

CHAPTER 2

2.1 Introduction

The integration of AI into project management is transforming the ways in which projects are planned, executed, and monitored. AI-powered tools enhance efficiency by automating repetitive tasks, improving decision-making through predictive analytics, and optimizing resource allocation with real-time insights. However, the successful application of these technologies demands a careful balance between the capabilities of AI and the expertise of human project managers. While AI excels at processing large volumes of data and streamlining specific processes, it cannot replace the strategic thinking, ethical decision-making, and leadership that project managers provide.

This chapter provides an in-depth review of the theoretical frameworks and literature surrounding the use of AI in project management. It examines key theories that explain the adoption of AI, the constraints influencing project outcomes, and the competencies project managers need to cultivate in AI-driven environments. Additionally, the chapter explores how AI improves project workflows, the various ways in which it is utilized, and the challenges of managing project constraints within a technologically advanced context.

By establishing this theoretical foundation, the chapter lays the groundwork for analyzing the interactions between AI, project constraints, and project manager competencies. This serves as the foundation for the research framework that will be developed in the subsequent chapters.

2.2 Theoretical Framework

2.2.1 Theories Related to AI Usage in Project Management

2.2.1.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is one of the most utilized frameworks for understanding how individuals adopt and utilize technology. Created by Fred Davis in 1989, TAM suggests that two primary factors mainly influence the acceptance of technology. The first is the Perceived Usefulness (PU), which refers to the extent to which a user perceives that using a specific technology will improve their performance. The second factor is the Perceived Ease of

Use (PEoU), which refers to the degree to which a user believes that using the technology will be easy and require little effort. These factors impact the Attitude Toward Using (ATU) the technology, which subsequently influences the Behavioral Intention (BI) to use it, ultimately resulting in Actual Use (AU) (Davis, 1989). Over time, TAM has been expanded with additional variables to enhance its explanatory capacity, such as trust, ethics, subjective norms, and project management maturity (Mustofa et al., 2025; Pejić Bach, Zoroja, & Čeljo, 2017).

The growing integration of Artificial Intelligence (AI) in professional settings, including project management, has led to adjustments in traditional TAM frameworks. AI-powered tools such as machine learning, predictive analytics, chatbots, robotic process automation (RPA), and decision support systems are revolutionizing project management by enhancing efficiency, decision-making, and resource allocation. However, the adoption of AI is influenced by factors beyond Perceived Usefulness (PU) and Perceived Ease of Use (PEoU), including trust, ethics, subjective norms, and organizational readiness (Mustofa et al., 2025).

Studies indicate that Perceived Usefulness (PU) is a strong predictor of AI adoption, as users place high value on AI's ability to enhance decision-making and improve project efficiency. In contrast, Perceived Ease of Use (PEoU) has a lesser impact, especially in environments where users are already technologically proficient (Mustofa et al., 2025). This suggests that for project managers, the tangible benefits of AI are more significant than its ease of use, particularly when AI is introduced as a decision-support tool rather than a fully autonomous system. Additionally, studies on the adoption of Business Intelligence Systems (BISs) suggest that perceived ease of implementation is a more significant factor than ease of use, especially when assessing AI adoption at the organizational level (Pejić Bach et al., 2017). Therefore, AI adoption in project management should prioritize showcasing tangible benefits and ensuring seamless integration with existing systems, rather than focusing solely on usability.

2.2.1.2 Diffusion of Innovation Theory (DOI)

The Diffusion of Innovation (DOI) Theory, initially introduced by Everett Rogers in 1962 and expanded in 2003, is a widely accepted framework that outlines how innovations spread within a social system over time. The theory identifies five key characteristics of innovations that affect their adoption: relative advantage, compatibility, complexity, trialability, and observability.

(Rogers, 2003). These factors play a crucial role in explaining how technological innovations, such as Artificial Intelligence (AI) tools, are integrated into organizations.

One of the core components of the DOI theory is relative advantage, which refers to the perceived benefits of an innovation compared to existing solutions. AI tools offer significant advantages in project management, including predictive analytics, automated reporting, real-time decision support, and risk assessment. Studies suggest that organizations with a strong understanding of AI's benefits are more likely to adopt it into their workflows (Mustofa et al., 2025). For example, small and medium-sized enterprises (SMEs) are more inclined to adopt AI due to its ability to enhance operational efficiency and streamline decision-making processes. However, AI adoption tends to be slower in organizations where the perceived benefits are unclear or difficult to measure (Aish & Noor, 2025), which aligns with the DOI theory's principle that technologies with clear, measurable advantages are adopted more quickly.

Another important attribute in the DOI theory is compatibility, which relates to how well an innovation fits with an organization's existing systems, values, and processes. AI adoption is generally more successful in organizations that have already implemented digital transformation and data-driven decision-making frameworks (Aish & Noor, 2025). These organizations are more likely to adopt AI tools faster than those still relying on traditional project management methodologies. AI tools must also integrate seamlessly with existing systems like enterprise resource planning (ERP), project tracking software, and communication platforms. If AI tools require significant restructuring or cultural changes, adoption may be delayed.

Complexity is another critical factor influencing AI adoption. This refers to the level of difficulty in understanding and using an innovation. In organizations with limited technical expertise or resistance to change due to lack of AI literacy, AI adoption may face significant challenges (Mustofa et al., 2025). For instance, SMEs often struggle with the high implementation costs and the steep learning curve associated with AI adoption (Aish & Noor, 2025). To mitigate these challenges, organizations that offer AI training programs, provide user-friendly interfaces, and implement phased rollouts of AI tools tend to experience higher adoption rates. This aligns with the DOI principle that technologies perceived as simpler and more intuitive are more likely to be adopted quickly.

The concept of trialability also plays a crucial role in the diffusion process. This refers to the extent to which an innovation can be tested on a small scale before full-scale adoption. Organizations that test AI tools, such as scheduling tools or chatbots, on a pilot basis before fully integrating them into their systems often experience smoother adoption (Aish & Noor, 2025). The ability to experiment with AI tools without significant upfront investment reduces the perceived risk and fosters a positive adoption experience.

Observability, which refers to how visible the benefits of an innovation are to potential adopters, also influences AI adoption. When organizations observe successful implementations of AI in similar industries, they are more likely to adopt AI tools themselves (Mustofa et al., 2025). For example, when a leading construction company successfully integrates AI-powered predictive maintenance models, other firms within the same industry are likely to follow suit. This highlights the role of case studies, industry reports, and peer influence in shaping AI adoption trends.

Rogers' DOI Theory further categorizes adopters into five groups: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. In the context of AI adoption in project management, Innovators are forward-thinking organizations that quickly adopt AI tools, such as those using AI-based risk management models. Early Adopters are organizations that test AI on a small scale before adopting it more widely. The Early Majority adopts AI once industry standards and proven best practices are established. The Late Majority waits for AI tools to become mainstream and affordable. Lastly, Laggards only adopt AI when forced by regulations or competitive pressures. Understanding where an organization falls within this adoption curve can help guide strategies for accelerating the diffusion process.

Several factors influence AI adoption, drawing from DOI theory and empirical studies in SMEs. Leadership support plays a key role in driving AI adoption, as strong managerial backing accelerates the process (Mustofa et al., 2025). The regulatory environment also impacts AI adoption, as government policies and incentives can encourage organizations to implement AI technologies (Aish & Noor, 2025). Moreover, industry competition often motivates organizations to adopt AI to stay competitive in the market. Finally, the evaluation of cost and ROI influences AI adoption decisions, as organizations weigh the implementation costs against the expected return on investment.

However, despite the potential benefits of AI, several barriers to adoption remain. Ethical and trust issues may arise, with some employees and managers skeptical of AI-generated decisions (Mustofa et al., 2025). There are also concerns regarding data security, as AI systems require access to vast datasets, raising privacy and confidentiality risks. Additionally, the lack of a skilled workforce can slow AI adoption, particularly in organizations that do not have AI-experienced personnel (Aish & Noor, 2025). To overcome these obstacles, organizations must create strong AI governance frameworks, establish ethical AI policies, and focus on upskilling their workforce in AI technologies.

In conclusion, the DOI theory offers a comprehensive framework to understand the factors that affect AI adoption in project management. By addressing the factors of relative advantage, compatibility, complexity, trialability, and observability, organizations can develop more effective strategies for integrating AI into their project management processes. The adoption of AI tools can enhance project efficiency and decision-making, but overcoming challenges such as ethical concerns, trust issues, and the need for skilled personnel remains crucial for successful implementation.

2.2.1.3 Socio-Technical Systems Theory (STS)

The Socio-Technical Systems (STS) Theory, developed by researchers at the Tavistock Institute in the 1950s, aims to explain the relationship between technology and human work systems (Trist & Bamforth, 1951). The core concept of STS is that organizations are composed of two interdependent subsystems: the social system and the technical system. The social system includes the human aspects such as employees, managers, leadership structures, and organizational culture, while the technical system encompasses the tools, technologies, workflows, and processes that help organizations achieve their objectives. In the context of Artificial Intelligence (AI) adoption in project management, organizations must strike a balance between both of these subsystems to optimize efficiency, collaboration, and innovation (Mustofa et al., 2025).

