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Proje Yönetim Yazılımlarının Değerlendirilmesi: SWARA ve CODAS Yöntemleriyle Karşılaştırmalı Bir Analiz

Evaluating Project Management Software: A Comparative Analysis Using SWARA and CODAS Methods

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Öz: Proje yönetim yazılımlarının değerlendirilmesi, birçok kriter ve alternatifin varlığı nedeniyle karmaşık bir süreçtir. Bu araştırma, bu süreci kolaylaştırmak amacıyla SWARA ve CODAS gibi çok kriterli karar verme yöntemlerini uygulamaktadır. SWARA yaklaşımı, profesyonel proje yöneticilerinin geri bildirimlerine dayanarak kriterlerin önem derecesini belirlemek için kullanılırken, CODAS tekniği farklı proje yönetim yazılımlarının etkinliğini değerlendirmek ve sıralamak için kullanılmaktadır. Kullanıcı arayüzü, entegrasyon ve ölçeklenebilirlik gibi parametreler değerlendirmede kritik öneme sahiptir. Araştırma sonuçları, "ClickUp, Hive ve Wrike" yazılımlarının en yüksek performansa sahip araçlar olduğunu göstermektedir. Bu araçlar, gelişmiş entegrasyon işlevleri ve ölçeklenebilirlik özellikleri sayesinde diğerlerinden ayrılmaktadır. Öte yandan Basecamp, bazı özelliklerin eksikliği nedeniyle son sırada yer almıştır. Bu çalışma, proje yönetimi alanındaki bilgi birikimine katkıda bulunmakta ve SWARA ile CODAS yöntemlerinin yazılım seçiminde uygulanabilirliğini ortaya koymaktadır. Ayrıca yazılım geliştiricilere, kullanıcı ihtiyaçlarını karşılamak için hangi özelliklere odaklanmaları gerektiği konusunda ipuçları vermektedir.

Anahtar Sözcükler: Proje Yönetimi Yazılımları, CODAS, SWARA, Çok Kriterli Karar Verme

JEL Sınıflandırması: D81, M15, O32

Abstract: The evaluation of project management software is an intricate process because of the existence of several criteria and alternatives. This research applies multi-criteria decision-making methods, such as SWARA and CODAS, to make this process easier. The SWARA approach is used to determine the importance of the criteria based on the feedback of professional project managers, while the CODAS technique is utilized to evaluate and rank the efficiency of different project management software solutions. Parameters like user interface, integration, and scalability are critically important in the evaluation. The outcomes indicate that "ClickUp, Hive, and Wrike" are the tools with the highest level of performance. These instruments differ from others owing to the fact that they have sophisticated integration functionalities, as well as scalability. On the contrary, Basecamp took the last place because of the absence of some features. This study adds to the body of knowledge in the area of project management and illustrates the applicability of the SWARA and CODAS methods in software selection. Furthermore, it gives software developers clues about which features they should concentrate on in order to satisfy user requirements.

Keywords: Project Management Software, CODAS, SWARA, Multi-Criteria Decision Making

JEL Classification: D81, M15, O32

1. Introduction

Effective project management is the key in modern organizations to making sure that complex tasks are carried out successfully and strategic objectives are attained. Today, the complexity of projects grows alongside rapid technological advancement, thereby inducing the development of project management software that has been designed to streamline

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workflows, improve collaboration, and optimize resource usage (Sane, 2019). Nevertheless, the large selection of tools that are on offer for companies becomes a considerable challenge in the proper software choice which is tailored to fit their needs the best (Ferreira & Tereso, 2014). With the rapid pace of technological advancement, project complexity has grown significantly, particularly in sectors such as telecommunications, which stands at the forefront of this transformation. In this regard, due to its applicability in the telecommunications sector as well as in other industries, multi-criteria decision-making techniques are suggested to be the structured means of evaluation and prioritization of software alternatives relying on various performance measures.

This research manifested the new synthesis of two Multi-Criteria Decision Making (MCDM) techniques, The Stepwise Weight Assessment Ratio Analysis (SWARA) and Combinative Distance-based Assessment (CODAS), to rank project management software appropriately. The SWARA is brought into play to measure the relative significance of the criteria, like cost, task management, integrations, and user-friendliness. This method is based on expert input, thus making SWARA a reliable structure for the assignment of weights that is subjective depending on the importance of each criterion (Popović et al., 2021; Stanujkic et al., 2017). The second one, CODAS, is used to order the software options by determining how far they are from the ideal solution and, thus, both Euclidean and Taxicab metrics are utilized to this end. The correlation of the scores returned by these methods generates a complete and accurate ranking that reflects the different performances of the software in each aspect (Pérez-Dominguez et al., 2021).

The novelty of this study lies in the integration of two complementary methodological approaches, a combination seldom found in project management software evaluation studies, partly because many researchers prefer less methodologically intensive frameworks. Previous research mainly uses individual Multiple Criteria Decision Making (MCDM) methods such as AHP, TOPSIS, and VIKOR, which may lack the flexibility or depth to handle complex decision-making scenarios involving subjective criteria weights and nuanced ranking processes (Mardani et al., 2015). This study, by incorporating SWARA and CODAS into the analysis, gives rise to a more dynamic and malleable analytical technique for software tools to be evaluated, thus meeting the traditional methods' weaknesses in this direction.

Further, this research is among the first that applied the suggested methodology to a real-life case study that encompassed the regular use of project management tools such as Monday.com, Jira, Asana, and Trello. The evaluation basis is 14 key criteria, including pricing, scalability, automation, and security, which are very important for companies of different sizes and industries. Its empirical account can be of great use to the practitioners opting for perfect project management tools and also to developers who are striving to improvised the current software.

According to the results of the study, the data are particularly valuable when compared to the digital transformation era where the demand for robust project management systems is increasing. Through a systematic assessment and ranking of the software alternatives, this study is not only supporting the approach of choosing the most compatible tools but also setting a precedent for future studies in software evaluation. The two-method strategy ensures alignment between expert evaluations and statistical performance assessments, making the process more robust, consistent, and effective.

To conclude, this study narrows the gap that exists between the theoretical developments of MCDM methods and the circumstances in which project management software selection suffers theoretical defect. The SWARA approach for criteria weighting and CODAS software ranking is an important development that tackles the challenges of multi-criteria assessments in a rapidly changing project management landscape.

