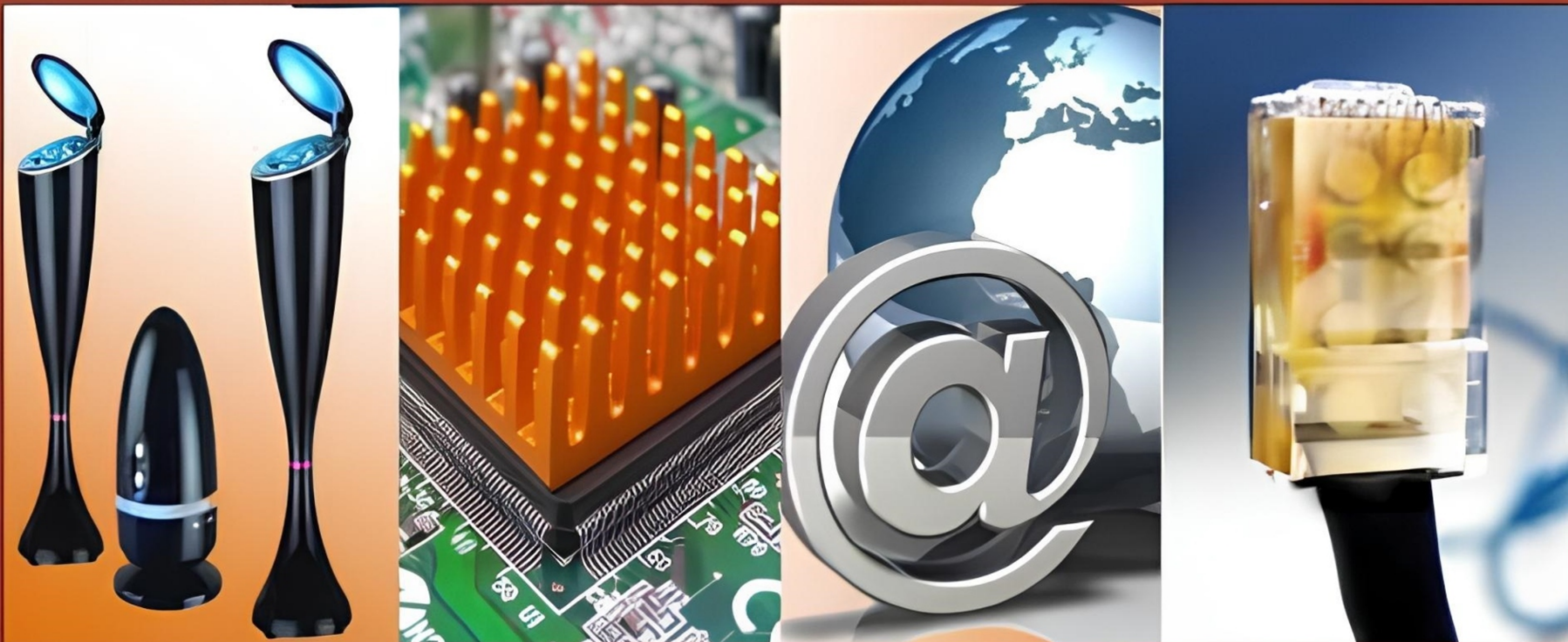

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DECISION-MAKING UNDER COMPLEXITY: APPLYING ELECTRE TO CHANGE MANAGEMENT STRATEGY

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ABSTRACT

This study applies the ELECTRE methodology to evaluate four change management strategies: Change Facilitation, Strategic Evolution, Adaptation Strategy, and Process Improvement Management. The evaluation considers parameters such as uncertainty, potential disputes, safety hazards, past experiences, reputation impact, and side costs from failure. Findings aim to guide organizations in selecting the most effective change management approach.

Research Significance: *This research is significant as it provides a structured approach to evaluating change management strategies in organizations. By applying the ELECTRE methodology, it offers insights into how factors like uncertainty, potential disputes, safety risks, and reputation impact influence the accomplishment of change projects. The results help people make better decisions in dynamic business environments.*

Methodology: *The ELECTRE A multi-criteria decision analysis technique called the (Elimination and Choice Expressing Reality) methodology is used to rank options according to a number of criteria. In this study, ELECTRE is applied to assess change* *management strategies, considering factors like uncertainty, safety hazards, reputation impact, and potential costs, providing a robust framework for decision-making.*

Alternative: *M1 Change Facilitation, M2 Strategic Evolution, M3 Adaptation Strategy, M4 Process Improvement Management*

Evolution parameter: *Uncertainty about final consequences (C1), Possible disputes in future (C2), Safety hazards (C3), Related experiences in the past (C4), The effect on the business's image (C5), incidentals because of the likelihood of failure (C6),*

Result: *The findings of this investigation show that the most appropriate change management strategy varies depending on the specific evaluation parameters. Alternatives such as Change Facilitation and Process Improvement Management offer distinct advantages in reducing risks, uncertainty, and safety concerns, while also considering past experiences and reputation impact for optimal decision-making.*

Keywords: Change Management, ELECTRE Methodology, Decision-Making, Risk Assessment, Strategic Evolution, Adaptation Strategy, Process Improvement Management, Organizational Change, Uncertainty, Safety Hazards, Reputation Impact, Multi-Criteria Decision Analysis, Organizational Strategy, Evaluation Parameters, Risk Mitigation.

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1. Introduction

It is highly recommended that all stakeholders participate actively in the procedure for managing change. Change management as a Decision Support System assist project managers in making structured decisions. Researchers have focused on identifying the causes and effects of changes within projects. All potential direct and indirect factors that affect project changes should be targeted by the change management system. The evolving The change management process's characteristics must be taken into account. Additionally, the problem-solving model should incorporate the concepts of uncertainty and ambiguity. Consequently, the article provides recommendations according to a case study of private investment projects in Iran, addressing the issue of construction delays.[1]

The existing change management further research on the subject is recommended. As an initial step, exploratory studies should be conducted to enhance understanding of organizational change management. The article also proposes developing methods to assess the effectiveness of organizational change management, enabling the evaluation of the value of any newly proposed frameworks.[2]

They contribute industry expertise, specialized resources, and change management experience to the project. After the change is implemented, organizations also document the lessons learned at both the project and organizational levels. Few organizations seem to undergo restructuring as part of their change management programs. Research indicates that most enabling factors involve implementing measures directly linked to the key drivers, anticipated benefits, or outcomes of the new processes. It highlights two key components of change management, which can be more effectively understood within the broader change framework.[3]

The success of a change management project will be explored in more detail. To better understand how the see-feel-change mindset is implemented, each step of Kotter's Change Model will be presented and discussed from the viewpoint of a healthcare manager.Selecting the appropriate team members is essential since they will guide the change management project through the next phases. While his model includes aspects for addressing the psychological impact of change, it is not exclusively focused on managing the transitions that take place during a change management project. This responsibility lies with Bridges and his theory of transitional management.[4]