As AI tools are integrated into project management, the interaction between AI systems and human project managers creates an evolving socio-technical system. AI aids in decision-making, offering data-driven insights and supporting predictive scheduling, risk assessment, and resource

management. However, human expertise remains essential for interpreting these outcomes, applying them within the project context, and managing the complexities that AI tools cannot fully address. This integration forms a hybrid socio-technical system, where AI and human project managers collaborate to optimize resource allocation, risk management, and stakeholder communication. Nevertheless, successful integration requires organizational alignment to ensure that AI complements human skills, rather than replacing them (Aish & Noor, 2025).

The STS framework for AI adoption in project management highlights three critical elements that need to be addressed for successful integration. First, human-AI collaboration is crucial, as AI should enhance, not substitute, human decision-making. Second, technology acceptance is key—project managers must view AI as a valuable tool that supports their role, rather than a threat. Third, organizational adaptation is necessary, as adopting AI requires adjustments to workflows, training programs, and governance structures to support the new tools and technologies effectively.

AI adoption in project management is not about replacing human project managers but transforming their roles. Project managers utilizing AI-driven decision support systems experience improvements in several areas. AI facilitates task automation, such as updating schedules and tracking progress, which allows managers to focus on higher-level strategic planning (Mustofa et al., 2025). It also supports predictive analytics, helping project managers forecast potential risks and resource constraints, offering valuable data-driven insights for decision-making (Aish & Noor, 2025). Moreover, AI-powered tools like chatbots and virtual assistants enhance communication, helping project managers engage stakeholders, address inquiries, and generate reports efficiently. Despite these advantages, human expertise remains vital for interpreting AI-generated insights and adapting them to the unique context of each project.

However, the adoption of AI in project management is influenced by socio-technical factors. Trust in AI systems is crucial, as project managers must have confidence in AI-generated recommendations for them to be effectively incorporated into decision-making processes (Mustofa et al., 2025). Additionally, ethical considerations play a significant role; AI algorithms must align with organizational values to ensure fairness, transparency, and accountability in decision-making (Aish & Noor, 2025). Training and AI literacy are also important for project managers to fully leverage AI technologies, making them more effective in applying AI tools to their workflows.

According to Socio-Technical Systems Theory, AI tools that are perceived as complex, unclear, or disruptive to team dynamics may face resistance from project managers, hindering their adoption (Mustofa et al., 2025). To overcome this, organizations must implement effective change management strategies, addressing concerns and facilitating the integration of AI tools into the existing project management systems.

For AI to be effectively adopted in project management, organizations must align AI technologies with human workflows. This involves redesigning work processes to integrate AI while ensuring human oversight remains intact. Additionally, developing AI governance policies is essential to establish ethical guidelines for AI usage in project decision-making. Encouraging cross-disciplinary collaboration between AI experts and project managers helps facilitate knowledge sharing and ensures that AI tools are applied in a way that complements human expertise. Aish and Noor (2025) highlight that AI adoption in project management represents a cultural and structural shift that influences how project teams collaborate and function, requiring organizations to adapt both technologically and organizationally.

Despite the many benefits of integrating AI into project management, challenges remain. Resistance to AI adoption is a common barrier, as project managers may perceive AI as a threat to their roles rather than a tool to assist them (Mustofa et al., 2025). Bias and ethical concerns must also be addressed, ensuring that AI-driven project decisions are transparent, unbiased, and fair to all stakeholders (Aish & Noor, 2025). Moreover, data privacy and security are critical concerns, as AI tools require access to vast amounts of data, raising questions about the confidentiality and protection of sensitive project information.

To mitigate these challenges, organizations must prioritize creating comprehensive AI training programs for project managers, ensuring that AI is used ethically and that a culture of collaboration between AI systems and human expertise is cultivated. As AI continues to evolve, the role of AI in project management is expected to expand, with emerging trends such as AI-augmented decision-making supporting, but not replacing, human project managers in making complex decisions. Human-AI co-leadership models are likely to emerge, where project managers collaborate with AI to enhance risk management, resource allocation, and stakeholder engagement. Additionally, adaptive AI systems will become more flexible, learning from human feedback to refine their recommendations and improve over time.

By applying STS Theory, organizations can develop AI adoption strategies that strike a balance between technological efficiency and human expertise. This will ensure that AI is integrated into project management in a sustainable, ethical, and effective manner, benefiting both the organization and its project teams.

2.2.2 Theories Related to Project Constraints

2.2.2.1 Theory of Constraints (TOC)

The Theory of Constraints (TOC), developed by Eliyahu M. Goldratt in the 1980s, focuses on identifying and managing the bottlenecks or constraints that hinder a system's overall performance (Goldratt, 1984). The central idea of TOC is that every system has at least one constraint, and the efficiency of the entire system is dependent on how well this constraint is managed (Şimşit, Günay, & Vayvay, 2014). In project management, TOC provides a structured approach to identifying limitations in areas such as resource allocation, scheduling, and execution. By targeting the most significant constraint in a project's workflow, TOC helps project managers optimize resource usage, reduce delays, and improve overall project performance (Grida & Zeid, 2019).

Goldratt's (1990) Five Focusing Steps are a key part of TOC, offering a framework for continuously improving systems by addressing constraints. These steps have been widely applied in project management to optimize performance and minimize risks. The first step is to identify the system's constraint(s), which involves pinpointing the most critical limitation in a project, such as resource shortages, inefficient workflows, or task dependencies (Şimşit et al., 2014). In project management, constraints often appear in areas like resource allocation, task sequencing, and stakeholder dependencies. Once the constraint is identified, the next step is to exploit the constraint, which aims to maximize its efficiency without requiring significant investment, such as optimizing team workloads, prioritizing important tasks, and ensuring that resources are available without interruptions (Grida & Zeid, 2019).

The third step is to subordinate other processes to the constraint, which involves adjusting other project activities to avoid exacerbating the constraint. This could mean postponing non-essential tasks or meetings that might interfere with the critical path (Şimşit et al., 2014). If the constraint still limits project performance, the next step is to elevate the constraint, which may require increasing capacity, securing additional resources, or implementing process improvements to address the bottleneck (Grida & Zeid, 2019). Finally, TOC emphasizes the importance of repeating

the process continuously, as once one constraint is resolved, another may emerge. This ongoing cycle ensures that project teams remain agile and proactive, continuously improving project execution by identifying and addressing bottlenecks as they arise (Şimşit et al., 2014).

One of the most well-known applications of TOC in project management is Critical Chain Project Management (CCPM). Unlike traditional project scheduling methods that focus primarily on task dependencies, CCPM also incorporates resource constraints to optimize project execution (Grida & Zeid, 2019). The core principle of CCPM involves identifying the critical chain, which includes both task dependencies and resource availability. By considering resource constraints alongside task sequencing, CCPM ensures smoother project progression and avoids conflicts over resource allocation.

CCPM also integrates buffer management strategies, which replace traditional safety margins added to individual tasks with consolidated buffers at key points in the project. The project buffer protects the overall project schedule from delays, while feeding buffers prevent non-critical paths from affecting the critical chain. In addition, resource buffers ensure that critical resources are available when needed, minimizing delays due to resource shortages. This approach helps reduce multitasking by ensuring that team members focus on one critical task at a time, leading to faster project completion and fewer delays. Research has shown that CCPM reduces project durations by eliminating unnecessary delays and optimizing resource allocation, making it an effective method in AI-driven project management (Grida & Zeid, 2019).

When combined with System Dynamics (SD), TOC provides a comprehensive approach to managing project constraints, especially in industries where complex interdependencies exist between human and technical resources. SD modeling has been used to identify resource constraints and bottlenecks, simulate the impact of various constraint management strategies on project performance, and improve throughput without increasing costs (Grida & Zeid, 2019). For example, a healthcare case study showed that applying TOC principles resulted in a 6% increase in system throughput without additional resources, and a 40% increase in critical resources (such as doctors) led to a 13% improvement in throughput and an 88% reduction in waiting times (Grida & Zeid, 2019). These results highlight TOC's effectiveness in resource-constrained environments, such as construction, IT, and manufacturing.

Despite its systematic approach to managing project constraints, the Theory of Constraints faces some challenges. One of the primary issues is identifying the right constraint; misidentifying the critical bottleneck can lead to ineffective solutions (Şimşit et al., 2014). To address this challenge, AI-powered predictive analytics can help accurately identify project bottlenecks and provide insights into potential issues. Another challenge is resistance to change, as organizations may be reluctant to adopt TOC-based approaches, especially when traditional scheduling methods have been deeply ingrained in the organizational culture (Grida & Zeid, 2019). Effective change management strategies, including leadership support, are essential for successful TOC implementation. Large-scale projects often involve multiple interacting constraints, making it difficult to prioritize one bottleneck over another, which leads to complex interdependencies. AI can help by modeling dynamic project environments and recommending optimal strategies for managing these constraints.

