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**The Mediating role of project manager's competencies in
the relationship between using artificial intelligence and
project constraints: A study on the contracting companies
in the eastern province of Saudi Arabia**

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الدور الوسيط لكفاءات مدير المشروع في العلاقة بين استخدام الذكاء
الاصطناعي وقيود المشروع: دراسة على شركات المقاولات في المنطقة
الشرقية من المملكة العربية السعودية

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Dedication

To my family,
for your endless support and patience.

To my parents,
for your sacrifices, your prayers, and your unwavering belief in me.

To my dear wife,
for your constant support, understanding, and strength throughout this journey.

To a hope that inspires patience, perseverance, and the pursuit of what is right.

With deepest gratitude,

I dedicate this thesis to you.

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Abstract

AI has become increasingly utilized across various industries due to its ability to improve efficiency, support decision-making, and enhance organizational performance. However, despite being widely utilized in many sectors, the utilization of AI in project management remains relatively limited, particularly within contracting companies. At the same time, project managers continue to face significant challenges in managing project constraints and achieving successful project outcomes. Therefore, this study aimed to examine the mediating role of Project Manager's Competencies in the relationship between the use of Artificial Intelligence and Project Constraints in large-scale contracting companies in the Eastern Province of Saudi Arabia.

The study adopted a quantitative research approach and used a structured questionnaire as the primary data collection instrument. The conceptual model consisted of three main variables: AI as the independent variable, Project Manager's Competencies as the mediating variable, and Project Constraints as the dependent variable. AI was measured through seven dimensions: Machine Learning, Natural Language Processing, Chatbots and Visual Assistants, Predictive Analytics, Robotic Process Automation, Data Visualization Tools, and Decision Support Systems. Project Manager's Competencies were assessed through Technical Competencies, Leadership and Behavioral Competencies, and Strategic and Business Competencies, while Project Constraints were measured through ten dimensions: Scope, Schedule, Cost, Quality, Risk, Resources, Stakeholder, Governance, Benefits, and Strategic Alignment.

Data were collected from 351 professionals working in project management positions within large scaled contracting companies classified by the Saudi Contractors Authority. The collected data were analyzed using descriptive statistics, reliability analysis, confirmatory factor analysis (CFA), correlation analysis, structural equation modeling (SEM), and mediation analysis.

The findings revealed a significant positive effect of AI on Project Manager's Competencies and a significant positive effect of Project Manager's Competencies on Project Constraints. The results also demonstrated that AI positively influences Project Constraints both directly and indirectly through Project Manager's Competencies,

confirming the mediating role of Project Manager's Competencies in strengthening the effectiveness of AI adoption in project environments. The findings also indicate that organizations can maximize the benefits of AI technologies by simultaneously investing in the development of managerial competencies that enable project managers to effectively interpret, utilize, and integrate AI-generated insights into project decision-making processes.

The study contributes to the existing body of knowledge by providing empirical evidence on the interaction between AI, managerial competencies, and project constraints within the contracting industry. It also offers practical implications for contracting companies, policymakers, and project management practitioners seeking to enhance project performance and achieve successful project outcomes through effective AI adoption.

Keywords

Saudi Arabia, Artificial Intelligence, Project Manager Competencies, Project Constraints, AI-Driven Construction Projects.

أصبح الذكاء الاصطناعي يُستخدم بصورة متزايدة في مختلف القطاعات نظراً لقدرته على تحسين الكفاءة، ودعم عملية اتخاذ القرار، وتعزيز الأداء المؤسسي. ومع ذلك، وعلى الرغم من انتشاره الواسع في العديد من المجالات، فإن استخدام الذكاء الاصطناعي في إدارة المشاريع لا يزال محدوداً نسبياً، ولا سيما في شركات المقاولات. وفي الوقت ذاته، يواصل مديرو المشاريع مواجهة تحديات جوهرية في إدارة قيود المشروع وتحقيق النتائج المنشودة. ومن هذا المنطلق، هدفت هذه الدراسة إلى بحث الدور الوسيط لكفاءات مديرو المشروع في العلاقة بين استخدام الذكاء الاصطناعي وقيود المشروع في شركات المقاولات الكبرى بالمنطقة الشرقية في المملكة العربية السعودية.

اعتمدت الدراسة المنهج الكمي، واستخدمت الاستبانة المنظمة بوصفها الأداة الرئيسة لجمع البيانات. وتكوّن النموذج المفاهيمي للدراسة من ثلاثة متغيرات رئيسة، هي: الذكاء الاصطناعي بوصفه المتغير المستقل، وكفاءات مدير المشروع بوصفها المتغير الوسيط، وقيود المشروع بوصفها المتغير التابع. وتم قياس الذكاء الاصطناعي من خلال سبعة أبعاد هي: تعلم الآلة، ومعالجة اللغة الطبيعية، وروبوتات المحادثة والمساعدات البصرية، والتحليلات التنبؤية، وأتمتة العمليات الروبوتية، وأدوات تصور البيانات، وأنظمة دعم القرار. كما تم قياس كفاءات مدير المشروع من خلال ثلاثة أبعاد هي: الكفاءات الفنية، والكفاءات القيادية والسلوكية، والكفاءات الاستراتيجية والتجارية. أما قيود المشروع فقد تم قياسها من خلال عشرة أبعاد هي: النطاق، والجدول الزمني، والتكلفة، والجودة، والمخاطر، والموارد، وأصحاب المصلحة، والحوكمة، والفوائد، والمواءمة الاستراتيجية.

تم جمع البيانات من (351) متخصصاً يشغلون مناصب مرتبطة بإدارة المشاريع في شركات المقاولات الكبرى المصنفة من قبل الهيئة السعودية للمقاولين. وتم تحليل البيانات باستخدام مجموعة من الأساليب الإحصائية شملت الإحصاء الوصفي، وتحليل الثبات، والتحليل العاملي التوكيدي (CFA)، وتحليل الارتباط، ونمذجة المعادلات الهيكلية (SEM)، وتحليل الوساطة.

أظهرت نتائج الدراسة وجود أثر إيجابي معنوي للذكاء الاصطناعي على كفاءات مدير المشروع، ووجود أثر إيجابي معنوي لكفاءات مدير المشروع على قيود المشروع. كما بينت النتائج أن الذكاء الاصطناعي يؤثر إيجابياً في قيود المشروع بصورة مباشرة وغير مباشرة من خلال كفاءات مدير المشروع، مما يؤكد الدور الوسيط لكفاءات مدير المشروع في تعزيز فاعلية تبني الذكاء الاصطناعي في بيئات المشاريع. كما أشارت النتائج إلى أن المنظمات تستطيع تعظيم الاستفادة من تقنيات الذكاء الاصطناعي من خلال الاستثمار المتزامن في تطوير الكفاءات الإدارية التي تمكن مديري المشاريع من تفسير المخرجات التي ينتجها الذكاء الاصطناعي والاستفادة منها ودمجها بفاعلية في عمليات اتخاذ القرار الخاصة بالمشاريع.

تسهم هذه الدراسة في إثراء المعرفة العلمية من خلال تقديم أدلة تجريبية حول التفاعل بين الذكاء الاصطناعي والكفاءات الإدارية وقيود المشروع في قطاع المقاولات. كما تقدم دلالات تطبيقية مهمة لشركات المقاولات وصناع السياسات وممارسي إدارة المشاريع الساعين إلى تحسين أداء المشاريع وتحقيق نتائج أكثر نجاحاً من خلال التبني الفاعل لتقنيات الذكاء الاصطناعي.

الكلمات المفتاحية

المملكة العربية السعودية, الذكاء الاصطناعي, كفاءات مدير المشروع, قيود المشروع, مشاريع البناء المدعومة بالذكاء الاصطناعي.

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List of Abbreviations

Abbreviation	Definition
AACE	Association for the Advancement of Cost Engineering
AGFI	Adjusted Goodness-of-Fit Index
AI	Artificial Intelligence
AMOS	Analysis of Moment Structures
ANOVA	Analysis of Variance
APM	Association for Project Management
AVE	Average Variance Extracted
BI	Behavioral Intention
BIM	Building Information Modeling

CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CCPM	Critical Chain Project Management
CMIN/DF	Minimum Discrepancy divided by Degrees of Freedom
CPM	Critical Path Method
DCT	Dynamic Capabilities Theory
DL	Deep Learning
DOI	Diffusion of Innovation Theory
DSS	Decision Support Systems
ERP	Enterprise Resource Planning
FM	Facility Management
GFI	Goodness-of-Fit Index
HCT	Human Capital Theory
HR	Human Resources
IPMA	International Project Management Association
ISO	International Organization for Standardization
IT	Information Technology
KPI	Key Performance Indicator
ML	Machine Learning
NFI	Normed Fit Index
NLP	Natural Language Processing
PMBOK	Project Management Body of Knowledge
PMCD	Project Management Competency Development Model
PMI	Project Management Institute
PMP	Project Management Professional
PMO	Project Management Office
PRINCE2	Projects IN Controlled Environments 2
RMSEA	Root Mean Square Error of Approximation
ROI	Return on Investment
RPA	Robotic Process Automation
SCA	Saudi Contractors Authority
SEM	Structural Equation Modeling
SMEs	Small and Medium-Sized Enterprises
SPSS	Statistical Package for the Social Sciences
STS	Socio-Technical Systems Theory
TAM	Technology Acceptance Model
TLI	Tucker-Lewis Index
TOC	Theory of Constraints
WBS	Work Breakdown Structure

CHAPTER 1

METHODOLOGICAL FRAMEWORK

Introduction

The rapid development of various technologies is shaking up many industries. One of these technologies is Artificial Intelligence (AI). AI now plays an indispensable role in the domain of project management, with trends such as intelligent monitoring systems and better possibilities for better outcomes. (Alshaikhi & Khayyat, 2021).

The ability of AI to collect vast amounts of data and process information, particularly for repetitive tasks, can support a project manager's decision-making abilities that help in improving planning strategies, along with risk management, communication, and resource allocation. AI alleviates complex decision-making protocols and enables staff members to concentrate on their involvement in the project as they can streamline everyday jobs, freeing people up for more intelligent work (Khatib & Falasi, 2021; Phaladi et al., 2022).

AI-enabled project management systems provide predictive analytics to effectively mitigate the constraints on their projects, executing them faster and producing better results. Moreover, project managers become more useful with AI as it helps them better manage resources and time when compared to traditional ways. AI plays an important role in helping organizations with planning, resource allocation, decision-making, and risk management (Prifti, 2022; Dam et al., 2019; Nagireddy, 2023).

This study examines the relationship between AI usage and project constraints within Saudi Arabia's contracting sector, a critical industry with an annual market size of approximately 255 billion Saudi Riyals. Understanding AI's role in this sector is important for using its potential to improve efficiency and achieve better project outcomes, as noted by the Saudi Contractors Authority.

Problem Statement

Project Management is an important part of any development, whether for Organizations or even Countries. Without properly managing the processes during the whole life cycle with the correct tools, the chances of not achieving the desired outcomes will be high. Therefore, as part of Saudi Vision 2030, a Project Management

Office (PMO) was established by the Saudi Government to manage government projects. (Vision 2030)

Although AI is widely used globally in several fields, the researcher's observations and discussions with experiences project management professionals concluded that it is not yet utilized in a wide range in the Project Management field. The Contracting sector in Saudi Arabia is no different, as it has not yet utilized the capabilities of AI technologies properly. Therefore, there is a need to understand the impact of AI on Project Management, specifically on the competencies of the Project Managers and the Project Constraints.

As with any other discipline, new technologies have impacts on Project Management in general, especially AI. Some major Multinational companies have already started to use AI to get their work done better and faster. However, it is unknown how AI is helping project managers do their jobs or how it makes it easier to finish projects on time and within budget.

Project managers need to keep up with technology, so they need new skills to work well with AI. Also, there is a need to look closely at whether AI is having an impact on the project constraints where it makes it easier in terms of dealing with them or it makes it more complicated.

It is worth noting that there is a scarcity of studies addressing the relationship between project managers' competencies and artificial intelligence, and linking it to project constraints in Arab countries in general, and in the Kingdom of Saudi Arabia in particular.

This research aims to look closely at how AI is affecting project managers' skills and the usual challenges in projects which is important for the Contracting sector in the Eastern Province of Saudi Arabia, where there are many ongoing construction and services projects. This research will help companies and project managers understand the pros and cons of using AI, so they can make better plans for the future and be ready for more technologies in their work.

The study will answer the following main question and sub-questions related to using AI in Project Management in general, particularly on Project Managers' Competencies and Project Constraints:

Q1- What is the impact of using AI on project managers' competencies in contracting companies in the Eastern Province of Saudi Arabia?

Q1.a- What are the new competencies required for project managers in the context of AI utilization in project management?

Q2- What is the impact of using AI on Project Constraints in contracting companies in the Eastern Province of Saudi Arabia?

Q3- What are the challenges faced by contracting companies in the Eastern Province when implementing AI in project management?

Importance of the Study

Theoretically, the study will help the companies and individuals within the study population to understand the difference between traditional project management and AI-enhanced project management.

Practically, it will make them aware of what is going on within the field of Project Management and what should be done by them to be in line with the technological trend that will change the contracting industry, and will also provide an overview of the new technologies within the Project Management field that embed AI and the recommended practices based on these new technologies.

