EDUCATION,
INNOVATION, KNOWLEDGE

How to cite this paper: Artashyan A. (2025). Multi-criteria Decision Making in the Field of Information Technology Based on Grey Relational Analysis. *Messenger of ASUE, 3*(81), 75-85.
DOI: 10.52174/1829-0280_2025.3-75
Received: 19.06.2025. ***Revision:*** 04.09.2025. ***Accepted:*** 29.12.2025.

ARGAM ARTASHYAN
Associate Professor of the Chair of Business Information Systems and Information Technologies, Head of the IT Department at the Armenian State University of Economics
https://orcid.org/0000-0002-4550-3491

MULTI-CRITERIA DECISION MAKING IN THE FIELD OF INFORMATION TECHNOLOGY BASED ON GREY RELATIONAL ANALYSIS

In the information technology (IT) sphere, the selection of an effective management information system (MIS) has become an organizational strategic choice. While choosing different systems, there are typically many conflicting criteria, hence the final decision-making process becomes complicated. The general aim of this study is to examine the application of the Grey Relational Analysis (GRA) technique in the selection procedure of an MIS based on the principle of multi-criteria decision-making (MCDM). The application of the technique is explained through a specific example, whereby SAP Business One, Microsoft Dynamics 365, Odoo ERP, and Zoho One systems are utilized for comparison. Functionality, price, installation duration, ease of use, technical support, and integration functionality were selected as evaluation factors.

Methodologically, the study involved data normalization, selection of an ideal reference sequence, and calculation of grey relational coefficients, enabling the identification of the alternative closest to the optimal solution. The findings demonstrate that the GRA method effectively handles multidimensional and uncertain data, facilitating objective decision-making. The results are particularly valuable for organizations seeking to choose the most appropriate MIS based on their specific needs and resources. Furthermore, the study confirms the applicability of the GRA technique across various domains, including IT management, risk assessment, and system selection processes.

Keywords: *Grey Relational Analysis, multi-criteria decision making, information technology, management information system, evaluation criteria*
JEL: C44, C61, L86
DOI: 10.52174/1829-0280_2025.3-75

INTRODUCTION. Multi-criteria decision-making (MCDM) is an important and complex issue in the fields of modern management and information technology (IT). Businesses typically face the need to choose between various technological projects, software packages, or IT systems, where it is essential to consider several conflicting criteria simultaneously - such as system performance, economy, implementation time, ease of use, and service capabilities.

Such problems should be addressed with modern, multi-faceted analysis methodologies capable of offering objective, soundly reasoned, and stable conclusions even when the data available are incomplete or partially imprecise. The Grey Relational Analysis (GRA) methodology is an effective methodology for addressing such problems since it can compare alternatives based on their closeness to an optimal solution and rank them with a set of a certain number of criteria for analysis.

By overcoming the limitations of traditional analysis techniques, GRA has been applied broadly in business management, manufacturing, quality control, and information technology, particularly in facilitating optimal decision-making.

This study aims to apply the Grey Relational Analysis method in the IT project choice process, analyzing its effectiveness as well as strategic alignment with organizational objectives. The results can be a worthwhile basis for the best use of resources and for organizational process improvement in IT management.

The article resolves the following key problems:

- development of the criteria set for the evaluation of management information systems;
- comparative ranking of alternatives by the GRA method;
- research of the extent to which different systems meet organizational requirements.

Multidimensional decision-making on the basis of the Grey Relational Analysis method enables the elimination of uncertainty and contradictions of information, producing complete, scientifically grounded, and practically meaningful solutions. This research improves the quality of IT management decision-making and helps organizations make optimal decisions aligned with technical, economic, and organizational requirements. Besides this, the proposed method opens up new directions for additional research and methodological development to address the challenges of the rapidly evolving IT world more efficiently.

LITERATURE REVIEW. Multi-criteria decision-making methods are an important area of research in the field of information technologies, especially when a decision has to be made based on multiple, often conflicting, criteria. The application of the Grey Relational Analysis method to this field provides a robust tool for dealing with uncertainty and fuzziness in real-life decision-making environments.