The integration of AI and automation tools with TOC principles offers a more robust approach to managing project constraints. AI-powered predictive analytics and automation tools can enhance TOC by forecasting potential constraints before they become critical issues, enabling project managers to take proactive measures to avoid disruptions (Grida & Zeid, 2019). This integration can improve the overall efficiency of project execution and ensure that resource constraints are addressed in a timely manner. By leveraging AI, organizations can optimize project management processes, enhancing the effectiveness of TOC-based strategies and ultimately leading to better project outcomes.

2.2.2.2 Project Management Triangle (Iron Triangle)

The Project Management Triangle (Iron Triangle) discusses the relationship between scope, time, and cost constraints. It was derived from TOC, which is a management approach that identifies and addresses the main constraint limiting an organization's capacity to achieve its objectives (Goldratt, 1984). TOC is grounded in the idea that every system has at least one constraint, and by removing or optimizing this constraint, significant performance gains can be achieved (Şimşit, Günay, & Vayvay, 2014).

In project management, TOC offers a structured method for identifying, managing, and alleviating constraints that affect project execution, such as resource bottlenecks, scheduling conflicts, and cost overruns (Grida & Zeid, 2019). Over time, TOC has influenced project management

frameworks, including Critical Chain Project Management (CCPM) and System Dynamics-based TOC models, which aim to enhance project performance by focusing on constraint-driven improvements.

Goldratt (1990) introduced the Five Focusing Steps, a methodical approach designed to help organizations identify and address their constraints. These steps are commonly applied in project management to boost efficiency and resolve limitations related to resources and scheduling (Şimşit et al., 2014).

The first step involves identifying the system's constraint(s). This process focuses on pinpointing the primary bottleneck in a project, such as resource limitations, slow task execution, or dependency issues (Grida & Zeid, 2019). Common constraints in project management include insufficient funding, workforce shortages, and technological limitations. Once a constraint is identified, the next step is to exploit it. This means optimizing the constraint's performance without requiring significant additional investments (Şimşit et al., 2014). For instance, in project environments, this could include reallocating team members, prioritizing essential tasks, or introducing automation to increase efficiency.

The third step is to subordinate other processes to the constraint. All project activities should be adjusted to avoid overburdening the identified constraint (Grida & Zeid, 2019). This often involves synchronizing non-critical tasks to prevent them from causing delays in the constrained process. If the constraint still limits performance, the next step is to elevate the constraint. In this case, additional resources, training, or technology upgrades may be needed to expand the constraint's capacity (Şimşit et al., 2014). For example, in project management, this could involve hiring more skilled workers, investing in AI-driven tools, or outsourcing critical tasks to enhance overall capacity.

The final step in the process is to repeat it continuously. After resolving one constraint, another may emerge, requiring ongoing monitoring and adjustments (Grida & Zeid, 2019). This cycle ensures that project teams remain flexible and proactive, continuously enhancing project execution by identifying and resolving constraints as they arise.

One of the most notable applications of the Theory of Constraints (TOC) in project management is Critical Chain Project Management (CCPM), which addresses issues related to resource

constraints and scheduling inefficiencies. Unlike traditional project scheduling methods that primarily use the Critical Path Method (CPM), CCPM accounts for both task dependencies and resource availability, aiming to optimize overall project execution (Grida & Zeid, 2019).

In CCPM, the Critical Chain is identified as the longest sequence of dependent tasks, taking into consideration both the time and availability of resources. Unlike CPM, which focuses solely on task sequences, CCPM ensures that resource bottlenecks are incorporated into the scheduling process. Another key feature of CCPM is Buffer Management. Rather than adding excessive safety margins to individual tasks, CCPM consolidates time buffers at strategic points throughout the project. These include the Project Buffer, which protects the overall project timeline, Feeding Buffers, which prevent non-critical paths from delaying the critical chain, and Resource Buffers, which help avoid resource shortages that could cause delays. Additionally, CCPM emphasizes reducing Multitasking, ensuring that team members focus on one critical task at a time, which leads to faster project completion.

Studies have shown that CCPM significantly reduces project duration and improves efficiency by eliminating unnecessary delays and optimizing resource allocation (Grida & Zeid, 2019). The integration of AI-driven project management tools can further enhance CCPM by utilizing predictive analytics to anticipate potential resource constraints and determine buffer requirements, ultimately streamlining the process and improving project outcomes.

The integration of System Dynamics (SD) with the Theory of Constraints (TOC) offers a valuable modeling approach to visualize and address complex project constraints. System Dynamics modeling has been used effectively to identify resource constraints and bottlenecks in project execution, simulate the impact of various constraint management strategies on overall project performance, and improve throughput and project efficiency without increasing costs (Grida & Zeid, 2019).

A case study focused on the application of System Dynamics-based TOC models in healthcare project management highlighted significant improvements. Throughput increased by 6% without the need for additional resources, and a 40% increase in critical resources led to a 13% improvement in throughput while reducing waiting times by 88% (Grida & Zeid, 2019). This evidence supports the potential use of AI-driven predictive models in project management, where

machine learning algorithms can dynamically identify and resolve constraints, further enhancing project performance.

While the Theory of Constraints (TOC) provides a structured approach to managing project constraints, several challenges can arise. One significant issue is the difficulty in identifying the right constraint. Misidentifying the primary constraint can lead to ineffective solutions that do not address the true bottleneck, ultimately hindering project progress (Şimşit et al., 2014). AI-powered predictive analytics can help overcome this challenge by accurately diagnosing project bottlenecks, ensuring a more precise identification of constraints.

Another challenge is resistance to change. Organizations may be reluctant to adopt TOC-based approaches, particularly in environments where traditional scheduling methods, such as the Critical Path Method (CPM), are deeply ingrained (Grida & Zeid, 2019). For successful implementation of TOC, strong change management strategies and leadership advocacy are essential to foster acceptance and smooth transitions.

Additionally, managing complex interdependencies can be difficult, particularly in large-scale projects that involve multiple interacting constraints. This complexity makes it challenging to prioritize and address a single bottleneck effectively (Şimşit et al., 2014). AI can assist by modeling dynamic project environments and suggesting optimal strategies for managing these constraints, allowing project managers to navigate the intricacies of complex project structures more efficiently.

2.2.2.3 Sustainability in Project Management Theory

Sustainability in Project Management Theory addresses not only governance and strategic alignment but also the alignment of project objectives with broader environmental and social goals.

It has become a crucial aspect of contemporary project management, prompting organizations to incorporate economic, environmental, and social factors into their decision-making processes. Traditionally, project management focused primarily on the Iron Triangle, which aimed to balance time, cost, and quality (Madureira et al., 2022). However, sustainable project management broadens this perspective, ensuring that projects not only align with broader governance frameworks and strategic goals but also contribute to long-term sustainability objectives (Armenia et al., 2019).

Sustainability in project management is more than just meeting regulatory requirements; it has become a strategic necessity that ensures projects deliver value to both current stakeholders and future generations (Friedrich, 2023). By incorporating sustainability into the core of project planning and execution, organizations can create lasting positive impacts while achieving their goals.

Governance in project management entails the development of frameworks, policies, and accountability mechanisms to ensure that projects are aligned with an organization's sustainability goals. Effective governance structures strike a balance between financial performance and the environmental and social responsibilities that are increasingly crucial in today's business landscape (Toljaga-Nikolic et al., 2020). By integrating these principles, organizations can ensure that their projects not only meet financial objectives but also contribute to sustainable development.

Corporate sustainability policies play a vital role in defining how sustainability principles are integrated into project governance. Armenia et al. (2019) suggest that sustainable project management governance consists of five key dimensions:

First, Corporate Policies and Practices focus on embedding sustainability into governance frameworks, ensuring that sustainability becomes a core element of decision-making. Resource Management is the second dimension, emphasizing the efficient use of human, financial, and environmental resources throughout the project lifecycle. Life Cycle Orientation extends project evaluation beyond just immediate deliverables, considering the long-term environmental and social impacts. Stakeholder Engagement involves incorporating diverse perspectives into project governance, ensuring that all relevant stakeholders are involved in decision-making. Lastly, Organizational Learning promotes the continuous improvement of sustainability practices, ensuring that each project builds upon previous experiences to enhance sustainability outcomes.

Together, these governance principles ensure that sustainability criteria are adhered to from the initiation to the closure of a project, improving transparency, accountability, and ethical decision-making across the organization.

Several frameworks support sustainability governance in project management, providing structured approaches to integrate sustainability into project governance. ISO 21505 (Project, Program, and Portfolio Management Governance) offers a governance structure specifically

designed for sustainability, guiding organizations in embedding sustainability principles throughout their projects. Similarly, PMI's Sustainability Framework aligns projects with the Triple Bottom Line approach, focusing on the balance between People, Planet, and Profit. The Sustainable Project Management Cube Model takes an integrated approach, considering the social, environmental, and economic impacts of projects (Madureira et al., 2022).

By adopting these governance models, project managers can ensure that sustainability is not treated as an afterthought but is instead embedded as a core component of project decision-making. This ensures that projects contribute to long-term sustainable development while meeting their objectives.