Hayes' comprehensive mechanistic approach in identifying the variables or determining factors that influence the change process offers a structured discussion on change management, encompassing both theories and practices.The goal of change management is to attain long-term resource utilization efficiency in order to meet company objectives, ultimately leading to organizational effectiveness. The expectancy theory applied to change management suggests that only individuals who anticipate a positive outcome from the change process will support it.[5]

These factors have three key characteristics. First, companies can measure them either directly or indirectly. Second, companies can effectively communicate their significance both within the organization and to external parties.[6]

Organizational Change management is becoming more and more common in public sector organizations in addition to private enterprises. Discussions and policies are shaped by a dominant concept of the nature and goals of organizational transformation, which has its roots in neo-liberalism. People align closely with the managerial ideology of change management, serving as an additional rationale and justification for the change initiative. Managerial Change management and strategies are examples of "the modernist project," which focuses on promoting professional management as a tool for controlling businesses.[7]

The goals of change management are outlined, along with a more precise definition of the distributed system environment in which it is intended to function. It also describes the nature of interaction between management. Composition offers a broader approach for system configuration and dynamic change management. For more detailed control, decomposition can be applied.[8]

The goal is to examine different models for organizational change management and pinpoint the critical elements that affect success. of change management. This is examined at a particular Moroccan construction business that has experienced a number of organizational changes recently. Construction firms face challenges in putting change management procedures into action. Nevertheless, because of these elements, the construction business is an interesting one to study organizational problems in. [9]

The author argues that project managers should be well-versed in organizational change management (OCM) by reviewing relevant supporting literature. highlights the importance of integrating change management and project management strategies, pointing out that the effective implementation of significant managerial innovations depends on this integration. Project management and change management employ distinct terminologies and methodologies. The advocates of each originate from different areas within the organization and have varied functional and educational backgrounds.[10]

Developing and implementing One proactive strategy for successfully managing change is to implement a project change management system prior to the project's start. The change management system's effectiveness in managing changes makes it advantageous for both consultants and clients. To accomplish this goal, an extensive After doing a literature search to gain a comprehensive grasp of change management, a questionnaire survey was administered.[11] was the goal of the next section, which was followed by a section outlining the elements that either attract or dissuade businesses from putting put change management into action. Compared to other projects, building projects may use change management more frequently, guaranteeing that modifications are addressed promptly and efficiently, thereby minimizing their impact on project performance.[12]

This is why change management should address both the organizational and the physical and technological levels argues that effective organizational change cannot occur without parallel changes in the physical workplace. However, offers a more moderate perspective, suggesting that organizational change can happen without altering the physical context.[14]

Many ERP systems still face resistance, despite some studies' attempts to address this problem by finding change management techniques that promote ERP deployment success. Management may discover that there is still significant resistance from the workforce regarding the operational changes brought about by installation of ERP. Top management should work hard to figure out what went wrong in these kinds of circumstances. For example, they might have to reconsider the demands of users and reexamine how the chosen change management techniques are being implemented in order to ensure a better alignment between the two.[15]

Early It is obvious that decision-making and change planning are essential to successful change management. However, model-based approaches could produce less accurate results than code-based ones since UML models represent the system at a higher degree of abstraction than the code.[16]

The degree to which this fictional quotation appears amusing, paradoxical, absurd, or simply incorrect reflects the strong influence of the power dynamics within discourses of change and change management in organizational studies and related fields. However, these perspectives are often silenced or sidelined in comparison to those advocating for change and change management. Furthermore, it appears that no one argues that stability or continuity is either achievable or desirable. Instead, stability is portrayed as what occurs when nothing changes, often seen as either a problem or a void.[17]

The link between these criteria, which are captured as parameters to promote collaboration, determines the participation of engineering partners and suppliers. This makes it possible to notify design partners in advance of the effects of design modifications. Distributed engineering change management is required for this. Making design choices early in the iterative phase of product development has benefits, but frequently leads to the need for modifications or engineering changes.[18]

Insurance businesses in Jordan use change management techniques. The study makes a contribution by suggesting that companies offer training courses to improve employees' capabilities by fostering empowering behaviors. It also suggests considering individual differences among employees, especially when assigning work and tasks.The study on Business organizations apply change management methods differently, according to the realities of the process in Syrian organizations. Furthermore, Syrian groups have an inadequate administrative accountability procedure for organizing change.[19]

According to the study, change management in the organizations under investigation is positively and significantly impacted by organizational culture. But it found little evidence of a clan culture or an adhocracy culture having a major impact on these firms' planned or emergent change management.[20]

2. Materials and method

2.1 Alternatives:

M1: Change Facilitation: Change facilitation focuses on guiding and supporting organizations through the process of transformation, guaranteeing that all parties involved are equipped to manage and adapt to changes effectively. This approach emphasizes providing the necessary resources, tools, and guidance to help employees and stakeholders understand and implement change, fostering a smooth transition and enhancing overall organizational adaptability.

M2: Strategic Evolution: Strategic evolution is about the gradual, adaptive transformation of an organization's strategy to meet evolving market demands and internal capabilities. This approach emphasizes long-term development, encouraging companies to continuously refine their strategic direction to remain competitive while balancing both innovation and stability. It allows for flexibility and responsiveness to external and internal changes.

M3: Adaptation Strategy: An adaptation strategy involves adjusting organizational practices, processes, and structures in response to modifications in the external environment, such changes in the market, improvements in technology, or changes in regulations modifications. This approach focuses on the ability of an organization to pivot quickly, ensuring that it remains relevant and efficient in dynamic environments by embracing necessary changes and continuously learning from them.

M4: Process Improvement Management: Process improvement management centers around optimizing organizational processes to improve overall performance, cut expenses, and boost efficiency. This approach is typically focused on continuous improvement efforts, utilizing methodologies like Lean or Six Sigma to identify areas of inefficiency or bottlenecks. By implementing targeted changes, organizations can achieve incremental improvements that lead to better outcomes over time.

2.2 Evaluation parameter:

C1: Uncertainty About Final Consequences: Uncertainty about the final consequences refers to the unpredictability surrounding the outcomes of a change initiative or project. This can include concerns about whether the change will lead to the desired improvements or result in unforeseen challenges. Evaluating this parameter involves assessing the degree of risk involved in the modification and figuring out whether the potential benefits outweigh the uncertainty of the results.

C2: Possible Disputes in the Future: Possible disputes in the future consider the likelihood of conflicts arising as a result of the change process. This can involve disagreements between stakeholders, teams, or even between the organization and external partners. Evaluating this parameter requires analyzing potential sources of conflict, such as differing expectations, miscommunications, or opposition to the change, and developing strategies to manage and mitigate these disputes proactively.