GRA is a useful method of ranking and assessing available alternatives with multiple criteria. *Wei (2011)* proposed integrating GRA with incomplete information to extend the scale of GRA to make it possible to work in terms of unknown weights of criteria, thus eliminating the common issue of unknown weights of criteria (Wei, 2011). The process provides a more accurate assessment, particularly in IT environments where decision-making occurs under uncertain situations.

Öztayşi (2014) in his study suggested a selection model for IT systems with the use of Analytic Hierarchy Process (AHP), TOPSIS, and GRA methods and their implementation in content management systems (Öztayşi, 2014). The model emphasizes the feature of the GRA method to be combined with other MCDM models so that the reliability and decision accuracy can be enhanced.

Another group of researchers significantly expanded the application range of GRA by proposing neutrosophic sets, which allow for uncertainty management in decision-making. They demonstrated how GRA can be employed to rank alternatives based on a neutrosophic environment, even if the weights of the criteria are vague (Biswas et al., 2014). Such models also use the information entropy method to calculate weights, enabling more precise analysis.

Another revolutionary input is the calculation of neutrosophic grey relational coefficient using Hamming distance, which brings tremendous power to ranking reliability in uncertain environments (Biswas et al., 2014). This enhanced methodology demonstrates the extent to which the GRA approach can be used to solve complex problems in the IT industry, especially where traditional exact numerical data are insufficient.

The applicability of GRA is also claimed through its application in the health sector: *Javed et al. (2018)* used GRA to measure patient satisfaction and quality of service (Javed et al., 2018). This study shows that it is possible to apply the same practices fairly effectively in the IT sector too, to assess user satisfaction and performance of service.

Additionally, *Chang and others (2013)* integrated GRA with the Failure Mode and Effects Analysis (FMEA) method to assess risks and vulnerabilities, a particularly relevant methodology in IT, especially in the field of cybersecurity (Chang et al., 2013). Then, *Ganin and others (2020)* point out the need for effective MCDM systems in the case of cyber risk evaluation, emphasizing the role of GRA in such a process (Ganin et al., 2020).

Despite the aforementioned success, there are still some gaps in using the GRA technique. First and foremost, no extensive research on combining GRA with advanced technologies such as machine learning or big data analytics has been conducted. Such combinations could enhance the robustness of GRA and make decision-making more informative. Second, though neutrosophic sets bring a new level in dealing with uncertainty, further research is needed to establish their viability in the majority of areas of IT. In particular, there is a scarcity of empirical research that validates and tests the effectiveness of the proposed models within real projects.

Finally, a rigorous evaluation must be conducted to determine how much GRA-based models perform better than traditional decision-making methods. Comparison studies, such as these, can potentially offer reasons why and when GRA can be employed more positively in favor of other methods.

To address the above-mentioned gaps, future research can explore the following directions:

- *integration with new technologies* – Investigate the integration of GRA with artificial intelligence (AI) and machine learning algorithms to enhance decision quality in the IT context.
- *practical applications* – Empirically validate the effectiveness of neutrosophic GRA models in various IT environments, such as software selection, project management, and cybersecurity.
- *comparative studies* – Make comparative analyses to assess the performance of GRA models relative to traditional multi-criteria decision-making methods.
- *dynamic environments* – Examine the flexibility of the GRA technique in dynamic environments in which the alternatives and criteria may change over time.

Overall, the integration of the Grey Relational Analysis method in information technology multi-criteria decision-making has been demonstrated to hold high potential for addressing real-world decision complexities. A survey of ongoing research highlights the flexibility of GRA, especially when combined with neutrosophic sets and other innovative methodologies. Nevertheless, there remain unexplored avenues in the field where further research can provide more concrete, reliable, and efficient decision-making models in IT strategy and management.