Research Objectives

- 1- Examine the Relationship between AI usage and Project Managers' Competencies.
- 2- Examine the Relationship between AI usage and Project Constraints.
- 3- Examine the Relationship between Project Managers' Competencies and Project Constraint

Literature Review

No	Title	Author	Year	Related Literature	Methodology	Statistical Tools	Sample Size	Country	Result	Recommendations
1	Investigating AI Applications in Construction Industry: A Systematic Review	Güray	2023	The paper examines how AI helps in handling the challenges in the Construction Industry.	• Systematic Literature Review (SLR). • quantitative bibliometric and scientometric review.	• Descriptive Analysis. • Bibliometric Analysis. • Scientometric Analysis.	452 Publications.	Global Systematic Review.	There is a strong linkage between Building Information Modeling (BIM), Digital Twins (DT), Machine Learning (ML), and Deep Learning (DL).	Increasing the research in the construction field, specifically the case studies about the AI Technologies being used in the Construction Industry.
2	Implementation of Artificial Intelligence in Project Management and effect in working personnel	Kelepouris	2023	This research studies the impact of AI in Project Management on the Working Personnel.	• Qualitative Case Study. • Literature Review. • Semi-Structured Interviews.	• Thematic Analysis of interview data. • Qualitative Content Analysis. • Literature Review analysis	10 Project Managers	• Greece • Sweden	Implementing AI in Project Management offers opportunities for boosting efficiency and achieving better results.	Considering a phased approach by Organizations in applying AI in Project Management.

3	Project Management in the Era of Artificial Intelligence	Sahadevan	2023	This research studies the pros of applying AI in Project Management on resource allocation, Risk Management, Decision Making, and Planning.	Conceptual / Literature Review	Descriptive and Conceptual review based on previously published literature	N/A The paper relies entirely on secondary sources and prior studies.	United States	AI improves all the different sides of Project Management, including decision-making and resource allocation.	• Encouraging learning and innovation within the Organizational Culture will help to improve the technologies. • Project Managers, Data Scientists, IT Professionals, and Business Leaders should collaborate to integrate AI in Project Management. • Project Management Professionals should be up to date with all the innovations and utilize the capabilities of the new Technologies.
4	A Qualitative Study on Artificial Intelligence and Its Impact on the Project Schedule, Cost, and Risk Management Knowledge Areas as Presented in PMBOK®	Fridgeirsson, et al.	2023	The paper discusses the impact of AI on 3 out of 10 of the PMBOK 6th edition Knowledge Areas, which are Cost Management, Schedule Management, and Risk Management.	Qualitative Cross-Sectional	• Weighted Average Calculations. • Descriptive Statistics. • Comparative ranking. • SEM • CFA	12 Experts	Iceland	AI will significantly impact Project Schedule, Cost, and Risk Management.	• Further research can give more specific results about the Impact of AI on Project Management. • Interviews with AI specialists could give exact answers on how AI can be used to help in the field of Project Management.

5	Artificial Intelligence and Its Impacts on Project Management	Nagireddy	2023	The study provides a literature review and case studies of adopting AI in Project Management and its impact.	Qualitative Research Approach	- Qualitative data analysis. - Coding and clustering techniques. - Thematic interpretation of interview responses. - Analysis of questionnaires and interviews.	15 Participants from Project Management Filed	United States	AI has the capability of improving Project Planning, resource allocation, Risk Management, and Decision-making.	Further research investigating AI-based solutions is required for specific functions from a scientific point of view.
6	The Role of Artificial Intelligence in Project Management	Odeh	2023	The paper discusses the importance of adopting AI in Project Management, stating that stakeholders are expecting to see new tools and techniques for managing a successful project.	Literature Review	N/A The paper is based on existing literature and industrial reports	N/A	United States	AI-supported applications can do better planning and other administrative tasks.	- Transforming from the Traditional project management approach to AI-supported applications is needed. - The Transformation process should be in phases involving people, processes, and technology.

7	Mapping Two Decades of AI in Construction Research: A Scientometric Analysis from the Sustainability and Construction Phases Lenses	Regona, et al.	2023	The study examined the effect of AI on enhancing productivity, sustainability, and efficiency in construction.	Quantitative Scientometric.	• Bibliometric Mapping. • Citation Analysis. • Co-authorship Analysis. • Co-occurrence Network Analysis.	3,710 Publications	Publications from 148 countries.	Utilizing Intelligent Systems shows an improvement in productivity, efficiency, safety, and sustainability in the construction industry.	Further research is required, focusing on the identified challenges like the cost-effectiveness of implementing AI in the construction industry, ensuring fair access to AI-driven solutions, and resolving the data integration and interoperability issues.
8	The possibility of applying artificial intelligence techniques to stakeholder management in project management in the Kingdom of Saudi Arabia	Almohammad, et al.	2022	The paper focuses on utilizing AI to provide information to Stakeholders that supports decision-making.	• Mixed Approach. • Deductive Approach. • Inductive Approach.	• SPSS. • Pivot Tables. • Power BI. • Cronbach's Alpha.	229 Respondents.	Saudi Arabia	• There is an acceptance of applying AI Technology to Stakeholder Management/. • Applying AI in Project Management will help in Decision-making. • Using AI in Project Management can help specify the causes of delay. • Utilizing AI in Project Management can help in identifying future risks.	• It is important to get assistance and support from AI Specialists. • It is important to clarify the importance of AI in Project Management in Managing Stakeholders. • Providing training to Stakeholders about AI. • Benefiting from other countries' experiences in utilizing AI in Project Management.
9	Knowledge management processes based on artificial	Alghamdi & Aldharman	2022	The paper discusses the impact of using AI on Knowledge Management processes in	Quantitative Research Approach.	• Frequencies. • Percentages. • Mean.	115 Contractors working in	Saudi Arabia	• Applying Knowledge Management through AI Applications has an impact on the Construction Industry.	Enhancing the use of Knowledge Management Processes based on AI to resolve the problems that are related to the

	intelligence in construction projects: an applied study in the Kingdom of Saudi Arabia			Construction Projects from the perspective of Contractors in Saudi Arabia.		• Standard Deviation. • Pearson Correlation. • Multiple Regression. • Stepwise Regression. • Cronbach's Alpha	Construction Projects		• There is a relationship between Knowledge Management Processes and AI Applications in Construction Projects.	progressing delay in the construction projects in Saudi Arabia, and taking care of the Financial side.
10	Adoption of Artificial Intelligence for Optimum Productivity in the Construction Industry	Victor	2022	The purpose of the study is to connect the benefits of AI with its practical applications in the construction industry by examining some case studies.	Qualitative Research Approach	N/A The study relied on Qualitative Analysis, literature review, Case Study Investigation, Observations, Webinars and Narrative interpretation of Findings.	3 Case Studies	• England. • United States. • Canada.	• Utilizing the Touchplan application increases the predictability and profitability of project outcomes. • Utilizing the Touchplan application saves time on projects by reducing rework in executing the projects.	• Increasing the allocated funds for scientific research in the construction sector. • Investigating AI systems for aspects other than planning, like Engineering Design and Facility maintenance. • Investigating individual demographics like gender, geography, and culture to understand the challenges presented by these factors. • Investigating the Government Programs and Policies that affect the adaptation rate of an organization.
11	An investigation into the Impact of Artificial Intelligence on the Future of Project Management	Alshaikhi & Khayyat	2021	The paper investigates the importance of AI and its impacts on Project Management. It also emphasizes that AI, Machines,	Qualitative Literature Review / Conceptual Study	N/A The paper used content analysis of secondary sources and literature.	N/A It analyzed secondary data, academic literature,	Saudi Arabia	Technologies and AI can run the machines and robots and perform some tasks but they can't replace humans.	• A skilled Project Manager is required to be able to utilize AI properly and achieve the desired outcomes of utilizing AI in Project Management.

				and Robots can automate tasks and tools, but they need humans to manage.			official reports, and published studies.			
12	Impact of Artificial Intelligence in South African Construction Project Management Industry	Makaula, et al.	2021	The purpose of this paper is to explore the influence of AI technology across various project lifecycle stages, intending to develop an integrated framework for construction management.	Qualitative Research Approach.	N/A The paper relied on a sequential literature review of published journal articles.	N/A It analyzed previously published literatures.	South Africa	AI is important in the Construction industry, and it can be used in several stages within the Project Lifecycle.	Innovated Technologies should be utilized in the Construction Sector, especially in Africa.
13	Research on the Application of Intelligent Construction Site in Construction Site Management	Zhang	2020	The paper discusses the use of Information Technology to make an intelligent worksite to manage the workers and the site and to have more efficient management than the traditional management style.	Qualitative Research Approach.	N/A The paper relies on literature review, conceptual discussion, and framework development.	N/A	China	It is important to utilize information technology in solving the problems in the construction industry with quality management and the utilization of intelligent construction sites.	• Adopting Information Technology to manage Personal and Construction Sites and implementing intelligent worksite concepts. • Implementing Training, Teaching, and Technical methods addressing quality and safety issues in construction sites. • Implementing BIM Technology. • Applying real-time management and control to improve efficiency.

14	Artificial Intelligence Enabled Project Management: A Systematic Literature Review	Taboada, et al	2023	The paper discusses the possibilities of improving project performance by applying AI.	Systematic Literature Review (SLR).	• Bibliometric Analysis. • Systematic Literature Review Analysis.	128 Research Papers	• Spain • Australia	• An Increase in publications related to AI-enabled Project Management. • There are various AI applications that can improve Project Management. • More research is required about the challenges of adopting AI in Project Management	• There is a need to do more research on AI applications. • A Developed Framework guiding the integration of AI. • Developing the skills of Project Managers to be able to utilize AI effectively.
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Table (1-1) Literature Review

Although research about AI in different fields is the trend nowadays. However, there are still more topics that are not yet completely covered in research in the field of AI that is related to Project Management. Therefore, this research will be a reference for future research related to AI in Project Management and will help in covering some of the topics that are not yet covered.

Based on the literature review, no research in the scientific community studies the impact of AI on Project Manager's Competencies and Project Constraints specifically on the Contracting Sector in Saudi Arabia. Therefore, this study is expected to explain the importance of AI to Project Managers, company owners, and decision-makers.

Research Hypotheses

The Hypotheses of these questions are:

- H.1-** There is a significant relationship between the use of AI, Project Constraints, and Project Managers' Competencies.
- H.2-** There is a positive impact of using AI on Project Managers' Competencies.
- H.3-** There is a positive impact of using AI on Project Constraints
- H.4-** There is a positive impact of Project Managers' Competencies on Project Constraints.
- H.5-** The significant impact of using artificial intelligence on project constraints increases when mediated by project managers' competencies.

The Role of Artificial Intelligence in Project Management

The term Artificial Intelligence was brought up by John McCarthy in the middle of the 1950s when he defined it as “The Science and Engineering of making intelligent machines” (Manning, 2020). It is simply a technical revolution that has invaded almost every field. From the righteous utilization like the medical field (Haleem et al., 2019) to the Banking sector (Balcıoğlu et al., 2022), reaching the Media sector (Díaz-Noci et al., 2024), and then to the evil side when humans started to utilize it in the Armies (Walker, 2023).

Project management is evolving with AI by applying advanced mathematics and computer science techniques, leading to global decision-making, automation of mundane tasks, and increased efficiency. AI's capability of processing huge datasets,

predicting results, and offering practical insights modernizes conventional project management processes. There are key AI-driven tools used in project management, such as Machine Learning, which provides better predictions, improves resource allocation, and analyzes historical data for forecasting project timelines and assessing risks. Machine learning and natural language processing (NLP) are two additional important tools that allow AI systems to comprehend and manipulate project communications and documentation related to development (Krishnan & Krishnan, 2023; Felicetti et al., 2024).

AI tools like chatbots and virtual assistants help improve project management by automating tasks such as communication, scheduling meetings, and sending reminders. Using historical data can predict how long projects will take, what they will cost, and where there may be a risk. This allows project managers to base their decisions on data. Additionally, RPA automates manual tasks like data entry and report generation. It also allows them to concentrate on more strategic work (Odeh, 2023; Savio & Ali, 2023; Krishnan & Krishnan, 2023).

Data Visualization Tools enable real-time monitoring of project performance, allowing managers to quickly identify and address potential issues. Additionally, Decision Support Systems that use AI analyze data to give recommendations for project planning, execution, and monitoring, also improve decision-making (Krishnan & Krishnan, 2023; Duică et al., 2022).

Benefits of AI for Project Constraints

With AI, project constraints are managed through data-driven decision making, resource allocation automation, and the performance of repetitive tasks in a smooth environment. It improves scheduling by looking at constraints and dependencies to create better project timelines. Timesheets and monitoring differences in the plans help project managers track variables that delay projects. This allows for timely decisions using an AI-powered scheduling tool (Savio & Ali, 2023). This approach helps avoid many project issues by allowing you to use available resources efficiently and stay on schedule.

Data-driven decision making is augmented using AI, which can predict with accuracy by analyzing past data, transforming into real-time analytics in managing

budgets while helping project leaders efficiently distribute resources, ensure expenditure tracking, and contain potential budget overdraws. AI can also examine the skills and workloads of team members to assign tasks more effectively. This helps ensure that resources are used efficiently. It puts the right resources on the right problems. This not only increases the efficiency of human capital but also improves overall project performance (Krishnan & Krishnan, 2023; Belharet et al., 2020).

In project management, AI helps in providing early warnings and suggesting mitigating actions to them so that they can handle risks that arise during any project phase before they accidentally become large enough for the project manager to avoid failure while remaining on time and within the scope of the development process. Furthermore, it allows the managers to track projects in real time and make sure that everything is on course, or else bring in arrangements if things are going awry, while also offering project-level visibility as well as timely status updates for stakeholders, leading to better control over and responsiveness to the projects. Furthermore, AI is now automating routine administrative tasks and contributing to the progress of project procedures while enabling project managers to help with high-level decision-making processes and value-adding activities, which result in improved efficiency within projects. Furthermore, AI Algorithms use Data analytics to analyze enormous datasets and draw relevant insights that aid in project planning and execution, as it helps those who are managing the project to make informed decisions while ensuring they meet the project's defined goals and limitations (Savio & Ali, 2023; Odeh, 2023; Krishnan & Krishnan, 2023).

In summary, AI enhances project management by offering tools and insights that effectively address constraints related to time, cost, resources, risk, and decision-making, ultimately improving project efficiency and outcomes.