C3: Safety Hazards: Safety hazards refer to potential risks that could endanger the health and well-being of employees, clients, or other stakeholders during the implementation of change. These could be physical hazards related to new processes, technologies, or operational practices. Evaluating this parameter involves conducting risk assessments, identifying potential safety issues, and ensuring that appropriate measures are in place to prevent accidents or injuries related to the change.

C4: Related Experiences in the Past: Related experiences in the past involve reflecting on previous instances where similar changes were implemented within the organization or industry. This evaluation parameter takes into account both successful and unsuccessful past efforts, offering insights into what worked and what didn't. Analyzing these experiences helps identify patterns, key lessons learned, and potential obstacles that may arise during the current change initiative, allowing for more informed decision-making.

C5: The Impact on the Company's Reputation; The impact on the company's reputation considers how the change process might affect the public perception of the organization. Positive changes can enhance a company's brand, while poorly managed changes may damage its reputation. This evaluation parameter involves assessing potential risks to the company's image, including how customers, investors, and other stakeholders may react to the change. Understanding this impact helps ensure that the organization takes steps to protect and enhance its reputation throughout the change process.

C6: Side Costs Due to Probable Failure: Side costs due to probable failure refer to the additional financial or operational costs that may arise if the change initiative fails or does not deliver as expected. These costs can include wasted resources, legal fees, damage control, and the cost of recovering from setbacks. Evaluating this parameter involves estimating the potential costs of failure and considering whether the organization has the financial and operational capacity to absorb these costs without significant damage.

3. ELECTRE

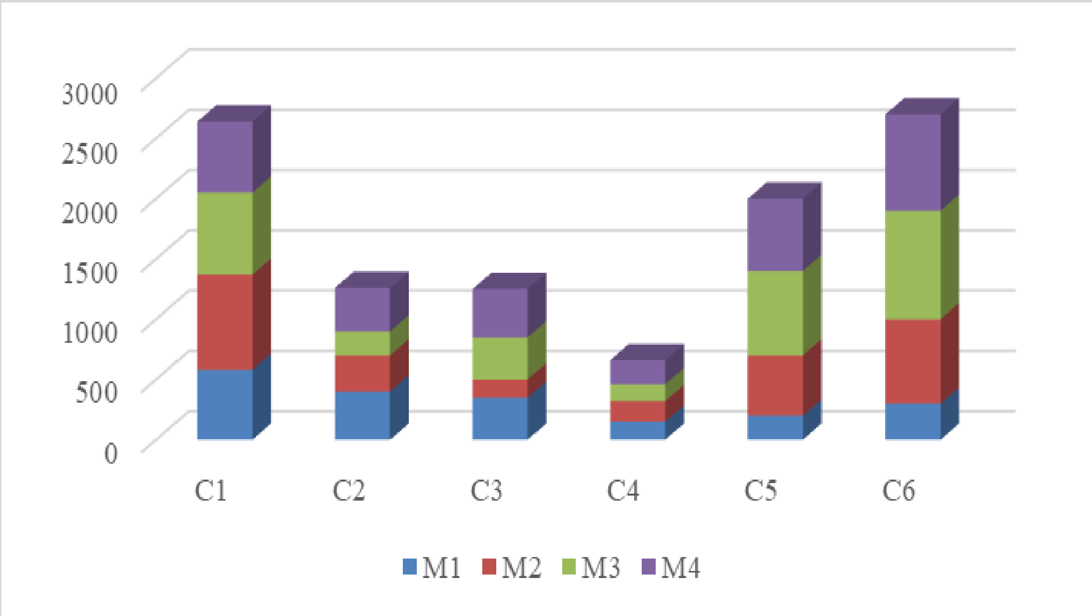
A primary focus was recognized as a priority area related to ELECTRE, specifically the central aspects studies of ELECTRE techniques or theoretical developments of ELECTRE principles that were thought to be most pertinent to Group D. We also identified papers that examine ELECTRE or ELECTRE-based approaches without explicitly mentioning or discussing their use. Here, we document the core elements, provide an example, and record the corresponding area as well. [1] This subsection highlights the main strengths The ELECTRE family of methods boasts several strengths. These include its capability to handle both qualitative and quantitative criteria, its versatility across diverse criteria types, and its effectiveness in managing inconsistencies in measurements and compensatory effects. ELECTRE methods are also adept at accommodating imperfect knowledge and arbitrary criteria, while skillfully managing the considerations for and against an outranking decision. Moreover, they are designed to preserve the qualitative nature of certain criteria, allowing original data to be utilized without requiring re-coding. Even though certain criteria are initially quantitative, in practice they are all regarded as qualitative. [2] they are inherently subjective and can vary based on the perspective of the decision-makers. This subjectivity introduces challenges in achieving consensus and ensuring the model accurately reflects the preferences and priorities of all stakeholders involved. Determining their values directly is difficult, and understanding the overall implications of these values on the model's output is challenging. Our approach to developing the ELECTRE TRI model seeks to replace the direct expression of model parameters with assignment examples. [3] A methodology is proposed to handle various types of interactions between criteria organized hierarchically. Extending this proposal, we explain in this paper how to address decision-making problems where hierarchical criteria exhibit different interactions, such as synergy, redundancy, and antagonistic effects. Although the method is primarily designed for ranking problems, it can also be applied to selection and ranking issues using criteria-importance interpretation methods, as seen in the ELECTRE methods. An overview of the ELECTRE method, highlighting its key concepts, applications, benefits, and drawbacks. At its essence, the ELECTRE method is part of the outranking family of MCDM (Multiple Criteria Decision Making) techniques, enabling direct comparisons. The method considers the preferences and priorities of decision-makers, generating a ranking of alternatives according to their relative advantages and disadvantages. The The ELECTRE technique is a powerful instrument for decision-making, and its broad range of applications demonstrates its versatility and adaptability in a variety of domains. Therefore, only when numerical scales are utilized to code the criterion and there is a chance of running into the rank should ELECTRE I be employed. With an emphasis on showcasing the application of a specific solution approach called ELECTRE, this study investigates the introduction and implementation of a methodology for project ranking in ECNZ Northern Generation. This is the first time these occurrences have been reported when using the ELECTRE methods. These two methods were also assessed against two other ranking tests, where they failed as well. Two real-life cases are presented to illustrate the occurrence of rank reversals with the ELECTRE method.When the alternatives are evaluated using the ELECTRE method, this fact and the previously described rank reversal examples demonstrate that there is no predetermined ranking of the alternatives. Potentially important boundary requirements for using a multi-criteria recruitment framework in an academic setting were identified, and the relevance of intellectual values was investigated. ELECTRE is a pairwise comparison-based decision-making technique. Although there are benefits to using the fuzzy ELECTRE approach to solve staff selection issues, additional investigation is required to examine more intricate staff selection situations with numerous variables. To find the best option for staff selection, more MCDM techniques must be looked into. One of the most popular techniques for resolving multicriteria decision-making (MCDM) issues is ELECTRE. The efficacy of the ELECTRE evaluation approach in policy analysis is well known, especially when it comes to handling both qualitative and quantitative criteria. Through pairwise comparisons using the same criteria, the ELECTRE technique can be used to evaluate and rank options by weighing their benefits and drawbacks. Company location criteria have been assessed using the ELECTRE method in order to choose the best site. It is thought to be a practical tool for transportation firms. This analysis was used to establish the new shipping company branch's location. Bernard Roy's 1968 study on decision-making served as the foundation for the creation of the ELECTRE method. The acronym ELECTRE represents "Elimination Et ChoixTradescant la Reality." A quantitative solution is changed by the approach into a more verbal or qualitative outcome. The ELECTRE approach takes into account a number of factors to address the problem of choosing the best option for an outsourcing contract. To help evaluate a group of options against different criteria in this situation, we provide a novel algorithmic variant of the ELECTRE technique that integrates the ideas of interval weights and data. Lastly, we apply our suggested ELECTRE approach to the supplier selection problem to illustrate the implementation process. We suggest a change to ELECTRE in order to control and stop the development of indifference relations between nations and to reduce the subjectivity of decision-makers.