Strategic alignment ensures that project objectives are closely aligned with an organization's sustainability goals, thereby maximizing long-term value. When there is a misalignment between projects and corporate sustainability strategies, it can lead to inefficiencies and the waste of resources, ultimately undermining the organization's sustainability efforts (Friedrich, 2023). Ensuring alignment between projects and sustainability objectives is crucial for achieving both operational and environmental goals effectively.

Strategic alignment necessitates that organizations incorporate sustainability into project objectives, risk management, and performance evaluation. According to Toljaga-Nikolic et al. (2020), this integration involves aligning sustainability with corporate mission statements and values, ensuring that project success metrics extend beyond the traditional focus on time, cost, and quality to also include environmental and social impacts. Furthermore, developing sustainability performance indicators is essential for tracking and ensuring alignment with the organization's broader sustainability goals. This comprehensive approach helps organizations achieve both project success and long-term sustainability.

Engaging stakeholders is essential for achieving strategic sustainability alignment. Armenia et al. (2019) argue that sustainability-focused projects must involve multiple stakeholder groups, including internal stakeholders such as executives and project teams, external stakeholders like clients, regulatory bodies, and communities, as well as future stakeholders, with consideration for long-term environmental and social impacts. Effective engagement with these groups ensures that projects address societal needs, promote long-term sustainability, and minimize resistance to

change. By involving a wide range of stakeholders, organizations can enhance the overall effectiveness and acceptance of sustainability-driven initiatives.

Despite the increasing adoption of sustainability principles in project management, several challenges persist. One major issue is balancing short-term and long-term goals, as many projects tend to prioritize immediate financial returns over long-term sustainability benefits (Madureira et al., 2022). Additionally, there is a lack of standardized metrics for sustainability, as sustainability indicators vary significantly across industries and projects, unlike the more universally accepted cost and schedule performance metrics (Toljaga-Nikolic et al., 2020). Lastly, resistance to change remains a barrier, as traditional project management approaches often resist shifting toward sustainability, making leadership advocacy and robust change management strategies essential for overcoming this challenge (Friedrich, 2023).

To address these challenges, future research should focus on several key areas. First, developing standardized sustainability metrics that can be universally applied across industries is crucial for creating consistency and comparability in measuring sustainability performance. Second, exploring the role of digitalization and AI in sustainability governance, particularly through tools like predictive analytics for carbon footprint management, can enhance the effectiveness of sustainability efforts. Lastly, strengthening stakeholder collaboration models is essential to improving long-term sustainability planning, ensuring that diverse perspectives are integrated into decision-making processes for more sustainable outcomes.

2.2.3 Theories Related to Project Managers' Competencies

2.2.3.1 Dynamic Capabilities Theory (DCT)

Dynamic Capabilities Theory (DCT) explains the adaptive competencies required in AI-driven projects by emphasizing three core capabilities: sensing, seizing, and reconfiguring. Teece (2007) identified three key components of dynamic capabilities—sensing, seizing, and reconfiguring—that enable organizations to respond to technological advancements, market disruptions, and innovation-driven changes. These capabilities are especially vital in AI-driven project environments, where the fast-paced evolution of technology demands ongoing learning and adaptation.

Sensing refers to an organization's ability to effectively scan, interpret, and anticipate shifts in market trends and technological advancements. In the context of AI-driven projects, this capability becomes even more critical as organizations need to stay ahead of the curve in adopting new technologies. For AI-driven projects, sensing involves recognizing emerging AI technologies that have the potential to optimize project processes. It also requires assessing the risks and ethical implications that may arise from the adoption of AI, ensuring that the technology is used responsibly. Additionally, building AI-awareness across project teams is essential to enhance decision-making, enabling teams to leverage AI insights and make more informed choices (Ellström et al., 2022).

Empirical evidence shows that firms with robust AI-sensing capabilities can effectively utilize AI-powered predictive analytics to optimize various aspects of project management, including resource allocation, risk assessment, and strategic planning (Simón et al., 2024). Furthermore, cross-industry digital sensing plays a crucial role by enabling organizations to identify AI applications beyond their immediate sector, which accelerates the integration of AI across different industries (Ellström et al., 2022).

Seizing refers to the process of translating identified opportunities into tangible strategies, investments, and project implementations. In the context of AI-driven project management, this involves developing AI-driven project roadmaps that align with the organization's strategic objectives. Additionally, it requires building models for human-AI collaboration to enhance decision-making and drive more effective outcomes. A critical aspect of seizing opportunities is managing organizational inertia and overcoming resistance to AI adoption, ensuring that teams and stakeholders are aligned and receptive to the changes AI brings (Steen, Ford, & Verreyne, 2021).

Empirical evidence highlights that while AI facilitates data-driven decision-making, organizations must invest in human-AI collaboration strategies to fully maximize value creation (Simón et al., 2024). Additionally, AI adoption requires a comprehensive enterprise-wide digital transformation, which involves strategic alignment and governance to ensure seamless integration across all levels of the organization (Ellström et al., 2022).

Reconfiguring involves the ongoing renewal and transformation of organizational capabilities, structures, and processes to maintain a competitive edge in AI-driven environments. This includes

upskilling project managers and teams to improve their AI competency, ensuring they can effectively leverage AI tools. It also requires redesigning workflows and business models to integrate AI-driven automation, streamlining operations for better efficiency. Furthermore, embedding AI ethics and governance into project decision-making is crucial to ensure responsible and transparent AI usage throughout the organization (Bleady et al., 2018).

Empirical evidence shows that reconfiguring organizational assets and competencies is essential for firms to maintain agility in digital transformation initiatives (Ellström et al., 2022). Additionally, trust-building mechanisms in human-AI interactions are key to fostering collaborative problem-solving and knowledge exchange, which in turn strengthens the organization's adaptive capabilities (Simón et al., 2024).

AI-driven projects require a significant shift in project management competencies to ensure successful integration. Traditionally, project managers focus on scope, cost, and schedule, but to effectively manage AI-driven initiatives, their skill set must be expanded to include technical AI literacy, strategic foresight, and change management capabilities. This shift is essential for aligning project management practices with the evolving demands of AI technologies.

Integrating AI into project management requires smooth collaboration between human project managers and AI systems. Research has identified three critical interactions that are vital for successful human-AI teaming. First, achieving interoperability is essential, as AI tools must align with existing human workflows to ensure their effective implementation. Second, building trust in AI is crucial, as organizations must cultivate confidence in AI-generated recommendations to enhance decision-making processes. Lastly, mutual knowledge gains emphasize that AI should complement and augment human decision-making, rather than replace it (Simón et al., 2024).

The ability of organizations to learn and adapt to AI innovations is another key factor for project success. For organizations to thrive in an AI-driven environment, they must invest in digital infrastructure that supports AI transformation (Ellström et al., 2022). Additionally, fostering a culture of continuous learning and experimentation is necessary to strengthen adaptive decision-making. Finally, organizations must develop AI governance frameworks to mitigate ethical risks and ensure compliance, ensuring responsible and sustainable AI use in project management (Bleady et al., 2018).

Despite its potential, implementing DCT-driven AI strategies presents several challenges.

One of the main hurdles is overcoming organizational resistance. Many companies face cultural resistance to AI adoption, making effective change management a critical factor in the process. Leadership buy-in is crucial to fostering a culture of AI-driven innovation and ensuring the successful integration of AI into organizational practices (Steen et al., 2021).

Another challenge is bridging the AI skills gap. Project managers must develop competencies in AI, data literacy, and digital leadership to stay relevant in an increasingly technology-driven environment (Bleady et al., 2018). To address this, organizations need to invest in AI training programs that will enhance workforce adaptability and ensure employees have the necessary skills to succeed in AI-powered environments (Ellström et al., 2022).

Finally, aligning AI with business strategy is essential for ensuring that AI implementation supports corporate objectives and creates long-term value. AI should be strategically integrated with the organization's goals to maximize its impact and contribute to sustained success (Simón et al., 2024).

2.2.3.2 Human Capital Theory (HCT)

Human Capital Theory (HCT) highlights the value of project managers' knowledge, skills, and continuous learning in enhancing project success, especially in dynamic, AI-driven environments.

It highlights the importance of knowledge, skills, experience, and competencies in enhancing both individual and organizational productivity. First introduced by Becker (1964) and Schultz (1961), the theory posits those investments in human capital, such as education, training, and professional development, lead to economic returns in the form of higher performance, innovation, and competitive advantage (Wuttaphan, 2017).

In the context of project management, HCT is particularly significant, as project success is largely determined by the expertise, leadership, and problem-solving capabilities of project managers. Organizations that prioritize the continuous development of their project managers' technical, leadership, and strategic competencies often see improved project outcomes, better risk management, and enhanced stakeholder engagement (McKinsey Global Institute, 2022).

Project managers are valuable intellectual assets, contributing unique knowledge and capabilities to organizations. Their ability to navigate complex project constraints, align projects with strategic

objectives, and lead teams effectively has a direct and significant impact on overall project performance (Implementation of the Human Capital Management Concept, 2024).

