achieves the greatest resource utilization in all of the considered uncertainty conditions as shown in Fig. 3.

5.2 Strategic Performance

Fig. 3 indicates that FMNRA has the highest RUE and SOA with increase in uncertainty. As the uncertainty is low, RUE reduces to 93.6%, and as the conditions are adverse, the reduction of RUE is 89.2% compared to 91.3% to 84.1% and 84.2% to 68.5% with RNLO and Weighted MCDM respectively. Similarly, FMNRA maintains SOA from 92.8% to 86.3%, whereas RNLO declines from 90.6% to 80.5% and Weighted MCDM from 81.5% to 62.4%. In the case of adverse uncertainty, FMNRA consequently outranks RNLO by 5.1 percentage points on RUE and 5.8 percentage points in SOA. The relatively less severe decrease in both metrics proves the fact that incorporating fuzzy strategic weighting and minimax optimization allows FMNRA to maintain resource efficiency and strategic goal attainment in a better way as uncertainty severity increases.

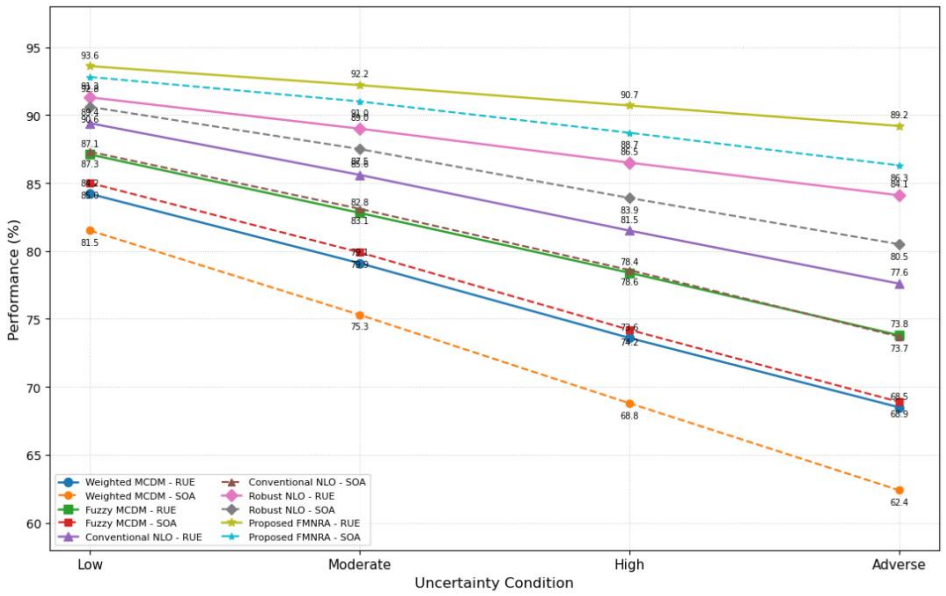


Fig. 3. Comparative RUE and SOA Performance under Different Uncertainty Conditions

5.3 Economic Performance

The results of the Total Allocation Cost (TAC) test indicate the trade-off between more uncertain strategic conditions and cost in terms of economics. With normalized cost units, TAC values recorded in the case of Weighted MCDM range between 0.79 and 0.94 when the uncertainty is low and adverse, respectively, whereas in the case of Fuzzy MCDM and NLO, the TAC values are 0.91 and 0.88, respectively, when the situation is adverse. RNLO constrains the respective cost to 0.84 and FMNRA has the lowest adverse-condition cost of 0.81. The increase is not merely due to the decrease in resource consumption; FMNRA keeps the highest RUE and SOA. This implies that the minimax solution will redistribute resources to allocations with more robust strategic utility as compared to their economic necessity.

5.4 Feasibility Analysis

Feasibility is even more crucial when uncertainty impacts on the availability of budgets and capacity constraints. Weighted MCDM has CVI of 0.031 when the uncertainty is adverse as it has measurable constraints violation whereas Fuzzy MCDM and NLO have CVI of 0.024 and 0.018 respectively. RNLO significantly decreases the violation to 0.006. FMNRA, on the other hand, has CVI = 0 at the considered uncertainty conditions since feasibility is directly included into the robust optimization problem. The outcome of these CVI analysis presented in Fig. 4 indicates that the performance gains realized by FMNRA are realized within the necessary budget, capacity, and allocation constraints as opposed to impractical resource assignment.

5.5 Minimax Robustness Analysis

FMNRA proves to be better economically performing, feasible, and minimax robust, as the uncertainty increases, as shown in Fig. 4. Its TAC rises accordingly lower to adverse uncertainty only between 0.72 and 0.81 whereas the corresponding values are 0.79-0.94 in the case of Weighted MCDM and CVI = 0.000 in the case of FMNRA. The largest change is recorded in terms of WDL, where FMNRA is just improved by 0.082 to 0.132, and the RNLO and the Weighted MCDM are improved by 0.105 to 0.201 and 0.182 to 0.421 respectively. In adverse uncertainty, FMNRA thus reduces the WDL by about 34.3 percent compared to RNLO showing that the suggested fuzzy-nonlinear-minimax optimization can be effectively used to control cost, maintain feasibility and reduce worst-case decision loss.