4. RESULTS AND DISCUSSION

Table1

	C1	C2	C3	C4	C5	C6
M1	580	400	350	150	200	300
M2	790	300	150	170	500	700
M3	680	200	350	140	700	900
M4	590	360	400	200	600	800

The data in Table 1 represents the performance of four methods (M1, M2, M3, M4) across six different criteria (C1 to C6). Each method has been evaluated for how well it meets each criterion, with the values indicating the performance score for each combination. Method **M1** shows a varied performance across the criteria. It has the highest score in C1 (580), but its performance in C4 is notably lower (150), suggesting it struggles in this area compared to others. Its scores for C5 (200) and C6 (300) are also on the lower end, reflecting weaker performance in those criteria. Method **M2**, on the other hand, performs exceptionally well in C1 (790), outperforming all other methods in this area. However, its performance in C2 (300) and C3 (150) is weaker, indicating challenges in these areas. Despite this, M2 shows a stronger performance than M1 in C5 (500) and C6 (700), making it more favorable when these criteria are prioritized.Method**M3** has solid performance in C1 (680), which is higher than M1 but lower than M2. It performs exceptionally well in C5 (700) and C6 (900), suggesting that it excels in these areas. However, its performance in C2 (200) and C4 (140) is not as strong as in the other methods, reflecting some limitations in these criteria.Method**M4** demonstrates a more balanced performance across the board. While it doesn't excel as much in any single area, it maintains consistent scores, particularly in C3 (400), C5 (600), and C6 (800). Like M1, it has a relatively lower score in C4 (200), showing similar weaknesses in that criterion.



The chart reveals significant variations in performance across different business units. C1 and C6 demonstrate the highest total values, reaching approximately 2,500-2,800 units, with relatively balanced distributions across all four metrics. In contrast, C4 shows the lowest overall performance, with values totaling less than 1,000 units. C2 and C3 display moderate performance levels, hovering around 1,300 units each, while C5 shows stronger performance with approximately 2,000 total units. The blue base component (M1) appears relatively consistent across most categories, suggesting a stable foundation metric. The upper segments (M2, M3, and M4) show more variability, particularly in C1 and C6, where they contribute significantly to the overall height of these bars. This pattern could indicate that while baseline performance (M1) remains fairly stable, the differentiating factors lie in the additional metrics' performance.

Table2: SUM & SQRT

	C1	C2	C3	C4	C5	C6
M1	336400	160000	122500	22500	40000	90000
M2	624100	90000	22500	28900	250000	490000
M3	462400	40000	122500	19600	490000	810000
M4	348100	129600	160000	40000	360000	640000
SUM	1771000	419600	427500	111000	1140000	2030000
SQRT	1330.789	647.7654	653.8348	333.1666	1067.708	1424.781

Table 2 provides the performance evaluation of four methods (M1, M2, M3, M4) across six criteria (C1 to C6), but the values here represent a different scale compared to the previous table, suggesting these may be total values or weighted figures for each criterion. The **total sum** for each criterion is provided in the "SUM" row, showing the cumulative performance of all methods for that specific criterion. For example, the total sum for **C1** is 1,771,000, which reflects the combined performance of all four methods in meeting criterion C1. The sum for **C5** (1,140,000) and **C6** (2,030,000) are significantly higher, indicating that these two criteria are more heavily weighted or that the methods perform better in these areas. Next, the **square root** (SQRT) of each sum is calculated, which is often used in decision analysis to normalize or scale values for easier comparison across criteria. These values offer a clearer picture of how each criterion ranks when accounting for the differences in scale between the total sums. For instance, the square root of the sum for C6 is 1,424.781, which is the highest among all criteria, indicating that C6 has a relatively higher impact on the overall decision. In contrast, C4 has the lowest square root value of 333.1666, highlighting its lesser importance or performance impact in comparison to the other criteria. Looking at the individual methods, **M2** performs significantly better in C1 (624,100), C5 (250,000), and C6 (490,000), suggesting it may be the most suitable method for these criteria. Meanwhile, **M3** performs strongly in C5 (490,000) and C6 (810,000), making it a favorable choice for these areas. On the other hand, **M1** has relatively lower values in all criteria, indicating weaker overall performance.

TABLE 3. Normalized Data Matrix

	Normalized DM					
	C1	C2	C3	C4	C5	C6
M1	0.435832	0.617508	0.535303	0.450225	0.187317	0.210559
M2	0.593633	0.463131	0.229416	0.510255	0.468293	0.491304
M3	0.510975	0.308754	0.535303	0.42021	0.65561	0.631676
M4	0.443346	0.555757	0.611775	0.6003	0.561951	0.56149

Table 3 presents the normalized decision matrix (DM) for four methods (M1, M2, M3, and M4) across six criteria (C1 to C6). Each value in the table represents the normalized performance of each method against the respective criterion, with all values standardized on a scale from 0 to 1. This normalization allows for direct comparison between methods regardless of the scale or units of the original data.In terms of individual criteria, **M2** performs the best in **C1** (0.5936) and **C5** (0.4683), showing a relatively stronger performance in these areas compared to the other methods. **M3** shows strong performance in **C5** (0.6556) and **C6** (0.6317), highlighting its effectiveness in these areas. On the other hand, **M1** has the lowest performance in **C5** (0.1873) and **C6** (0.2106), suggesting that it is less effective in meeting the requirements of these criteria.