The rest of the study will be structured as follows. The related work is discussed in Section 2. Methods are presented in Section 3 and, Section 4 illustrates the application. Moreover, Section 5 reports the main result.

2. Literature Review

The selection of project management software is highly important for any organization that aims to have effectively managed projects, especially in the environments with many criteria to be considered. The methods of Multi-Criteria Decision-Making are now frequently applied, and as such, they are often applied in the situations when the complexities are too high. These include the SWARA and CODAS which are both getting attention because of their unique combined great ability to control both subjective and objective measurement components.

SWARA, which was developed for the purpose of introducing the approach of experts for weight determination, has shown sufficient ability to shift priorities in a scenario where such shift is required (Keršuliene et al., 2010). That is, it has been applied in various industries like construction and supplier evaluation, where the judgment of the different weights is subtle (Štilić & Puška, 2023). CODAS, contrariwise, has more advantage in case of ranking of the alternatives according to Euclidean and Taxicab distances and hence support the decision effectively, even if one is faced with the conflicting criteria (Pérez-Dominguez et al., 2021).

The SWARA together with CODAS has been incorporated in the software evaluation process in several studies which have verified its potential to be one of the main components of the procedure. For instance, Mustajoki & Marttunen (2017) made use of MCDM methods including SWARA and CODAS in this method to be employed in environmental planning software, thereby, emphasizing the importance of such techniques in the complex decision-making processes. Likewise, Adali and Işik successfully made a transition to the enhanced hesitant fuzzy SWARA and VIKOR methods in a project management context which consequently pointed out the fact that both subjective and objective considerations are crucial in situations of providing alternatives (Geetha et al., 2020). Additionally, the combination of these two methods has been used in many fields, thus pointing to its wide applicability in dealing with tough multi-criteria decision problems. These works thus serve as the stepping stone towards the suggested two-way approach in the project management software evaluation.

The assessment of project management software is a fast-growing area in the field where MCDM methods have been very helpful. Previous works, such as those by (Mardani et al., 2015) and (Kostalova & Tetrevova, 2014), stressed the difficulties in software selection as the industries have different needs. The accommodation of SWARA and CODAS has opened the prospects for a comprehensive software evaluation, as can be witnessed in studies that have used these methods to evaluate environmental planning software and position project management tools. Newer researches concentrate on sophisticated tools and frameworks and examine factors like functionality, user-friendliness, and cost-effectiveness (Ferreira et al., 2023). The above work reveals the weaknesses of single-method approaches and hence recommends hybrid models for efficient decision-making.

It is also proven by the further things in the MCDM sector such as the creation of hybrid frameworks, which contain both subjective and objective methodologies, when decisions are to be made in dynamic environments (Zavadskas et al., 2016). These kinds of frameworks have been used in transportation, medical care, and information systems and have given insights that can be used by the other teams in project management.

To conclude, this research adds to the MCDM literature by emphasizing the harmony between SWARA and CODAS in the ranking of project management tools. It offers the strengths of the two approaches while at the same time it deals with the limitations of previous studies, thus providing organizations with important and practical insights that seek the best software solutions.

3. Methods

3.1. SWARA

The SWARA method, which was presented by Keršuliene et al. (2010), is a procedure of multi-criteria decision making that is used to find the relative importance of criteria by allowing the experts to express their opinions on a step-by-step basis. The steps of SWARA are the following:

1. List Criteria: Identify and list all criteria for the decision-making process.
2. Rank Criteria: Rank the criteria in descending order of perceived importance.
3. Calculate Comparative Importance: Starting from the second-ranked criterion, experts provide a relative importance coefficient (S_j) compared to the previous one.
4. Determine the Coefficient of Importance: Calculate the coefficient using;

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \#(1)$$

5. Weight Adjustment: Determine the recalculated weight (q_j) using ;

$$q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_j - 1}{k_j} & j > 1 \end{cases} \#(2)$$

6. Normalize Weights: Normalize the recalculated weights to get the final weights of the criteria:

$$w_j = \frac{q_j}{\sum_{J=1}^{n} q_j} \#(3)$$

3.2. CODAS

The CODAS method is a multi-criteria decision-making technique introduced by Keshavarz Ghorabaee et al. (2016). It involves assigning alternatives to ranks for the options based on the criteria and their performance evaluation. CODAS accounts for the Euclidean and Taxicab distances to the ideal solution simultaneously, which ensures a reliable decision support framework in cases where the decision criteria are contradicting. The stages of CODAS are listed below:

1. Decision matrix construction: Let the decision matrix be denoted as;

$$X = \begin{matrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ X_{n1} & X_{n2} & \ldots & X_{nm} \end{matrix} \#(4)$$

2. Normalization of the decision matrix: The matrix is transformed into a standardized decision matrix using linear normalization.

   If the criterion is benefit-oriented:

$$n_{ij} = \frac{x_{ij}}{max(i)x_{ij}} \#(5)$$

   If the criterion is cost-oriented:

$$n_{ij} = \frac{min(i)x_{ij}}{x_{ij}} \#(6)$$

3. The matrix normalized with the criterion weights: The values in the normalized decision matrix are multiplied by the criterion weights to obtain a new matrix.

$$r_{ij} = w_j * n_{ij} \#(7)$$

   w_j represents the weight of criterion j. Additionally, $0<w_j<1$ and $\sum_{j=1}^{m} w_j = 1$

4. Negative ideal point:

$$ns = \left[ns_j\right]_{1xm} \qquad ns_j = min(i)r_{i_{ij}} \#(8)$$

5. To determine the distance of the alternatives from the negative ideal point: Euclidean (E) and Taxicab (T)

$$E_i = \sqrt{\sum_{j=1}^{m}\left(r_{ij} - ns_j\right)^2} \#(9)$$

$$T_i = \sum_{j=1}^{m}\left|r_{ij} - ns_j\right| \#(10)$$

6. Relative assessment matrix:

$$Ra = [h_{ik}]_{nxn} \#(11)$$

$$h_{ik} = (E_i - E_k) + \left(\psi(E_i - E_k) * (T_i - T_k)\right)\#(12)$$

   In the equation $k\epsilon\{1,2,\dots n\}$; ψ is defined as a threshold function used to distinguish the Euclidean distance between two alternatives.

$$\psi(x) = \begin{cases} 1, & if|x| \geq \tau \\ 0, & if|x| < \tau \end{cases} \#(13)$$

According to the equation, if the difference between the distances E_i for two alternatives is smaller than τ, these alternatives are also compared with their T_i distances. τ is the threshold parameter and is determined by the decision-maker. This parameter τ was set to 0.02 by Keshavarz Ghorabaee et al. (2016).