METHODOLOGY. Grey Relational Analysis is a robust technique grounded in Grey System Theory, especially designed for system analysis when dealing with incomplete, indeterminate, or "grey" data. Its fundamental idea is to quantify the degree of similarity or dissimilarity between sequences. This typically involves comparing a selected reference sequence, which may signify an ideal or optimal solution, with various comparable sequences, which signify alternative solutions to be compared.

In the Multi-criteria Decision-Making environment, GRA is particularly valuable at ranking alternatives with respect to their "grey relational grade," a quantitative measure of their overall closeness to the optimal solution. It is particularly beneficial when decision-making happens in high-complexity environments where standard statistical methods are disadvantaged by imperfections in data or inherent uncertainty.

Though GRA is designed to handle "grey" data, the acceptability and credibility of its "objective" findings need to have a meticulous recording of every equation, step, and assumption in the methodology section. Such unsealing is necessary not so much because it responds to academic discipline as because it allows decision-makers to observe how outcomes are produced, even where input data are imperfect. Without such an open explanation, the approach could be viewed as a "black box," with the risk of losing confidence in its results.

ANALYSIS. The rapid development of information technologies and the widening role of digital solutions in business management systems have grown dramatically in recent years. Proper selection of MIS can play a significant role in implementing an organization's strategic goals, improving business processes, and competitiveness. Simultaneously, the variability of the proposed solutions and the multi-factorality of their evaluation make the correct choice more complicated.

The current research work aims to apply the Grey Relational Analysis method for a comparative study of various management information systems and select the optimal alternative. A list of major criteria will be examined with the aid of this method, based on which the solutions will be ranked and the best alternative selected.

The selection of an optimal management information system (MIS) for an organization depends on a combination of essential evaluation criteria. To illustrate this process, the following section examines a real company that faced several alternative solutions and needed to select the most appropriate system for its operational needs. For confidentiality reasons, the company's name is not disclosed. The systems evaluated included SAP Business One, Microsoft Dynamics 365, Odoo ERP, and Zoho One.

By way of a general rule, management information systems are judged on the basis of several criteria. To begin with, the system's functionality is taken into account and rated 1 to 10, where 10 marks represent greater functionality. Next, the cost in terms of thousand US dollars is also taken into consideration, with a lesser cost being a point in its favor. The third is the time of implementation, in weeks; the lower, the better the rating of the system implementation. The fourth is ease of use, also on a scale of 1 to 10, with the higher the number, the greater the ease of use. The fifth is technical support, also on a scale of 1 to 10, determined by the quality and availability of the support. Finally, ease of integration is evaluated–how easy it is to integrate the system with the rest of the organization's information systems–and also noted on a scale of 1 to 10.

By combining all these elements, the decision is made on what information system suits the organization best.

Table 1

Alternatives characteristics

Alternative	*Alternative name*	*Functionality*	*Price (1000 Dollars)*	*Installation Time*	*Ease of use*	*Support*	*Integration*
A	SAP	9.0	40.0	12.0	6.0	9.0	9.0
B	MS	9.0	35.0	10.0	8.0	9.0	9.0
C	Odoo	8.0	20.0	8.0	9.0	7.0	8.0
D	Zoho	7.0	15.0	6.0	9.5	7.0	6.0

Table 2

Ideal options

Criteria	*The best value*
Functionality	9.0
Price	15.0
Installation Time	6.0
Ease of use	9.5
Technical Support	9.0
Integration	9.0

The second step is to perform normalization, and subsequently compute GRC and GRG.

1. **Normalization**

A few of the criteria contain values in different units; they must be made comparable. Different formulas are used in normalizing depending on the type of criterion:

- *If the goal is to increase the criterion value (the minimum value is considered worse):*

$$x_i^*(k) = \frac{x_i(k) - min\, x_i(k)}{max\, x_i(k) - min\, x_i(k)}$$

- *If the goal is to decrease the criterion value (a lower value is better):*

$$x_i^*(k) = \frac{max\, x_i\,(k) - x_i(k)}{max\, x_i(k) - min\, x_i(k)}$$

where:

$x_i(k)$ - the actual value of the *k*-th criterion for the *i*-th alternative;

$x_i^*(k)$- the normalized value;

$max\, x_i(k), min\, x_i(k)$- maximum and minimum values of the given criterion among all alternatives.

