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THE IT PROJECT LIFECYCLE IN R&D: AN ADAPTIVE APPROACH TO PROJECT MANAGEMENT

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Purpose: This article examines a structured framework for the IT research and development (R&D) project lifecycle, focusing on critical phases of effective project management and success.
Design/methodology/approach: This study examines project cycle management (PCM), project management institute (PMI), and PRINCE2 methodologies through a detailed literature review and comparative analysis of these frameworks about a project in the IT R&D sector. The focus is on adapting the life cycle to the specifics of an IT R&D project, taking into account classic and agile methods, and analyzing the variability of resource utilization at different stages of these projects.
Findings: The results indicate that dividing IT R&D projects into clearly defined phases promotes effective control and adaptive management. Each phase is also characterized by different relevance and resource utilization, which influences the need to adjust management actions depending on the stage of the IT R&D project. In addition, some phases are iterative, which harmonizes with the tenets of agile management of this type of project.
Research limitations/implications: To achieve optimal project results, it is recommended to adapt the life cycle to the specifics of the IT R&D project, emphasizing the importance of its different phases in the context of adaptive management. The article proposes a project management approach that combines the structured phases of PCM with the adaptability of PMI and PRINCE2 methodologies and agile methods to better suit R&D objectives.
Practical implications: The research highlights the need to adapt traditional project management models to the specific nature of IT R&D projects by incorporating iterative processes and greater flexibility. The proposed hybrid project lifecycle model enhances management efficiency, optimizes resource allocation, and enables quicker responses to changing conditions and stakeholder needs. Applying this approach can contribute to shorter development cycles, reduced risks, and faster market introduction of innovations. The findings have significant practical implications, supporting organizations in achieving better project outcomes and gaining a competitive advantage.
Originality/value: By focusing on the unique needs of IT R&D projects, this paper contributes valuable insights to the field of project management, highlighting the role of structured life cycles in maximizing the effectiveness of IT R&D projects.
Keywords: adaptive project management, project life cycle, IT R&D projects.
Category of the paper: research paper and viewpoint.

1. Introduction

Information Technology (IT) research and development (R&D) projects are central to driving innovation, technological advancements, and scientific discovery across industries. However, the management of these projects presents unique challenges due to the inherently uncertain nature of R&D activities (Flitz Turkmen, Topcu, 2021). Unlike more predictable, linear projects, IT R&D initiatives often operate in complex environments where project goals may evolve in response to emerging findings, stakeholder feedback, or external pressures (Wang et al., 2007). In these projects, there is also iteration in the solution design (Beck et al., 2001) phase which affects the need to develop a less linear cycle. Effective management of these projects thus requires a structured yet adaptable approach to ensure alignment with broader organizational objectives, efficient resource utilization, and successful solutions generation (Kerzner, 1981).

The tools that support the management efficiency of projects in the organization are methodologies and project life cycle (Kostalova, Tetrevova, 2016). Project management is based on the assumption that projects are cyclical in nature, that is, they are closed wholes consisting of recurring phases and stages (Project Management Institute, 2013). Especially in research and development projects, the life cycle of a project is highly visible, as each phase of the project ends with some documented checkpoint (Li et al., 2020), representing a tangible result of the work carried out, this may be a proposal for an application for funding, an implementation contract, or a final project report. In addition, these projects are typically cyclical in nature, as the result of one project, can directly contribute to the start of another.

Separate phases play an important role in IT R&D projects; they are almost separate, closed phases that merge into a complete cycle. The various phases of a project differ in terms of duration, degree of resource commitment, and the methods used for guidance, planning, and control. Phases are usually time-bound, with a start and end point or control point. In addition, when planning the assumptions of each process in an IT R&D project, it is necessary to detail the scope of activities that will go into a phase in order to move on to the next phase (PMBOK® Guide). During each phase, the content of the project documents can be analysed and revised and then moved to the next phase. Such a system makes the project concept and the context in which it is implemented transparent, allowing more effective monitoring and evaluation of a given project. Each stage in the life cycle of a project is important and should not be overlooked, as the overall goal of the project may change depending on the phase the project is in (de Wit, 1988).

Defining the cycle of an IT R&D project, identifying its important and resource-intensive phases, and using the life cycle of that project in a disciplined way can help managers manage it effectively. It will also overcome two key technical problems: the late identification or abandonment of key project elements (such as risks, tasks, functions, resources needed,

contractor roles and responsibilities, and stakeholder influences) and the unwarranted continuation of the project in the event of failure (Kloppenborg, Petrick, 1999).

The purpose of the article is to analyse existing project life cycles based on selected methodologies and management frameworks - Project Cycle Management, PRINCE2, and PMI - and adapt them to the specifics of an IT R&D project. The analysis identifies and evaluates the role and value of project phases. The correlation between these phases and the number of resources used in them was also examined. Next, three phases of the IT R&D project life cycle that are critical to the project were identified.

Based on this analysis, the paper proposes a generic approach tailored to R&D projects in the IT department which offers adaptability through iterative cycles and continuous feedback. The article concludes with a summary of the results, recommendations for IT R&D project managers, and a brief discussion of the study's limitations and potential directions for further research.

2. Literature review

The literature on project life cycle management often overlooks the specific requirements of IT R&D projects, where high degrees of uncertainty, the need for iteration at the product stage, and the need for stakeholder alignment complicate traditional project management practices. Studies indicate that while standard frameworks such as Project Cycle Management (PCM), the Project Management Institute (PMI) standards, and PRINCE2 are widely used in various industries, their application in R&D remains under-explored and requires modifications to fit the dynamic nature of research environments (Kerzner, 2017). PCM, for example, provides a highly structured approach with defined phases that facilitate accountability and resource allocation, making it suitable for projects requiring rigorous oversight. However, its rigid structure can pose challenges in highly flexible environments like IT R&D, where project goals may shift as research progresses. Similarly, PMI's framework supports adaptability and resource optimization, which aligns with the needs of R&D projects but may lack the necessary focus on iterative evaluation which is critical in IT scientific research (Project Management Institute, 2013).

One major challenge in IT R&D project management is the coordination and engagement of diverse stakeholders, including funders, researchers, industry partners, and end-users, who each bring different expectations and requirements (Smith, Johnson, 2022). Stakeholder engagement is particularly crucial in R&D, as projects often involve significant public or private investment, and their outcomes have implications for innovation, policy, and societal benefits. An effective project life cycle approach must integrate stakeholder input at every stage

to ensure that the project remains aligned with external expectations and is capable of generating impactful results (Pinto, Slevin, 1988).