Challenges of AI Implementation

The journey of AI adoption in project management highlights below challenges for the organizations to resolve and implement successfully:

1. The quality and amount of available data: The use of AI systems requires large amounts of high-quality and highly relevant data for analysis and decision-

- making, etc. Incorrect conclusions and losses happen because of incomplete or not accurate data or an outdated project (Sahadevan, 2023; Duică et al., 2022).
2. **Insufficient Experience:** A significant shortage of skilled professionals capable of designing, developing, and implementing AI systems effectively poses a major challenge. This skills gap can hinder the successful integration of AI into project management workflows (Sahadevan, 2023; Alshaikhi & Khayyat, 2021).
 3. **Seamless integration with current platforms:** Incorporating AI technologies into existing project management systems can be complex and time-consuming, especially in large organizations. Successful integration is crucial to fully realizing the benefits of AI (Sahadevan, 2023; Duică et al., 2022).
 4. **Change Resistance:** Since any change in an organization will face resistance from some people who are part of the organization, adopting AI is no different. Due to the worries of losing their jobs or not willing to use a new technology instead of what they used to for a long time, they might resist adopting AI. Therefore, an effective change management strategy has to be implemented for a smoother change leading to acceptance (Vegar & Mijač, 2024; Oyekunle et al., 2024).
 5. **Ethical Controversies:** There are some ethical challenges in using AI that include bias and privacy of the data. Therefore, organizations have to ensure that they impose ethical standards. This helps people trust you and keep their faith in the organization (Oyekunle et al., 2024; Duică et al., 2022).
 6. **Implementation Expenses:** There is a high initial cost that covers AI tools, the infrastructure required to run AI, and training, which is necessary to prepare employees to use it. This high cost might be a challenge for some organizations. (Sahadevan, 2023)
 7. **Independence and Authority:** As AI systems become more independent, project managers might find it harder to oversee and control AI-driven processes. This can raise concerns about accountability and transparency in decision-making (Belharet et al., 2020).
 8. **Creativity and Human Intuition:** Unlike humans, AI doesn't have creativity and intuition that are usually important in project management. This limitation might make AI less useful in situations where new ideas or careful decision-making are needed (Belharet et al., 2020).

Addressing these challenges requires thoughtful planning, a well-defined AI strategy, and a commitment to continuous learning and adaptation within organizations. By fostering a culture of innovation and collaboration, organizations can successfully navigate the complexities of AI integration and maximize its potential benefits.

Project Constraints and Their Impact on Project Success

Overview of Project Constraints

The traditional project constraints, commonly known as the "triple constraints" or the "iron triangle," comprise scope, time, and cost. These constraints are essential elements of project management and have a profound impact on project outcomes (Kerzner, 2017). However, there are several Project Management Organizations that are making the standards and certifications in the project management field. The most famous organizations among them are:

- Project Management Institute (PMI).
- International Project Management Association (IPMA).
- Association for Project Management (APM).
- AXELOS (PRINCE2®).
- Australian Institute of Project Management (AIPM).

Each of these organizations has identified project constraints from its point of view. PMI identified the constraints as Scope, Time, Cost, Quality, Resources, and Risk, and this is what IPMA identified as constraints (PMI, 2021; IPMA, 2015). APM, AXELOS, and AIPM have identified constraints exactly similar to PMI & IPMA but they have also added other things. APM has identified Stakeholder Engagement and Governance as a Constraint to be added to the previous list (APM, 2019). AXELOS added to the list of PMI and IPMA Benefits as a constraint (AXELOS, 2017). AIPM added Strategic Alignment and Governance as a constraint (AIPM, 2014). These constraints greatly affect the project's outcomes.

A project scope defines the parameters of a project, detailing what will be accomplished and identifying specific deliverables and tasks needed to fulfill it. When the scope is clearly defined, everyone will share a common understanding of the project goals. Scope creep often happens because of weak scope management. This occurs when new features or requirements are added without changing the budget or timeline.

Those types of changes may hinder the project in terms of achieving success (Nagireddy, 2023).

The Time pertains to the project's timeline, outlining the schedule for completing deliverables. Following the schedule and meeting the deadline is very important because it has a cost impact and will also affect the satisfaction of the stakeholders. Effective time management requires developing a realistic schedule and maintaining adherence to it, which is vital for sustaining project momentum and meeting deadlines (Davahli, 2020).

The Cost involves the budget allocated for the project, covering all resources needed to complete it. Keeping costs under control is crucial because overspending jeopardizes the success of a project. It is imperative to estimate costs accurately and monitor the budget constantly to ensure the financial feasibility of the project. This helps ensure the project stays financially feasible (Rahman et al., 2020).

Quality refers to the standards and requirements a project needs to meet in order to satisfy stakeholders. Inadequate quality management can result in rework, increased costs, and diminished stakeholder satisfaction (PMI, 2021). Deliverables that fail to meet quality expectations can harm the organization's reputation and long-term success. Achieving consistent quality demands clear specifications, ongoing monitoring, and strict adherence to established standards.

Resources include the people, materials, equipment, and tools needed to complete a project. Poor use of resources can cause delays, cost overruns, and lower productivity (IPMA, 2015). For example, not having enough skilled workers can hurt project performance. On the other hand, giving too many resources can lead to team burnout and reduce efficiency.

Risk means uncertainty and the potential for negative events that can jeopardize project success. The lack of effective risk management can result in unforeseen disruption, financial and time overrun (AACE International, 2016). Identifying any risk in advance, evaluating the likelihood of it happening, and putting a plan to minimize it from going wrong is helpful in bringing down its impact and determining how much it can stand in the way of your project.

Stakeholder engagement means finding out what people or groups who are affected by or can affect the project want and need, and then meeting those needs. If people aren't involved enough, the project's goals may not be met, expectations may not be met, and people may not want to see the project's results, which could put the project's success at risk (APM, 2019). Good engagement encourages teamwork, builds trust, and ensures that the needs of all stakeholders are considered during project planning and execution.

Governance ensures that projects are carried out within the organizational framework, following established processes, standards, and policies. Bad governance can lead to scope creep, poor use of resources, and a lack of accountability, all of which can hurt the success of a project (APM, 2019). On the other hand, strong governance structures make it clear who is responsible for what, make sure that laws and morals are followed, and help people make decisions based on facts, all of which lead to better project outcomes.

Benefits are a key constraint in project management, focusing on ensuring that projects deliver tangible value to stakeholders, inform decision-making, and align with organizational goals. In order to achieve long-term success and sustainable outcomes, effective management of these constraints is important (AXELOS, 2017).

Strategic alignment ensures that projects are contributing to the organization's higher-level objectives. This perfectly reasonable (and valid) constraint must be managed well in order to deliver some long-term value and make stakeholders happy (AIPM, 2014).

The interaction among these constraints implies that a change in one can significantly impact the others. For instance, adding more to the project's scope may require more time and resources, which will raise costs. On the other hand, if the project deadline is moved up, it may be necessary to cut back on features or spend more money to meet the new deadline. In short, project constraints are all connected and are very important for the success of a project as a whole (Mohammad & Chirchir, 2024).

Impact of AI on Constraints

There are some AI tools that can help in improving scope management if utilized properly, which help in identifying and managing project requirements and

changes. For example, machine learning algorithms can look at past project data to find patterns and trends. This aids in defining and refining the project scope when it comes to project management(Krishnan & Krishnan, 2023). They can also help to track the deliverables in any project so that they don't go beyond what is described within scope, limiting the risk of making scope creep (Odeh, 2023).

Through the use of predictive analytics and automation, AI tremendously aids in successful time management along with accurate cost estimation. It can do so by automating scheduling tasks, such as setting deadlines and managing resource calendars, freeing up project managers to concentrate on higher-level strategic activities. The AI-based tools send alerts when the project is delayed, allowing managers to address such potential issues well in advance; this availability increases the accuracy of time estimates and ensures work progresses without any stoppages. AI enables cost management by analyzing historical data and current project metrics to produce accurate budget forecasts and anticipate potential cost overruns in advance, allowing project managers to forecast future expenses as they monitor their accounts, advising on cost-saving strategies. Moreover, AI allows for judicious resource allocation such that financial resources are expended optimally across project tasks to yield significant cost savings (Belharet et al., 2020; Odeh, 2023; Wardi, 2024; Krishnan & Krishnan, 2023).

In summary, AI enhances project management by optimizing the management of project constraints through automation, predictive analytics, and data-driven insights, ultimately driving more successful project outcomes.

Limitations of AI in Addressing Constraints

AI has benefits in project management, but there are times it doesn't meet certain limitations. This is why human judgment is crucial.

1. **Complex Decision-Making:** AI excels when it comes to performing very specific tasks like combing through a dataset and identifying potential trends, but has limitations with more nuanced applications requiring familiarity with context. For example, stakeholders are often contradictory and have diverse goals to fulfill for the projects. These circumstances require the sort of human intuition, judgment, and expertise that cannot be effectively managed otherwise (Bushuyev et al., 2024).

2. Emotional Intelligence: AI is incapable of comprehending or responding to human feelings. This skill is crucial to facilitate team dynamics and maintain relationships with stakeholders. Project managers are normal human beings who have emotions and empathy toward their team members. They resolve conflicts and inspire the team members, which cannot be provided by machines. (Bushuyev et al., 2024; Kelepouris, 2023).
3. Creative Problem-Solving: While AI can examine data and suggest solutions based on past patterns, it often struggles to come up with innovative ideas or address unique challenges in a creative way. Human creativity is essential for brainstorming, planning strategies, and adjusting to new situations that require original thinking (Bushuyev et al., 2024).
4. Ethical and Moral Judgments: AI systems do not normally have the capabilities to deal with ethical problems and moral questions that arise during the project. Therefore, human judgment is needed for decisions about fairness, equity, and ethical issues to make sure they match company and social values (Kelepouris, 2023).
5. Data Quality and Availability: To achieve the best performance, AI relies on high-quality, structured data. There is a high possibility of having an unreliable result if the data is incomplete, inconsistent, or biased. Human oversight is essential to evaluate data quality, fill gaps, and make informed decisions based on the available information (Belharet et al., 2020; Alshaikhi & Khayyat, 2021).
6. Change Management: The implementation of AI systems can face resistance from team members within the organization due to the feeling of being threatened by the new system. The project managers can play an important role in the implementation process and minimize the resistance through effective communication with the team members to explain the benefits of AI and encourage the team members to cooperate in successfully implementing it (Kelepouris, 2023).
7. Interpersonal Relationships: Establishing trust and connection among team members and stakeholders is essential for project success. Human project managers use their interpersonal skills to build strong relationships and foster collaboration in ways that AI cannot match (Bushuyev et al., 2024).

In brief, AI can help in doing work smarter and provide important information about project management, but in the areas that require emotions, creativity, and ethical reasoning, humans still can't be replaced. Therefore, it is important to have a balance between AI functions and the experience of human beings in order to succeed in the project (Kelepouris, 2023; Bushuyev et al., 2024).

Key Competencies of Project Managers in AI-Driven Projects

Technical Competencies

Project managers need a range of technical skills to effectively integrate AI into project management. These skills help them use AI tools and technologies to improve project outcomes.

1. **Data Analysis and Interpretation:** Project managers must be skilled at analyzing data produced by AI systems, which means understanding how to interpret insights, forecasts, and recommendations generated by AI. These perceptions help them make informed decisions (Bushuyev et al., 2024; Tubman, 2022).
2. **Familiarity with AI Tools and Technology:** Project managers need to know about different AI tools and platforms that help with project management. For example, running an algorithm-enabled software solution, or having its own features such as task automation, predictive analytics, and resource allocation tools (Wardi, 2024; Lokhande, 2022)
3. **Machine Learning Basics:** Familiarity with machine learning basics allows project managers to learn how AI systems train on data and make predictions. An understanding of this is key to appropriately integrating AI into project pipelines and using it intentionally (Taboada et al., 2023).
4. **Technical Project Management Skills:** A proper understanding of project management methodologies is a must. Project managers have to prove that they can integrate AI within the frameworks, which is expected to enhance project performance, agility, and outcome (Kelepouris, 2023; Dam et al., 2019).
5. **Risk Management:** Understanding how artificial intelligence can pinpoint and address risks is absolutely critical. Project managers are advised to leverage AI-driven tools to assess potential risks, forecast their consequences, and formulate preemptive strategies for their effective management (Krishnan & Krishnan, 2023; Tubman, 2022).

6. **Knowledge of Automation Processes:** Knowing automation techniques and how to use them in project management is important. This includes understanding how to automate repetitive tasks, like scheduling and reporting, to save time. This allows project managers to focus on more strategic responsibilities (Wardi, 2024; Belharet et al., 2020).
7. **Collaboration and Communication Tools:** Being skilled in collaboration tools with integrated AI features is essential for improving team communication, simplifying project tracking, and ensuring smooth coordination among stakeholders (Kelepouris, 2023; Belharet et al., 2020).
8. **Understanding of Ethical Considerations:** It is important to recognize the ethical issues related to using AI in project management. This includes understanding problems with data privacy and algorithmic bias. It also requires maintaining transparency in AI-driven decision-making processes (Belharet et al., 2020).

By building these technical skills, project managers can effectively use AI to improve project management processes, drive efficiency, and achieve better results.

Leadership and Behavioral Competencies

Working with AI technologies introduces a different type of challenge to project management – in order to meet those challenges, project managers must cultivate an artful set of leadership and behavioral skills unique to AI-driven projects. These skills are:

1. **Adaptability:** AI technologies are rapidly evolving, and due to this, project managers need to be flexible and open. This skill is especially important for keeping projects on track and successful, as the ability to adjust strategies based on new data or changing dynamics of a project is absolutely vital (Oyekunle et al., 2024).
2. **Data-Driven Decision-Making:** Project managers need to be skilled at understanding AI-generated insights and using data analytics to make informed decisions. Being comfortable and skilled in using data to guide strategies and actions is essential for managing AI-driven projects effectively (Oyekunle et al., 2024; Müller et al., 2024).
3. **Collaboration and Teamwork:** AI-driven projects often need teamwork across different fields. Project managers must foster a culture of working together. This

means encouraging collaboration among team members with various skills to ensure smooth project execution (Oyekunle et al., 2024; Kelepouris, 2023)..