Since, in our example, optimum values for characteristics Functionality, Ease of Use, Support, and Integration are greater, we use the first formula for normalization. For Price and Installation Time, where optimum values are smaller, we use the second formula.

We will compute the maximum and minimum values for all attributes.

Table 3

Maximum and minimum values of characteristics

Criteria	*Max*	*Min*
Functionality	9.0	6.5
Price (1000 US dollars)	40.0	15.0
Installation Time	12.0	6.0
Ease of use	9.5	6.0
Support	9.0	6.5
Integration	9.0	6.0

Let us perform the calculations of normalized values.

Table 4

Calculations of normalized values

Alternative	*Functionality (higher is better)*	*Price (lower is better)*	*Installation Time (lower is better)*	*Ease of use (higher is better)*	*Support (higher is better)*	*Integration (higher is better)*
A	$\frac{9.0-6.5}{9.0-6.5}=1.00$	$\frac{40-40}{40-15}=0.00$	$\frac{12-12}{12-6}=0.00$	$\frac{6-6}{9.5-6}=0.00$	$\frac{9.0-6.5}{9.0-6.5}=1.00$	$\frac{8.5-6.0}{9.0-6.0}=0.83$
B	$\frac{8.5-6.5}{9.0-6.5}=0.80$	$\frac{40-35}{40-15}=0.20$	$\frac{12-10}{12-6}=0.33$	$\frac{8-6}{9.5-6}=0.57$	$\frac{8.5-6.5}{9.0-6.5}=0.80$	$\frac{9.0-6.0}{9.0-6.0}=1.00$
C	$\frac{7.5-6.5}{9.0-6.5}=0.40$	$\frac{40-20}{40-15}=0.80$	$\frac{12-8}{12-6}=0.67$	$\frac{9-6}{9.5-6}=0.80$	$\frac{7.0-6.5}{9.0-6.5}=0.20$	$\frac{7.5-6.0}{9.0-6.0}=0.50$
D	$\frac{6.5-6.5}{9.0-6.5}=0.00$	$\frac{40-15}{40-15}=1.00$	$\frac{12-6}{12-6}=1.00$	$\frac{9.5-6}{9.5-6}=1.00$	$\frac{6.5-6.5}{9.0-6.5}=0.00$	$\frac{6.0-6.0}{9.0-6.0}=0.00$

2. Reference Series

The reference series $x_0^*(k)$ is the vector of the most desirable or best normalized values:

$$x_0^*(k) = \max_i x_i^*(k)$$

In our case, the best normalized values are 1.00.

3. Grey Relational Coefficient (GRC)

We find the difference between every alternative and the ideal for the $\Delta_i(k)$:

$$\Delta_i(k) = |x_0^*(k) - x_i^*(k)|$$

The grey relational coefficient is found as:

$$\varepsilon_i(k) \frac{\Delta_{min} + \sigma \cdot \Delta_{max}}{\Delta_i(k) + \sigma \cdot \Delta_{max}}$$

where:

$\Delta_{min} = min_{i,k}\ \Delta_i(k)$- the minimum difference among all data;

$\Delta_{max} = max_{i,k}\ \Delta_i(k)$- the maximum difference;

σ- the distinguishing coefficient ($0 \le \sigma \le 1$), commonly taken as 0.5.

This formula shows how close a given alternative is to the ideal according to the k-th criterion.