This study seeks to bridge the gap in the literature by examining how established project management methodologies PCM, PMI, and PRINCE2 can be adapted to meet the unique needs of IT R&D projects. The aim is to understand how these frameworks align with R&D's iterative and high-stakes environments, where project goals, deliverables, and success metrics are often fluid rather than fixed (Meredith, Mantel, 2011). By analysing the strengths and limitations of each framework, this paper addresses the following research questions:

- **Q1: How do PCM, PMI, and PRINCE2 align with the demands of IT R&D projects?**
- **Q2: What modifications can improve the effectiveness of these frameworks in IT R&D contexts?**

Ultimately, this study aims to contribute to the growing body of knowledge on IT R&D project management by offering a model of the IT R&D project lifecycle aimed at increasing efficiency, accountability, and success rates in these projects (Kerzner, 2019). The role of the Project Life Cycle framework in IT R&D

The project life cycle is foundational in traditional project management and typically includes phases such as initiation, planning, implementation, monitoring, and closure (Turner, Müller, 2003). In general industry settings, this life cycle structure helps in organizing resources, defining deliverables, and tracking progress. However, in R&D environments, project goals often evolve in response to findings, leading to a need for flexible, adaptive management structures. IT R&D lifecycle frameworks must therefore accommodate feedback loops, iterative processes, and frequent evaluations to guide decision-making effectively (Kerzner, 2019).

IT R&D projects are distinct from traditional projects due to their exploratory nature and iterative nature (Hevner et al., 2004). Often operating with high uncertainty, these projects rely on a phased approach to break down complex tasks, assess progress at each stage, and enable decision points where changes to scope, methodology, or objectives may be necessary. PCM, PMI, and PRINCE2 each provide phase-based structures that can support this adaptive approach but differ in their level of flexibility and focus on stakeholder engagement. The literature indicates that these adaptations are crucial, as IT R&D projects require ongoing adjustments that traditional life cycle frameworks may not fully support (Turner, 2014).

2.1. Project Cycle Management (PCM) in IT R&D projects

Project Cycle Management (PCM) is one of the earliest frameworks for structuring projects, and it is particularly recognized for its application in the European Union's funded projects, where transparency and accountability are paramount (European Commission, 2004). PCM divides projects into six stages: planning, identification, formulation, financing, implementation, and evaluation. Each stage is defined by distinct objectives and deliverables,

making PCM suitable for projects requiring structured oversight. Its emphasis on progressive assessment and defined checkpoints aligns well with IT R&D projects, as these stages facilitate controlled decision-making and resource allocation (Basu, 2015).

However, PCM's highly structured approach can pose challenges in the flexible IT environment of R&D, where the scope of research projects may change as new information emerges. The structured nature of PCM can sometimes hinder rapid adaptation, a critical aspect of scientific research. Literature suggests that modifications to PCM may be necessary, particularly in the development and implementation stages, to allow for iterative assessments and the incorporation of real-time feedback from stakeholders (Pinto, Slevin, 1989).

2.2. Project Management Institute (PMI) framework and its application to IT R&D

The PMI framework, outlined in the Project Management Body of Knowledge (PMBOK® Guide), is one of the most widely used project management standards globally. PMI emphasizes five core processes: initiation, planning, execution, monitoring and control, and closing. PMI's flexibility and focus on resource optimization make it a robust choice for IT R&D projects, where project requirements may shift as new discoveries are made. PMI's framework also incorporates risk management strategies, which are essential in R&D settings, where uncertainty is a significant factor (Kerzner, 2017).

In IT R&D projects, the monitoring and control phase of PMI plays a key role, providing continuous oversight that is consistent with the iterative nature of these projects. The adaptability of this structure allows project managers to adjust resources and schedules based on emerging needs. However, some researchers argue that PMI could benefit from an expanded emphasis on iterative assessments, as traditional PMI practices may not fully address the ongoing needs of assessing and revising IT R&D projects (Smith, 2010). Integrating feedback loops at key milestones within PMI could increase its applicability to IT R&D, allowing project managers to refine goals and adjust stakeholder expectations as the project evolves (López et al., 2021).

2.3. PRINCE2 and its suitability for IT R&D projects

PRINCE2 (Projects in Controlled Environments) is a process-driven project management methodology that segments projects into preparation, initiation, execution, and closure phases, with a strong emphasis on business justification and risk management (Smith, Brown, 2020). Initially developed for government projects in the United Kingdom, PRINCE2 has gained global recognition for its structured, process-based approach. This methodology's focus on business case justification and stakeholder involvement makes it particularly well-suited for projects with high external visibility and funding requirements, common traits of many IT R&D initiatives (Young, 2016).

PRINCE2's emphasis on stakeholder engagement and justification aligns with the needs of IT R&D projects, where external partners, including funding agencies and industry collaborators, play a critical role in defining project success. The methodology's structured phase-gate approach provides clear decision points, enabling ongoing stakeholder engagement and iterative project evaluations. PRINCE2's "manage by stages" principle is particularly valuable in IT R&D, where each stage can be evaluated to determine if the project should continue, pivot, or conclude (Zwikael, Smyrk, 2019). However, PRINCE2's structured nature can sometimes limit flexibility, and IT R&D project managers may need to modify PRINCE2's rigid phase transitions to better accommodate iterative scientific exploration (Cleland, 2007).

2.4. Adaptation of life cycle models for IT R&D

The literature emphasizes that IT R&D projects benefit most from project management frameworks that include adaptability, iterative phases of product development, and stakeholder alignment (Miller, Hobday, 2020). PCM, PMI, and PRINCE2 offer benefits when applied to IT R&D but also require specific adaptations to meet the iterative and evolving needs of these projects. Many researchers advocate a hybrid approach that incorporates elements of PCM structure, PMI flexibility, and PRINCE2 stakeholder alignment to better meet the demands of IT R&D projects, especially those in high-stakes, innovation-driven environments (Crawford, Pollack, 2004).

2.5. Agile methods in IT R&D Projects

Agile methods have emerged as a popular approach to managing IT R&D projects, particularly due to their focus on adaptability and responsiveness in uncertain and dynamic environments. These methods prioritize iterative development cycles and continuous stakeholder feedback, enabling teams to adjust to changing requirements and unforeseen challenges effectively (Beck et al., 2001). Agile's flexibility makes it well-suited for projects where innovation and exploration are key drivers, as it allows project teams to refine objectives and outcomes throughout the development process.