4. **Communication Skills:** AI technologies need to be explained well, as many people around us believe in them, but they do not know how much they affect their lives. Hence, project managers should distill advanced AI concepts into layman's terms and present them explicitly so that team members engage in productive discussions (Oyekunle et al., 2024; Kelepouris, 2023).
5. **Change Management:** It is important as embedding AI typically means changes to existing inputs and workflows. Team resistance can be overcome if project managers develop the proper change management plans that go with it to minimize human resistance and create acceptance for new technologies in organizations (Kelepouris, 2023).
6. **Ethical Awareness:** Project managers must understand the ethical implications associated with utilizing AI, including data privacy, bias, and accountability. They must make sure that AI applications comply with ethical standards and respect the organization's values, along with social expectations (Kelepouris, 2023; Bushuyev et al., 2024).
7. **Critical Thinking and Problem-Solving:** It is an important skill to be used with AI due to the need of analyzing situations carefully and come up with solutions. Project managers should review outputs generated by AI to support decision-making based on their knowledge and experience, following the decision-making cycle (Bushuyev et al., 2024).
8. **Leadership and Motivation:** An example of how AI will impact more traditional roles is in the Inspirational & Motivational. You need to ensure your team has skills that breed inspiration and motivation because while the 'Robot' can perform admin jobs well, you could also open them up to human activities. An atmosphere in which creativity is valued, innovation encouraged, and team members can adapt to new responsibilities should be created by project managers (Oyekunle et al., 2024; Kelepouris, 2023).

By developing these skills, project managers can successfully lead AI-driven projects, leveraging AI without compromising project management excellence.

Strategic and Business Competencies

Project managers play an important role in AI projects related to company goals and making strategic decisions. To manage this complex environment well, they need a variety of skills, including:

1. **Technical Knowledge of AI:** Project managers should have a strong grasp of AI technologies, such as machine learning, data analytics, and automation tools. This knowledge helps them assess the viability of AI projects and figure out how to effectively incorporate these technologies into current processes and workflows (Kelepouris, 2023; Wardi, 2024).
2. **Strategic Thinking:** The ability to think strategically is indispensable to aligning AI projects with organizational goals. Today, project managers must see the broader business context and consider recommendations on how AI usefully adds value, improves efficiency, or contributes to the organization's long-term objectives (Kelepouris, 2023; Müller et al., 2024).
3. **Leadership and Change Management:** Strong leadership is essential in leading teams through the changes wrought by AI implementation. Project managers must effectively manage change, overcome resistance, and nurture an atmosphere that embraces innovation in constant iterations (Kelepouris, 2023; Bushuyev et al., 2024).
4. **Data-Driven Decision-Making:** Project administrators must be astute at examining and interpreting data-- that's the basis for making decisions deriving from AI-generated insights, free of blind spots. They must use data analytics to forecast trends, appraise risks, and calculate project performances accurately (El Khatib & Al Falasi, 2021; Tubman, 2022).
5. **Communication Skills:** If a project manager tries to explain to the stakeholders the benefits and effects of AI, it would be important to have good communication skills. Gel managers must translate complex AI ideas into clear, understandable language for non-technical board owners and trustees. This will ensure that the latter understand AI projects and have the necessary latitude to support them (Kelepouris, 2023; Odeh, 2023).
6. **Collaboration and Interpersonal Skills:** Project managers must promote collaboration among teams that include data scientists, IT professionals, and business stakeholders. Building strong relationships and encouraging teamwork

is crucial for successfully integrating AI into project management practices (Kelepouris, 2023; Duică et al., 2022).

7. **Ethical Awareness:** Understanding ethical issues that pertain to AI is crucial. This includes concerns about data privacy, bias, and accountability. Needed is the translation of standards of morality into every product and project. Post testing for ethical compliance should take place soon after operation and on regular intervals if not continuously throughout the project lifecycle. So the artificial intelligence-related work can indeed begin. Ethical considerations are therefore fundamental. Project managers have an obligation to meet not only the letter of ethical standards but also to bear in mind what their organization's colleagues and the public expect from them (Bushuyev et al., 2023; Kelepouris 2024).
8. With AI technologies changing rapidly, project managers must be flexible and committed to lifelong learning. One also cannot afford to fall behind on the latest advances in AI project management methodologies if one is to remain competitive and see one's project through successfully (Kelepouris, 2023; Wardi, 2024).

The project manager, by improving these abilities, can successfully connect AI initiatives to company goals, elevate their decision-making levels, and achieve successful project results.

For a project to have a good outcome, the project manager needs a solid understanding of the capabilities and limitations of AI technology. Aimed at development project managers and software engineers, this knowledge can assist them in integrating AI tools into project workflows, thereby maximizing their effectiveness outside ideal conditions. For example, if a manager knows that AI is good at handling repetitive work (Belharet et al., 2020; Bushuyev et al., 2024), he can let his team focus on more important work, which will improve outcomes for the entire project team and its customers.

Skills in data analysis and interpretation are important for project managers to make informed decisions with AI-generated insights. While AI can process large datasets and provide recommendations, project managers need the ability to understand these insights and apply them effectively to project planning and execution. This skill

improves risk management, optimizes resource allocation, and enhances overall project performance (Fridgeirsson et al., 2021; Bushuyev et al., 2024).

AI implementation normally requires changes to the existing processes and workflows. Project managers with strong change management skills can guide their teams through these transitions. These skills are essential for addressing concerns, reducing resistance, and fostering a culture that supports innovation. The effective use of AI tools and maximizing their potential requires these abilities (Kelepouris, 2023; Bushuyev et al., 2024).

To effectively manage interactions between artificial intelligence systems and their project teams, project managers must develop strong collaboration and communication skills. As AI tools become more integrated into project management, the ability to facilitate communication between human team members and AI systems is becoming increasingly important. This capability is instrumental in ensuring that stakeholders remain well-informed and in optimizing the utilization of AI's contributions to the project's objectives (Tubman, 2022; Bushuyev et al., 2024).

It is crucial for project management to have ethical and compliance skills in AI. Project managers need to understand the ethical aspects of AI because it involves problems like data protection and algorithm discrimination. By addressing these issues, they can ensure that AI is used responsibly. In the end, this benefits all of us. And further, this principle is crucial for maintaining people's trust in the project as well as preserving its integrity (Kelepouris, 2023; Bushuyev et al., 2024).

The rapid development of AI technologies requires project managers to keep learning. Building skills in new technologies and methods helps them stay updated and modify their strategies as needed. This flexibility is crucial for effectively using AI and ensuring project success in a constantly changing environment (Fridgeirsson et al., 2021; Bushuyev et al., 2024).

In summary, through a strong link, competencies enable project managers to acquire the skills necessary to understand and work effectively with AI technologies. Organizations can improve their project management practices and achieve better results by developing these competencies.

Competencies play a key role in how effective AI is in managing project constraints, either enhancing its potential or limiting its impact. Project managers who have a strong grasp of AI technologies can use AI tools to handle constraints like time, cost, and scope. Skills in data analytics and machine learning enable them to make sense of AI-generated insights, leading to more accurate forecasts and better decision-making (Kelepouris, 2023; Müller et al., 2024).

To effectively manage project constraints, data quality and availability are crucial. Project managers who have strong skills in data management can ensure that the data used by AI systems is both accurate and reliable. This is critical, for AI systems operate better with good-quality historical data sets (Fridgeirsson et al., 2021; Savio & Ali, 2023).

Changing existing processes and workflows is often necessary if AI project management is to succeed. For project managers with change management expertise, they can help ensure a smooth transition. They guide teams in the use of new AI tools and methods. This adaptability of style is important for full utilization of the potential brought to management by AI in project constraints (Kelepouris, 2023; Bushuyev et al., 2024).

Strong communication skills are essential to help all stakeholders understand the role of AI in project management. Project managers who can clearly explain the benefits and limitations of AI tools encourage teamwork among team members. This improves the overall effectiveness of AI in managing project constraints (Kelepouris, 2023; Müller et al., 2024).

Competencies in ethical AI use are becoming more important. Project managers need to recognize potential biases in AI algorithms. They must ensure that AI applications are used transparently and fairly. This awareness helps prevent problems that can come from poorly managed AI systems. It also protects project outcomes and maintains stakeholder trust (Bushuyev et al., 2024; Savio & Ali, 2023).

AI may be able to automate tasks, but in project management, the human element remains crucial. Project managers with a high degree of leadership and emotional intelligence will have an effective way to help their team through to the end. These actions save people from many of those complex issues that AI integration can bring.

These people processes are critical if morale is to be maintained and AI is to be effectively used (Fridgeirsson et al., 2021; Kelepouris, 2023).

Thus, it is the project manager's skill that determines how AI is able to manage project constraints. By learning and mastering relevant methodologies as well as tools, can we achieve such significant results for our projects? Without these key skills, the successful deployment of artificial intelligence in project management is likely to flounder.

Integrative Analysis and Synthesis

Project manager competencies are essential for helping AI handle project constraints. These skills allow project managers to use AI technologies effectively, which leads to better project performance while managing key limitations. Project managers with a solid understanding of AI technologies can seamlessly integrate AI tools into project workflows. This expertise enables them to select the most suitable AI applications to automate tasks, optimize resource allocation, and enhance decision-making, effectively addressing project constraints (Kelepouris, 2023; Müller et al., 2024).

Proficiency in data analysis helps project managers interpret AI-generated insights. By using AI for data collection and reporting, they can make informed decisions to reduce risks, manage project timelines, and deal with issues related to project delivery (Müller et al., 2024; Fridgeirsson et al., 2021).

In an AI-driven environment, flexibility is crucial. Project managers who can adopt new technologies and methods are better prepared to adjust their strategies based on AI insights. This enables them to respond effectively to changing project conditions and challenges (Oyekunle et al., 2024; Kelepouris, 2023)

Project managers skilled in change management can effectively help their teams adopt AI tools. They address resistance to change and promote a culture of innovation. This ensures that AI systems are fully used to manage project constraints successfully (Kelepouris, 2023; Bushuyev et al., 2024)

Effective communication skills help project managers explain the benefits and functions of AI tools to teams and stakeholders. This understanding promotes

collaboration and helps tackle issues that arise from miscommunication or poor coordination. It ensures a smoother project execution (Kelepouris, 2023; Müller et al., 2024)

One important thing for project managers is recognizing the moral implications of using AI by ensuring the AI applications they deploy are used responsibly. They can handle increased danger relating to data privacy and discrimination. This can help avoid project delay and lessen constraints (Bushuyev et al., 2024; Kelepouris, 2023)

Project managers with strong leadership skills and emotional intelligence can inspire and motivate their teams to use AI technologies. This support improves team performance and resilience, allowing for better management of project constraints (Kelepouris, 2023; Müller et al., 2024).

In summary, project manager competencies are vital in maximizing AI's effectiveness in addressing project constraints. Project managers can seamlessly integrate AI technologies into project management practices, resulting in enhanced efficiency, improved decision-making, and successful project outcomes by leveraging their expertise and skills.

Conceptual Model

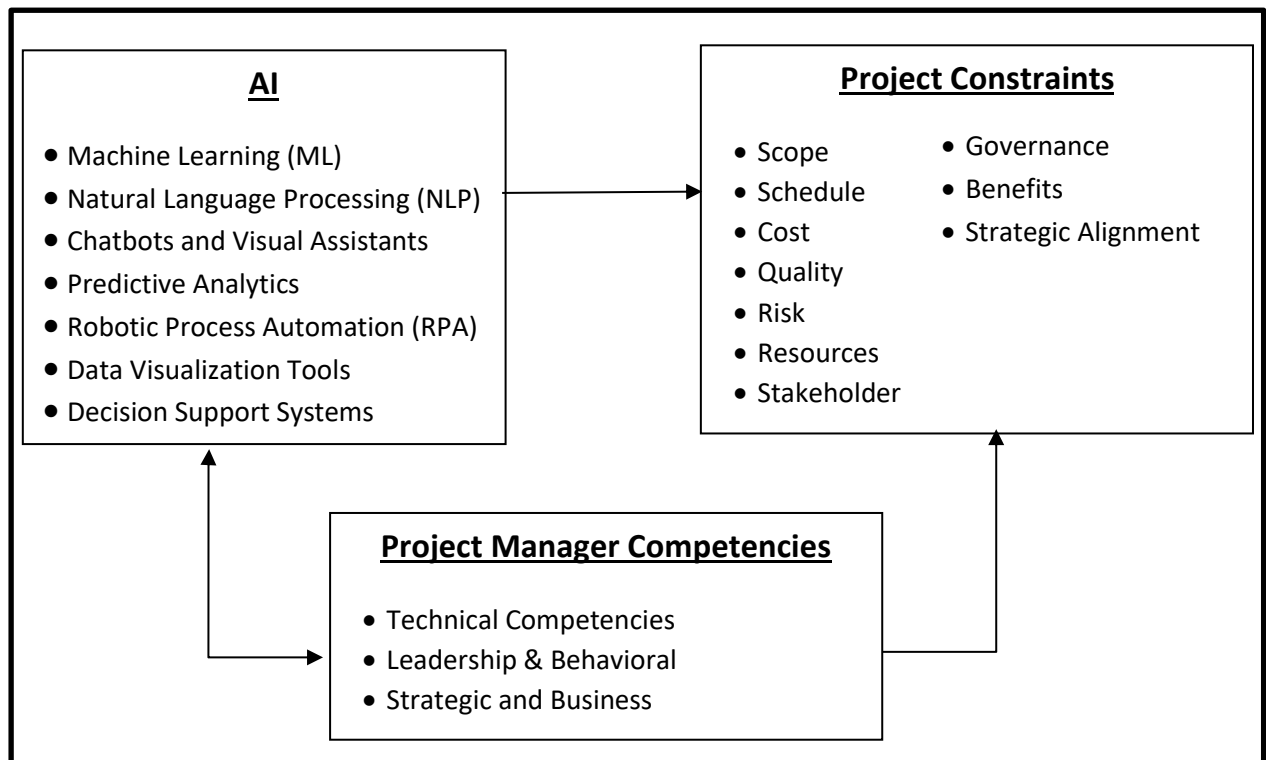


Figure (1-1): Conceptual Model

CHAPTER 2

THEORETICAL FRAMEWORK

2.1 Introduction

AI is transforming projects and their planning, execution, and tracking. AI tools also increasingly increase efficiency by streamlining repetitive organizational tasks through automated processes, facilitating decision-making via predictive analytics, and optimizing resource allocation using real-time insights. But to take advantage of these technologies, a delicate balance of what AI can do and the expertise of human project managers needs to be struck. But project managers are one of the many human components that AI can not replace because, while it is great at dealing with an immense volume of data and streamlining certain processes, there are aspects of projects for which we depend increasingly on the strategic reasoning, ethical choice-making, and leadership that only a person can 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. TAM, which was created in 1989 by Fred Davis, 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 Perceived Ease of Use (PEoU). This refers to how easy a user thinks it will be to use the technology with little effort. These factors affect the Attitude Toward Using (ATU) the technology. This attitude then influences the Behavioral Intention (BI) to use it, which ultimately leads to 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 technologies, including machine learning, predictive analytics, chatbots, robotic process automation (RPA), and decision support systems, are reshaping the landscape of project management. AI enhances efficiency, decision-making, and resource distribution. Nevertheless, the adoption of AI by individuals is contingent upon factors that extend beyond Perceived Usefulness (PU) and Perceived Ease of Use (PEoU). Moreover, elements including trust, ethical considerations, subjective norms, and an organization's readiness also play a significant role in this context (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 Theory of Diffusion of Innovation (DOI) was initially created by Everett Rogers in 1962 and expanded upon in 2003; it is a widely recognized framework for explaining the spread of innovations throughout time, within a social system. The theory identifies five major factors of innovation that impact their rate of adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). These aspects also matter when it comes to studying how technological novelties, such as AI tools, are used in organizations.