Table 5

Calculations of normalized values

Alternative	*Functionality*	*Price*	*Installation time*	*Ease of use*	*Support*	*Integration*
A	0.00	1.00	1.00	1.00	0.00	0.17
B	0.20	0.80	0.67	0.43	0.20	0.00
C	0.60	0.20	0.33	0.20	0.80	0.50
D	1.00	0.00	0.00	0.00	1.00	1.00

Reminder: $\Delta_{min} = 0, \Delta_{max} = 1, \sigma = 0.5$ (expected distinguishing coefficient).

$$\varepsilon_i(k) \frac{0 + 0.5 \cdot 1}{\Delta_i(k) + 0.5 \cdot 1} = \frac{0.5}{\Delta_i(k) + 0.5}$$

Let us calculate, for example, the Grey Relational Coefficient (GRC) of option A's functionality criterion.

$$\varepsilon_i(Functionality) \frac{0.5}{0 + 0.5} = 1.0$$

Calculate the GRC for all criteria.

Table 6

Calculations of GRC values

Alternative	*Functionality*	*Price*	*Installation time*	*Ease of use*	*Support*	*Integration*
A	1.00	0.33	0.33	0.33	1.00	0.71
B	0.71	0.38	0.43	0.54	0.71	1.00
C	0.31	0.71	0.60	0.71	0.38	0.50
D	0.25	1.00	1.00	1.00	1.25	0.25

4. Grey Relational Grade (GRG)

The overall relational coefficient (or rating) of the *i*-th option is calculated as:

$$\gamma_i = \frac{1}{n} \sum_{k=1}^{n} \varepsilon_i(k)$$

where:

n - the number of criteria;

γ_i - the overall closeness degree of the *i*-th option to the ideal option.

In our example, the Grey Relational Grade (GRG) value is calculated from the above equation:

$$\gamma_i = \frac{1}{6}\sum_{k=1}^{6} \varepsilon_i(k)$$

Table 7

Calculations of GRG values

Alternative	*GRG γ_i*
A	$\frac{1.00+0.33+0.33+0.33+1.00+0.71}{6} = 0.61$
B	$\frac{0.71+0.38+0.43+0.54+0.71+1.00}{6} = 0.62$
C	$\frac{0.31+0.71+0.60+0.71+0.38+0.50}{6} = 0.53$
D	$\frac{0.25+1.00+1.00+1.00+0.25+0.25}{6} = 0.62$

5. Selection

The optimum choice is that with the highest γ_i value. In our example, options B (Microsoft Dynamics 365) and D (Zoho One) both have identical, highest GRG values of 0.62, i.e., both are closest to ideal according to all criteria.

CONCLUSION. The study was able to demonstrate well the robust application of the Grey Relational Analysis method in resolving complex multi-criteria evaluation and ranking problems in the area of IT projects, specifically for the selection of MIS. The method adequately facilitated joint consideration of a number of crucial criteria, including system performance, price, implementation duration, ease of use, quality of technical support, and integration capacity. Following the rule of closeness between relations, GRA facilitated an objective and complete analysis of project alternatives, resulting in an adequately outlined ranking and best solution selection consistent with organizational strategic objectives.

The findings indicate GRA's strength in handling multidimensional and fuzzy data, a common characteristic of real-world IT decision-making settings. The result is most beneficial to organizations trying to reach well-informed decisions regarding MIS adoption and, ultimately, maximize resource allocation and enhance general organizational performance. The research result, indicating Microsoft Dynamics 365 and Zoho One as equally optimum based on the chosen criteria, presents a real-world validation of GRA's use. GRA's methodology has the strength of transforming intrinsically subjective views or qualitative assessments (e.g., "ease of use," "quality of technical support," "integration functionality") into quantifiable, mathematically derived outputs. This approach successfully "objectifies" what would otherwise be a subjective, opinion-based choice, making the reasoning more transparent and defendable. This development is of specific value to IT management, where decisions are often challenged by numerous stakeholders. GRA thus serves as a robust middle ground between qualitative judgments and quantitative intensity in IT decision-making, providing an organized and unbiased approach to overcoming natural uncertainty and subjective considerations, thereby enhancing the credibility and defensibility of strategic alternatives.