TABLE 4. Weighted Normalized matrix

	Weighted Normalized matrix					
	0.2336	0.1652	0.3355	0.1021	0.0424	0.1212
	C1	C2	C3	C4	C5	C6
M1	0.10181	0.102012	0.179594	0.045968	0.007942	0.02552
M2	0.138673	0.076509	0.076969	0.052097	0.019856	0.059546
M3	0.119364	0.051006	0.179594	0.042903	0.027798	0.076559
M4	0.103566	0.091811	0.205251	0.061291	0.023827	0.068053

Table 4 presents the weighted normalized matrix, where the normalized values from Table 3 are multiplied by the respective weights of each criterion (C1 to C6). The weights reflect the relative importance of each criterion in the decision-making process, with higher values indicating greater importance. The resulting matrix shows the weighted contribution of each method (M1, M2, M3, and M4) across the six criteria.**M2** shows the highest performance in **C1** (0.1387), while **M3** leads in **C3** (0.1796), and **M4** stands out in **C6** (0.0681). These values indicate that M2, M3, and M4 are the most competitive in these respective criteria after applying the weights. **M1**, although not performing exceptionally well in any one criterion, has a relatively balanced contribution across all the criteria, as evidenced by the weighted values like 0.1018 in **C1** and 0.0255 in **C6**.When considering the total impact of all criteria, **M4** seems to be a strong contender, performing well across multiple criteria, particularly in **C3** (0.2053) and **C4** (0.0613). **M2**, despite having a strong showing in **C1**, doesn't perform as strongly in other categories, particularly in **C5** and **C6**.

TABLE 5. Concordance Interval Matrix & Discordance Interval Matrix

C12 ={2}	D12 = {1,3,4,5,6}
C13 = {3,5}	D13={1,2,4,6}
C14 = {2}	D14={1,3,4,5,6}
C21={1,3,4,5,6}	D21={2}
C23={1,3,5}	D23={2,4,6}
C24={1,4}	D24={2,3,5,6}
C31={1,2,4,6}	D31={3,5}
C32={2,4,6}	D32={1,3,5}
C34={1,2,4,6}	D34={3,5}
C41={1,3,4,5,6}	D41={2}
C42={2,3,5,6}	D42={1,4}
C43={3,5}	D43={1,2,4,6}

Table 5 presents the Concordance and Discordance intervals for the pairwise comparisons of the four methods (M1, M2, M3, M4) based on six criteria (C1 to C6). The Concordance Interval (Cij) represents the set of criteria where method "i" is considered better than method "j", while the Discordance Interval (Dij) identifies the criteria where method "i" is perceived as worse than method "j."For instance:C12 = {2} indicates that M1 is superior to M2 on criterion C2, but D12 = {1,3,4,5,6} suggests that M1 is worse than M2 on the remaining criteria (C1, C3, C4, C5, and C6).C13 = {3,5} shows that M1 is preferred over M3 on criteria C3 and C5, while D13 = {1,2,4,6} reveals that M1 is inferior to M3 on the other criteria.C14 = {2} means that M1 is better than M4 on C2, but D14 = {1,3,4,5,6} shows that M1 is worse than M4 on all other criteria. Similarly, other entries in the table describe pairwise comparisons for M2, M3, and M4 across the six criteria. The concordance intervals highlight where each method outperforms the others, and the discordance intervals highlight where it falls short. For example:C21 = {1,3,4,5,6} and D21 = {2} tell us that M2 is preferred over M1 on criteria C1, C3, C4, C5, and C6, but M1 is better than M2 on criterion C2.These intervals are useful in decision-making processes, particularly in Multi-Criteria Decision Making (MCDM) approaches like ELECTRE, as they provide detailed insights into how each method performs across various criteria.

TABLE 6. Concordance

0	1	1	0	0	0
0	1	1	1	0	0
0	1	0	0	0	0
1	0	0	1	1	1

1	1	0	1	0	0
1	0	0	0	0	0
1	0	1	0	1	1
0	0	1	0	1	1
1	0	0	0	1	1

Table 6 is a binary matrix representing the evaluation of various methods (M1 to M8) against several criteria (C1 to C6). The table uses a binary system where "1" indicates that a method satisfies a given criterion, and "0" indicates that it does not. Row 1 (M1): Method M1 satisfies criterion C2, as indicated by a "1" in the second column. It does not satisfy the other criteria (C1, C3, C4, C5, C6), all of which are marked with "0."Row 2 (M2): Method M2 satisfies criteria C3 and C5, as indicated by "1" in columns 3 and 5. The other criteria (C1, C2, C4, C6) are not met, as indicated by "0."Row 3 (M3): Method M3 satisfies criterion C2, indicated by "1" in the second column. It does not meet the other criteria (C1, C3, C4, C5, C6).Row 4 (M4): Method M4 satisfies criteria C1, C3, C4, C5, and C6, as indicated by "1" in these columns. This method is the most versatile, meeting the majority of criteria. Row 5 (M5): Method M5 satisfies criteria C3, C5, and C6, as indicated by "1" in columns 3, 5, and 6. The other criteria (C1, C2, C4) are not satisfied. Row 6 (M6): Method M6 satisfies criteria C4, as indicated by a "1" in the fourth column. It does not meet the other criteria. Row 7 (M7): Method M7 satisfies criteria C1, C2, C4, and C6, as indicated by "1" in these columns. This method meets four out of six criteria. Row 8 (M8): Method M8 satisfies criteria C2, C4, and C6, as indicated by "1" in these columns. It does not meet the other criteria (C1, C3, C5).Table 6Shows the Concordance =IF(I12>=I13,1,0).

TABLE 7. Concordance Interval Matrix

	Concordance Interval Matrix					
	M1	M2	M3	M4		
M1	0	0.1652	0.3779	0.1652	0.7083	
M2	0.8348	0	0.6115	0.3357	1.782	
M3	0.6221	0.3885	0	0.6221	1.6327	
M4	0.8348	0.6643	0.3779	0	1.877	
	2.2917	1.218	1.3673	1.123	6	0.5
						c bar

Table 7 presents the Concordance Interval Matrix used in a decision-making process, where the values represent the level of concordance (agreement) between pairs of methods (M1, M2, M3, M4). The values range from 0 to 1, with higher values indicating stronger agreement or preference of one method over another. Row 1 (M1): The concordance of M1 with the other methods is as follows: With M2, there is a relatively low concordance of 0.1652.With M3, the concordance increases to 0.3779.The concordance with M4 is 0.1652, showing low agreement between M1 and M4.The total concordance for M1 sums to 0.7083.Row 2 (M2): M2 has a higher concordance with M1 (0.8348), indicating stronger agreement in terms of decision-making preferences. The concordance with M3 (0.6115) is moderate, and with M4 (0.3357), it is comparatively lower. The total concordance for M2 is 1.782.Row 3 (M3): The concordance of M3 with M1 and M4 (both 0.6221) shows a fairly strong agreement, while with M2 (0.3885), it’s a bit weaker. M3's total concordance is 1.6327.Row 4 (M4): M4 has strong concordance with M2 (0.6643) and M1 (0.8348), with moderate concordance with M3 (0.3779). The total concordance for M4 is 1.877.