However, despite these strengths, agile methods often lack the structured planning and financial frameworks required for managing large-scale IT R&D projects, especially those reliant on external funding. Unlike traditional methodologies such as PCM or PRINCE2, Agile does not inherently include defined mechanisms for resource allocation, business justification, or stage-gate reviews, which are critical in high-stakes R&D environments (Smith, Johnson, 2022). The absence of these elements can pose significant challenges in securing and managing funding, as well as in maintaining accountability to stakeholders, including funders, regulators, and end-users.

For IT R&D projects, which often operate under strict financial constraints and high levels of scrutiny, the lack of formalized planning processes in agile can hinder its effectiveness. These projects require not only adaptability but also clear frameworks for resource

commitment, risk management, and progress evaluation. To address this gap, hybrid approaches that combine agile's iterative and adaptive principles with the structured oversight of traditional methodologies are increasingly recommended. Such integrations aim to provide the flexibility needed to navigate the uncertainties of R&D while ensuring the accountability and resource efficiency demanded by stakeholders (Kerzner, 2019).

This perspective underscores the necessity of refining existing methodologies to better align with the unique requirements of IT R&D projects, balancing the agility needed for innovation with the structure required for project governance and success.

2.6. Summary of Literature Insights

The adaptation of PCM, PMI, and PRINCE2 for IT R&D projects highlights the need for a tailored approach to project management. By incorporating elements from each framework, project managers can develop a life cycle structure that promotes accountability, stakeholder engagement, and flexibility. Research emphasizes that such a hybrid approach allows IT R&D managers to meet project goals effectively while accommodating the iterative and uncertain nature of scientific research (Meredith, Mantel, 2011). The insights from this literature review provide a foundation for the proposed methods in this study, which will analyse the application of these frameworks to the life cycle stages of IT R&D projects.

In summary, PCM, PMI, and PRINCE2 each provide valuable contributions to IT R&D project management when applied adaptively. This study seeks to refine these insights by examining how each framework aligns with IT R&D's unique requirements, identifying potential adaptations, and proposing an integrated life cycle approach that maximizes project success and stakeholder engagement (Patanakul, 2010).

3. Research method

In This study uses a qualitative approach to analyse the application and adaptability of three core project management methodologies - Project Cycle Management (PCM), the Project Management Institute (PMI) framework, and PRINCE2 - in the context of IT R&D projects. The goal is to assess how these frameworks meet the unique requirements of this type of research, including the need for iteration of certain phases, flexibility of resources, and active stakeholder involvement. The method includes a literature review, a comparative study of lifecycle frameworks, and a viewpoint analysis based on benchmarking IT R&D projects. The viewpoint analysis incorporated qualitative perspectives gathered during the benchmarking process, providing deeper insights into the strengths and limitations of each framework in practical applications. The final stage of the study is to design an IT project lifecycle that is tailored to the specifics of this type of project and addresses its needs. The author's IT R&D

project life cycle is designed to apply adaptive management methods to the various phases of the project, which can influence its successful completion.

The study evaluates the life cycles of PCM, PMI, and PRINCE2 according to four basic criteria:

- **Adaptability:** this criterion assesses the framework's ability to adapt to changes in project scope, objectives, and resource needs that are typical of R&D projects as new findings emerge. Adaptable frameworks are essential in R&D for IT projects, where rigid structures can hinder necessary adjustments (Jetter, Albar, 2016).
- **Stakeholder engagement:** effective stakeholder management is critical in IT R&D projects because of the involvement of various stakeholders, such as researchers, funders, industry partners, customers, and regulators. This criterion assesses the extent to which each structure facilitates stakeholder inclusion in decision-making processes, ensuring alignment with evolving project goals (Urbinati et al., 2021; Hooge, Dalmasso, 2015).
- **Iterability:** IT R&D projects often require iterative processes and continuous evaluation to refine methods, validate findings, and adjust objectives. This criterion examines the extent to which a given project lifecycle supports iterability, enabling the project to respond effectively to new data and stakeholder feedback (Wynn, Eckert, 2017).
- **Resource Allocation:** R&D resource management in IT projects is challenging due to changing requirements and the need for expertise. This criterion focuses on each framework's approach to resource allocation, including flexibility in reallocating resources (Toppila et al., 2011).

Data collection included an extensive literature review of academic publications, project management textbooks, and institutional guidelines on PCM, PMI, and PRINCE2 methodologies. Benchmarking techniques were used to highlight the strengths and weaknesses of each framework as applied to IT R&D projects. The approach provided a detailed understanding of how each methodology supports or constrains IT R&D project management, particularly in terms of adaptation to dynamic research processes and integration of feedback mechanisms (Mahindra, Srivastava, 2019).

To evaluate the effectiveness of PCM, PMI, and PRINCE2, a benchmarking process was conducted. This involved:

- Comparing the incidence of each phase using in IT R&D projects across case studies.
- Mapping the key strengths and weaknesses of each framework in the context of the four criteria.

Additionally, project lifecycle phases identified in the selected frameworks were analyzed for their relevance and effectiveness in IT R&D settings. For example, phases such as planning, implementation, and deployment were scrutinized for their adaptability to iterative processes.

4. Results

The first stage of the research was to identify potential phases of an IT R&D project based on the selected three methodologies of PCM, PRINCE2, and PMI, and to evaluate them taking into account the developed criteria for: adaptability, stakeholder involvement, and iterability (Table 1). Based on the research, six phases were identified: planning, financing, implementation, deployment, monitoring and control, and evaluation. These phases are important for IT R&D projects because they take into account specific aspects of these ventures, such as the need to use agile management methods and the need for adaptability, iteration, and stakeholder participation in the project process.

The next stage of the research included an assessment of resource utilization in each phase of the life cycle of the methodologies under consideration, along with an assessment of resource utilization in terms of the IT R&D project (Table 2). At this stage, only the phases of the IT R&D project that scored highest in the previous survey were considered. The research results show that most resources are used in the implementation phase of the project, but they are also used significantly in the planning and deployment phases. This indicates the high importance of these phases in the process of managing an IT R&D project and the focus on the need for iteration, stakeholder engagement, and continuous evaluation and adaptation.