7. Evaluation scores of the alternatives: The alternative with the highest H_i value is considered the best alternative.

$$H_i = \sum_{j=1}^{m} h_{ij} \#(14)$$

4. Application and Findings

To understand project management software, the multidimensional concept of MCDM was used. The SWARA method was utilized in the first step, where the weights of the financial ratios, which were the ranking criteria, were found. Seven decision-makers were selected based on their professional experience in project management and active use of project management software. All experts were required to have a minimum of five years of experience in their respective fields and to come from different sectors, including IT, telecommunications, and consulting. This diversity was aimed at achieving a wider and more objective assessment of the criteria. In the second problem ranking the alternatives according to the weights of the criteria was the method used in CODAS. The actual mathematical computations that these methods required were covered through the use of MS Excel.

4.1. Selection of Alternatives and Criteria

Through online searches and verified literature, 15 alternative software solutions were found which include not only those which have been widely applied in small, medium, and large companies but also those which are offered as a premium option (these software solutions are listed in Table 1). By this method, it was guaranteed that the selected software products were in accordance with the study's objectives, that they possessed high representational power, and were effective in carrying out the evaluation process.

Table 1. Alternatives

Alternatives' Code	Softwares/Tools
A-1	Asana (Premium)
A-2	Monday.com (Pro)
A-3	ClickUp (Business)
A-4	Wrike (Business)
A-5	Smartsheet (Business)
A-6	Microsoft Project (Online Plan 3)
A-7	Trello (Premium)
A-8	Jira (Premium)
A-9	Basecamp (Business)
A-10	Zoho Projects (Premium)

A-11	Airtable (Pro)
A-12	Notion (Team Plan)
A-13	Teamwork (Deliver Plan)
A-14	ProofHub (Ultimate Control)
A-15	Hive (Enterprise)

After reviewing the literature, the criteria for evaluating the alternatives, as well as their descriptions, are presented in Table 2.

The cost of a license is the fee that is related to acquiring and keeping the rights to use the project management software for a business. The license covers the initial license fee, the subscription charges, and any subsequent payments for updates, support, or additional features. Assessing the licensing cost is a pivotal step in the decision-making process as it reflects the total cost of the software (Ghosh et al., 2019).

Integration of the project management software is the capability of the software to easily link and coordinate with other systems, applications, or tools that are being used in the organization. It refers to features like API integration, data exchange, and cross-platform compatibility that are available to the software for interfacing with the existing technology ecosystem in the organization. Strong integration capabilities give users the ability to smooth out workflows, increase data sharing, and therefore, enhance the overall productivity by eliminating manual data entry and switching between multiple applications (Thomas & Nejmeh, 1992).

Mobile App Support is the possibility that a mobile app or mobile-friendly version of the project management software is available. This feature gives people the opportunity to access and apply the various software services to their smartphones or tablets, thus allowing them to do so and also remain productive while on their way. A good mobile app can give the users a seamless and pleasant experience which implies that they are able to manage the tasks, and share the ideas, as well as access the real-time project updates, from anywhere. A well-oriented mobile app may reinforce the general usability and accessibility of the release software, hence, the users can be productive and make such decisions that are based on information derived even while they are far away from their desktops (Silvius & Silvius, 2015).

Scalability is the software's capacity to accommodate higher complexity, time, and size of the projects. Another factor is the software's capacity to handle an increasing number of users, tasks, projects, and data while maintaining its original performance and functionality. Scalable project management software allows the business to power it up or down to meet the company's changing needs, thus ensuring that the system is still efficient and effective as the enterprise develops or project requirements are modified. This aspect is very important for enterprises that expect to grow rapidly, operate in a market with high demand for their services, or have to handle and manage multiple large-scale projects. The scalability of project management software is measured according to various factors such as the number of users supported, its potential to handle the data and projects, and its ability to integrate with other enterprise-level systems as the organization's needs develop (Eve, 2007).

The user interface is the visual components, the layout, and the interactive elements of the project management software that users deal with. It includes the design, the functionality, and the responsiveness of the software's graphical user interface including the navigation menus, dashboards, task management tools, and reporting modules. An easy-to-use and appealing UI is the main key to boosting user experience and productivity. It shows how smoothly users get and use the tools offered by the software (Pratama & Cahyadi, 2020).

Automation means the use of technology and tools in project management software to simplify and boost various workflows and processes. Among the features here, we have automated task assignments, update schedules, track progress, and report generation. The automated systems are able to replace manual labor, increase productivity, and project management can be enhanced. Automation means that automated processes can work well without human interference. Therefore, users get more time, errors are minimized, and tasks and activities are consistently and on time executed. Moreover, automated tools can offer project managers a more detailed and accurate look at the data as it is being updated in real-time, including the tracking of the project's progress, the availability of resources, and potential bottlenecks. The degree of the form of blocked automation given by the project management software can be a key criterion for the evaluation of the possibility of it to fit the organization's specific occasional needs and requirements (Özkan & Mishra, 2019).

Customizability means the project management software's ability to be so modified and adjusted as to perfectly suit the individual needs and tastes of an organization or its users. Here are some of the features that are part of the customization of dashboards, reports, workflows, and user roles and permissions. A project management software tool that is highly configurable allows users to set up the system according to their desired business practices, project methodologies, and organizational structures. As a result, the companies will be able to maximize the software according to their own needs, which in turn will not only lead to the adoption of the software being maximum, productivity being at an all-time high, and overall effectiveness being on top. The customizability of the project management software is crucial to the perfect implementation of the system within the organization via its processes and workflows without any major changes or compromises. Moreover, customizability can also increase user satisfaction and engagement, as users can adjust the software to their work styles and preferences (Bertram et al., 2012).