According to the McKinsey Global Institute (2022), human capital refers to the collective skills, experience, and abilities of individuals, which play a crucial role in contributing to both economic and organizational success. In project management, these elements are vital for various aspects of project execution.

Project managers rely heavily on their expertise for problem-solving and decision-making, enabling them to make informed choices and mitigate potential risks. Additionally, their knowledge is key to ensuring strategic alignment, as they align project goals with broader business objectives, ensuring that each project contributes to the organization's overall strategy. Furthermore, skilled project managers foster adaptability and innovation within teams, enabling projects to adjust to technological advancements and market changes effectively.

A study on human capital management in small enterprises revealed that companies investing in training and knowledge-sharing experienced higher productivity and better project success rates (Implementation of the Human Capital Management Concept, 2024). This highlights the critical role of continuous learning and skill development for project managers in driving improved project outcomes and overall organizational success.

To evaluate the contribution of human capital to project success, organizations use various quantifiable metrics. One key metric is the project success rate, which measures the percentage of projects completed on time, within scope, and on budget. Another important indicator is the Return on Investment (ROI) in training, which assesses the impact of project management certifications and leadership programs on performance. Additionally, employee retention and engagement are crucial metrics, as organizations with strong human capital investment strategies tend to report higher employee commitment and lower turnover rates (McKinsey Global Institute, 2022). These indicators enable organizations to assess the effectiveness of their human capital development strategies, ensuring that project managers continue to remain competitive and adaptable in an ever-evolving business environment.

Investing in the human capital of project managers through education, training, and leadership development has a significant positive impact on project performance. Research indicates that

project managers who undergo continuous skills training and leadership coaching are better equipped to manage key project constraints, such as scope, cost, and stakeholder expectations, with greater efficiency (Wuttaphan, 2017). This ongoing investment in professional growth ensures that project managers are well-prepared to handle the complexities of project execution and deliver successful outcomes.

Organizations that allocate resources toward formal project management training and AI-driven learning tend to experience increased efficiency and innovation. Human capital-focused organizations emphasize providing learning opportunities, including certifications like PMP, PRINCE2, and Agile methodologies. These training investments are directly linked to higher project success rates and enhanced decision-making, as project managers are better equipped with the skills and knowledge needed to navigate complex project challenges effectively.

The impact of human capital on project leadership is significant, as leadership skills are a crucial component influencing project execution. Effective project managers demonstrate strategic thinking by aligning projects with organizational goals, while also possessing change management skills that enable them to navigate uncertainties and implement adaptive strategies. Furthermore, strong stakeholder management abilities allow them to build and maintain productive relationships with sponsors, clients, and team members. A study by Wuttaphan (2017) found that companies investing in leadership training for project managers saw a 30% increase in project efficiency and higher client satisfaction, highlighting the direct benefits of developing leadership capabilities in project management.

As artificial intelligence (AI) and digital tools continue to be increasingly adopted in project management, there is a growing need to place greater emphasis on human capital development. Future project managers will need to possess hybrid skills that combine technical expertise with leadership and strategic foresight (Implementation of the Human Capital Management Concept, 2024). This combination of skills will enable them to navigate the evolving project landscape, ensuring successful project outcomes while leveraging the full potential of emerging technologies.

As AI continues to transform project workflows, adaptive learning, digital literacy, and automation management are becoming crucial human capital investments (McKinsey Global Institute, 2022). Organizations that prioritize AI-integrated training programs will not only enhance their project execution but also gain a competitive edge in managing risks effectively. By investing in these

competencies, companies can ensure that their teams are well-equipped to leverage AI technologies, driving efficiency and innovation across projects.

Research highlights that project managers without AI and data analytics competencies may struggle to lead technology-driven projects effectively. To address this challenge, organizations must invest in AI and digital training for project leaders, ensuring they possess the necessary skills to navigate advanced technologies. Additionally, developing cross-functional expertise within teams can enhance project adaptability, enabling more flexible responses to changing project demands. Encouraging continuous learning programs will also help project managers stay up-to-date with industry advancements, ensuring they remain competitive and capable of managing evolving project landscapes.

2.2.3.3 Project Management Competency Model (PMCD)

The Project Management Competency Model (PMCD) defines the essential technical, leadership, and strategic and business skills project managers need to succeed, especially in complex and AI-enhanced project environments. It was established by the Project Management Institute (PMI), offers a systematic approach to evaluating and enhancing the competencies of project managers. The framework highlights three key competency areas: technical, leadership, and strategic and business management competencies, all of which are vital for successful project delivery and alignment with organizational objectives (Koi-Akrofi et al., 2024).

Skilled project managers are essential for the successful execution of projects, particularly in complex and AI-driven settings. A lack of competence in any of the critical areas can lead to project failure, suboptimal resource management, and ineffective stakeholder engagement, which can severely impact the project's success (Fazly et al., 2024).

The PMCD model classifies project management competencies into three primary areas. Technical Competencies encompass knowledge of project management methodologies, tools, and techniques that are essential for effective project execution. Leadership Competencies involve the ability to guide teams, influence stakeholders, and promote collaboration to achieve project goals. Finally, Strategic and Business Management Competencies focus on understanding business strategy, organizational governance, and financial acumen, which are crucial for aligning projects with broader organizational objectives.

Technical competencies are fundamental for the planning, execution, and control of projects. These competencies encompass several key areas: project scope management, which involves defining project deliverables and ensuring they align with the overall objectives; risk and cost management, which focuses on identifying potential risks and optimizing budgets to avoid financial overruns; scheduling and resource allocation, which ensures projects are delivered on time while making efficient use of available resources; and quality assurance, which ensures that standards are implemented to maintain the desired level of project quality (Rustam et al., 2024).

A study conducted in the Iran Gas Engineering and Development Company (IGEDC) found that technical competencies are crucial for project success, with expertise in engineering judgment, project knowledge, and risk management playing a vital role in ensuring successful outcomes (Hatefi & Behi, 2024). Additionally, research in construction project management underscores the importance of skills such as monitoring, scheduling, and stakeholder engagement, which are critical technical competencies required for effective project delivery (Edrizal et al., 2020).

Leadership is a central competency in project management, as project managers must influence their teams, resolve conflicts, and communicate effectively. Key leadership competencies include emotional intelligence, which involves managing interpersonal relationships and fostering collaboration; decision-making and problem-solving, which enables project managers to address challenges proactively; motivational leadership, which inspires teams to achieve project goals; and negotiation and conflict resolution, which ensures smooth communication and alignment among stakeholders (Koi-Akrofi et al., 2024).

A study conducted in the Afghanistan construction sector found that project managers' leadership skills significantly influence the relationship between project planning and project success. This indicates that strong leadership can mitigate planning deficiencies, underscoring its importance in achieving successful project outcomes (Fazly et al., 2024). Furthermore, the Iran Gas Engineering study identified leadership as the most crucial competency, even more important than technical expertise. The study highlighted decision-making, judgment, and team management as key factors contributing to project success (Hatefi & Behi, 2024).

Strategic and business competencies are essential for project managers to ensure that their projects align with broader organizational goals. These competencies include strategic thinking, which involves understanding how projects contribute to the overall business objectives; financial

acumen, which ensures effective management of project budgets; governance and compliance, which guarantees that projects adhere to relevant regulations and corporate policies; and market awareness, which involves staying informed about industry trends and competitive dynamics (Rustam et al., 2024).

Research on competency frameworks in the construction sector reveals that project managers with strong business and strategic management skills are better equipped to navigate industry disruptions, regulatory changes, and financial constraints (Sanchaniya et al., 2024). Additionally, a systematic review of project manager competencies found that combining strategic competencies with leadership and technical skills plays a key role in driving long-term organizational success (Koi-Akrofi et al., 2024). This integration of competencies ensures that project managers are capable of leading projects effectively while aligning with the strategic priorities of the organization.

Several methods are employed to measure project management competencies, each providing valuable insights into a project manager's abilities. Competency gap analysis is used to identify skill deficiencies and training needs, helping organizations target areas for improvement. Performance-based assessments evaluate competencies by analyzing project outcomes, offering a clear picture of how effectively skills are applied in real-world situations. Behavioral indicators assess leadership and strategic decision-making capabilities, focusing on how project managers navigate complex situations and engage with teams.

In a study, the Best-Worst Method (BWM) was used to assign numerical weights to various competencies, revealing that leadership, project knowledge, and decision-making were the top-ranked competencies for project managers (Hatefi & Behi, 2024). This methodology helps prioritize the most essential competencies, guiding organizations in their development efforts.

Organizations can enhance project manager competencies through various approaches, including certification programs such as PMP, PRINCE2, and Agile, which provide formal recognition of expertise. Additionally, on-the-job training and mentorship offer practical experience and guidance, enabling project managers to refine their skills in real-world settings. AI-driven competency development tools (Fazly et al., 2024) also provide personalized learning experiences, enhancing skill development with data-driven insights. Furthermore, cross-functional experience,

where project managers gain exposure to different business areas, helps broaden their understanding and improves their ability to handle complex project challenges.