Table 1.
Determination of the most important phases of the IT R&D project life cycle on the basis of exemplary management methodologies (PCM, PRINCE2, PMI)

No.	Mapped project phases (PCM, PRINCE2, PMI)	Relevance of phase occurrence in an IT R&D project	Relevance of phase occurrence in PCM	Relevance of phase occurrence in PRINCE2	Relevance of phase occurrence in PMI	Total points
1.	Preparation	1	0	3	0	4
2.	Initation	1	2	0	2	5
3.	Planning	3	3	0	3	**9**
4.	Identification	1	2	0	0	3
5.	Appraisal	2	2	0	0	4
6.	Funding	3	3	0	0	**6**
7.	Implementation[1]	3	0	3	3	**9**
8.	Deployment	3	3	0	0	**6**
9.	Monitoring and control	3	0	0	3	**6**
10.	Closing	1	0	2	2	5
11.	Evaluation	3	3	0	0	**6**

Note. 3 - decisive/key, 2 - significant, 1 - irrelevant, 0 - not present.

Source: own study.

[1] Implementation is often understood as the deployment of a solution. However, in this context it refers to its execution of the IT R&D project.

Table 2.
Use of resources in the different phases of the designated R&D project life cycle with reference to selected management methodologies (PCM, PRINCE2, PMI)

No.	Mapped project phases (PCM, PRINCE2, PMI)	Resource intensity of phase occurrence in an IT R&D project	Resource intensity of phase occurrence in PCM	Resource intensity of phase occurrence in PRINCE2	Resource intensity of phase occurrence in PMI	Total points
1.	Planning	2	2	0	2	**6**
2.	Funding	1	1	0	0	**2**
3.	Implementation	3	0	3	3	**9**
4.	Deployment	3	3	0	0	**6**
5.	Monitoring and control	2	0	0	1	**3**
6.	Evaluation	1	1	0	0	**2**

Note. 3 - large, 2 - medium, 1 - small, 0 - not present.

Source: own study.

Figure 1 and Figure 2 in addition to Table 1 indicate how the relevance of the phases is shaped for all the phases designated by the selected methodologies (Figure 1) and for the selected, more important phases of the IT R&D project. The planning and implementation phases play the largest role. It was also found that the identification, preparation, and appraisal phases are the least frequent in this type of project.

Figure 3 shows the use of resources in selected phases of an IT R&D project. The implementation and planning phases represent moments of increased use of project resources.

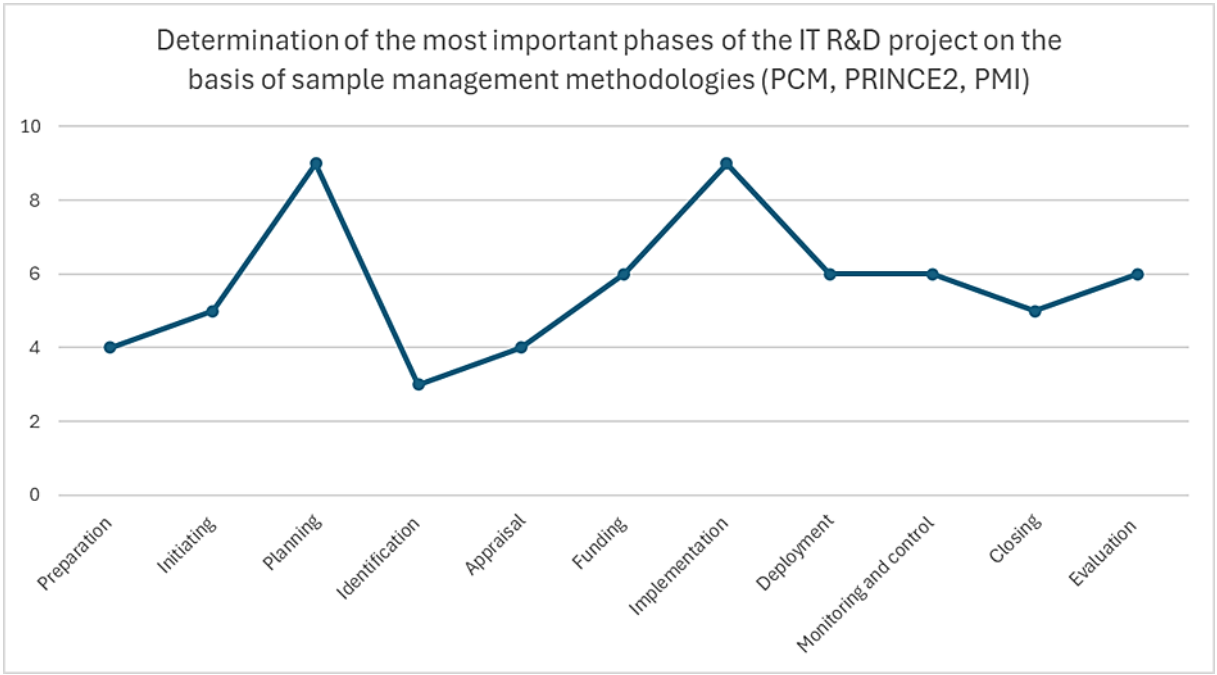

Figure 1. Indication of the relevance of the different phases of the IT R&D project life cycle using selected management methodologies (PCM, PRINCE2, PMI).

Source: own study.

