A multicriteria framework proposition for project management approaches

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Abstract. One of the primary challenges in project management is to establish an effective methodology that can lead to both successful planning and stakeholder satisfaction. This is a critical decision that needs to be made at the beginning of the project, before the project's product, service, or object has been realized. In the case of technology-related projects, the complexity is even greater, as the evolution of systems and impacts on visibility may only become evident during the execution phase. To address this challenge, we aim to deliver and validate an MDCM (Multiple-Criteria Decision Analysis) framework that can support the selection of an appropriate project management methodology. To achieve this goal, we have extracted relevant literature on the influencing factors for project management. Our framework provides a comprehensive multicriteria approach that integrates the most critical factors identified in the literature to assist project managers in selecting the most suitable project management approach. In summary, this work proposes a quantitative method that combines the most influential factors in the current project management literature with a multicriteria framework to support project management approach selection.

Keywords: Project Management, Hybrid Approach, Technology.

1 Introduction

The research on project management topics is mainly based on more waterfall literature, which does not always bring an adequate methodology or investigation of flow to solve or bring a workaround solution for the management problems. The PMBOK® itself is diffuse and multidisciplinary [1] and it is a fact that management is the sustainable basis of any project, always depending on a well-planned process [2]. The dynamic nature of projects involves many parallel streams of investigation, as Padalkar and Gopinath suggested [3]. Constant comparisons must be made to observe quick changes in how terms are used in the literature to identify emerging trends and avoid fads [1]. More waterfall methodologies have a standard framework, which needs to be adapted to each area to increase management efficiency and address the numerous complex problems

that companies, and other organizations face daily [4]. In this sense, adaptable approaches to project design and management in complex and turbulent operational environments suggest that projects conceived as experiments can contribute to decision-making [5]. The flexibility of the renegotiation must be maintained, where factors can assume different weight or relevance than initially planned, not only in the core disciplines but in the gaps created by more vertical project management. This helps to explore the intersection of project management and development to benefit from as-yet-untapped opportunities for project managers [6].

In this context, it is characterized as a "Problem Field" in decision-making, the choice of an approach and/or method for the most appropriate management for the project manager and her team, given the various influencing factors. Thus, the purpose of this study is to offer a framework based on multi-criteria methods that serve as a tool and guide for the project manager to select the most appropriate approach for a given project. To develop this framework, a literature review was carried out, where 27 articles were prioritized that included discussions on technological project management approaches and their influencing factors. The framework considers as input the project requirements, which comprises the market/customer demand, its product or service specifications, and essential factors such as scope, time, cost, and risk, always present in the projects. As an underlying basis, the framework considers the different approaches to project management, ranging from the waterfall method to the agile methodology, with all its intrinsic characteristics, such as rigidity or flexibility in management and documentation [7,8]. It also considers each approach's influencing factors, such as the environment in which the project is inserted, and social, economic, legal, cultural, organizational, and maturity factors, to name a few.

The proposed framework then, through a multi-criteria decision-making support method, associates all input data, i.e., the project requirements, their influencing factors, and the characteristics of the management approaches, to order by degree of preference, the best approach to adopt and on which factor it should be adopted. Thus, it breaks the project into criteria and associates them individually with management approaches, providing a more granular view of the entire management of a specific project. Finally, the framework is validated from real applications in technology projects with different natures, the first being a technical platform evolution project, where information security modules and performance improvements are prioritized. In a second project, we have the development of a factory application, where the priority is the user experience and productivity improvements. Furthermore, in the last project, we have the expansion of a business unit, where service standards and operation synchronism are the main requirements of the project. Thus, the framework allows validating, from the selection of influencing factors in a literature review on project management, the selection of the most suitable approach for technological projects.

2 Theoretical background

2.1 Critical factors in the Waterfall (Traditional) Approach

The waterfall approach is applied to well-planned projects with defined content, executed according to pre-determined guidelines. These are predictable and linear projects, which allow for detailed planning and monitoring without many changes [2]. This brings security when we look at the main pillars of the waterfall approach, such as strict cost control and proposed deadline. However, in some technology projects, there is significant scope variability during their execution, either due to the need to change the process or even the frequent emergence of new technologies [8]. In addition, the product's very non-materialization in the project's initial phases causes frequent observations from stakeholders to cause changes in the course. This can generate customer dissatisfaction due to non-compliance with agreed items; after all, all rework generates increased costs and time.