Studies on road construction project management in West Sumatra, Indonesia, suggest that project managers who participate in structured competency development programs show higher performance in key areas such as risk management, team coordination, and resource allocation (Edrizal et al., 2020). These findings highlight the effectiveness of targeted development programs in enhancing project manager capabilities and overall project success.

As AI continues to be integrated into project management, competency frameworks must evolve to include new areas of expertise. AI literacy becomes crucial, as project managers need to understand AI-driven decision support systems to make informed decisions. Additionally, data analytics skills are essential, enabling project managers to utilize predictive analytics for better risk and cost management. Furthermore, hybrid leadership is necessary to effectively balance human-AI collaboration in project execution, ensuring that both technology and team dynamics are optimized (Sanchaniya et al., 2024).

To stay competitive and improve project outcomes, organizations must adapt their competency models to encompass technical, leadership, and strategic competencies that leverage AI and automation. This adaptation will enable project managers to harness the power of AI while maintaining effective project oversight and decision-making (Rustam et al., 2024).

2.3 AI in Project Management

AI is revolutionizing project management by improving efficiency, decision-making, and resource allocation. The integration of AI technologies has gained momentum because of their ability to analyze large volumes of data, predict project risks, automate repetitive tasks, and enhance decision-making. As projects become more complex and the need for real-time insights grows, AI tools have emerged to streamline project execution and optimize outcomes (Lee et al., 2020).

One of the most impactful ways AI is shaping project management is through predictive analytics and machine learning. These technologies analyze historical project data and identify trends to generate predictive insights, enabling project managers to anticipate potential issues and adjust strategies proactively. Machine learning algorithms continuously improve their accuracy by learning from past project data, helping teams forecast risks, estimate costs, and optimize

schedules with greater precision (Riesener et al., 2023). Predictive analytics has become a vital tool for mitigating uncertainties by examining extensive historical data and pinpointing risks, cost overruns, and scheduling conflicts (Buvik & Rolfsen, 2015).

Beyond risk management, AI is also enhancing workflow automation. Many routine project management tasks—such as scheduling meetings, tracking progress, and updating documents—are time-consuming and repetitive. AI-driven automation tools can handle these administrative duties, allowing project managers to focus on more strategic decisions. For instance, AI-based task management systems can automatically update project schedules, issue reminders, and allocate resources based on real-time data analysis, leading to improved productivity and fewer errors, ensuring that project deliverables stay on track (Phillips, 2010).

Another impactful application of AI in project management is Natural Language Processing (NLP). It allows AI systems to understand and generate human language, facilitating the development of advanced communication tools like AI-powered chatbots, virtual assistants, and automated reporting systems. These tools can analyze meeting notes, project updates, and stakeholder feedback to extract essential insights and create summaries, ultimately saving time and enhancing communication within project teams (Chen et al., 2021).

AI also plays a critical role in resource optimization. AI tools can identify available resources, forecast workloads, and ensure optimal distribution of personnel and materials. Traditional project management often involves manual resource allocation, which can be inefficient and time-consuming. In contrast, AI-powered resource planning systems consider various factors, including team availability, task dependencies, and project timelines, to recommend the most effective allocation of resources. This leads to greater efficiency, reduced costs, and enhanced project performance (McKinsey, 2009).

While AI offers numerous advantages in project management, its implementation also presents several challenges. One of the most prominent obstacles is the quality and accessibility of data. AI models require vast amounts of high-quality data to function properly, but many organizations face difficulties with incomplete or fragmented datasets. Without accurate and comprehensive data, AI tools may provide unreliable predictions, which can lead to poor decision-making. Additionally, data security and privacy concerns remain significant challenges, especially when managing sensitive project data (Wysocki, 2014).

Another major challenge is the integration of AI with existing project management systems. Many organizations still depend on outdated systems that may not be compatible with advanced AI tools. Shifting to AI-driven project management requires substantial investments in both infrastructure and employee training. Additionally, there is often resistance to AI adoption among project managers and team members who may not be familiar with the technology or may be skeptical about its effectiveness. To successfully integrate AI, organizations must invest in AI literacy and data analytics training for their project managers (Burghardt, 2013).

Looking ahead, the role of AI in project management is expected to grow and evolve further. AI-driven project assistants, cognitive computing, and intelligent decision-support systems are likely to become more advanced, automating project planning, enhancing team collaboration, and improving strategic alignment with business objectives. Moreover, AI-powered sentiment analysis tools could be used to assess stakeholder satisfaction and uncover communication gaps, promoting better engagement and decision-making (Project Management Institute, 2016).

In conclusion, AI is transforming project management by automating tasks, improving decision-making, and optimizing resource allocation. Although challenges such as data quality, integration difficulties, and resistance to change remain, organizations that embrace AI will gain a competitive edge. As AI technology continues to advance, project managers must leverage these tools to drive innovation, increase efficiency, and ensure the successful execution of projects in a rapidly changing and complex landscape (Deloitte, 2019).

2.4 Dimensions of AI Usage in Project Management

Artificial Intelligence (AI) has brought a transformative shift to project management by automating workflows, optimizing decision-making, and enhancing project efficiency. AI-powered tools have been integrated across various project management functions to boost performance, mitigate risks, and improve communication with stakeholders. These tools use historical project data, real-time analytics, and predictive modeling to assist managers in making more informed decisions, thereby driving project success (Oyekunle & Boohene, 2024). This section explores the different aspects of AI usage in project management, focusing on its impact on contemporary project execution.

Machine Learning (ML) is a core dimension of AI in project management, primarily used for risk assessment and predictive analytics. ML algorithms enable project managers to anticipate potential delays, budget overruns, and resource shortages by analyzing past data and identifying trends. These insights allow teams to take proactive actions, ultimately enhancing overall project performance. ML-based risk models are particularly valuable in industries like construction and software development, where uncertainty and complexity frequently challenge project execution (Connor & Liu, 2023). Additionally, ML facilitates automated scheduling and dynamic project planning, which ensures flexibility in rapidly changing environments (Pinto-Alves, 2023).

Natural Language Processing (NLP) is widely used for communication analysis in project management, improving stakeholder interaction, and document understanding. NLP-powered tools streamline stakeholder interactions by analyzing emails, meeting notes, and project reports, extracting valuable insights to assist project managers in making informed decisions. NLP tools also support sentiment analysis, allowing teams to gauge stakeholder concerns and address issues proactively. Furthermore, NLP-driven chatbots and virtual assistants enable the automation of responses to frequently asked questions, reducing administrative tasks and enhancing overall efficiency (Vilas-Boas & Barbosa, 2023).

Chatbots and Virtual Assistants have become vital in AI-powered project management, enhancing workflow efficiency and promoting collaboration. These AI tools automate tasks such as assigning work, sending project updates, and supporting real-time collaboration among team members. By using AI chatbots, project managers can reduce the need for manual intervention in routine administrative duties, enabling them to focus on higher-level decision-making. Virtual assistants also help boost productivity by providing data-driven recommendations and optimizing resource allocation (Oyekunle & Boohene, 2024).

Predictive Analytics is another crucial AI element in project management, providing data-driven insights into project performance. AI-powered predictive models analyze historical project data to forecast potential outcomes, helping managers identify risks and allocate resources efficiently. Predictive analytics aids decision-making by offering real-time performance metrics, allowing project teams to identify and address bottlenecks before they affect project timelines (Connor & Liu, 2023). This tool is especially valuable in agile project management environments, where quick adjustments to project strategies are often necessary (Pinto-Alves, 2023).

Robotic Process Automation (RPA) is a key AI dimension focused on task management, automating repetitive functions such as data entry, report generation, and scheduling. RPA tools handle functions like data entry, report generation, and task scheduling, which allows project managers to focus on more strategic activities. By minimizing human involvement in routine processes, RPA improves project accuracy and efficiency while reducing the likelihood of errors. Numerous organizations have successfully implemented RPA in resource planning and financial forecasting, resulting in improved project outcomes (Oyekunle & Boohene, 2024).

Data Visualization Tools have significantly impacted project management by offering interactive dashboards and real-time reporting capabilities. AI-driven data visualization platforms consolidate and present project data in intuitive formats that make decision-making easier. These tools help project managers track key performance indicators (KPIs), monitor resource usage, and identify trends that affect project success. With AI-powered visual analytics, project teams can quickly assess project progress and make informed decisions that align with organizational objectives (Connor & Liu, 2023).

Lastly, Decision Support Systems (DSS) leverage AI capabilities to assist project managers in making complex decisions. These AI-driven systems integrate real-time data with historical insights, allowing managers to evaluate different scenarios and choose the most effective course of action. DSS enhances strategic planning by suggesting optimal solutions to project challenges such as budget limitations, risk management, and stakeholder engagement. By utilizing AI-based decision support, project managers can improve project efficiency and increase the likelihood of successful outcomes (Pinto-Alves, 2023).