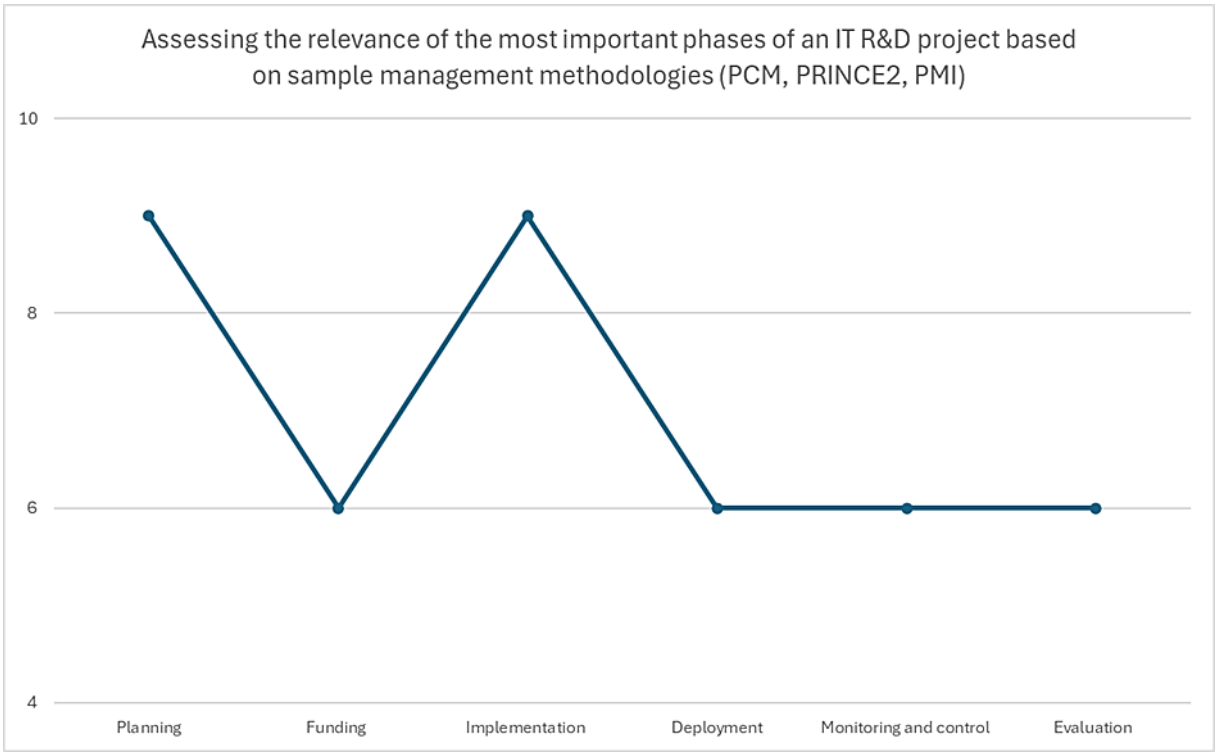

Figure 2. Assessing the relevance of different phases of the IT R&D project life cycle using selected management methodologies (PCM, PRINCE2, PMI).

Source: own study.

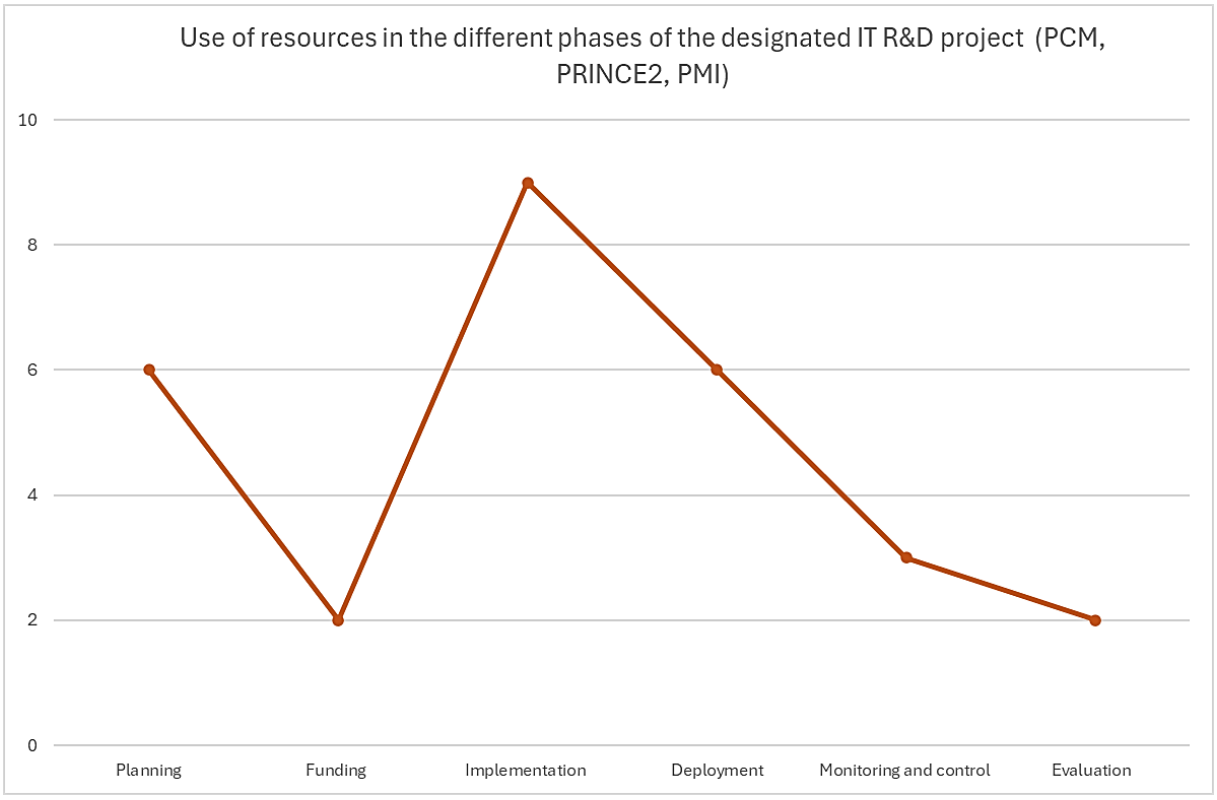

Figure 3. Use of resources in the different phases of the IT R&D project life cycle using selected management methodologies (PCM, PRINCE2, PMI).

Source: own study.