One important part of the DOI theory is relative advantage. This term refers to the perceived benefits of an innovation compared to current solutions. AI tools provide significant benefits in project management. Predictive analytics, automated reporting, real-time decision support, and risk assessment are among the key applications. Research indicates that organizations that grasp the advantages of AI are more inclined to integrate it into their operational procedures (Mustofa et al., 2025). Small and medium-sized enterprises (SMEs), for example, demonstrate a greater propensity for AI adoption, primarily due to its potential to enhance operational efficiency and accelerate decision-making. Conversely, the pace of AI adoption frequently slows within organizations where the advantages are either ambiguous or challenging to quantify (Aish & Noor, 2025). This finding aligns with the DOI theory, which posits that technologies offering readily apparent, quantifiable benefits experience more rapid adoption.

Compatibility is another important aspect of the DOI theory. This is known as the fit of an innovation with an organization's existing systems, values, and processes. Organizations that have undergone digital transformation and employ data-driven decision-making frameworks demonstrate greater success in their AI adoption endeavors (Aish & Noor, 2025). These entities typically exhibit a more rapid integration of AI tools compared to those still utilizing conventional project

management methodologies. Moreover, successfully using AI tools requires that they work well with existing systems, including enterprise resource planning (ERP) software, project management applications, and communication platforms. If AI tools require fundamental shifts in the structure or culture, adoption will probably take longer.

Complexity is another key factor affecting AI adoption. This refers to how difficult it is to understand and use a new technology. In organizations with limited technical skills or a reluctance to change because of low AI knowledge, adopting AI can be tough (Mustofa et al., 2025). For example, small and medium-sized enterprises (SMEs) often face high implementation costs and a steep learning curve when adopting AI (Aish & Noor, 2025). To tackle these issues, organizations that offer AI training programs, provide user-friendly interfaces, and introduce AI tools gradually tend to see higher adoption rates. This backs the DOI principle that technologies viewed as simpler and more intuitive are more likely to be adopted quickly.

Trialability is a key factor in how innovations spread. It refers to how easily an innovation can be tried out on a small scale before it's widely used. Organizations that test and evaluate AI tools, like scheduling software or chatbots that can be easily added to their current systems, are often more likely to adopt these tools (Aish & Noor, 2025). Having the opportunity to play with AI tooling without a large upfront investment reduces the risk threshold while creating a more positive path toward adoption.

Observability is the extent to which people can see the benefits of an innovation on others. It also impacts AI adoption. Success stories of AI usage in similar industries positively impacted organizations to implement AI tools (Mustofa et al, 2025). For example, when one of the top construction companies adopts AI-driven predictive maintenance models successfully, other players in that industry will probably follow suit. This reflects the significance of case studies, industry reports and peer influence in determining AI adoption trends.

Rogers' DOI Theory divides adopters into five groups: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards. In terms of AI adoption in project management, Innovators are organizations that quickly embrace AI tools, like those using AI-based risk management models. Early Adopters are organizations that experiment with AI on a small scale before using it more widely. The Early Majority

starts using AI once industry standards and proven best practices are in place. The Late Majority waits for AI tools to become popular and affordable. Finally, Laggards only adopt AI when required by regulations or competitive pressures. Knowing where an organization stands in this adoption curve can aid in developing strategies to speed up the diffusion process.

DOI theory and research in SMEs help understand the factors that influence AI adoption. For this reason, managerial support is vital for accelerating AI implementation (Mustofa et al., 2025). The adoption of AI is also affected by the regulatory environment in which organizations operate, as government policies and incentives can motivate companies to adopt AI technologies (Aish & Noor, 2025). Furthermore, the industry is highly competitive, motivating organizations to embrace AI in order to keep up. Finally, cost analysis and ROI influence AI implementations. Organizations evaluate costs for implementation versus expected return on investment. However, even with the potential benefits of AI, several barriers to adoption exist. Ethical and trust issues may come up, as some employees and managers are skeptical of decisions made by AI (Mustofa et al., 2025). There are also concerns about data security, since AI systems need access to large sets of data, which raises privacy and confidentiality risks. Furthermore, the shortage of skilled workers can hinder AI adoption, especially in organizations without personnel experienced in AI (Aish & Noor, 2025). To tackle these challenges, organizations should build solid AI governance frameworks, set up ethical AI policies, and focus on improving their workforce's skills in AI technologies.

To sum up, the DOI theory is a valuable framework for understanding the factors that affect project management AI adoption. Here, organizations can draw from the existing literature by examining innovations in relative advantage, compatibility, complexity, trialability, and observability. This can help execute projects and make decisions faster. Nonetheless, solutions to challenges such as ethical concerns, trust issues, and the need for skilled personnel must be addressed before implementation can be successful.

2.2.1.3 Socio-Technical Systems Theory (STS)

The Socio-Technical Systems (STS) Theory, created by researchers at the Tavistock Institute in the 1950s, explains the relationship between technology and human work systems (Trist & Bamforth, 1951). The main idea of STS is that organizations consist of two interdependent parts: the social system and the technical system. The social system includes human elements like employees, managers, leadership structures, and organizational culture. The technical system includes the tools, technologies, workflows, and processes that help organizations reach their goals. When adopting Artificial Intelligence (AI) in project management, organizations need to find a balance between these two parts to improve efficiency, collaboration, and innovation (Mustofa et al., 2025).

With the integration of AI tools into project management, the interaction between artificial intelligence systems and human project managers is also shifting. The AI is used for improved decision-making and tailored strategies. It also has support for scheduling, risk assessment, and resource management. Nevertheless, the results need human interpretation and application to the project. There are also complexities that AI tools cannot take care of completely, and humans oversee them. This results in a hybrid model where AI and human project managers collaborate with each other, enhancing resource allocation, risk management, and interaction with stakeholders. However, the successful integration requires the organization to ensure that the AI helps human skills, not replaces them (Aish & Noor, 2025).

The STS framework for using AI in project management highlights three key elements that are crucial for successful implementation. The human-AI collaboration is essential because AI needs to augment, not replace, human decision-making. Another thing is that the acceptance of the technology is crucial; project managers must view A.I. as a helpful tool that complements their role rather than being menaced by it. Third, the need for organizations to adapt: Bringing AI into play means reshaping workflows and changing training programs and governance structures designed to best support new tools and technologies.

Therefore, the goal of project management AI adoption is not to replace human project managers; it is to enhance their work as well. For project managers using AI-powered decision support systems, there are benefits in several areas. AI facilitates

automating tasks such as schedule updates and progress tracking. This will allow managers to concentrate on more critical strategic planning (Mustofa et al., 2025). It also helps with predictive analysis, allowing project managers to anticipate potential risks and resource constraints. This provides useful data-driven viewpoints which help us to make decisions (Aish & Noor, 2025). AI tools like chatbots and virtual assistants help improve communication. They allow project managers to talk with stakeholders, answer questions, and create reports more easily. However, humans still need to understand and use the data generated by AI in relation to their specific projects.

Social and technical factors impact the use of AI in project management. It is also important for project managers to have trust in AI systems as part of decision-making processes, since suggestions generated through AI need to be trusted by them (Mustofa et al., 2025). Furthermore, AI can have major ethical implications. It is important to align AI algorithms with organizational values to ensure fairness, transparency, and accountability in decision-making (Aish & Noor, 2025). Project managers also need training and knowledge about AI so they can use these technologies to their advantage. They must learn how to apply them effectively within their projects.

This implies that complex, vague, or disruptive AI tools in terms of team collaboration may meet with resistance from project managers, and they should not be adopted (Mustofa et al., 2025) as per Socio-Technical Systems Theory. To tackle this, organizations need to develop efficient change management techniques that help in taking care of these concerns and incorporate AI tools into their respective project management structures.

To leverage the potential of AI in project management, organizations need to harmonize human workflows with AI technology. Integrating artificial intelligence necessitates a reconfiguration of workflow processes, incorporating human oversight at critical junctures. A further obstacle lies in the formulation of ethical frameworks governing AI's application in goal-oriented decision-making processes. Fostering collaboration between AI specialists and project managers facilitates the exchange of expertise and guarantees that human cognition is augmented by AI capabilities. Aish and Noor (2025) posit that the integration of AI into project management represents a transformative shift, reshaping organizational culture, structural design, and the

dynamics of project team collaboration. Consequently, this transformation compels organizations to undergo concurrent technological and structural adaptations.

Despite the many benefits of incorporating AI into project management, challenges still exist. Resistance to AI adoption is a common barrier. Project managers may see AI as a threat to their roles rather than a helpful tool (Mustofa et al., 2025). There are also biases and ethical issues that need attention. It is essential that AI-driven project decisions are clear, unbiased, and fair to all stakeholders (Aish & Noor, 2025). Additionally, data privacy and security are significant concerns. AI tools need access to large amounts of data, which raises questions about the confidentiality and protection of sensitive project information.

Successful deployment of generative AI necessitates several practical strategies. These include providing project managers with thorough training on the advantages and disadvantages of AI, establishing ethical guidelines for its application, and fostering a collaborative environment between AI assistants and human team members. Furthermore, novel trends will likely surface, such as AI-enhanced decision-making processes that support human project managers in navigating intricate decisions without supplanting them, thereby facilitating the expansion of AI's role within project management. This will give rise to human-AI co-leadership models, where project managers work in conjunction with AI systems to improve risk management, resource allocation and stakeholder engagement. And adaptive AI systems will be more nimble, adapting their recommendations based on continual input from humans to get better with time.

By using STS Theory, organizations can create AI adoption strategies that balance technological efficiency with human expertise. This will help integrate AI into project management in a sustainable, ethical, and effective way, 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) is a concept created by Eliyahu M. Goldratt in the 1980s. It emphasizes the identification and control of constraints within the system that constrain overall productivity (Goldratt, 1984). TOC's core concept is that every system has at least one constraint, and the overall efficiency of the whole system is directly correlated to how well this constraint is handled (Şimşit, Günay & Vayvay, 2014). TOC provides a way for project managers to find constraints in things such as resource allocation, scheduling, and execution. TOC aims to improve resource utilization, eliminate delays, and increase overall project performance in any given project by directing the attention of project managers through focusing their energy towards addressing only the most impactful constraint within a project's workflow (Grida & Zeid, 2019).

The Five Focusing Steps (Goldratt, 1990) are core elements of TOC. They offer a means to iteratively improve systems by discussing constraints. But these steps are actually common in project management, and serve to maximize performance and minimize risk. The first step involves determining the system constraint(s), identifying the most significant limiting factor in a project, whether it be a lack of resources, improper workflows, or dependencies (Şimşit et al., 2014). In project management, constraints frequently manifest in components such as resource distribution, activity sequencing, or stakeholder dependencies. Once the constraint is identified, we need to exploit the constraint. Several studies emphasized the importance of managing the teams' workloads, determining important tasks, and making sure these tasks are done actively without a lack of resources (Cosca et al., 2019; Grida & Zeid, 2019).

Step three is to subordinate other processes to the constraint. This adjustment includes other project activities to not make the constraint worse. To illustrate, postponing non-mission-critical work or meetings that may conflict with the critical path (Şimşit et al., 2014). If project performance is still constrained, the next step is to act on that constraint. This can entail expanding capacity, procuring additional resources, or taking other actions to eliminate the bottleneck (Grida & Zeid, 2019). Finally, TOC emphasizes that the process is recursive: alleviating one bottleneck

simply pushes your next constraint further down the line. This continuous process keeps the project team dynamic and forward-thinking, which leads to improved execution of projects due to the prevention of bottlenecks (Şimşit et al., 2014).

Critical Chain Project Management (CCPM) is one of the most famous TOC applications in project management. Whereas traditional project scheduling techniques primarily consider task dependencies, CCPM also incorporates resource constraints to improve the execution of projects (Grida & Zeid, 2019). The core concept of CCPM is finding the critical chain, which considers both dependencies and resource availability. CCPM does it differently and takes into account the resource constraints along with task sequencing to make sure that the project progresses smoothly without any fights for resources.