2.2 Critical factors in the Agile Approach

Project development is increasingly subject to the concept of agility, which still does not have a consensus on its definition, but which refers to the ability to change the configuration of a system, in the face of unforeseen changes, to gain competitiveness and improve the innovation capabilities of a project. This concept is related to factors of flexibility, speed, simplicity and readiness, and its management requires practices, tools, and techniques for project development and execution, as well as facilitators for its implementation [9,10,11,12]. In other words, agile approach is a way to manage a project by breaking it up into several short phases to accelerate its cycle.

In theory, these would be required features in any project, but this is not what happens in practice. For example, technology projects often require strict compliance with deadlines so as not to jeopardize an operation or even an information security guarantee. This can compromise the subsequent process in complex project chains, causing irreparable damage.

2.3 Critical factors in the Hybrid Approach

While the waterfall methodology is focused on planning and validation, it is less effective in developing more unpredictable, uncertain projects needing rework. On the other hand, agile methodology is more innovative and focuses on organizational responsiveness and flexibility. The hybrid methodology combines the characteristics of the previous models. For this reason, it is not easy to adopt, as it requires a precise alignment between the project team, organizational objectives, and project implementation [13]. In technology projects, the hybrid approach presents itself as an alternative to optimize potentials and eliminate gaps from previous methodologies. However, the criteria for adopting it must be carefully observed. One should not make the mistake of adapting deficiencies in the methodology. If resources are lacking, this must be a gap mapped and resolved, regardless of the approach adopted. The selection of influencing factors can be a differential to achieve the desired results.

3 Methodology

The main objective of this article is to propose and validate a framework with a multi-criteria approach to define the degree of priority, selection, and application of a technology project management method, depending on its influencing factors. To achieve this objective, qualitative-quantitative applied research was performed. The methodology for building the framework was a literature review on the conceptual foundations of project management approaches with the application of experimental cases in the technological area.

The framework was developed by applying the MDCM (Multiple-Criteria Decision Analysis) algorithm to support the selection and prioritization of the project management approach according to the factors that influence it, allowing these factors to be evaluated individually in terms of their method of management. Multi-criteria decision-making support methods are being increasingly adopted by managers in the political, organizational, and financial fields, being a critical support tool for solving increasingly complex problems where there are many risks and uncertainty criteria to be considered and possible alternatives to be adopted [14].

The TOPSIS method (Technique for Order of Preference by Similarity to Ideal Solution) was adopted for this framework because it is a multi-criteria decision analysis method that compares and selects alternatives based on criteria and their respective weights, normalizing their scores. Moreover, calculating the geometric distances between each alternative of the ideal solutions, seeking the approximation of the positive solution and the distance of the negative solution. This is an exciting solution for technology projects, as it mitigates the incidences of complexity and uncertainty.

4 Literature review and bibliometrics

This topic aims to explain the flow adopted for the research to determine the decision framework for choosing a methodology for application in technology projects. The research started by consulting keywords (Project cost OR Project time or Project scope OR Agile, hybrid AND traditional methodology OR Project Changes OR Project Success Factors OR External Factors in Projects) typically used in projects, forming a bank of 41,449 articles. We have noticed an evolution in the number of searches increasing significantly in recent years, as shown in Figure 1.

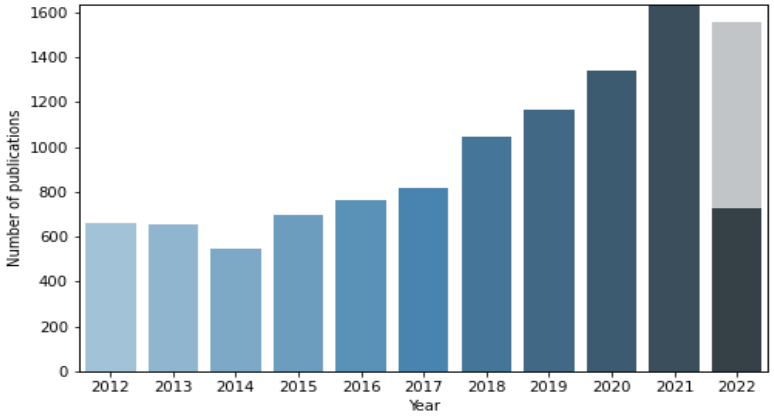

Fig. 1. Number of publications per year.

Figure 2 brings us a heat map, highlighting regions of the world with greater interest in the topic.