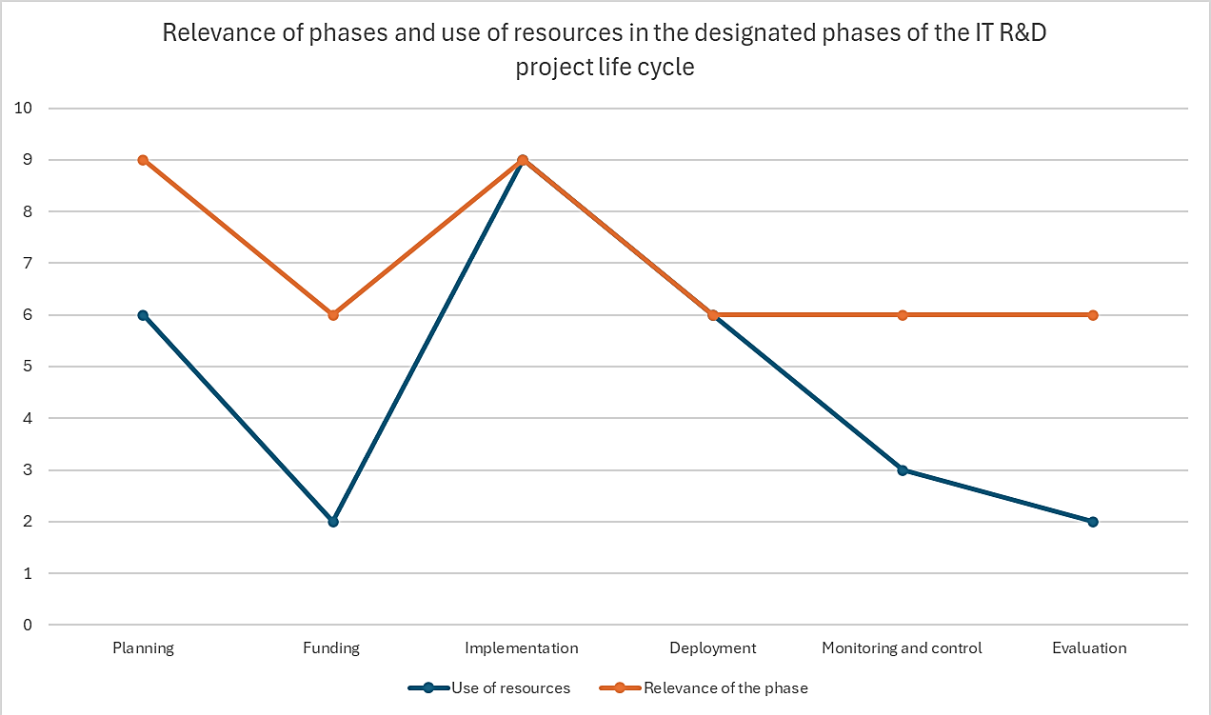

Figure 4. The importance of the different phases of the IT R&D project and the use of resources in the design life cycle phases.

Source: own study.

After analysing the relevance of the phases of the IT R&D project and determining the use of resources in each phase, the results are summarized in Figure 4 to show the relationship between them. Considering the results obtained, it can be seen that the implementation phase is characterized by high materiality as well as significant resource utilization. This indicates that there is a great need to support management processes in this phase and their adaptation. High use of resources in relation to the importance of the phase also occurs in the planning and deployment phases. All of these phases are important points for the project that can determine its success.

It can also be seen from the figure that the evaluation monitoring and control phases, despite their importance, do not require the use of too many resources. In IT R&D projects, evaluation is very important, especially when iterations are made, stakeholder involvement is strong, and resource use is variable. In addition, when running this type of project, it is necessary to keep in mind its high risk and constantly monitor and control it. In the case of IT R&D projects, monitoring and control should be carried out at all relevant stages of the project. And it is necessary to remember to prepare a risk analysis in the initial phases of this project.

The research conducted gives an understanding of the formation of the main project phases, which have a significant impact on the success of an IT R&D project due to their relevance and use of resources.

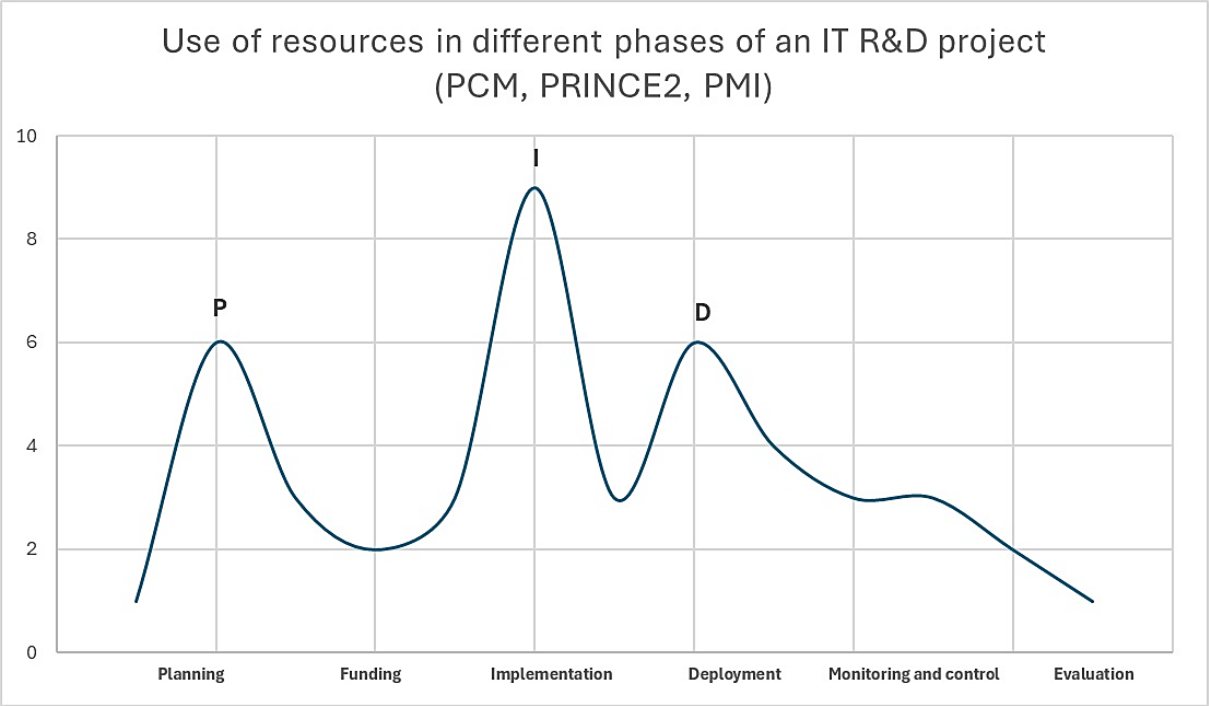

Figure 5. The importance of the different phases of the IT R&D project and the use of resources in the design life cycle phases.

Source: own study.

Figure 5 shows a breakdown of the resource intensity of the various phases of an IT R&D project in relation to their importance. It can be observed that the implementation phase is characterized by both high importance and resource use. The planning (P) phase, on the other hand, is just as important as the implementation (I) phase but uses far fewer resources. By this, we mean how important the planning phase is for the project, when with little cost in terms of resource utilization we can develop a highly relevant plan of action for the IT R&D project. Also important for the IT R&D project is the deployment (D) phase of the technology, and in this case also needs to use significant resources, however not as many as in the case of the implementation phase.

The results show the high relevance of three project phases in terms of resource commitment: planning, implementation, and deployment (PID). These phases require targeted management methods to take care of their positive implementation and incorporate their high risk into the project process.