CCPM also applies buffer management strategies. It replaces adding traditional safety margins to individual tasks with consolidated buffers at key points in the project. Project buffer protects the master project schedule from any delays on the critical path, and feeding buffers protect non-critical paths so that a delay in the non-critical path does not prevent completion of critical chain. Resource buffers ensure that critical resources are available when required, alleviating delays due to shortages. They help reduce multitasking as team members get to focus on one job at a time, completing the project in less time with fewer delays. According to studies, CCPM is a powerful tool of project management based on AI since it reduces the project lead-time by removing non-essential delays and effectively using resources (Grida & Zeid, 2019).

In particular, TOC has proven to be a casement to provide a full way of managing project restraints when merged with System Dynamics (SD) in areas affected by complex interaction of human and technical resources. SD modeling has the potential to recognize resource limitations and bottlenecks, simulate how various methods of managing constraints influence project performance, and help increase throughput without increasing cost (Grida & Zeid, 2019). For instance, one healthcare case study demonstrated a 6% throughput boost using TOC principles without additional resources. When critical resources like doctors increase by 40%, throughput improved by 13% while waiting times decreased by 88% (Grida & Zeid, 2019). The results demonstrate TOC's power in resource-restricted areas as construction, IT and manufacturing.

TOC is systematic in handling the constraints of a project but has certain drawbacks. A big part of the problem is knowing what constraint to identify. A wrong assumption about the critical bottleneck will render solutions ineffective (Şimşit et al., 2014). AI-driven predictive analytics can help to solve this issue by precisely identifying project bottlenecks and forecasting issues. A further challenge is related to resistance to change; there may be reluctance in organizations to adopt TOC-based methods of project planning and scheduling, particularly when traditional scheduling practices have become ingrained in their culture (Grida & Zeid, 2019). For TOC to be successfully embedded, effective change management strategies, including supportive leadership styles are required. When constraint points have many interacting constraints, it can become intractable to prioritize one bottleneck over another for large projects. AI can handle this complexity, thanks to its ability to model such dynamic project environments and propose optimal solutions for working around these constraints.

The combination of TOC principles paired with AI and automation tools is a perfect solution to managing constraints in projects. AI driven predictive analytics and automation can enhance TOC by predicting appear of bottlenecks before they become serious problem to take preemptive actions by project managers to prevent disruptions (Grida & Zeid, 2019). This mix leads to better efficiency in project execution and is also a timely way for resource constraint management. Implementing AI can enhance the processes undertaken in project management, thus improving how TOC-based strategies work and consequently resulting in successful projects.

2.2.2.2 Project Management Triangle (Iron Triangle)

The Project Management Triangle describes the relationship between scope, time, and cost. This concept comes from the Theory of Constraints (TOC), a method for finding and dealing with the main limitation that prevents an organization from reaching its goals (Goldratt, 1984). The TOC is based on the idea that every system has at least one constraint. Therefore, by removing or improving this constraint, organizations can achieve significant improvements in performance (Şimşit, Günay, & Vayvay, 2014).

In project management, TOC provides a clear method for finding, managing, and easing constraints that impact project execution. These constraints can include

resource bottlenecks, scheduling conflicts, and cost overruns (Grida & Zeid, 2019). Over time, TOC has shaped project management frameworks like Critical Chain Project Management (CCPM) and System Dynamics-based TOC models. These frameworks aim to improve project performance by focusing on improvements driven by constraints.

Goldratt (1990) introduced the Five Focusing Steps, a systematic method to help organizations find and address their constraints. These steps are often used in project management to improve efficiency and tackle limitations related to resources and scheduling (Şimşit et al., 2014).

The first step is identifying the system's constraints. This involves finding the main bottleneck in a project, such as resource shortages, slow task execution, or dependency issues (Grida & Zeid, 2019). Common constraints in project management include insufficient funds, workforce shortages, and technology limitations. Once a constraint is found, the next step is to exploit it. This means optimizing the constraint's performance without needing significant extra investments (Şimşit et al., 2014). For example, in project settings, this could mean reallocating team members, prioritizing essential tasks, or using automation to improve efficiency.

The next step requires adjusting related processes to fit the identified constraint. All project activities must be changed to avoid overloading the specific constraint (Grida & Zeid, 2019). This often involves coordinating less important tasks to reduce their potential to slow down the constrained process. If the constraint continues to limit performance, the next step is to increase its capacity.

This may necessitate the allocation of supplementary resources, the provision of training, or the implementation of technological enhancements to augment the constraint's capacity (Şimşit et al., 2014). For example, this could encompass the recruitment of more proficient personnel, the investment in artificial intelligence tools, or the outsourcing of critical tasks to enhance overall capacity.

The final step requires continuous repetition. After a constraint is addressed, another might appear, requiring ongoing monitoring and adjustments (Grida & Zeid, 2019). This cycle keeps project teams flexible and proactive, constantly improving project execution by identifying and resolving constraints as they come up.

A notable application of TOC in project management is Critical Chain Project Management (CCPM), which focuses on issues related to resource constraints and scheduling problems. Unlike traditional project scheduling methods that mainly use the Critical Path Method (CPM), CCPM considers both task dependencies and resource availability to optimize overall project execution (Grida & Zeid, 2019).

In CCPM, the Critical Chain is defined as the longest sequence of dependent tasks, taking into account both time and resource availability. Unlike CPM, which focuses only on task sequences, CCPM incorporates resource bottlenecks into the scheduling process. Another important aspect of CCPM is Buffer Management. Instead of adding large safety margins to individual tasks, CCPM combines time buffers at strategic points throughout the project. The Project Buffer safeguards the project's overall schedule. Feeding Buffers, on the other hand, keep non-critical paths from holding up the critical chain. Resource Buffers are there to prevent resource shortages that might lead to delays. Moreover, CCPM cuts down on multitasking. This allows team members to focus on a single critical task, which in turn speeds up project delivery.

Studies show that CCPM significantly cuts project duration and boosts efficiency by eliminating unnecessary delays and optimizing resource use (Grida & Zeid, 2019). Integrating AI-driven project management tools can further enhance CCPM by using predictive analytics to foresee potential resource constraints and determine buffer needs, ultimately streamlining the process and improving project results.

Combining System Dynamics (SD) with TOC provides a useful modeling approach to visualize and tackle complex project constraints. SD modeling has effectively identified resource constraints and bottlenecks in project execution. It simulates the impact of various constraint management strategies on overall project performance and improves throughput and project efficiency without increasing costs (Grida & Zeid, 2019).

A case study on the use of SD-based TOC models in healthcare project management showed significant improvements. Throughput increased by 6% without needing extra resources, and a 40% increase in critical resources led to a 13% boost in throughput while reducing waiting times by 88% (Grida & Zeid, 2019). This evidence

supports the potential for AI-driven predictive models in project management, where machine learning algorithms can dynamically identify and resolve constraints, further enhancing project performance.

While TOC offers a clear approach to managing project constraints, some challenges can arise. One major issue is the difficulty in identifying the right constraint. Misidentifying the primary constraint can lead to ineffective solutions that fail to address the actual bottleneck, ultimately slowing project progress (Şimşit et al., 2014). AI-powered predictive analytics can help solve this problem by accurately diagnosing project bottlenecks and ensuring better identification of constraints.

Another challenge is resistance to change. Organizations may hesitate to adopt TOC-based methods, especially where traditional scheduling techniques like CPM are already in place (Grida & Zeid, 2019). Successful implementation of TOC requires strong change management strategies and leadership support to encourage acceptance and smooth transitions. Moreover, managing complex interdependencies can be challenging, particularly in large-scale projects that have multiple interacting constraints. This complexity makes it difficult to prioritize and effectively address a single bottleneck (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 complexities of large projects more efficiently.

2.2.2.3 Sustainability in Project Management Theory

Sustainability in Project Management Theory involves not just governance and strategic alignment, but also matching project objectives with larger environmental and social goals. This focus has become vital for modern project management. Organizations are now expected to factor in economic, environmental, and social issues when making decisions. Traditionally, project management centered on the Iron Triangle, which focused on balancing time, cost, and quality (Madureira et al., 2022). However, sustainable project management expands this viewpoint. It ensures that projects not only fit within governance frameworks and strategic goals but also support long-term sustainability objectives (Armenia et al., 2019).

Sustainability in project management means more than just meeting legal requirements. It has become a necessary strategy for making sure projects benefit both

current stakeholders and future generations (Friedrich, 2023). By embedding sustainability into project planning and execution, organizations can create lasting positive effects while achieving their goals.

Governance in project management involves creating frameworks, policies, and accountability systems to make sure projects align with an organization's sustainability goals. Effective governance structures balance financial performance with essential environmental and social responsibilities in today's business world (Toljaga-Nikolic et al., 2020). By following these principles, organizations can make sure their projects meet financial targets while contributing to sustainable development.

Corporate sustainability policies are crucial in guiding how sustainability principles fit into project governance. Armenia et al. (2019) identify five key dimensions of sustainable project management governance:

Corporate policies and practices reinforces corporate Governance by embedding sustainability into its governance so it is the first point of consideration. The second dimension, Resource Management refers to the judicious use of human, financial, and environmental resources across a project. Life Cycle Orientation is not only focused on the deliverables of a project, rather, it considers the long-term environmental and social impacts. Stakeholder Engagement ensures diverse voices participate in project governance, making sure all relevant individuals are included in decision-making. Lastly, Organizational Learning encourages continuous improvement of sustainability practices, so each project builds on past experiences to improve sustainability outcomes.

These governance principles combined ensure that sustainability criteria are followed from project start to finish, enhancing transparency, accountability, and ethical decision-making throughout the organization.

Several frameworks assist in sustainability governance for project management. They provide structured methods for incorporating sustainability into project governance. The ISO 21505 (Project, Program and Portfolio Management Governance) provides a governance framework tailored for sustainability that can help organizations with the application of sustainability principles throughout their projects. In the same vein, PMI created its Sustainability Framework to align projects with the Triple Bottom

Line approach that balances People, Planet and Profit. The Sustainable Project Management Cube Model adopts an integrated approach that considers the social, environmental, and economic consequences of projects (Madureira et al., 2022).

By adopting these governance models, project managers can ensure sustainability is a core part of project decision-making and not an afterthought. This integration helps projects contribute to long-term sustainable development while achieving their goals.

Strategic alignment of projects to organizational goals provides the most long-term value in terms of meeting sustainability targets. Mismatches between projects and corporate sustainability strategies waste resources and lead to inefficiencies that undermine sustainability initiatives (Friedrich, 2023). Aligning between projects and sustainability goals is critical in addressing operational as well as environmental outcomes.

Strategic alignment requires organizations to incorporate sustainability into project objectives, risk management, and performance evaluation. According to Toljaga-Nikolic et al. (2020), this means linking sustainability with corporate mission statements and values. It ensures that project success metrics go beyond traditional measures of time, cost, and quality to also include environmental and social impacts. Furthermore, developing sustainability performance indicators is vital for tracking progress and maintaining alignment with the organization's broader sustainability goals. This well-rounded approach helps organizations succeed in projects while promoting long-term sustainability.

Engaging stakeholders is key to achieving strategic sustainability alignment. Armenia et al. (2019) argue that sustainability-focused projects must involve various stakeholder groups. This includes internal stakeholders like executives and project teams, external stakeholders such as clients, regulatory bodies, and communities, as well as future stakeholders with a focus on long-term environmental and social impacts. Effectively engaging these groups helps projects meet societal needs, foster long-term sustainability, and reduce resistance to change. By involving a wide range of stakeholders, organizations can improve the effectiveness and acceptance of sustainability-driven initiatives.

Despite the growing acceptance of sustainability principles in project management, challenges remain. It is one of the most strategic things to get right, ensuring that your project's ultimate objectives closely align with the goals and priorities of an organization surrounding sustainability. This will serve to insert long-term value into any solution by making sure that its aims, delivery, and outcomes target organizational goals on sustainability. The lack of coherence of projects with corporate sustainability strategies leads to inefficiencies and waste, jeopardizing efforts toward sustainability altogether (Friedrich, 2023). Iterate alignment between projects and sustainability impact for effectively achieving operational and environmental goals.

To address the challenges identified above, future research should focus on several key areas. Standardizing sustainability metrics that can be applied across multiple industries is a superb first step toward consistency and comparability in assessing sustainability performance. Second, it is crucial to explore the role of digitalization and AI in sustainability governance mechanisms, particularly through initiatives such as predictive analytics for carbon footprint management. Lastly, enhancing stakeholder collaboration models is vital for long-term sustainability planning. This would ensure that various perspectives are included in decision-making 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) provides the best explanation for adaptive skills required during an AI initiative by explaining three specific capabilities, namely sensing, seizing, and reconfiguring. In this context, it is embedded in Otter and Marius (2007) that these central elements enable organizations to respond to technological transformations, market contingencies, and innovations. These skills are vital in the age of AI, where technology is progressing at an unprecedented speed; adapting to that progress involves lifelong re-education and learning.

Sensing is the ability of an organization to detect, interpret, and predict shifts in market trends and technology. This ability is even more critical in AI-driven projects to be at the forefront of adopting new technologies. For such projects, sensing means recognizing new AI technologies that can enhance processes. It also needs to assess the risks and ethical challenges of AI adoption for responsible usage. Moreover, awareness

of AI around project teams is key to being able to make decisions based on what you learned from AI (Ellström et al., 2022).

Research shows that organizations with strong AI-sensing capabilities can use easy access to AI-driven predictive analytics to assist project managers with various aspects of their projects, such as resource allocation, risk assessment, and strategic planning (Simón et al., 2024). Also, digital sensing across industries helps organizations find AI use cases beyond their field and speeds up the adoption of AI in different areas (Ellström et al., 2022).

In seizing, identified opportunities must be translated into tangible strategies, investments, and project actions. In AI project management, this implies developing AI-created project tasks that connect with the organization's objectives. It means showing how people interact with AI to improve decision-making and results. Managing resistance and getting past organizational inertia while ensuring the support of teams and stakeholders regarding the changes that AI brings is an important part of seizing opportunities (Steen, Ford, & Verreynne, 2021).