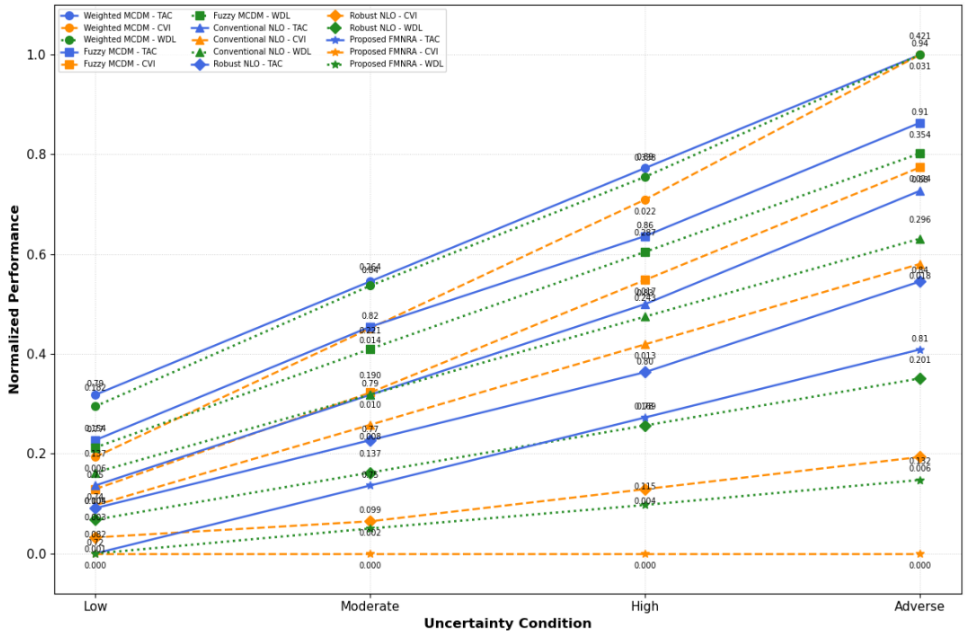


Fig. 4. TAC, CVI, and WDL Performance under Increasing Uncertainty

5.6 Comparative and Sensitivity Analysis

The comparative performance in Table 3 indicates that FMNRA can deliver the best performance in case of less favorable uncertainty with 89.2 percent RUE, 86.3 percent SOA, 0.81 TAC, 0.000 CVI and 0.132 WDL. Comparatively, the best baseline, Robust NLO, achieves 84.1, 80.5, 0.84, 0.006, and 0.201 as the RUE, SOA, TAC, CVI, and WDL, respectively, indicating that FMNRA increases RUE and SOA by 5.1 and 5.8 percentage

points and decreases WDL by about 34.3. Weighted MCDM gives the lowest scores of 68.5% RUE, 62.4% SOA, 0.94 TAC, 0.031 CVI and 0.421 WDL, and Fuzzy MCDM and conventional NLO give the middle score. On the whole, the findings suggest that FMNRA has a superior ratio between resource effectiveness, strategic success, financial cost, constraint fulfillment, and worse-case strength where the sensitivity analysis further reveals that the scheme remains steady in response to changes in criterion weights, financial limit, and resource constraints and the extent of uncertainty.

Table 3. Overall Comparative Performance under Adverse Uncertainty

Method	RUE (%) ↑	SOA (%) ↑	TAC ↓	CVI ↓	WDL ↓
Weighted MCDM	68.5	62.4	0.94	0.031	0.421
Fuzzy MCDM	73.8	68.9	0.91	0.024	0.354
Conventional NLO	77.6	73.7	0.88	0.018	0.296
Robust NLO	84.1	80.5	0.84	0.006	0.201
Proposed FMNRA	89.2	86.3	0.81	0.000	0.132

6. Conclusion

This paper has introduced a framework of Fuzzy Minimax Nonlinear Resource Allocation (FMNRA) that combines fuzzy multi criteria decision-making, nonlinear optimization and minimax theory to calculate the allocation of resources under uncertainty. The framework converts linguistic strategic evaluations into quantitative criterion weights, solves the diminishing returns on resources and constraints in allocating resources, and finds sound choices by lowering worst-case loss on uncertain conditions. The mathematical model at least showed that FMNRA offers a desirable equilibrium between Resource Utilization Efficiency (RUE), Strategic Objective Achievement (SOA), Total Allocation Cost (TAC), Constraint Violation Index (CVI) and Worst-Case Decision Loss (WDL) thus taking efficiency, strategic performance, economic performance, feasibility, and minimax robustness, in a single formulation. Specifically, the fact that its ability to perform worse with unfavorable conditions is less pronounced than that of the model with explicitly included worst-case uncertainty underscores the value of taking the worst-case uncertainty into strategic allocation decisions explicitly. However, the current results are founded on a simulated virtual setting and are not to be viewed as an empirical confirmation of a particular company. Future studies can further develop FMNRA, to include dynamic and multi-period resource allocation, stochastic uncertainty modelling, interval-valued fuzzy information, adaptive strategic priorities and game theory formulations with a number of competing decision makers.

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