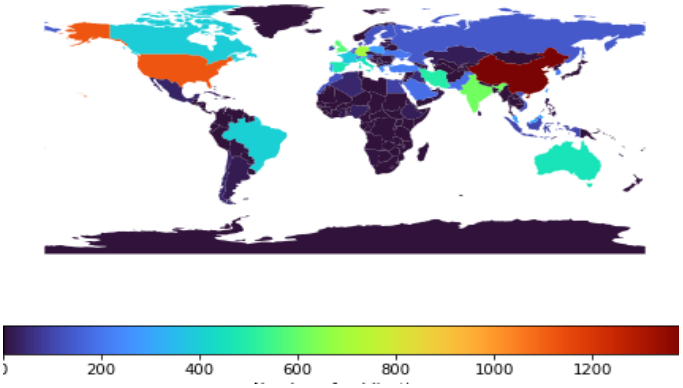

Fig. 2. Number of research by region.

The next step focused on applying inclusion and exclusion criteria, as shown in Table 1, to focus on the methodology approach theme, as well as segmenting for specific projects in the technology area:

Table 1. Exclusion and Inclusion Criteria.

I/E	CRITERIA	JUSTIFICATION
Exclusion	CRE-01	Papers with project management topics for specific products and services that do not address applied methodologies.
	CRE-02	Papers not available in full.

	CRE-03	Papers without interchange between project management chapters.
Inclusion	CRI-01	Papers including uncertainties and complexities in project management.
	CRI-02	Papers including project management methodologies in technology products or services.
	CRI-03	Papers including changes and evolution of project management over the time.
	CRI-04	Papers including practical experience in project management methodologies.

After the exclusion and inclusion criteria, our final basket resulted in 27 prioritized articles, which served as the basis for the framework's application through the main influencing factors found in project management literature. The summary of these main prioritized articles can be found in the Supplemental File A of this research. In the next step, Wordclouds [15] was used to rank the importance of keywords according to the number of appearances, in addition to a grouping of similarities and translations, which shaped the influencing factors contained in the framework (Table 2).

5 Proposed framework

Figure 3 shows the concept of the proposed framework, which is based on multi-criteria decision-making support methods for choosing the most appropriate approach to managing a technology project, considering all its influencing factors retrieved from our literature review on project management.

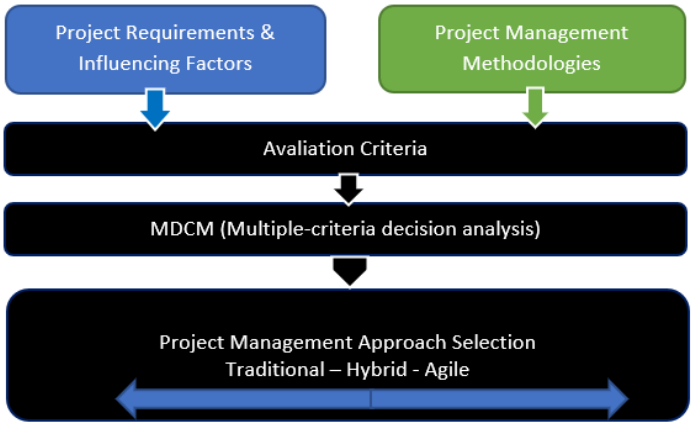

Fig. 3. Proposal Framework – Concept Diagram.

The influencing factors of the projects were previously raised by their frequency of occurrence in the studies found in our literature review, as shown in Table 2. They were related to the waterfall and agile approaches to technology project management according to their characteristics.

Table 2. Project Influencing Factors.

INFLUENCING FACTORS			
1	Scope	11	Complexity
2	Time	12	Technical
3	Cost	13	Behavior
4	Risks	14	Context
5	Stakeholders	15	Organization
6	Quality	16	Planning
7	Acquisitions	17	Control
8	Humas Resources	18	Changes
9	Integration	19	Culture
10	Success	20	Monitoring

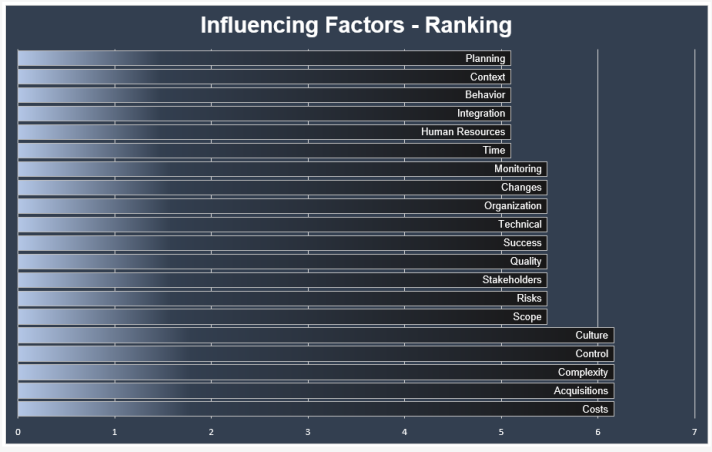

Fig. 4. Example of ranking of Influencing Factors in the project management: result of TOPSIS comparison.