We believe that human-AI collaboration is necessary. It helps AI function smoothly (Lin et al., 2023) and also adds value. Our previous research at ØBI University indicates that while AI improves data-driven decision-making in organizations, companies must invest in strategies for human-AI collaboration (Simón et al., 2024). Moreover, AI adoption involves an enterprise-level transformation of the digital culture, including streamlining strategies and governance to smooth integration across all levels (Ellström et al., 2022).

Reconfiguring means using and restoring the organization's skills, structures, and processes to stay relevant in AI-driven environments. This involves improving project managers and teams' AI skills so they can use these tools effectively. This also means rethinking workflows and business models to include AI-assisted automations that improve efficiency. Finally, it is important to include AI ethics and governance in every operational decision related to an investment project. This ensures there are clear guidelines for responsible and transparent use of AI throughout the organization (Bleady et al., 2018).

According to research, a focus on realigning organizational assets and skills is critical for companies in order to remain agile in their digital transformation efforts (Ellström et al., 2022). Trust-building in human-AI interaction is particularly important for encouraging collaborative problem-solving and knowledge sharing that can enhance adaptive capacities of the organization (Simón et al., 2024).

There is a significant change required in project skills as AI-oriented projects go through the pipeline. In the project management world, scope, cost, and schedule are so important. But to properly govern AI-driven initiatives, organizations need their own skills base to extend and include technical knowledge of AI, strategic foresight, and change management capability. All systems at all times are changing. Most of the time, Project Management needs to be reformed according to AI technologies.

The integration of AI will make a productive collaboration between human project managers and AI systems. Three essential interactions have been identified in research for successful human-AI teaming. First, interoperability is key; the best AI tools function seamlessly with current human workflows. Second, there is a need to build trust in AI as organizations must be able to trust AI-generated recommendations if they are going to enhance decision-making. Finally, mutual knowledge gains are essential; AI must complement and not supplant human decision making (Simón et al., 2024).

The second major factor in whether or not AI projects are successful is the structure of an organization and its society to learn and adapt with respect to change in AI. In an AI-oriented environment, organizations need to build digital infrastructure capable of enabling AI transformation (Ellström et al., 2022). Furthermore, there is a need to foster and create a culture rooted in continuous learning and experimentation to improve adaptive decision-making. Finally, organizations need to create governance frameworks for AI. These frameworks will reduce ethical risks and ensure compliance. They will also encourage responsible and sustainable use of artificial intelligence methods in project management (Bleady et al., 2018). While the prospects are promising, leveraging DCT-powered AI strategies depends on overcoming a few hurdles.

A significant challenge is to overcome the resistance internal to the organization. For many companies, however, cultural barriers stand in the way of

adopting AI, and effective change management becomes the key. To create an environment of AI-led innovation and implement AI in organizational practices successfully, leadership support is essential (Steen et al., 2021).

The other challenge is closing the AI skills gap. Due to the transition into a technology-centered world, project managers will need to acquire new competencies within areas such as AI, data literacy, or digital leadership in order to stay current (Bleady et al., 2018). To achieve this, organizations need to engage in AI training programs that promote workforce adaptability and equip employees with the skills needed to thrive in an AI-driven environment (Ellström et al., 2022).

Last, business strategy should inform AI alignment; in other words, you must ensure that your corporate goals guide your implementation of AI and its long-term value. To potentially do more harm than good, AI must be aligned with the organization's objectives (Simón et al., 2024).

2.2.3.2 Human Capital Theory (HCT)

Human Capital Theory (HCT) emphasizes the importance of project managers' knowledge, skills, and continuous learning in improving project success, especially in fast-changing, AI-driven environments. It underscores the value of knowledge, skills, experience, and abilities in boosting both individual and organizational productivity. First introduced by Becker in 1964 and Schultz in 1961, the theory suggests that investing in human capital, including education, training, and professional development, can lead to economic benefits like better performance, innovation, and a competitive advantage, according to Wuttaphan in 2017.

In project management, HCT is crucial because the success of projects largely depends on the expertise, leadership, and problem-solving skills of project managers. Organizations that focus on the continuous development of their project managers' technical and leadership skills often see better project results, improved risk management, and greater stakeholder engagement (McKinsey Global Institute, 2022).

Project managers are valuable assets, bringing unique knowledge and abilities to their organizations. Their skill in navigating complex project challenges, aligning projects with strategic goals, and effectively leading teams has a significant impact on

project performance (Implementation of the Human Capital Management Concept, 2024).

According to the McKinsey Global Institute (2022), human capital refers to the combined skills, experience, and abilities of individuals, which are essential for both economic and organizational success. In project management, these factors are critical for various aspects of executing projects.

Project managers use their skills to solve problems and make decisions. This helps them make informed choices and lower potential risks. Their knowledge is also important for making sure project goals fit with the larger business aims. Additionally, skilled project managers encourage flexibility and new ideas within teams, allowing projects to adapt well to technological changes and market trends.

A study on human capital management in small businesses found that companies that invest in training and knowledge-sharing see higher productivity and better project success rates (Implementation of the Human Capital Management Concept, 2024). This highlights the important role of ongoing learning and skill development for project managers in achieving better project outcomes and overall success for the organization.

To assess the contribution of human capital to project success, organizations use various measurable metrics. One key metric is the project success rate, which tracks the percentage of projects completed on time, within scope, and on budget. Another important measure is the Return on Investment (ROI) in training, which evaluates the effect of project management certifications and leadership programs on performance. Additionally, employee retention and engagement are important metrics. Companies that invest well in their workforce often see higher employee commitment and lower turnover rates, according to the McKinsey Global Institute in 2022. These measures help organizations assess how effective their workforce development strategies are. They also ensure that project managers stay competitive and flexible in a changing business environment.

Investing in the human capital of project managers through education, training, and leadership development positively affects project performance. Research shows that project managers who undergo continuous skills training and leadership coaching

manage key project constraints, such as scope, cost, and stakeholder expectations, more efficiently (Wuttaphan, 2017). This ongoing investment in professional growth prepares project managers to handle the complexities of executing projects and achieving successful outcomes.

Organizations that invest in formal project management training and AI-supported learning usually experience greater efficiency and innovation. Companies focused on their workforce make it a priority to offer learning opportunities, including certifications such as PMP, PRINCE2, and Agile methodologies. These training investments link directly to higher project success rates and better decision-making. Project managers gain the skills and knowledge needed to handle complex project challenges effectively.

The influence of human capital on project leadership is significant since leadership skills are essential for project execution. Effective project managers display strategic thinking by aligning projects with organizational goals while also possessing change management abilities that help them navigate uncertainties and implement flexible strategies. Strong stakeholder management skills help build productive relationships with sponsors, clients, and team members. A study by Wuttaphan (2017) found that companies that invest in leadership training for project managers experience a 30% increase in project efficiency and higher client satisfaction. This illustrates the advantages of building leadership skills in project management.

As artificial intelligence (AI) and digital tools become more prevalent in project management, there is a growing need to emphasize human capital development. Future project managers will require a mix of technical expertise, leadership, and strategic foresight (Implementation of the Human Capital Management Concept, 2024). This blend of skills will help them navigate the changing project landscape, ensuring successful project outcomes while fully utilizing emerging technologies.

As AI changes project workflows, adaptive learning, digital literacy, and automation management are becoming essential for people (McKinsey Global Institute, 2022). Organizations that emphasize training programs, including AI, will not only improve their project execution but also gain an advantage in managing risks effectively. By investing in these skills, companies can make sure their teams are ready to use AI technologies, boosting efficiency and innovation in their projects.

Research shows that project managers without AI and data analytics skills may find it hard to lead technology-driven projects effectively. To tackle this issue, organizations need to invest in AI and digital training for project leaders, making sure they have the skills to manage new technologies. Also, building expertise across different areas within teams can improve project flexibility, enabling better responses to changing demands. Supporting continuous learning programs will help project managers stay updated with industry changes, keeping them competitive and capable in a shifting project environment.

2.2.3.3 Project Management Competency Model (PMCD)

The Project Management Competency Model (PMCD) outlines the key technical, leadership, and business skills that project managers need to succeed, especially in complex, AI-driven settings. The Project Management Institute (PMI) developed it. The model provides a clear way to evaluate and improve project managers' skills. It highlights three main competency areas: technical skills, leadership abilities, and business management skills. Each of these areas is important for delivering successful projects and achieving organizational goals (Koi-Akrofi et al., 2024).

Skilled project managers are vital for executing projects successfully, particularly in complicated and AI-driven situations. Lacking competence in any key areas can lead to project failure, poor resource management, and ineffective communication with stakeholders, all of which can negatively affect a project's success (Fazly et al., 2024).

The PMCD model breaks down project management competencies into three main categories. Technical competencies include knowledge of project management methods, tools, and techniques needed for effective project execution. Leadership competencies focus on the ability to lead teams, influence stakeholders, and encourage collaboration to achieve project goals. Lastly, strategic and business management competencies involve understanding business strategy, organizational governance, and financial skills. These are important for connecting projects with the organization's larger aims.

Technical skills are vital for planning, executing, and managing projects. These skills cover several important areas: project scope management, which involves defining project deliverables and ensuring they align with overall goals; risk and cost

management, which focuses on identifying potential risks and keeping budgets in check; scheduling and resource allocation, which ensures timely project delivery while using available resources effectively; and quality assurance, which guarantees that standards are upheld for project quality (Rustam et al., 2024).

A study at the Iran Gas Engineering and Development Company (IGEDC) found that technical competencies are vital for project success. Expertise in engineering judgment, project knowledge, and risk management plays a critical role in achieving successful results (Hatefi & Behi, 2024). Furthermore, research in construction project management emphasizes the importance of skills like monitoring, scheduling, and stakeholder engagement. These are key technical competencies necessary for effective project delivery (Edrizal et al., 2020).

Leadership is a key competency in project management. Project managers need to influence their teams, resolve conflicts, and communicate effectively. Key leadership skills include emotional intelligence, which involves managing relationships and promoting teamwork. Decision-making and problem-solving help project managers tackle challenges head-on. Motivational leadership inspires teams to achieve project goals. Negotiation and conflict resolution improve communication and collaboration among stakeholders (Koi-Akrofi et al., 2024).

Research in the Afghanistan construction sector indicates that leadership skills among project managers strongly affect the link between project planning and success. This shows that effective leadership can reduce planning shortcomings and is crucial for successful project outcomes (Fazly et al., 2024). Additionally, the Iran Gas Engineering study identified leadership as the most important competency, even more vital than technical skills. The study pointed out decision-making, judgment, and team management as significant factors for project success (Hatefi & Behi, 2024).

Strategic and business skills are important for project managers to make sure their projects support larger organizational goals. These skills involve strategic thinking, which is understanding how projects contribute to business goals. They also include financial knowledge, which helps manage budgets effectively. Governance and compliance ensure that projects follow relevant laws and company policies. Lastly, market awareness means staying updated on industry trends and competition (Rustam et al., 2024).

Research on competency frameworks in the construction sector shows that project managers with strong business and strategic management skills deal better with industry changes, regulatory shifts, and financial limits (Sanchaniya et al., 2024). A systematic review of project manager competencies found that combining strategic skills with leadership and technical skills is crucial for driving long-term organizational success (Koi-Akrofi et al., 2024). This mix of skills helps project managers lead effectively while staying aligned with the organization's strategic goals.

Several ways exist to assess project management competencies, each offering insights into a project manager's skills. Competency gap analysis identifies gaps in skills and areas needing training, helping organizations focus their development efforts. Performance-based assessments evaluate skills by looking at project results, giving a clear view of how effectively skills are applied in real situations. Behavioral indicators evaluate leadership and strategic decision-making abilities, focusing on how project managers handle complex situations and interact with their teams.

One study used the Best-Worst Method (BWM) to assign numerical weights to different skills. It found that leadership, project knowledge, and decision-making were among the most important skills for project managers (Hatefi & Behi, 2024). This method helps prioritize essential skills, guiding organizations in their development efforts.

Organizations can improve project manager skills using various strategies. Certification programs like PMP, PRINCE2, and Agile provide formal recognition of these abilities. On-the-job training and mentorship give hands-on experience and guidance, helping project managers refine their skills in real-world situations. AI-driven tools for skill development (Fazly et al., 2024) offer personalized learning experiences that improve skills with data-driven insights. Additionally, experience in different business areas helps project managers expand their understanding and enhances their ability to tackle complex project challenges.

Studies on road construction project management in West Sumatra, Indonesia, suggest that project managers who take part in structured competency development programs show better performance in key areas like risk management, team coordination, and resource allocation (Edrizal et al., 2020). These findings highlight

how effective targeted development programs are in boosting project manager's capabilities and enhancing overall project success.

As AI becomes more of a part of project management, competency frameworks must change to include new skill areas. AI literacy is essential. Project managers need to understand AI-driven decision support systems for informed decision-making. Data analytics skills are also crucial. These skills allow project managers to use predictive analytics to improve risk and cost management. Additionally, hybrid leadership is necessary to manage human and AI collaboration in project execution effectively. This ensures that both technology and team dynamics are optimized (Sanchaniya et al., 2024).

To stay competitive and improve project outcomes, organizations must update their competency models to include technical, leadership, and strategic skills that leverage AI and automation. This update will help project managers use AI effectively while maintaining strong project oversight and decision-making (Rustam et al., 2024)

2.3 AI in Project Management

AI is changing project management by increasing efficiency, improving decision-making, and optimizing resource use. The adoption of AI technologies is rising because they can analyze large amounts of data, predict project risks, automate repetitive tasks, and boost decision-making. As projects grow more complex and the demand for real-time insights increases, AI tools have developed to streamline project execution and improve outcomes (Lee et al., 2020).

One key way AI is impacting project management is through predictive analysis and machine learning. These technologies examine past project data to find trends and generate insights. This helps project managers foresee potential issues and make strategic adjustments. Machine learning algorithms improve over time by learning from past data. This helps teams predict risks, estimate costs, and adjust schedules more accurately (Riesener et al., 2023). Predictive analytics has become crucial for handling uncertainties. It does this by examining large amounts of historical data to identify risks, budget issues, and scheduling conflicts (Buvik & Rolfsen, 2015).