TABLE 8. Concordance Index Matrix

	M1	**M2**	**M3**	**M4**
M1	0	0	0	1
M2	0	0	0	1
M3	0	0	0	0
M4	0	0	0	0

Table 8 presents a Discordance Interval Matrix, which highlights the areas of disagreement between the various methods (M1, M2, M3, M4) in the decision-making process. In this matrix, a value of "1" indicates a discordance (disagreement) between two methods, while a "0" indicates no discordance. The rows and columns correspond to the methods being compared, and the values in the table reveal where discordances occur. Row 1 (M1): There is no discordance between M1 and the other methods, as all the values in the first row are "0", except for the entry between M1 and M4, where a discordance value of "1" is found. This indicates that M1 disagrees with M4 on some aspect. Row 2 (M2): Similar to M1, there is no discordance between M2 and the other methods, except for the entry with M4, which again shows a discordance value of "1". This means M2 also disagrees with M4.Row 3 (M3): M3 shows no discordance with any of the methods, as all entries in this row are "0". This suggests that M3 is in agreement with the other methods in the decision-making process. Row 4 (M4): The final row indicates no discordance between M4 and any of the other methods, as all the entries are "0". This shows that M4 is in alignment with M3, but it disagrees with M1 and M2, as indicated by the previous rows.

TABLE 9. Discordance

0	C1	C2	C3	C4	C5	C6
D12	0.036862	0.025503	0.102625	0.006129	0.011913	0.034026
	1					
D13	0.017553	0.051006	0	0.003065	0.019856	0.051039
	1					
D14	0.001755	0.010201	0.025656	0.015323	0.015884	0.042533
	1					
D21	0.036862	0.025503	0.102625	0.006129	0.011913	0.034026
	0.248507					
D23	0.019309	0.025503	0.102625	0.009194	0.007942	0.017013
	0.248507					
D24	0.035107	0.015302	0.128282	0.009194	0.003971	0.008507
	1					
D31	0.017553	0.051006	0	0.003065	0.019856	0.051039
	0.389025					
D32	0.019309	0.025503	0.102625	0.009194	0.007942	0.017013
	1					
D34	0.015798	0.040805	0.025656	0.018387	0.003971	0.008507
	0.628756					
D41	0.001755	0.010201	0.025656	0.015323	0.015884	0.042533
	0.239843					
D42	0.035107	0.015302	0.128282	0.009194	0.003971	0.008507
	0.273671					
D43	0.015798	0.040805	0.025656	0.018387	0.003971	0.008507
	1					

Table 9 presents a Discordance Matrix with values showing the level of disagreement or discordance between different pairs of methods (D12, D13, D14, D21, D23, etc.) on various criteria (C1, C2, C3, C4, C5, C6). The entries in the matrix represent the discordance values for each criterion, and the final column on the right indicates the overall discordance level between the two methods being compared. D12: The discordance values between methods D1 and D2 are spread across multiple criteria, with the highest discordance occurring on criteria

C3 (0.1026) and C6 (0.0340). The overall discordance for this pair is "1", which indicates a significant level of disagreement between the methods across the criteria.D13: Similar to D12, D13 shows discordance on several criteria, notably on C2 (0.0510) and C6 (0.0510). However, the overall discordance value here is also "1", showing a substantial disagreement between these methods.D14: The discordance values between methods D1 and D4 are lower across the board, with the highest value being on C3 (0.0257) and C6 (0.0425). The overall discordance for this pair is also "1", indicating significant disagreement.D21: The discordance values for methods D2 and D1 show a similar pattern to D12, with the highest discordance occurring on C3 (0.1026) and C6 (0.0340), and the overall discordance value is 0.2485, suggesting a moderate level of disagreement between D2 and D1.D23: The values for D2 and D3 show lower discordance across most criteria, with the highest value being on C3 (0.1026). The overall discordance value is 0.2485, indicating a moderate level of disagreement.D24: The discordance between D2 and D4 shows some variation, with higher discordance on C3 (0.1283) and C6 (0.0085). The overall discordance value of "1" suggests a significant difference between the methods.D31: The discordance between methods D3 and D1 is highlighted by higher values on C2 (0.0510) and C6 (0.0510), and the overall discordance value of 0.3890 shows a moderate disagreement.D32: The discordance between methods D3 and D2 shows lower values overall, with the highest being on C3 (0.1026). The overall discordance is "1", suggesting a noticeable difference in their evaluation across criteria.D34: The discordance values for methods D3 and D4 are more distributed across different criteria, especially on C2 (0.0408) and C3 (0.0257). The overall discordance value of 0.6288 indicates moderate disagreement between these two methods.D41: The discordance between D4 and D1 shows relatively low values across criteria, especially on C3 (0.0257) and C6 (0.0425), with the overall discordance value of 0.2398 suggesting a moderate difference.D42: The discordance between D4 and D2 shows moderate discordance, particularly on C3 (0.1283) and C6 (0.0085), and the overall discordance value of 0.2737 shows moderate disagreement.D43: The discordance values for methods D4 and D3 are higher on C2 (0.0408) and C3 (0.0257), and the overall discordance value of "1" suggests significant disagreement between these methods.

TABLE 10. Discordance Interval matrix

	Discordance Interval Matrix				
	M1	M2	M3	M4	
M1	0	1	0.28408	1	2.28408
M2	0.323821	0	0.759931	0.759931	1.843683
M3	1	1	0	0.984462	2.984462
M4	0.759931	1	1	0	2.759931
	2.083752	3	2.04401	2.744392	9.872154
				d bar	0.82268