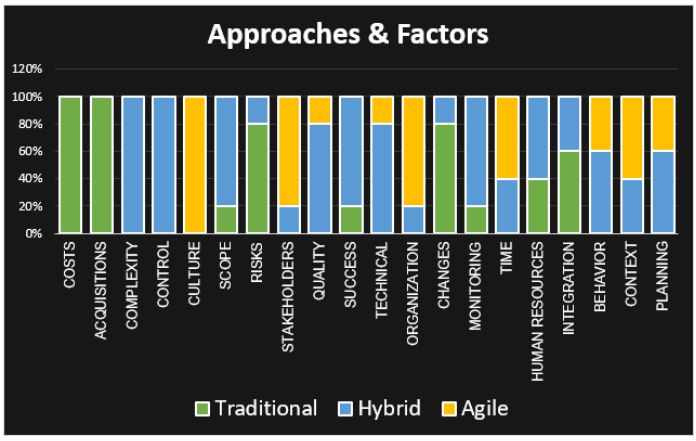

Fig. 5. Example of the individual relationship between project influencing factors and project management approaches.

To develop such framework, we pondered the scales using TOPSIS method with the opinions of experts in the three projects. This supported our methodology to be validated in such a technological context. This is relevant since in a context where more technological and Industry 4.0 projects are demanded [17, 20, 21]. Thus, this can guarantee the sustainability [18] and innovativeness [19, 22] of projects.

6 Conclusion

The present study aimed to build and present a framework based on multi-criteria method, which serves as a tool and guide for the project manager to select the most appropriate approach to be applied in the development of a given project or even in a portfolio of projects. This is because considering the various influencing factors relevant to each management approach makes this choice difficult.

The literature review on project management approaches made it possible to identify their main influencing factors, which will be considered as criteria in the TOPSIS method for selecting and prioritizing the most appropriate approach to a given project. With the application of the proposed framework in cases of real projects, it was possible to verify the best approach to be adopted depending on the nature of the project, which facilitates the project manager's decision. Furthermore, the proposed framework, due to its versatility in the configuration and choice of influencing factors that serve as evaluation criteria, allows the manager to adapt new criteria and new approaches without specific limitations to a specific area of projects. In this sense, our main contribution is in the practical field for project managers, despite we considered the most relevant influencing factors on project management literature.

Thus, the framework allows the continuity of application for future studies by sharing knowledge with the scientific and academic community and with industry to bring both together in managing projects of any nature. Nevertheless, it is worth highlighting

the limitations found in the development of this study about the lack of scientific studies that relate the factors of influence in the projects according to their management approach.

The scientific contribution of this work is in the tool to support the selection of the approach to be adopted in managing a project based on its influencing factors since the current models do not have this characteristic. The proposed framework combines decision-making support methods, project management approaches, and their influencing factors, which allows flexibility and versatility in choosing an approach depending on the specific characteristics of a project, enabling more fantastic alternatives for project managers. As a continuation proposal for future studies, the presented framework can be applied in other case studies to select the project management approach in other areas of development like artificial intelligence [23]. In addition, some multicriteria techniques could be integrated with such a framework for high technological context, as proposed by Almeida [16], to associate monetary values to each influencing factor and support decision-makers in the following steps.