Collaboration Features refer to the software's ability to organize and promote the interaction of the project stakeholders. Moreover, these are features like real-time file sharing, document co-editing, group discussions, and notification systems that can encourage smooth cooperation and coordination between team members. The collaboration features allow the members of the team to work together productively, share information, and develop a tighter and more cohesive project team (Attaran & Attaran, 2002).

Task Management refers to the software's capabilities of planning, organizing, and tracking project tasks and activities. This includes features like task scheduling, task assignment, progress tracking, and status updates. Strong task management features help project managers to distribute workloads, check the accomplishment of tasks, and make sure that all related work is carried out correctly and promptly according to the plan (Sutawidjaya & Nawangsari, 2020).

Resource Management refers to the software's ability to administer the project resources, which means team members, equipment, budgets, etc., to be used most optimally. The effective management of resources would include the allocation of resources, capacity planning, time tracking, and cost management. The project managers are provided with features for the management of resources that are helpful to them in making knowledgeable decisions, reducing resource conflicts, and achieving the successful deployment of resources across various projects (Sutawidjaya & Nawangsari, 2020).

The reporting features are the tools that provide the project managers along with the stakeholders a chance to filter information from the project to make reports that are inclusive and specific according to their needs. Furthermore, dashboards, KPI tracking, and data visualization tools are examples of features that are utilized for the analysis and interpretation of project data easily. Reporting functionalities that provide detailed and insightful information can some of the data-driven decision-making processes, improve the transparency levels, and ensure the adherence to good project governance (Williams, 2015).

AI Support relates to the wire of artificial intelligence, and machine learning approaches unimproved the project management software. Some of the projects that can be said to have AI features are predictive analytics, automated task recommendations, and intelligent scheduling assistants. AI-powered features serve as a helping tool project managers to make precise decisions, recognize potential risks and opportunities, and facilitate the various project management processes. The level of AI support given by the application can be one of the main reasons why a product is more efficient than a person (Crawford et al., 2023).

Security, a project management software package must have very strong security features to protect information that is sensitive and to ensure that quality data is possessed, confidentiality, and availability of knowledge. This can involve user access controls, data encryption, secure communication protocols, and audit logging capabilities. Security strategies are effective if they reduce the possibility of incidents like unauthorized access, data breaches, and non-compliance to the minimum (Borky & Bradley, 2019).

Support Services, without the reliable and responsive professionals in the support division, the proper operation of the project management software is practically impossible. It covers aspects like user area documentation, training mediums, help desk, and regular software updates and patches. Intuitive support services can make the users 100% sure they can resolve any tech issues, not only keep up with the software's capabilities, but also explode the capability of project management tools (Ferreira & Tereso, 2014).

Table 2. Criteria

Criteria's Code	Criteria	Target
C-1	Licencing Cost	Min.
C-2	Integration	Max.
C-3	Mobile App. Support	Max.
C-4	Scalability	Max.
C-5	User Interface	Max.
C-6	Automation	Max.
C-7	Customizability	Max.
C-8	Collaboration	Max.
C-9	Task Management	Max.
C-10	Resource Management	Max.
C-11	Reporting	Max.
C-12	AI Support	Max.
C-13	Security	Max.
C-14	Support Services	Max.

4.2. Weighting of the Criteria

The SWARA method was used for the weighting of the criteria. Seven decision makers (DM), consisting of expert project managers, were asked to fill out the questionnaire based on their experience with Zoom. Then, the final weights of the criteria were determined by using equations (1), (2), and (3) with the information collected from each decision maker and by taking their arithmetic averages. The results from each decision maker are provided in Appendix-1. The results of the calculations based on this data are presented in Table 3.

Table 3. Weighting of the criteria

Criteria	DM-1	DM-2	DM-3	DM-4	DM-5	DM-6	DM-7	Weights	Rank
C-1	0,039	0,043	0,092	0,082	0,127	0,117	0,051	**0,089**	**6**
C-2	0,065	0,145	0,063	0,078	0,121	0,048	0,114	**0,102**	**2**
C-3	0,029	0,033	0,047	0,005	0,025	0,078	0,023	**0,038**	**14**
C-4	0,098	0,025	0,045	0,312	0,031	0,053	0,030	**0,093**	**5**
C-5	0,220	0,053	0,101	0,020	0,115	0,050	0,125	**0,109**	**1**
C-6	0,023	0,160	0,052	0,021	0,077	0,058	0,068	**0,073**	**9**
C-7	0,021	0,083	0,057	0,006	0,044	0,061	0,095	**0,058**	**12**
C-8	0,019	0,067	0,083	0,114	0,048	0,046	0,054	**0,069**	**11**
C-9	0,191	0,126	0,111	0,010	0,069	0,064	0,062	**0,100**	**3**
C-10	0,141	0,115	0,076	0,041	0,060	0,067	0,033	**0,086**	**7**
C-11	0,047	0,100	0,069	0,071	0,080	0,074	0,043	**0,079**	**8**
C-12	0,017	0,020	0,043	0,006	0,042	0,135	0,075	**0,053**	**13**
C-13	0,075	0,017	0,122	0,160	0,073	0,026	0,137	**0,097**	**4**
C-14	0,016	0,014	0,041	0,074	0,088	0,123	0,090	**0,071**	**10**

According to these results, the most important criterion is the user interface (0.109), while the least important criterion is mobile app support (0.038).

4.3. Ranking of Alternatives

The CODAS method was used to rank the alternatives. All the information provided on the software websites was compiled, and the decision matrix (equation 4), for the software based on the criteria was created as shown in Table 4.