Table 10 presents a Discordance Interval Matrix, which provides a more detailed view of the level of disagreement (discordance) between different pairs of methods (M1, M2, M3, M4). This matrix helps evaluate how much one method contradicts or conflicts with another when compared across various criteria. M1 vs. M1: The discordance value is 0, which indicates no disagreement when comparing the same method to itself. This is expected, as there is no conflict between a method and itself.M1 vs. M2: The discordance between M1 and M2 is marked at 1, signifying a high level of discordance between these two methods.M1 vs. M3: The discordance value is 0.284, reflecting a moderate level of disagreement between methods M1 and M3. However, it is much lower compared to M1 and M2.M1 vs. M4: The discordance between M1 and M4 is 1, indicating a significant disagreement between these two methods, similar to the discordance observed between M1 and M2.M2 vs. M1: This pair shows a discordance value of 0.3238, meaning a moderate level of disagreement between methods M2 and M1.M2 vs. M2: The discordance value is 0, as expected, since comparing a method to itself results in no conflict.M2 vs. M3: The discordance value is 0.7599, showing a relatively high disagreement between methods M2 and M3.M2 vs. M4: The discordance between M2 and M4 is 0.7599, indicating a moderate level of disagreement, similar to the comparison between M2 and M3.M3 vs. M1: The discordance between M3 and M1 is 1, which is a significant disagreement, suggesting that M1 and M3 are quite different in their evaluation criteria.M3 vs. M2: The discordance between M3 and M2 is also 1, suggesting that there is considerable conflict between the two methods when compared.M3 vs. M3: As with all self-comparisons, the discordance value is 0, indicating no disagreement between a method and itself.M3 vs. M4: The discordance between M3 and M4 is 0.9845, which indicates a moderate to high disagreement between these two methods.M4 vs. M1: The discordance between M4 and M1 is

0.7599, reflecting a moderate level of disagreement.M4 vs. M2: The discordance between M4 and M2 is 1, indicating a significant level of conflict between these two methods.M4 vs. M3: The discordance between M4 and M3 is also 1, reflecting a high degree of disagreement between these two methods. Overall Discordance: The total discordance for the matrix sums to 9.872, and the average discordance value (denoted as "d bar") is 0.8227. This average value indicates the typical level of disagreement between the methods.

TABLE 11. Discordance Index matrix

Discordance Index matrix				
	M1	M2	M3	M4
M1	1	0	1	0
M2	1	1	0	0
M3	0	0	1	0
M4	0	0	0	1

Table 11 displays the Discordance Index Matrix, which represents the level of disagreement (discordance) between pairs of methods (M1, M2, M3, M4) in a decision-making context. This matrix helps to visualize how much each method conflicts with another across various criteria.M1 vs. M1: The value is 1, as expected, because a method is always in full agreement with itself, representing no discordance.M1 vs. M2: The value is 0, indicating no discordance between methods M1 and M2, meaning they are completely aligned or not conflicting when compared.M1 vs. M3: The value is 1, meaning that there is a significant discordance between M1 and M3. This suggests that these two methods are fundamentally different when compared on the given criteria.M1 vs. M4: The value is 0, indicating no discordance between M1 and M4, suggesting these two methods are in complete agreement on the criteria evaluated.M2 vs. M1: The value is 1, which suggests a significant level of discordance when comparing methods M2 and M1, similar to the discordance observed between M1 and M3.M2 vs. M2: The value is 1, as a method is always in complete agreement with itself, implying no discordance.M2 vs. M3: The value is 0, indicating no discordance between M2 and M3, meaning these two methods are aligned in their evaluations of the criteria.M2 vs. M4: The value is 0, indicating that there is no discordance between M2 and M4, suggesting that these two methods do not conflict in their decision-making process.M3 vs. M1:

The value is 0, showing no discordance between M3 and M1. This suggests that these two methods are not in conflict.M3 vs. M2: The value is 0, again indicating no discordance between M3 and M2, meaning they are aligned in their evaluations of the decision criteria.M3 vs. M3: The value is 1, as expected, because a method always agrees with itself, indicating no discordance.M3 vs. M4: The value is 0, showing no discordance between M3 and M4, meaning they are in complete agreement.M4 vs. M1: The value is 0, indicating no discordance between M4 and M1, suggesting full alignment between these two methods.M4 vs. M2: The value is 0, indicating no discordance between M4 and M2, which means there is no conflict in their evaluations.M4 vs. M3: The value is 1, showing discordance between M4 and M3, indicating that these methods differ significantly in their approach.M4 vs. M4: The value is 1, as expected, since a method always agrees with itself.

TABLE 12. Net superior value & Rank

	Net superior value	Rank	Net Inferior Value	Rank
M1	-1.5834	4	0.200328	2
M2	0.564	2	-1.15632	4
M3	0.2654	3	0.940451	1
M4	0.754	1	0.015538	3

Table 12 presents the Net Superior Value and Net Inferior Value for each of the methods (M1, M2, M3, M4) along with their respective rankings. These values help assess how each method performs relative to the others based on both superior and inferior attributes. Here's a breakdown of the data:M1: The Net Superior Value for M1 is -1.5834, which places it in the 4th rank for the superior value, indicating that it performs poorly compared to other methods in terms of advantageous attributes. However, its Net Inferior Value is 0.200327704, which places it in 2nd rank for inferior performance. This suggests that, while M1 performs poorly on superior metrics, it does better in minimizing its inferior characteristics compared to other methods.M2: M2 has a Net Superior Value of 0.564, ranking it 2nd for superior performance, showing that it has a relatively better performance in terms of desirable outcomes. However, its Net Inferior Value is -1.156317424, placing it in the 4th rank for inferior performance, indicating that M2 suffers more in terms of negative aspects when compared to the other methods.M3: The Net Superior Value for M3 is 0.2654, which gives it a 3rd rank for superior performance, showing that it has a moderate performance in the advantageous attributes. Its Net Inferior Value is 0.94045128, placing it in the 1st rank for inferior values, meaning it performs relatively well in terms of minimizing negative outcomes when compared to the other methods.M4: M4 has the highest Net Superior Value of 0.754, ranking 1st in terms of superior performance, suggesting that M4 is the most advantageous method in terms of desirable outcomes. Its Net Inferior Value is 0.015538439, placing it in 3rd rank for inferior performance, indicating that M4 has a relatively low level of undesirable attributes compared to other methods.