5. Discussion

Traditional project management frameworks, with their structured phases, have long provided a stable foundation for managing projects across various industries. However, the dynamic nature of IT R&D projects presents unique challenges that traditional models

struggle to address effectively. These projects are characterized by high levels of uncertainty, frequent shifts in objectives, and the need for iterative development cycles. Moreover, the involvement of diverse stakeholders ranging from funders and researchers to industry partners and end-users requires constant coordination and alignment of expectations throughout the project lifecycle.

In addition to stakeholder complexity, IT R&D projects face inherent risks, such as technological uncertainty, evolving resource requirements, and the need for rapid adaptation to new discoveries or external changes. These factors demand a more flexible approach to project management, one that integrates the structured reliability of traditional frameworks with iterative, adaptive processes.

Given the research findings, this paper proposes an IT R&D project lifecycle model to address these needs by combining traditional project management phases with iterative cycles of implementation, evaluation, and deployment. This hybrid approach ensures continuous stakeholder engagement, risk management, and the ability to align resources while maintaining the overarching structure necessary to maintain project integrity. In this way, it provides a robust method for navigating the uncertainty and complexity of IT R&D projects, paving the way for more efficient and innovative results. The designed model reflects the growing realization that success in IT R&D depends not only on technical expertise but also on the ability to adapt and evolve in an ever-changing project environment.

The project lifecycle model illustrated in Figure 6 highlights the key integration of iterative phases in a traditional project management framework. Beginning with planning, financing, implementation, deployment, evaluation, and monitoring and control, the model highlights the importance of flexibility and adaptability in modern IT R&D projects. Incorporating adaptive iterations between the implementation, deployment, and evaluation phases ensures that projects can respond dynamically to emerging challenges of resource utilization, risk, and stakeholder feedback.

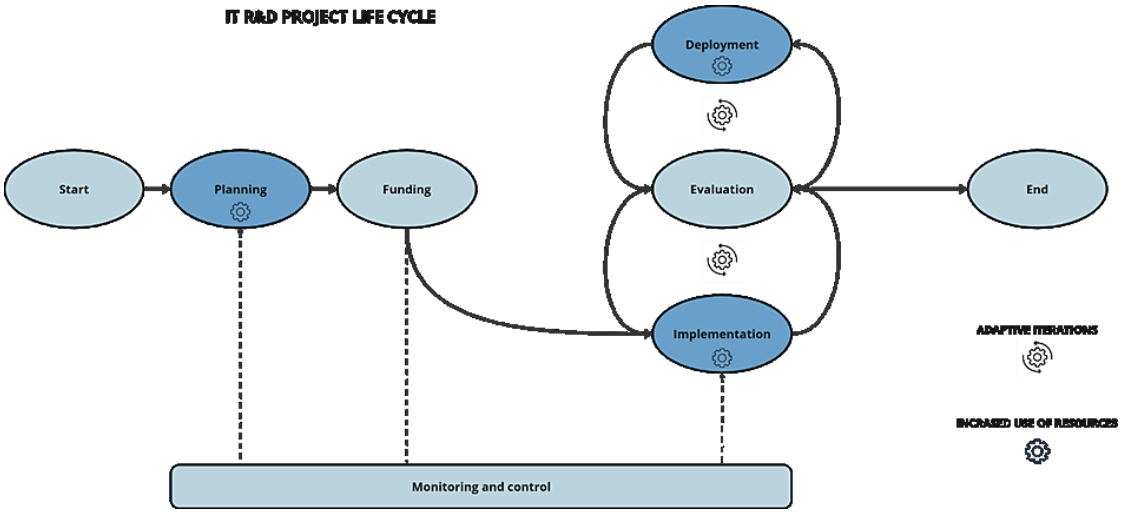

Figure 6. IT research and development project life cycle considering adaptive iterations.
Source: own study.

Monitoring and control serve as the backbone of this lifecycle, providing continuous oversight and enabling adaptation at each stage. This iterative and adaptive approach fits well with the unique requirements of IT R&D projects, where evolving goals, stakeholder engagement, iterability, resource variability, and risk management require a departure from rigid methods. Ultimately, the model demonstrates that combining traditional structure with iterative adaptability is essential for successful outcomes in complex and exploratory project environments.

The IT R&D project lifecycle model illustrates various decision-making pathways depending on the outcomes of each phase. Possible scenarios include: (1) terminating the project after the implementation phase if insurmountable technical challenges are encountered or the project loses relevance; (2) completing the project after execution and evaluation without deployment, in cases where the sole objective was to validate a technology; (3) implementing the solution and concluding the project; and (4) implementing, evaluating, and potentially further developing the project through adaptive iterations. This approach enables dynamic adjustments to change circumstances, allowing for iterative returns to earlier phases, such as implementation or evaluation, to improve outcomes, mitigate risks, or respond to stakeholder feedback. Adaptive iterations, characterized by their flexibility in strategic decision-making, support both the innovation process and efficient resource management.

The proposed hybrid project lifecycle model addresses many of the gaps identified in traditional frameworks, particularly when applied to IT R&D projects. Traditional methodologies such as PSM, PMI, or PRINCE2 provide a structured approach to project management, emphasizing sequential processes and business justification (Wrona, Ladwig, 2020). However, as highlighted in the literature, these methodologies often lack the flexibility to handle the iterative and exploratory nature of IT R&D projects (Hevner et al., 2004). The new model builds on prior research by integrating adaptive iterations and stakeholder engagement, drawing inspiration from agile methods, which prioritize adaptability and responsiveness (Chin, Spowage, 2010).

Previous studies have also emphasized the critical role of iterative feedback loops in complex projects (López et al., 2021). For instance, frameworks incorporating iterative phases have been shown to improve project outcomes by allowing teams to reassess objectives and align stakeholder expectations regularly. This iterative approach is especially relevant to IT R&D projects, where innovation cycles and resource requirements are highly variable (Smith, Johnson, 2022). By incorporating adaptive iterations into the traditional project lifecycle, the proposed model bridges the gap between structured processes and the need for flexibility in dynamic environments.

However, this model is not without limitations. One potential drawback is its increased complexity compared to linear frameworks, which may require additional training and resources to implement effectively. Furthermore, the model assumes that organizations have

the capacity to manage iterative processes and maintain continuous stakeholder engagement, which may not always be feasible in resource-constrained settings (Concannon et al., 2014).