Table 4. Decision Matrix

Alternatives/ Criteria	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14
A-1	10,99	100	5	4	4	4	5	5	4	4	4	3	5	5
A-2	16	200	5	5	4	4	5	5	4	3	5	3	5	5
A-3	19	1000	5	5	3	4	5	5	4	5	5	3	5	5
A-4	24,8	400	5	5	3	4	5	5	4	5	5	5	5	5
A-5	25	70	5	5	2	3	4	4	4	5	5	3	5	5
A-6	30	200	5	5	2	3	2	3	4	5	5	2	5	3
A-7	10	30	5	3	5	3	3	4	4	2	2	1	3	1
A-8	14,5	500	5	5	2	4	3	5	4	4	5	3	5	5
A-9	15	10	5	3	4	2	1	4	3	2	2	1	3	1
A-10	6	50	5	4	3	3	5	5	4	3	4	2	5	1
A-11	20	100	5	3	4	3	5	4	4	4	4	3	5	1
A-12	8	30	5	4	4	2	4	5	4	3	4	1	3	1
A-13	12,5	70	5	5	3	4	5	5	4	5	5	3	5	1
A-14	89	100	5	5	3	4	5	5	4	5	5	3	5	5
A-15	40	50	5	5	3	5	5	5	5	5	5	5	5	5
Max-Min	6	1000	5	5	5	5	5	5	5	5	5	5	5	5

Here, the Licensing Cost is expressed in unit $ and monthly premium fees, where lower cost receives a higher score (very affordable: 5, moderate: 3, expensive: 1). Integration is expressed numerically according to the level of support for integration with other tools (full integration: 5, partial: 3, minimal or none: 1). For Mobile App Support, the score is 5 if available and 1 if not. Scalability and Customizability features are rated as Very High: 5, High: 4, Medium: 3, Limited: 2, Low: 1; “Very High” corresponds to tools capable of supporting enterprise-level multi-project environments, “High” to tools suitable for large teams but not full enterprise environments, “Medium” for medium-sized teams, “Limited” for small teams, and “Low” for minimal support. User Interface, Automation, and Task Management features are rated as Very Advanced: 5, Advanced: 4, Medium: 3, Limited: 2, Low: 1, reflecting the sophistication and completeness of these functions. Resource Management, Reporting, AI Support, and Security features are rated as Excellent: 5, Good: 4, Medium: 3, Basic: 2, None: 1, based on feature availability and effectiveness. Support Services are rated as 24/7: 5, during working hours: 3, and email-only: 1.

All scores in the decision matrix were cross-validated for objectivity and reproducibility using independent sources, such as Capterra reports. Where the sources showed discrepancies, the final scores were verified by consultation with selected experts. Features such as scalability, customization, user interface, and support were scored against clear criteria and standardized on a 1–5 scale. These procedures were put in place to minimize author bias and ensure that the review process is transparent, consistent, and replicable.

Subsequently, the normalized decision matrix was calculated using equations (5) and (6) and is presented in Table 5.

Table 5. Normalized Decision Matrix

Alternatives/ Criteria	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14
A-1	0,55	0,1	1	0,8	0,8	0,8	1	1	0,8	0,8	0,8	0,6	1	1
A-2	0,38	0,2	1	1	0,8	0,8	1	1	0,8	0,6	1	0,6	1	1
A-3	0,32	1	1	1	0,6	0,8	1	1	0,8	1	1	0,6	1	1
A-4	0,24	0,4	1	1	0,6	0,8	1	1	0,8	1	1	1	1	1
A-5	0,24	0,07	1	1	0,4	0,6	0,8	0,8	0,8	1	1	0,6	1	1
A-6	0,20	0,2	1	1	0,4	0,6	0,4	0,6	0,8	1	1	0,4	1	0,6
A-7	0,60	0,03	1	0,6	1	0,6	0,6	0,8	0,8	0,4	0,4	0,2	0,6	0,2
A-8	0,41	0,5	1	1	0,4	0,8	0,6	1	0,8	0,8	1	0,6	1	1
A-9	0,40	0,01	1	0,6	0,8	0,4	0,2	0,8	0,6	0,4	0,4	0,2	0,6	0,2
A-10	1,00	0,05	1	0,8	0,6	0,6	1	1	0,8	0,6	0,8	0,4	1	0,2
A-11	0,30	0,1	1	0,6	0,8	0,6	1	0,8	0,8	0,8	0,8	0,6	1	0,2
A-12	0,75	0,03	1	0,8	0,8	0,4	0,8	1	0,8	0,6	0,8	0,2	0,6	0,2
A-13	0,48	0,07	1	1	0,6	0,8	1	1	0,8	1	1	0,6	1	0,2
A-14	0,07	0,1	1	1	0,6	0,8	1	1	0,8	1	1	0,6	1	1
A--15	0,15	0,05	1	1	0,6	1	1	1	1	1	1	1	1	1

The weighted normalized matrix and negative ideal solution values were calculated using equations (7) and (8) and are presented in Table 6.

Table 6. The weighted normalized matrix and negative ideal solution

Alternatives/ Criteria	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11	C-12	C-13	C-14
A-1	0,048	0,010	0,189	0,074	0,087	0,059	0,058	0,069	0,080	0,069	0,063	0,032	0,097	0,071
A-2	0,033	0,020	0,189	0,093	0,087	0,059	0,058	0,069	0,080	0,052	0,079	0,032	0,097	0,071
A-3	0,028	0,102	0,189	0,093	0,065	0,059	0,058	0,069	0,080	0,086	0,079	0,032	0,097	0,071
A-4	0,021	0,041	0,189	0,093	0,065	0,059	0,058	0,069	0,080	0,086	0,079	0,053	0,097	0,071
A-5	0,021	0,007	0,189	0,093	0,044	0,044	0,046	0,056	0,080	0,086	0,079	0,032	0,097	0,071
A-6	0,018	0,020	0,189	0,093	0,044	0,044	0,023	0,042	0,080	0,086	0,079	0,021	0,097	0,042
A-7	0,053	0,003	0,189	0,056	0,109	0,044	0,035	0,056	0,080	0,034	0,031	0,011	0,058	0,014
A-8	0,037	0,051	0,189	0,093	0,044	0,059	0,035	0,069	0,080	0,069	0,079	0,032	0,097	0,071
A-9	0,035	0,001	0,189	0,056	0,087	0,029	0,012	0,056	0,060	0,034	0,031	0,011	0,058	0,014
A-10	0,089	0,005	0,189	0,074	0,065	0,044	0,058	0,069	0,080	0,052	0,063	0,021	0,097	0,014
A1-1	0,027	0,010	0,189	0,056	0,087	0,044	0,058	0,056	0,080	0,069	0,063	0,032	0,097	0,014
A-12	0,067	0,003	0,189	0,074	0,087	0,029	0,046	0,069	0,080	0,052	0,063	0,011	0,058	0,014
A-13	0,043	0,007	0,189	0,093	0,065	0,059	0,058	0,069	0,080	0,086	0,079	0,032	0,097	0,014
A-14	0,006	0,010	0,189	0,093	0,065	0,059	0,058	0,069	0,080	0,086	0,079	0,032	0,097	0,071
A-15	0,013	0,005	0,189	0,093	0,065	0,073	0,058	0,069	0,100	0,086	0,079	0,053	0,097	0,071
Weights	0,089	0,102	0,038	0,093	0,109	0,073	0,058	0,069	0,100	0,086	0,079	0,053	0,097	0,071
ns_j	0,006	0,001	0,189	0,056	0,044	0,029	0,012	0,042	0,060	0,034	0,031	0,011	0,058	0,014