References

1. Pollack, J.; Adler, D.: Emergent trends and passing fads in project management research. A scientometric analysis of changes in the field. Project Management Journal 33(1), 236–248 (2015).
2. Lalmi, A.; Fernandes, G.; Souad, S. B.: A conceptual hybrid project management model for construction projects. Procedia Computer Science 181, 921–930 (2020).
3. Padalkar, M.; Gopinath, S.: Are complexity and uncertainty distinct concepts in project management? A taxonomical examination from literature. Project Management Journal 34(4), 688–700 (2016).
4. Jovanovic, P.; Beric, I.: Analysis of the available project management methodologies. Management Journal of Sustainable Business and Management Solutions in Emerging Economies 23(3), 1-13 (2018).
5. Picciotto, R.: Towards a new project management movement? An international development perspective. Project Management Journal 38(8), 474–485 (2020).
6. Ika, L. A.; Hodgson, D.: Learning from international development projects: blending critical project studies and critical development studies. International Journal of Project Management 32(7), 1182-1196 (2014).
7. Gemino, A.; Horner Reich, B.; Serrador, P. M.: Agile, waterfall, and hybrid approaches to project success: Is hybrid a poor second choice? Project Management Journal 52(2), 161–175 (2021).
8. Copola Azenha, F.; Reis, D. A.; Fleury, A. L.: The role and characteristics of hybrid approaches to project management in the development of technology-based products and services. Project Management Journal 52(1), 90–110 (2021).
9. Conforto, E. C.; Amaral, D. C.; Da Silva, S. L.; Di Felippo, A.; Kamikawachi, D. S. L.: The agility construct on project management theory. Project Management Journal 34(4), 660–674 (2016).
10. Serrador, P.; Pinto, J. K.: & J. K. Pinto: Does agile work? - A quantitative analysis of agile project success. Project Management Journal 33(5), 1040–1051 (2015).

11. Conforto, E. C.; Salum, F.; Amaral, D. C.; Da Silva, S. L.; De Almeida, L. F. M.: Can agile project management be adopted by industries other than software development? Project Management Journal 45(3), 21–34 (2014).
12. Hobbs, B.; Petit, Y.: Agile methods on large projects in large organizations. Project Management Journal 48(3), 3–19 (2017).
13. Zasa, F. P.; Patrucco, A.; Pellizzoni, E.: Managing the hybrid organization: How can agile and waterfall project management coexist? Research-Technology Management 64(1), 54–63 (2020).
14. Wątróbski, J.; Ziemba, P.; Karczmarczyk, A.; Zioło, M.: Generalised framework for multi-criteria method selection. Omega (86), 107-124 (2019).
15. Wordclouds Homepage, https://www.wordclouds.com, last accessed 2022/07/01
16. Almeida, R. P.; Ayala, N. F.; Benitez, G. B.; Kliemann Neto, F. J.; Frank, A. G.: How to assess investments in industry 4.0 technologies? A multiple-criteria framework for economic, financial, and sociotechnical factors. Production Planning & Control, 1-20 (2022).
17. Benitez, G. B.; Lima, M. J. D. R. F.; Lerman, L. V.; Frank, A. G. (2019). Understanding Industry 4.0: Definitions and insights from a cognitive map analysis. Brazilian Journal of Operations & Production Management [recurso eletrônico]. Rio de Janeiro, RJ. Vol. 16, no. 2 (June 2019), p. 192-200.
18. Frank, A. G.; Benitez, G. B.; Ferreira Lima, M.; Bernardi, J. A. B. (2022). Effects of open innovation breadth on industrial innovation input–output relationships. European Journal of Innovation Management, 25(4), 975-996.
19. Kai, D. A.; Jesus; É. T. D.; Pereira E. A. R.; Lima, E. P. D.; Tortato, U. (2017). Influence of organisational characteristics in sustainability corporate strategy. International Journal of Agile Systems and Management, 10(3-4), 231-249.
20. Kai, D. A.; de Jesus, É. T., Pereira, E. A.; de Lima, E. P.; Tortato, U. (2016, October). Influence of Organizational Characteristics in the Sustainability Strategy. In ISPE TE (pp. 176-185).
21. Kai, D. A.; de Lima, E. P.; Cunico, M. W. M.; da Costa, S. G. (2016). Additive manufacturing: A new paradigm for manufacturing. In Proceedings of the 2016 Industrial and Systems Engineering Research Conference, Availability, Development (Vol. 14, p. 102).
22. Baierle, I. C., Siluk, J. C. M., Gerhardt, V. J., Michelin, C. D. F., Junior, Á. L. N., & Nara, E. O. B. (2021). Worldwide innovation and technology environments: research and future trends involving open innovation. Journal of Open Innovation: Technology, Market, and Complexity, 7(4), 229.
23. Moraes, J. D., Schaefer, J. L., Schreiber, J. N. C., Thomas, J. D., & Nara, E. O. B. (2020). Algorithm applied: attracting MSEs to business associations. Journal of Business & Industrial Marketing, 35(1), 13-22.