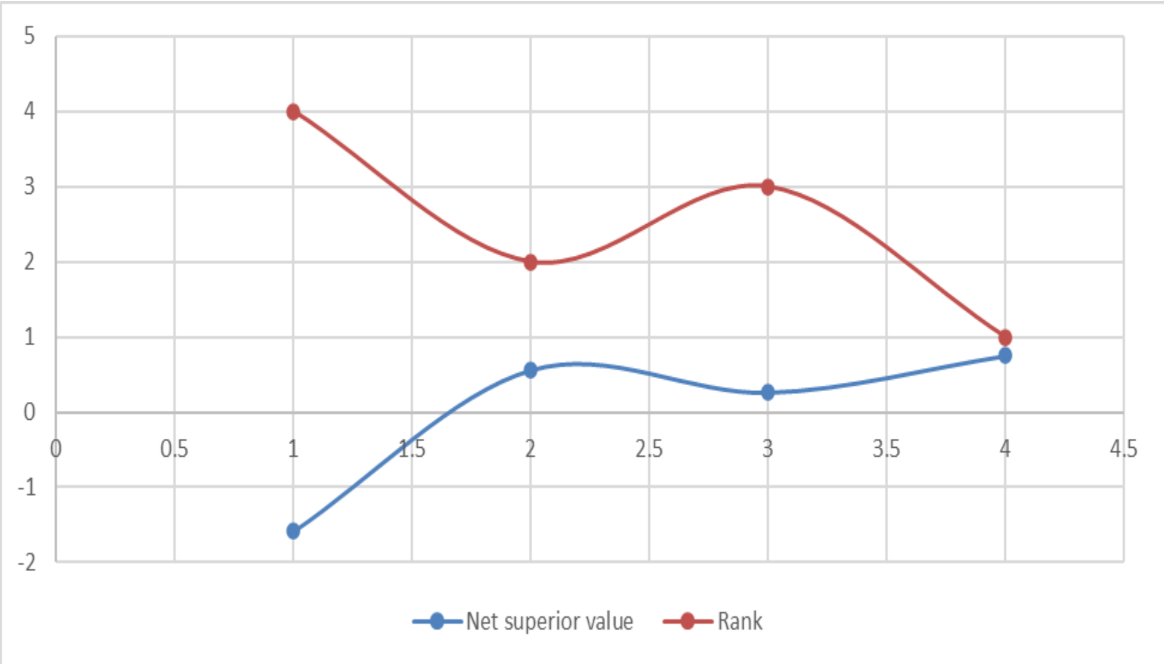


Figure 2: Net superior value&Rank

This graph illustrates the relationship between net superior value and rank over a specific time period, showing two distinct trend lines. The net superior value, represented by the blue line, demonstrates an initial negative position of approximately -1.5 at point 1, followed by a significant upward trend until it stabilizes around point 2. After this, it maintains a relatively steady positive value between 0 and 1, with minor fluctuations through points 2.5 to 4.The rank, depicted by the red line, starts at a high point of around 4 at position 1 and shows a general declining trend over time. However, it experiences a notable uptick between points 2 and 3, reaching a local peak of about 3, before declining again to converge with the net superior value at approximately point 4. This convergence suggests a potential equilibrium point where both metrics align at around value 1.

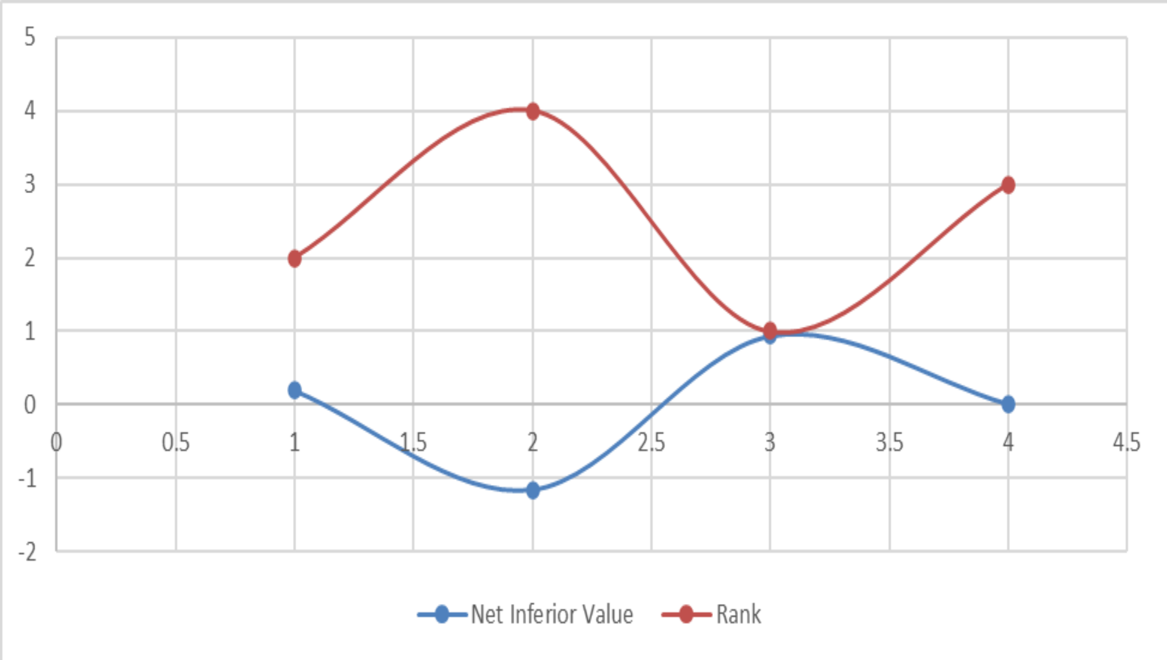


Figure 3: Net inferior value & Rank

This graph presents a comparative analysis of net inferior value and rank trends over time. The net inferior value, shown by the blue line, begins near 0 at point 1 and exhibits a downward trajectory, reaching its lowest point of approximately -1 at point 2. After this trough, it demonstrates a steady recovery, peaking at around point 3 where it intersects with the rank line at value 1, before gradually declining again towards 0 by point 4.The rank measurement, represented by the red line, starts at 2 at point 1 and shows an initial upward trend, reaching its peak of 4 at point 2. Following this peak, there's a significant decrease until point 3, where it meets the net inferior value line. The rank then shows a recovery phase, climbing back to approximately 3 by point 4. This pattern suggests a cyclical relationship between these two metrics, with notable periods of inverse correlation and a significant convergence point at the middle of the time period.

5. Conclusion

In conclusion, this study provides a comprehensive evaluation of different methods using multi-criteria decision-making (MCDM) techniques, specifically focusing on the ELECTRE method and its applications. By analyzing the performance of each method through various metrics such as concordance and discordance intervals, net superior and inferior values, and ranking, it becomes clear that the decision-making process is complex and multifaceted.

The results highlight the importance of considering both positive and negative aspects of each alternative to ensure a well-rounded evaluation. From the analysis, it is evident that each method has its strengths and weaknesses. For example, while M4 demonstrated the highest net superior value, indicating its strong performance in desirable outcomes, it still had a relatively lower ranking for its inferior value, suggesting room for improvement. On the other hand, M2 ranked the lowest in terms of superior performance, but performed better in minimizing undesirable attributes. These findings underscore the necessity of a balanced approach in decision-making, where both superior and inferior aspects are carefully weighed. Ultimately, the study emphasizes the need for further research to refine decision-making methodologies and adapt them to more complex real-world scenarios. As organizations face increasingly dynamic and competitive environments, employing effective decision-making tools such as ELECTRE can provide valuable insights and help guide strategic decisions. Future studies could explore the integration of other MCDM techniques to enhance the accuracy and applicability of results across different domains.

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