Euclidean and taxicab distance values were calculated using equations (9) and (10) and are presented in Table 7.

Table 7. Euclidean and taxicab distance values

	E_i	T_i
A-1	0,12497	0,41944
A-2	0,12740	0,43157
A-3	0,16381	0,52094
A-4	0,13867	0,47403
A-5	0,11701	0,35704
A-6	0,09970	0,29093
A-7	0,08860	0,18641
A-8	0,12630	0,41622
A-9	0,05439	0,08692
A-10	0,11880	0,33394
A-11	0,09741	0,29409
A-12	0,09787	0,25596
A-13	0,11934	0,38373
A-14	0,12704	0,40668
A-15	0,14052	0,46474

The relative assessment matrix was presented in Table 8 using equations (11), (12), and (13).

Table 8. The relative assessment matrix

	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14	A-15
A-1	0,00000	-0,00243	-0,03876	-0,01369	0,00797	0,02533	0,03654	-0,00133	0,07105	0,00618	0,02763	0,02719	0,00563	-0,00207	-0,01554
A-2	0,00243	0,00000	-0,03634	-0,01126	0,01041	0,02778	0,03899	0,00111	0,07351	0,00862	0,03008	0,02964	0,00807	0,00036	-0,01311
A-3	0,03891	0,03647	0,00000	0,02516	0,04695	0,06440	0,07571	0,03759	0,11036	0,04517	0,06670	0,06629	0,04458	0,03685	0,02331
A-4	0,01372	0,01128	-0,02511	0,00000	0,02171	0,03911	0,05036	0,01239	0,08493	0,01993	0,04142	0,04098	0,01937	0,01165	-0,00185
A-5	-0,00795	-0,01038	-0,04664	-0,02161	0,00000	0,01733	0,02851	-0,00928	0,06296	-0,00179	0,01963	0,01918	-0,00233	-0,01002	-0,02346
A-6	-0,02520	-0,02762	-0,06381	-0,03883	-0,01728	0,00000	0,01113	-0,02653	0,04550	-0,01908	0,00230	0,00184	-0,01960	-0,02728	-0,04068
A-7	-0,03620	-0,03861	-0,07470	-0,04979	-0,02831	-0,01108	0,00000	-0,03752	0,03428	-0,03011	-0,00879	-0,00925	-0,03062	-0,03827	-0,05163
A-8	0,00133	-0,00111	-0,03743	-0,01236	0,00930	0,02666	0,03787	0,00000	0,07238	0,00751	0,02896	0,02852	0,00696	-0,00075	-0,01421
A-9	-0,07011	-0,07251	-0,10846	-0,08363	-0,06228	-0,04513	-0,03414	-0,07143	0,00000	-0,06409	-0,04284	-0,04333	-0,06457	-0,07219	-0,08548
A-10	-0,00616	-0,00858	-0,04484	-0,01982	0,00179	0,01912	0,03029	-0,00748	0,06473	0,00000	0,02141	0,02097	-0,00054	-0,00823	-0,02166
A-11	-0,02749	-0,02991	-0,06610	-0,04112	-0,01958	-0,00230	0,00882	-0,02882	0,04319	-0,02138	0,00000	-0,00046	-0,02190	-0,02957	-0,04297
A-12	-0,02701	-0,02943	-0,06559	-0,04063	-0,01910	-0,00183	0,00928	-0,02834	0,04362	-0,02090	0,00046	0,00000	-0,02142	-0,02909	-0,04248
A-13	-0,00562	-0,00805	-0,04434	-0,01930	0,00234	0,01968	0,03086	-0,00695	0,06534	0,00054	0,02198	0,02153	0,00000	-0,00770	-0,02114
A-14	0,00207	-0,00036	-0,03668	-0,01161	0,01004	0,02740	0,03861	0,00075	0,07312	0,00825	0,02970	0,02926	0,00770	0,00000	-0,01346
A-15	0,01557	0,01313	-0,02326	0,00185	0,02356	0,04096	0,05221	0,01424	0,08678	0,02178	0,04326	0,04283	0,02121	0,01349	0,00000

Finally, the final scores and rankings were obtained using equation (14) (Table 9, Figure 1).

Table 9. H_i values and rankings of the software

	Hi	Rank
A-1	0,13371	**7**
A-2	0,17027	**4**
A-3	0,71845	**1**
A-4	0,33990	**3**
A-5	0,01413	**10**
A-6	-0,24516	**11**
A-7	-0,41061	**14**
A-8	0,15361	**6**
A-9	-0,92017	**15**
A-10	0,04101	**9**
A-11	-0,27958	**13**
A-12	-0,27246	**12**
A-13	0,04917	**8**
A-14	0,16481	**5**
A-15	0,36761	**2**