One significant challenge lies in resource constraints, particularly during the planning, deployment, and implementation phases, which are resource-intensive and critical for project success. In the planning phase, insufficient resources can hinder the development of a robust project roadmap, leading to inefficiencies and gaps in aligning objectives with available capabilities. Similarly, the implementation phase often requires substantial investments in personnel, equipment, and expertise, which may strain budgets and lead to bottlenecks if resources are not managed effectively. The deployment phase, which involves transitioning project outcomes into practical use, is equally demanding, as it often requires additional funding and technical support to address unforeseen challenges or modifications.

Additionally, the model's success depends on the commitment of all stakeholders to participate actively throughout the project's duration, which can be challenging in large, multidisciplinary projects with competing priorities. IT R&D projects typically involve a wide array of stakeholders, including researchers, industry partners, funders, and end-users, each with distinct goals, priorities, and expectations. This diversity can lead to conflicting interests and resistance to change, especially when new management approaches or workflows are introduced. Ensuring consistent engagement and alignment among stakeholders is a complex task that demands substantial time and effort, as well as effective communication strategies. Without proactive management of these issues, stakeholder resistance can undermine the hybrid model's effectiveness, delaying progress and impacting project outcomes.

This study addresses the research questions by analyzing how PCM, PMI, and PRINCE2 align with the demands of IT R&D projects and proposing modifications to improve their effectiveness. PCM's structured approach supports oversight but struggles with flexibility, PMI provides adaptability yet requires stronger iterative processes, and PRINCE2 emphasizes stakeholder engagement but benefits from adaptations for iterative phases.

The proposed hybrid lifecycle model responds to these challenges by integrating adaptive iterations, continuous stakeholder engagement, and flexible phase transitions. This combination enhances resource utilization, risk management, and adaptability, ensuring the model meets the dynamic needs of IT R&D projects.

In response to the first research question **(Q1)**, this study analyzed how PCM, PMI, and PRINCE2 align with the demands of IT R&D projects. PCM offers strong accountability and structured phases but struggles with the flexibility required for dynamic R&D environments. PMI provides adaptability and resource optimization but lacks sufficient iterative mechanisms, crucial for continuous improvement. PRINCE2 emphasizes stakeholder engagement and risk management, making it suitable for externally funded projects, but its rigid phase transitions limit its application to iterative scientific exploration. These findings underscore the need to adapt this framework to better meet the iterative and adaptive requirements of IT R&D projects.

Addressing the second research question **(Q2)**, the proposed hybrid lifecycle model integrates adaptive iterations, continuous stakeholder engagement, and flexible resource allocation. It incorporates iterative feedback mechanisms in key phases like implementation and evaluation, enhances stakeholder involvement throughout the project lifecycle, and ensures resource adaptability to evolving needs. This tailored approach supports critical phases such as planning, implementation, and deployment, improving project responsiveness and alignment with dynamic objectives.

The implications of this model are significant for both practice and research. For practitioners, it provides a roadmap for managing IT R&D projects in a way that accommodates uncertainty and promotes collaboration. By fostering continuous evaluation and adjustment, the model ensures that project goals remain aligned with stakeholder expectations and emerging findings. For researchers, the model highlights the importance of further exploring hybrid approaches that combine traditional and iterative elements, as well as examining their applicability across different project types and industries.

6. Conclusions

This study offers an in-depth analysis of IT R&D project management, emphasizing the critical need to adapt traditional project lifecycle frameworks to meet the unique demands of IT R&D environments. By examining established methodologies such as PCM, PMI, and PRINCE2 through the lenses of adaptability, stakeholder engagement, iterability, and resource allocation, as well as conducting a benchmark analysis of IT R&D projects, the research identifies key areas where these frameworks excel and where they fall short in addressing the dynamic nature of IT R&D projects. The benchmarking provided a comparative perspective, highlighting practical successes and challenges in real-world applications, which further informed the evaluation of these methodologies and their suitability for iterative and resource-intensive environments.

The findings underscore that traditional methodologies provide a strong foundation for accountability and resource allocation. However, they often lack the flexibility required to accommodate the iterative processes and evolving objectives inherent in IT R&D projects. PCM's structured phases ensure transparency and oversight but struggle with rapid adaptation. PMI offers flexibility and resource optimization yet requires stronger iterative mechanisms to align with ongoing research. PRINCE2 excels in stakeholder engagement but benefits from more fluid phase transitions to support iterative evaluations and adjustments. On the other hand, agile methods provide some complement to classical methods and help adjust management activities at certain stages of an IT research and development venture.

The proposed hybrid IT R&D project lifecycle model integrates the strengths of this framework while addressing its limitations using agile methods. Adaptive iteration, continuous stakeholder engagement, and flexible resource allocation are the cornerstones of this model, enabling it to respond dynamically to changing research conditions, feedback, and emerging challenges. In particular, the planning, implementation, and deployment phases prove critical, requiring significant resources. In contrast, the implementation, deployment, and evaluation phases use iterations to adapt to high-stakeholder impact and minimize project risk.

The developed model serves as a generalized framework that combines key elements of various project management methodologies, such as PCM, PMI, PRINCE2, and agile approaches, to meet the specific needs of IT R&D projects. Its structured but flexible design harmonizes traditional project management phases with the iterative and exploratory nature of R&D. Agile methods are particularly valuable within adaptive iterations that occur between critical phases such as implementation, evaluation, and deployment. These methods, which emphasize incremental progress and continuous feedback, blend seamlessly with the iterative aspects of the model. By incorporating agile principles, the model enhances its ability to respond dynamically to changes made by project stakeholders, optimize resources, and adapt to changing project goals. This unified perspective ensures that the lifecycle model provides a practical and comprehensive tool for managing the complexity of IT R&D projects while maintaining consistency and adaptability.

The proposed model offers a practical framework for IT R&D project management that enhances efficiency, accountability, and success rates. For practitioners, this model provides a roadmap for balancing the structured reliability of traditional frameworks with the flexibility needed to navigate the uncertainties of IT R&D projects. It ensures that projects remain aligned with evolving objectives while optimizing resource utilization and mitigating risks.

Future research should focus on validating the hybrid model across diverse industries and project scales to assess its adaptability and scalability. Additionally, exploring strategies to streamline its implementation, particularly in resource-constrained settings, will be critical. Further investigations could also delve into the integration of emerging technologies, such as AI and machine learning, to enhance iterative decision-making and stakeholder collaboration in IT R&D projects.

This study contributes to the growing body of knowledge on adaptive project management by proposing a model that addresses the critical needs of IT R&D projects. By emphasizing adaptability, stakeholder engagement, iterability, and resource allocation, it lays a foundation for future advancements in managing high-stakes, innovation-driven initiatives.

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