2.5 Overview of Project Constraints in Project Management

Project constraints are the factors that limit and shape a project's execution, success, and deliverables. Traditionally, project management has been framed around the triple constraint model (scope, time, and cost), which defines the primary boundaries within which a project must operate (Project Management Institute [PMI], 2021). However, modern project management acknowledges a wider array of constraints, including quality, resources, risk, stakeholder engagement, governance, benefits realization, and strategic alignment (Agarwal & Kalmar, 2020). These constraints influence decision-making, determine whether a project is feasible, and ultimately affect its outcome.

Project constraints are interconnected, meaning that a change in one constraint often impacts the others. For instance, increasing the project scope may necessitate more time and higher costs, while cutting costs could compromise quality or resource availability (Ghisetti et al., 2020). Successful project management requires finding a balance among these constraints to ensure that projects are delivered successfully while meeting both stakeholder expectations and business objectives.

Effectively managing project constraints is vital for ensuring successful project outcomes, maintaining operational efficiency, and meeting the expectations of stakeholders. When constraints are managed properly, organizations can achieve several key objectives. First, it enhances project predictability by enabling more accurate forecasting of risks, costs, and resource requirements, thus reducing uncertainties and providing clearer insights for decision-making (Koppenjan & Enserik, 2020). It also helps to optimize resource utilization, ensuring that financial, human, and material resources are allocated efficiently, preventing teams from being overburdened and budgets from being exceeded (Agarwal & Kalmar, 2020).

Additionally, effective constraint management ensures the quality and compliance of the project by adhering to industry standards and regulatory requirements, which helps meet stakeholder expectations and mitigate potential legal or operational risks (PMI, 2021). Improving stakeholder satisfaction is another important outcome, as clear communication and alignment between project goals and stakeholder needs foster collaboration, build trust, and encourage long-term engagement (Ghisetti et al., 2020). Moreover, by successfully managing constraints such as scope, time, cost, and quality, projects are more likely to increase success rates, enabling them to meet their objectives, align with strategic goals, and deliver measurable benefits (PMI, 2021).

With the integration of Artificial Intelligence (AI) in project management, constraint management is becoming more proactive and data-driven. AI-powered tools like predictive analytics, automated risk assessments, and real-time resource optimization are increasingly incorporated into project management frameworks, enhancing decision-making processes and minimizing the challenges that constraints can pose (Agarwal & Kalmar, 2020). These advancements help project managers anticipate and address potential issues more effectively, ensuring smoother project execution in a rapidly changing environment.

2.6 Dimensions of Project Constraints

Effectively managing project constraints such as scope, schedule, cost, quality, risk, resource allocation, and stakeholder engagement is crucial for the successful delivery of projects, maintaining efficiency, and meeting organizational goals. These constraints, including scope, schedule, cost, quality, risk, resources, stakeholders, governance, benefits realization, and strategic alignment, have a significant impact on decision-making, project feasibility, and overall project outcomes.

Scope defines the limits, objectives, and deliverables of a project. Proper scope management ensures that a project stays aligned with its original goals, minimizing the risk of scope creep, where additional work is introduced without adjusting the budget, timeline, or resources (PMI, 2021). Poor scope management can lead to cost overruns, extended timelines, and overuse of resources, ultimately compromising the project's success (Ghisetti et al., 2020). To avoid scope-related issues, it is essential to establish a clear work breakdown structure (WBS) and engage stakeholders early in the planning process (Koppenjan & Enserik, 2020).

Schedule constraints are the time limitations set to complete project activities. A well-defined schedule helps ensure that deliverables are completed within agreed timeframes. However, project timelines can be affected by external dependencies, unforeseen delays, and inefficient sequencing of tasks (Agarwal & Kalmar, 2020). If not managed well, scheduling constraints can result in project delays, cost overruns, and dissatisfaction among stakeholders (PMI, 2021). Modern methodologies like Agile and Lean incorporate flexibility into scheduling, allowing quick adjustments to unexpected disruptions (Ghisetti et al., 2020). Additionally, AI-driven scheduling tools optimize workflows and predict bottlenecks in real time (Koppenjan & Enserik, 2020).

Cost is a vital constraint that influences financial feasibility and resource allocation within a project. Budget overruns are a common challenge, often caused by inaccurate cost estimation, scope changes, or external economic factors (PMI, 2021). Managing cost constraints requires effective budget forecasting, financial tracking, and contingency planning (Ghisetti et al., 2020). AI-powered budgeting tools analyze historical expenditure patterns and predict future cost deviations, improving financial management and ensuring cost control (Agarwal & Kalmar, 2020). Organizations that implement strict cost control measures can increase project efficiency and financial sustainability (Koppenjan & Enserik, 2020).

Quality constraints define the performance standards that project deliverables must meet. Even if a project is completed on time and within budget, it may still be deemed unsuccessful if it doesn't meet quality expectations or industry standards (PMI, 2021). Quality management involves continuous monitoring, inspections, and adherence to best practices to guarantee successful project outcomes (Agarwal & Kalmar, 2020). Inadequate quality control can lead to customer dissatisfaction, legal issues, and expensive rework (Ghisetti et al., 2020). AI-driven quality management systems are increasingly used to monitor project quality in real-time and ensure compliance with specifications (Koppenjan & Enserik, 2020).

Risk constraints refer to potential uncertainties and threats that could disrupt project execution. These risks can arise from economic shifts, regulatory changes, supply chain disruptions, or operational failures (PMI, 2021). Effective risk management involves identifying and assessing risks, as well as developing strategies to mitigate their impact (Ghisetti et al., 2020). Organizations that neglect risk management often face unexpected challenges and cost increases (Agarwal & Kalmar, 2020). AI-based predictive risk assessment models are now used to analyze historical data and forecast potential risks (Koppenjan & Enserik, 2020).

Resource constraints refer to the availability and distribution of human, financial, and material resources required for project execution. Many projects face challenges such as workforce shortages, equipment limitations, and budget restrictions, all of which affect project timelines and productivity (PMI, 2021). Proper resource planning helps optimize the allocation of staff and materials, ensuring efficient project progress (Ghisetti et al., 2020). AI-driven resource management tools assist project managers in analyzing workload distribution, predicting shortages, and automating resource scheduling (Agarwal & Kalmar, 2020).

Stakeholder constraints arise from conflicting interests, communication gaps, and shifting expectations among project participants. Dissatisfied stakeholders can cause project delays, withdraw funding, or create regulatory challenges (PMI, 2021). Managing stakeholder constraints requires ongoing engagement, transparent communication, and involving key stakeholders in decision-making (Agarwal & Kalmar, 2020). AI-based sentiment analysis tools help project managers assess stakeholder concerns and improve engagement strategies (Ghisetti et al., 2020).

Governance constraints ensure that projects comply with legal, ethical, and organizational policies. Weak governance can result in legal liabilities, reputational damage, and operational inefficiencies

(PMI, 2021). Organizations that establish strong governance frameworks improve accountability and ensure transparency in decision-making (Agarwal & Kalmar, 2020). AI-powered compliance tracking systems assist project managers in monitoring adherence to policies and mitigating governance risks (Koppenjan & Enserik, 2020).

Benefits realization constraints ensure that the project delivers long-term value to the organization. Some projects meet scope, time, and cost constraints but fail to provide strategic value or meet the expected outcomes (PMI, 2021). Effective benefits management ensures that project outcomes align with business goals and contribute to organizational growth (Agarwal & Kalmar, 2020). AI-driven performance tracking tools are increasingly used to monitor post-project benefits and evaluate their long-term impact (Ghisetti et al., 2020).

Lastly, strategic alignment ensures that projects support the organization's vision, goals, and long-term objectives. Misaligned projects can result in wasted resources and missed opportunities (PMI, 2021). Organizations that utilize AI-based project portfolio management tools can prioritize projects that align with corporate strategy, maximizing return on investment and long-term benefits (Agarwal & Kalmar, 2020).

2.7 Overview of Project Manager's Competencies in Project Management

Project manager competencies refer to the essential knowledge, skills, and abilities needed to manage projects effectively, lead teams, and achieve successful project outcomes. These competencies combine technical project management expertise, leadership qualities, and strategic business insight (Project Management Institute [PMI], 2021). A proficient project manager ensures timely project delivery, adherence to budget and quality standards, while managing risks and ensuring that project results align with the broader organizational goals (Agarwal & Kalmar, 2020).

The competencies of a project manager play a critical role in determining the success of a project, influencing key aspects such as efficiency, risk management, team performance, and stakeholder satisfaction. Well-developed competencies enable project managers to enhance project predictability, minimize resource waste, and make more informed decisions, all of which contribute to smoother project execution (PMI, 2021). These competencies, particularly in technical expertise, leadership, and strategic thinking, have a profound effect on how projects are planned, executed, and delivered.

Project efficiency and delivery are directly impacted by the competencies of the project manager. A project manager with strong technical and strategic skills can ensure that planning, scheduling, and execution are handled efficiently, preventing delays and optimizing resource allocation (Agarwal & Kalmar, 2020). Furthermore, effective risk management strategies and proactive mitigation efforts reduce the likelihood of unexpected disruptions, helping maintain a smooth workflow and better project outcomes (Ghisetti et al., 2020).