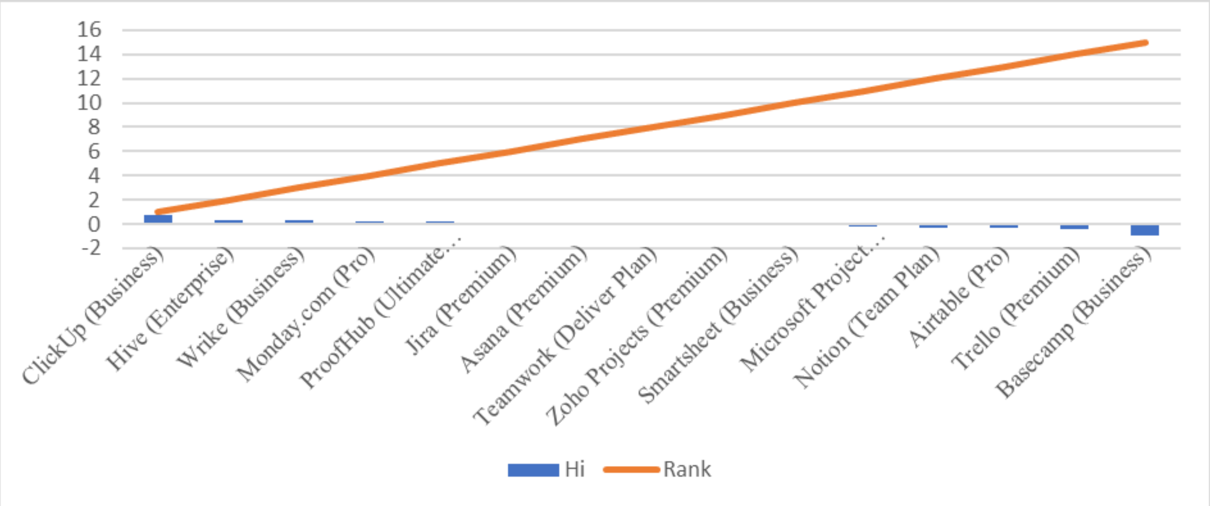

Figure 1. H_i values and rankings of the software relations

According to these results, the three key software solutions are ClickUp, Hive (Enterprise), and Wrike (Business) that tops the list. Top integration and scalability features, especially for extremely big enterprises, are probably the main reasons that make these software solutions unique. Furthermore, the software is distinguished by its intuitive and user-friendly design, with ample customization capabilities, and powerful collaboration features. On top of it, Basecamp (Business) got the lowest rating. In this case, it is the absence of some key features, such as user interface and customizability, that are really lacking in Basecamp.

4.4. Sensitivity Analysis

A sensitivity analysis was carried out to check the consistency of the analysis above. In this sensitivity analysis, the effect of changing threshold parameter τ on the results of the analysis was studied. Five different analyses were run with values of τ ranging from 0.01 to 0.05; their rankings are given in Table 10. It can be noted from Table 10 that even when different values for threshold parameter τ (0.01-0.05) are used, the rankings do not change for alternatives. Hence, this analysis is considered consistent.

Table 10. Sensitivity Analysis

τ	**0,01**	**0,02**	**0,03**	**0,04**	**0,05**
			Rankings		
A1	7	7	7	7	7
A2	4	4	4	4	4
A3	1	1	1	1	1
A4	3	3	3	3	3
A5	10	10	10	10	10
A6	11	11	11	11	11
A7	14	14	14	14	14
A8	6	6	6	6	6
A9	15	15	15	15	15
A10	9	9	9	9	9
A11	13	13	13	13	13
A12	12	12	12	12	12
A13	8	8	8	8	8
A14	5	5	5	5	5
A15	2	2	2	2	2

5. Result

This research effectively describes a method for the evaluation of project management software through SWARA and CODAS multi-criteria decision methods that define criterion weights and sort alternative solutions. The results are in agreement with the earlier studies (e.g., Kerzner, 2023; Turner, 2016), highlighting that software selection is a preeminent factor in organizational success. The choice of proper project management tools is a factor not only in increasing the operational efficiency but also in guaranteeing the quality of the outcomes of the projects.

The SWARA method enabled an objective assessment of the relative importance of the criteria. The fact that the user interface criterion ranked first indicates that project managers prefer an interface that is easy to use, straightforward, and allows for smoother navigation.

Additionally, another significant criterion is integration. Software that communicates seamlessly with other systems, facilitates data retrieval from various platforms, and saves project managers time enhances its overall effectiveness. Mobile application support, on the other hand, was identified as the least weighted criterion. This suggests that project managers prefer to conduct their work using laptops or desktop computers. Alternatively, it can be interpreted that since all software solutions offer mobile application support, users may not find this feature particularly attractive or noteworthy, making it the least significant criterion.

The evaluation carried out by CODAS method demonstrated how 15 different project management software solutions are performing. ClickUp (Business), Hive (Enterprise), and Wrike (Business), respectively were the highest-performing software. These tools were the most effective ones of all the criteria, thus they are the most outstanding choices for project management.

Basecamp (Business), on the other hand, was the lowest-performing software in the analysis. This finding coincides with the literature (PMI, 2021), which refers that tools focusing on minimal features, for example, Basecamp, are not of much use in big or complicated projects.

When checked against the independent organization Capterra, Notion rated 4.7, ClickUp rated 4.6, and Monday.com were the top three highest-rated software (Capterra, n.d.). This study has found that ClickUp and Monday.com also fall into these top positions; however, variations for Notion were observed across different studies. Basecamp came in last place in both studies. Comparisons with an independent source Capterra do not seem inconsistent with the outputs of this study. The criteria used on Capterra were Ease of Use, Customer Service, Features, and Value for Money. Some differences in certain software are noted but can be considered normal given the selected criteria and perspectives of evaluation even though they exist.

Results from the sensitivity analysis validate the robustness of the methodology proposed. The rankings of alternative software solutions did not change even when the threshold parameter τ varied from 0.01 to 0.05. This finding confirms that overall ranking outcomes are not very sensitive to small variations in the threshold parameter, thus providing confidence in the reliability and consistency of the analysis. Therefore, this approach can be considered stable and applicable for real-world decision-making regarding project management software alternatives.

This supported developments in project management literature, and the software selection is driven by SWARA and CODAS methods which provide a structure for decision makers to manage in a more objective and data-driven manner. This is consistent with existing studies in the literature (Popović et al., 2021), which brings out the effectiveness of multi-criteria decision-making methods in the selection of project management software.

Furthermore, the results obtained are very informative to be used by the software providers. The creation of features that incorporate feedback from users and are easy to use seems to boost the software's competitiveness. The research project in this setting is a tool that not only the users but also the developers can easily understand.