Also, the successful application of GRA in this study highlights its profound influence and broad implications for IT decision-making. GRA empowers IT professionals and managers with the capacity to move beyond intuition, thereby enabling them to make more rational, fact-based decisions. This leads to optimal resource utilization, investments being directed towards solutions that best meet specific needs and strategic needs, hence the overall effectiveness of organizational processes.

The method is very useful in complex, multi-criteria decision-making cases, particularly where data are partially incomplete, fuzzy, or expressed by inherent uncertainty. It can cope with "grey" information, which renders it distinct from traditional methods that prefer precise, complete data. By providing a systematic approach for contrasting alternatives with a complete set of criteria, GRA ensures IT project choices that are not only technically accurate but also tactically relevant to high-level organizational objectives. This produces an enhanced, integrated, and efficient IT strategy.

References

1. Benitez-Amado, Jose, & Walczuch, R. (2012). Information technology, the organizational capability of proactive corporate environmental strategy and firm performance: a resource-based analysis. *European Journal of Information Systems*, 21, 664-679. http://doi.org/10.1057/ejis.2012.14
2. Biswas, P., Pramanik, Surapati, Giri, B., & Ghosh, Nandalal. (2014). Entropy-Based Gray Relational Analysis Method for Multi-Attribute Decision Making under Single-Valued Neutrosophic Assessments. *Neutrosophic Sets and Systems*, 2, 102-110. http://doi.org/10.5281/ZENODO.22459
3. Chang, Kuei-Hu, Chang, Yung-Chia, & Tsai, I-Tien. (2013). Enhancing FMEA assessment by integrating gray relational analysis and the decision-making trial and evaluation laboratory approach. *Engineering Failure Analysis*, 31, 211-224. http://doi.org/10.1016/J.ENGFAILANAL.2013.02.020
4. Ganin, A., Quach, Phu., Panwar, Mahesh., Collier, Zachary A., Keisler, J., Marchese, Dayton., & Linkov, I. (2020). Multi-criteria Decision Framework for Cybersecurity Risk Assessment and Management. *Risk Analysis*, 40. http://doi.org/10.1111/risa.12891
5. Javed, S., Liu, Sifeng, Mahmoudi, A., & Nawaz, Muhammad. (2018). Patients' satisfaction and public and private sectors' health care service quality in Pakistan: Application of gray decision analysis approaches. *The International Journal of Health Planning and Management*, 34, e168-e182. http://doi.org/10.1002/hpm.2629

6. Öztayşi, Başar. (2014). A decision model for information technology selection using AHP integrated TOPSIS-Grey: The case of content management systems. *Knowl. Based Syst.*, 70, 44-54. http://doi.org/10.1016/j.knosys.2014.02.010
7. Panda, A., Sahoo, A., & Rout, A. (2016). Multi-attribute decision making, parametric optimization, and modeling in hard turning using ceramic insert through gray relational analysis. *Decision Science Letters*, 5, 581-592. http://doi.org/10.5267/J.DSL.2016.3.001
8. Surapati, P., & Dulal, M. (2011). Gray Relational Analysis-based Intuitionistic Fuzzy Multi-Criteria Group Decision-Making Approach for Teacher Selection in Higher Education. *International Journal of Computer Applications, 34*, 21-29.
9. Wang, Peng, Meng, Peng, Zhai, Ji-Ying, & Zhu, Zhou-Quan. (2013). A hybrid method using experiment design and gray relational analysis for multiple criteria decision-making problems. Knowl. Based Syst., 53, 100-107. http://doi.org/10.1016/j.knosys.2013.08.025
10. Wei, G. (2011). Gray relational analysis method for 2-tuple linguistic multiple attribute group decision making with incomplete weight information. *Expert Syst. Appl.,* 38, 4824-4828. http://doi.org/10.1016/j.eswa.2010.09.163
11. Wei, G. (2011). Gray relational analysis model for dynamic hybrid multiple attribute decision making. *Knowl. Based Syst.,* 24, 672-679. http://doi.org/10.1016/j.knosys.2011.02.007