Leadership and communication competencies are essential for fostering team productivity and collaboration. Project managers who excel in these areas are skilled at motivating teams, resolving conflicts, and promoting collaboration. Those with high emotional intelligence (EI) are particularly adept at understanding team dynamics, encouraging knowledge sharing, and maintaining a positive project environment (Koppenjan & Enserik, 2020). Strong leadership also ensures that diverse teams, particularly in remote or cross-functional settings, work effectively together, driving project success (PMI, 2021).

Risk and crisis management are other critical areas where project manager competencies make a difference. A project manager with robust risk management skills can anticipate potential risks, implement proactive strategies, and respond effectively to crises. This ability to manage uncertainties leads to more resilient and adaptable project execution (Ghisetti et al., 2020). The integration of AI-driven risk management tools can further enhance a manager's ability to predict risks and make informed decisions through predictive analytics and scenario-based insights (Agarwal & Kalmar, 2020).

Stakeholder engagement and client satisfaction are influenced by a project manager's ability to communicate progress, align expectations, and resolve conflicts. Miscommunication or misalignment with stakeholders can lead to project delays, scope creep, and budget overruns (PMI, 2021). Effective strategic engagement ensures that projects meet the needs of businesses and end users, delivering real value (Koppenjan & Enserik, 2020). A competent project manager ensures that stakeholders are well-informed and that their expectations are managed throughout the project lifecycle.

Financial and resource optimization are critical areas where project manager competencies can significantly impact project success. A skilled project manager allocates financial resources effectively, optimizes workforce productivity, and manages procurement strategies to maintain

project quality while controlling costs (Agarwal & Kalmar, 2020). With the increasing integration of AI and automation in project management, it is essential for project managers to adapt to data-driven decision-making processes and predictive financial planning, ensuring that resources are managed efficiently (Ghisetti et al., 2020).

Managing and continuously developing project manager competencies is essential for improving project performance, boosting organizational competitiveness, and adapting to evolving industry trends. Organizations that invest in competency development programs for project managers experience higher project success rates, improved cost efficiency, and fewer project failures (PMI, 2021). Regular training in leadership, risk management, and technical skills helps project managers stay adaptable in the face of new challenges and industry shifts (Agarwal & Kalmar, 2020).

Competency management also ensures that projects align with business strategies. Strong strategic competencies allow project managers to ensure that projects contribute to organizational goals and long-term business objectives (Ghisetti et al., 2020). Companies that foster business acumen in their project managers often see higher ROI, better decision-making, and enhanced innovation strategies (Koppenjan & Enserik, 2020).

As AI and automation continue to reshape the landscape of project management, organizations must prepare their project managers to effectively navigate AI-driven tools, data analytics, and digital transformation frameworks (Agarwal & Kalmar, 2020). Developing AI literacy allows project managers to interpret AI-generated insights, oversee automation processes, and optimize technology adoption, making them better equipped to manage increasingly complex projects (PMI, 2021).

Leadership competencies are also essential for enhancing stakeholder relationships and strengthening the overall leadership impact. Project managers who excel in leadership can build trust, engage stakeholders, and lead high-performing teams. Organizations that prioritize leadership development in their project managers benefit from stronger stakeholder engagement, reduced conflicts, and improved collaboration across projects (Ghisetti et al., 2020).

Finally, effective competency management helps reduce project failures and uncertainties. Inadequate project management competencies are often the root cause of budget overruns, delayed timelines, and project failures. By establishing competency frameworks and continuous

improvement programs, organizations ensure that their project managers are well-equipped to navigate risks, optimize resources, and drive long-term success (PMI, 2021). This ongoing development of project management competencies is key to ensuring that projects are delivered on time, within budget, and meet the desired outcomes.

2.8 Dimensions of Project Manager's Competencies

Technical Competencies

Technical competencies encompass the specialized knowledge, tools, and methodologies needed to effectively plan, execute, and control projects. These competencies are crucial for project managers to manage critical project elements, such as schedules, budgets, resources, risk management, and quality assurance (Ghisetti et al., 2020). Mastery in these areas allows project managers to steer projects toward successful completion while adhering to established goals.

One key aspect of technical competencies is project planning and scheduling. Project managers must be proficient in tools like work breakdown structures (WBS), Gantt charts, and critical path analysis (CPA) to ensure that projects stay on track and meet deadlines (PMI, 2021). Effective risk and issue management is another critical competency, allowing project managers to identify potential risks, evaluate their impacts, and put in place strategies to mitigate or address them as needed (Koppenjan & Enserik, 2020). Additionally, budget and cost control are essential, as effective financial management ensures that projects remain within budget while optimizing the use of resources (Agarwal & Kalmar, 2020).

As the role of technology in project management expands, technology proficiency has become an increasingly important competency. Project managers must now be skilled in using data analytics, AI-driven decision support systems, and cloud-based project management tools to enhance their decision-making processes (Ghisetti et al., 2020). These technologies support predictive scheduling, automated risk assessments, and improved cost forecasting, making project management more efficient and accurate. Finally, quality management plays a significant role in technical competencies. Project managers must establish clear performance standards, implement continuous improvement processes, and ensure that project deliverables meet stakeholder expectations and industry standards (PMI, 2021).

The growing integration of AI in project management has broadened the scope of technical competencies. With AI-driven tools, project managers can predict project timelines more accurately, automate risk assessments, and forecast costs with higher precision, enhancing the overall project management process and enabling better, data-informed decision-making (Agarwal & Kalmar, 2020).

Leadership & Behavioral Competencies

Leadership and behavioral competencies are fundamental for managing teams, promoting collaboration, and ensuring effective stakeholder engagement in project management. Project managers must inspire trust, communicate effectively, and resolve conflicts to maintain a productive environment throughout the project lifecycle (Ghisetti et al., 2020). These competencies are crucial in creating a harmonious and efficient team dynamic, helping ensure that the project stays on track.

A core aspect of leadership and behavioral competencies is communication and negotiation. Effective communication ensures that project objectives are clearly defined, stakeholder expectations are well-managed, and team responsibilities are assigned appropriately. Additionally, strong negotiation skills are necessary for handling contracts, managing budgets, and maintaining good vendor relationships (PMI, 2021). Another important component is emotional intelligence (EI), which enables project managers to better understand team dynamics, resolve conflicts, and maintain high levels of motivation among team members. This is particularly important in fostering a positive team culture and ensuring smooth cooperation (Koppenjan & Enserik, 2020).

Problem-solving and decision-making are also critical leadership skills. While AI tools can provide valuable insights, project managers must rely on their judgment, ethical reasoning, and contextual awareness to make the final decisions. These human capabilities ensure that decisions align with the overall goals and values of the project (Agarwal & Kalmar, 2020). In addition, project managers must possess adaptability and change management skills, especially in an era of rapid technological advancements and changing market conditions. Their ability to lead change and adapt to new challenges is essential for ensuring long-term project success (Ghisetti et al., 2020).

While AI-driven tools enhance leadership and behavioral competencies by automating administrative tasks and improving team collaboration through AI-powered chatbots, human

leadership remains essential. Project managers are needed to build trust, address conflicts, and foster creativity within teams, which AI cannot replicate. These human elements are vital for ensuring that AI tools complement rather than replace effective leadership, contributing to a cohesive and innovative project team (PMI, 2021).

Strategic & Business Competencies

Strategic and business competencies are critical in ensuring that projects align with organizational goals, contribute to financial sustainability, and provide a long-term competitive advantage. These competencies enable project managers to effectively align project execution with corporate strategy, making it easier to optimize resource allocation and drive project success (Koppenjan & Enserik, 2020). They play a key role in ensuring that projects are not just completed but also deliver maximum value to the organization.

One important aspect of strategic and business competencies is strategic thinking and vision. Project managers must have a clear understanding of how individual projects fit within the broader business context and how their outcomes contribute to the overall growth of the organization (PMI, 2021). Additionally, financial and resource management is essential. Project managers need to manage budgets, procurement processes, and workforce allocation efficiently to ensure that projects deliver value while controlling costs (Agarwal & Kalmar, 2020). Another crucial element is stakeholder and client relationship management. Effective engagement with stakeholders helps build trust, align expectations, and foster long-term collaboration, which is essential for sustained project success (Ghisetti et al., 2020). Lastly, governance and compliance are vital, as project managers must ensure that projects adhere to regulatory requirements, ethical standards, and corporate governance frameworks, safeguarding the organization from legal and operational risks (Koppenjan & Enserik, 2020).

AI-powered business intelligence tools can support project managers by helping track project performance, measure return on investment (ROI), and identify opportunities for strategic improvements. However, despite the advancements in AI, human expertise remains essential in interpreting AI-generated insights and making informed strategic decisions that align with the organization's objectives (PMI, 2021). The combination of AI tools and human judgment helps create a balanced approach to strategic decision-making and business management within project execution.

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