The bottom line of the research is the point that decision makers should pay attention to the weight of the elements and do a detailed analysis of all the alternatives (criteria) when developing project management software. The SWARA and CODAS methods can be investigated for the software selection problem to the other industries to check their broader applicability. Apart from this, the findings of this study could be made more comprehensive by working with larger sample groups and different datasets.

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Appendix-1: Weights of Decision Makers

DM-1					
Criteria	**Importance order**	**s_j**	**k_j**	**q_j**	**w_j**
C-2	1		1	1,000	0,220
C-9	2	0,15	1,15	0,870	0,191
C-10	3	0,35	1,35	0,644	0,141
C-5	4	0,45	1,45	0,444	0,098
C-13	5	0,3	1,3	0,342	0,075
C-3	6	0,15	1,15	0,297	0,065
C-11	7	0,4	1,4	0,212	0,047
C-1	8	0,2	1,2	0,177	0,039
C-4	9	0,35	1,35	0,131	0,029
C-6	10	0,25	1,25	0,105	0,023
C-7	11	0,1	1,1	0,095	0,021
C-8	12	0,1	1,1	0,087	0,019
C-12	13	0,1	1,1	0,079	0,017
C-14	14	0,1	1,1	0,072	0,016

DM-2					
Criteria	**Importance order**	**s_j**	**k_j**	**q_j**	**w_j**
C-6	1		1	1,000	0,160
C-3	2	0,1	1,1	0,909	0,145
C-9	3	0,15	1,15	0,791	0,126
C-10	4	0,1	1,1	0,719	0,115
C-11	5	0,15	1,15	0,625	0,100
C-7	6	0,2	1,2	0,521	0,083
C-8	7	0,25	1,25	0,417	0,067
C-2	8	0,25	1,25	0,333	0,053
C-1	9	0,25	1,25	0,267	0,043
C-4	10	0,3	1,3	0,205	0,033
C-5	11	0,3	1,3	0,158	0,025
C-12	12	0,25	1,25	0,126	0,020
C-13	13	0,2	1,2	0,105	0,017
C-14	14	0,2	1,2	0,088	0,014

DM-3					
Criteria	**Importance order**	**s_j**	**k_j**	**q_j**	**w_j**
C-13	1		1	1,000	0,122
C-9	2	0,1	1,1	0,909	0,111
C-2	3	0,1	1,1	0,826	0,101
C-1	4	0,1	1,1	0,751	0,092
C-8	5	0,1	1,1	0,683	0,083
C-10	6	0,1	1,1	0,621	0,076
C-11	7	0,1	1,1	0,564	0,069
C-3	8	0,1	1,1	0,513	0,063

C-7	9	0,1	1,1	0,467	0,057
C-6	10	0,1	1,1	0,424	0,052
C-4	11	0,1	1,1	0,386	0,047
C-5	12	0,05	1,05	0,367	0,045
C-12	13	0,05	1,05	0,350	0,043
C-14	14	0,05	1,05	0,333	0,041

DM-4					
Criteria	**Importance order**	s_j	k_j	q_j	w_j
C-5	1		1	1,000	0,312
C-13	2	0,95	1,95	0,513	0,160
C-8	3	0,4	1,4	0,366	0,114
C-1	4	0,4	1,4	0,262	0,082
C-3	5	0,05	1,05	0,249	0,078
C-14	6	0,05	1,05	0,237	0,074
C-11	7	0,05	1,05	0,226	0,071
C-10	8	0,7	1,7	0,133	0,041
C-6	9	0,95	1,95	0,068	0,021
C-2	10	0,05	1,05	0,065	0,020
C-9	11	0,95	1,95	0,033	0,010
C-7	12	0,75	1,75	0,019	0,006
C-12	13	0,05	1,05	0,018	0,006
C-4	14	0,25	1,25	0,014	0,005

DM-5					
Criteria	**Importance order**	s_j	k_j	q_j	w_j
C-1	1		1	1,000	0,127
C-3	2	0,05	1,05	0,952	0,121
C-2	3	0,05	1,05	0,907	0,115
C-14	4	0,3	1,3	0,698	0,088
C-11	5	0,1	1,1	0,634	0,080
C-6	6	0,05	1,05	0,604	0,077
C-13	7	0,05	1,05	0,575	0,073
C-9	8	0,05	1,05	0,548	0,069
C-10	9	0,15	1,15	0,476	0,060
C-8	10	0,25	1,25	0,381	0,048
C-7	11	0,1	1,1	0,347	0,044
C-12	12	0,05	1,05	0,330	0,042
C-5	13	0,35	1,35	0,244	0,031
C-4	14	0,25	1,25	0,196	0,025

DM-6					
Criteria	**Importance order**	s_j	k_j	q_j	w_j
C-12	1		1	1,000	0,135
C-14	2	0,1	1,1	0,909	0,123
C-1	3	0,05	1,05	0,866	0,117

C-4	4	0,5	1,5	0,577	0,078
C-11	5	0,05	1,05	0,550	0,074
C-10	6	0,1	1,1	0,500	0,067
C-9	7	0,05	1,05	0,476	0,064
C-7	8	0,05	1,05	0,453	0,061
C-6	9	0,05	1,05	0,432	0,058
C-5	10	0,1	1,1	0,392	0,053
C-2	11	0,05	1,05	0,374	0,050
C-3	12	0,05	1,05	0,356	0,048
C-8	13	0,05	1,05	0,339	0,046
C-13	14	0,75	1,75	0,194	0,026

DM-7					
Criteria	**Importance order**	**s_j**	**k_j**	**q_j**	**w_j**
C-13	1		1	1,000	0,137
C-2	2	0,1	1,1	0,909	0,125
C-3	3	0,1	1,1	0,826	0,114
C-7	4	0,2	1,2	0,689	0,095
C-14	5	0,05	1,05	0,656	0,090
C-12	6	0,2	1,2	0,547	0,075
C-6	7	0,1	1,1	0,497	0,068
C-9	8	0,1	1,1	0,452	0,062
C-8	9	0,15	1,15	0,393	0,054
C-1	10	0,05	1,05	0,374	0,051
C-11	11	0,2	1,2	0,312	0,043
C-10	12	0,3	1,3	0,240	0,033
C-5	13	0,1	1,1	0,218	0,030
C-4	14	0,3	1,3	0,168	0,023