In addition to risk management, AI is improving workflow automation. Many routine project tasks, like scheduling meetings, tracking progress, and updating

documents, can take up a lot of time. AI-driven automation tools can take care of these administrative tasks, which allows project managers to concentrate on more strategic decisions. For example, AI-based task management systems can automatically update project schedules, send reminders, and allocate resources based on real-time data analysis. This leads to higher productivity and fewer errors, helping ensure that project goals are met on time (Phillips, 2010).

Another important use of AI in project management is Natural Language Processing (NLP). This technology allows AI systems to understand and generate human language. It helps create communication tools such as AI-powered chatbots, virtual assistants, and automated reporting systems. These tools can examine meeting notes, project updates, and feedback from stakeholders to extract key insights and create summaries. This ultimately saves time and improves communication within project teams (Chen et al., 2021).

AI is also essential for optimizing resources. AI tools can spot available resources, predict workloads, and ensure the best distribution of staff and materials. Traditional project management often relies on manual resource allocation, which can be slow and ineffective. AI-powered systems consider different factors, such as team availability, task dependencies, and project schedules. This helps suggest the best way to allocate resources. As a result, efficiency increases, costs decrease, and project performance improves (McKinsey, 2009).

While AI has so many benefits in project management, it poses some challenges as well. Data quality and accessibility are two of the bigger obstacles. Many models require large amounts of good-quality data to function effectively, but the vast majority of organizations are faced with incomplete or inconsistent data sets. Unprecedented predictions by Artificial Intelligence tools based on unreliable data will lead to poor decisions. In addition to these issues, there are worries with regard to data security and privacy (particularly with sensitive project information) (Wysocki, 2014).

Another key issue is integrating AI with current project management systems. Many organizations still depend on old systems that might not work well with modern AI tools. Switching to AI-driven project management requires significant investments in infrastructure and training. Additionally, project managers and team members may be hesitant to adopt AI because they might not know how to use the technology or may

doubt its benefits. To successfully integrate AI, organizations need to prioritize training project managers in AI skills and data analysis (Burghardt, 2013).

Looking to the future, the role of AI in project management is set to grow and evolve. AI-driven project assistants, cognitive computing, and smart decision-support systems will likely become more advanced. They will automate project planning, improve team collaboration, and connect more effectively with business goals. Furthermore, AI-powered sentiment analysis tools could evaluate stakeholder satisfaction and identify communication gaps, leading to improved engagement and better decision-making (Project Management Institute, 2016).

In summary, AI is changing project management by automating tasks, improving decision-making, and optimizing resource use. There are challenges like data quality, integration problems, and resistance to change. However, organizations that embrace AI will have an edge over their competitors. As AI technology continues to develop, project managers must use these tools to drive innovation, improve efficiency, and ensure successful project results in a fast-changing and complex environment (Deloitte, 2019).

2.4 Dimensions of AI Usage in Project Management

AI has significantly changed project management by automating workflows, improving decision-making, and increasing project efficiency. AI tools have been integrated into different project management areas to improve performance, reduce risks, and enhance communication with stakeholders. These tools examine historical project data, real-time analytics, and predictive modeling to help managers make better decisions. This leads to more successful projects (Oyekunle & Boohene, 2024). This section explores the different ways AI is used in project management, especially its impact on modern project execution.

Machine Learning (ML) plays a key role in AI for project management. It helps assess risks and perform predictive analytics. ML algorithms allow project managers to predict possible delays, budget issues, and resource shortages by looking at past data and identifying trends. These insights allow teams to take proactive steps, ultimately boosting overall project performance. ML-based risk models are especially useful in industries like construction and software development, where uncertainty and

complexity often pose challenges during project execution (Connor & Liu, 2023). Additionally, ML supports automated scheduling and dynamic project planning, providing flexibility in rapidly changing situations (Pinto-Alves, 2023).

Natural Language Processing (NLP) is commonly used to analyze communication in project management, which improves interactions with stakeholders and understanding of documents. NLP tools enhance stakeholder engagement by reviewing emails, meeting notes, and project reports to pull out useful insights that help project managers make informed choices. These tools also support sentiment analysis, helping teams understand stakeholder concerns and address issues early. Furthermore, NLP-based chatbots and virtual assistants automate replies to common questions, cutting down on administrative work and improving overall efficiency (Vilas-Boas & Barbosa, 2023).

Chatbots and Virtual Assistants are significant tools for AI-led project management as they ensure that you can increase workflow efficiency and retain collaboration. These AI tools are used to automate tasks that include work assignment, project updates, and real-time collaboration among members. Using AI chatbots, project managers can reduce the low-end work associated with regular administrative tasks, enabling them to focus on superordinate choice creation. Virtual assistants also help boost productivity by offering data-driven recommendations and improving resource allocation (Oyekunle & Boohene, 2024).

Predictive Analytics is another key aspect of AI in project management, as it provides data-driven insights about project performance. AI-powered predictive models analyze historical project data to forecast possible outcomes, helping managers spot risks and allocate resources effectively. Predictive analytics enhances decision-making by giving real-time performance metrics, enabling project teams to recognize and solve bottlenecks before they impact timelines (Connor & Liu, 2023). This tool is particularly valuable in agile project management environments, where quick adjustments to project strategies are often required (Pinto-Alves, 2023).

Robotic Process Automation (RPA) focuses on task management by automating repetitive functions like data entry, report generation, and scheduling. RPA tools handle tasks like data entry and scheduling. This lets project managers focus on more strategic activities. By minimizing human involvement in routine processes, RPA boosts project

accuracy and efficiency while decreasing the likelihood of errors. Many organizations have successfully used RPA in resource planning and financial forecasting, leading to better project outcomes (Oyekunle & Boohene, 2024).

Data Visualization Tools have made a significant impact on project management by providing interactive dashboards and real-time reporting. AI-driven data visualization platforms organize and display project data in easy-to-understand formats, simplifying decision-making. These tools help project managers track key performance indicators (KPIs), monitor resource usage, and recognize trends that affect project success. With AI-powered visual analytics, project teams can quickly review project progress and make informed choices that align with organizational goals (Connor & Liu, 2023).

Finally, Decision Support Systems (DSS) use AI to help project managers make complex decisions. These AI systems combine real-time data with historical insights, enabling managers to assess different scenarios and select the best course of action. DSS improves strategic planning by suggesting optimal solutions to challenges like budget constraints, risk management, and engaging stakeholders. With AI-based decision support, project managers can enhance project efficiency and boost the chances of successful outcomes (Pinto-Alves, 2023).

2.5 Overview of Project Constraints in Project Management

Constraints are the elements that restrict and define a project's execution, success, and deliverables. In the classical approach towards project management, we were only concerned with three constraints from a project perspective: scope, time and cost. This model identifies the main constraints within which a project should exist (Project Management Institute [PMI], 2021) But current project management acknowledges a greater variety of constraints, such as quality, resources, risk, stakeholder engagement, governance, benefits realization and strategic alignment (Agarwal & Kalmar, 2020). These constraints influence decision-making, determine a project's feasibility, and ultimately affect its outcome.

Project constraints are connected. A change in one constraint often impacts the others. For example, increasing the project scope may require more time and higher costs, while cutting costs could compromise quality or resource availability (Ghisetti et

al., 2020). Successful project management demands finding a balance among these constraints to ensure that projects meet both stakeholder expectations and business goals.

Effectively managing project constraints is vital for reaching successful project outcomes and keeping operations running smoothly. When organizations handle these constraints effectively, they can achieve key goals. It improves project predictability by enabling better forecasting of risks, costs, and resource needs. This lowers uncertainties and offers clearer insights for decision-making (Koppenjan & Enserik, 2020). It also improves resource use by making sure financial, human, and material resources are allocated efficiently. This helps prevent teams from becoming overwhelmed and keeps budgets from being exceeded (Agarwal & Kalmar, 2020).

Additionally, effective constraint management ensures project quality and compliance by following industry standards and regulatory requirements, which helps meet stakeholder expectations and reduce potential legal or operational risks (PMI, 2021). Improving stakeholder satisfaction is another key result, as clear communication and alignment between project goals and stakeholder needs build trust and encourage long-term engagement (Ghisetti et al., 2020). Moreover, managing constraints like scope, time, cost, and quality well increases project success rates, enabling them to achieve objectives, align with strategic goals, and deliver measurable benefits (PMI, 2021).

With the rise of AI in project management, constraint management is becoming more proactive and driven by data. AI tools, like predictive analytics, automated risk assessments, and real-time resource optimization, are increasingly used in project management. These tools improve decision-making and lessen the problems that constraints can cause (Agarwal & Kalmar, 2020). These advancements help project managers predict and tackle 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 helps a project stay focused on its original goals, reducing the risk of scope creep. This occurs when extra work is added without changing the budget, timeline, or resources (PMI, 2021). Poor scope management can result in cost overruns, extended timelines, and excessive resource use, ultimately threatening the project's success (Ghisetti et al., 2020). To prevent scope-related problems, it is important to create a clear work breakdown structure (WBS) and involve 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 an important limitation that affects financial viability and resource allocation in a project. One of the most common challenges faced are budget overruns which often arise from inaccurate cost estimation, changes in scope or even external economic factors (PMI; 2021). Cost constraints must be successfully managed, including effective budget forecasting and financial tracking as well as contingency planning (Ghisetti et al., 2020). AI tools have the ability to analyze past expenditure patterns and predict future cost variants enhancing the financial management with cost control (Agarwal & Kalmar, 2020). Organizations that implement strict cost control measures can increase project efficiency and financial sustainability (Koppenjan & Enserik, 2020).

Quality constraints set the performance standards for project deliverables. A project can finish on time and within budget, but it may still be viewed as a failure if it

does not meet quality expectations or industry standards (PMI, 2021). Quality management involves ongoing monitoring, inspections, and following best practices to achieve successful project outcomes (Agarwal & Kalmar, 2020). Poor quality control can lead to unhappy customers, legal issues, and expensive rework (Ghisetti et al., 2020). AI-driven quality management systems are now used more often to track project quality in real-time and ensure it meets specifications (Koppenjan & Enserik, 2020).

Risk constraints refer to potential uncertainties and threats that could disrupt project execution. These risks may be due to economic changes, regulatory modifications, supply chain interruptions or performance mistakes (PMI, 2021). Risk management includes risk identification and assessment, followed by risk mitigation strategy development (Ghisetti et al., 2020). As found in numerous studies, those companies that do not manage risk effectively get caught off guard and forced to deal with unintended situations rushing into their system, like sudden cost inflation (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 improve the use of staff and materials. This ensures that projects progress efficiently (Ghisetti et al., 2020). AI-driven resource management tools support project managers in examining workload distribution, predicting shortages, and scheduling resources automatically (Agarwal & Kalmar, 2020).

Stakeholder constraints come from conflicting interests, communication gaps, and changing expectations among project members. Unsatisfied stakeholders can lead to project delays, pull funding, or create regulatory issues (PMI, 2021). To manage stakeholder constraints, you need to keep engaging with them, communicate openly, and involve 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 limits but do not deliver strategic value or achieve the expected results (PMI, 2021). Good benefits management ensures that project outcomes support business goals and help the organization grow (Agarwal & Kalmar, 2020). AI-driven performance tracking tools are being used more often to monitor post-project benefits and assess their long-term impact (Ghisetti et al., 2020).

Lastly, strategic alignment makes sure that projects support the organization's vision, goals, and long-term objectives. Projects that are not aligned can lead to wasted resources and missed opportunities (PMI, 2021). Organizations that use AI-based project portfolio management tools can prioritize projects that match corporate strategy. This approach maximizes returns and long-term benefits (Agarwal & Kalmar, 2020).

2.7 Overview of Project Manager's Competencies in Project Management

Project manager competencies are the necessary knowledge, skills, and abilities for managing projects well, leading teams, and achieving successful outcomes. These competencies include technical project management skills, leadership traits, and business insight (Project Management Institute [PMI], 2021). A skilled project manager ensures projects are delivered on time, stay within budget, and meet quality standards. They also manage risks and make sure project results support the organization's overall 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's technical and strategic expertise is crucial for the efficient management of planning, scheduling, and execution, thereby minimizing delays and maximizing resource allocation (Agarwal & Kalmar, 2020). Moreover, the implementation of effective risk management strategies, coupled with proactive mitigation measures, diminishes the probability of unforeseen disruptions, which in turn contributes to a more streamlined workflow and improved project results (Ghisetti et al., 2020).

Leadership and communication skills are crucial for boosting team productivity and teamwork. Project managers who are strong in these areas know how to motivate their teams, settle disputes, and encourage collaboration. Those with high emotional intelligence (EI) can grasp team dynamics well, promote knowledge sharing, and keep a positive project atmosphere (Koppenjan & Enserik, 2020). Good leadership also helps diverse teams, especially in remote or cross-functional situations, to work well together and achieve project success (PMI, 2021).

Risk and crisis management are other critical areas where project manager competencies make a difference. A project manager possessing strong risk management capabilities is able to foresee potential risks, institute preemptive measures, and react effectively during periods of crisis. This capacity to navigate uncertainties contributes to more robust and flexible project implementation (Ghisetti et al., 2020). Furthermore, the incorporation of AI-powered risk management instruments can augment a manager's capacity to forecast risks and facilitate informed decision-making through predictive analytics and scenario-based analyses (Agarwal & Kalmar, 2020).

The ability of a project manager to communicate progress, manage expectations, and mitigate conflicts is crucial for stakeholder engagement and client satisfaction. Poor communication or mismatched expectations with stakeholders can cause project delays, changes in scope, 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 important areas where a project manager's skills can greatly influence project success. A skilled project manager uses financial resources wisely, improves workforce productivity, and manages procurement strategies to uphold project quality while keeping costs in check (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 focus on developing skills for project managers see higher project success rates, better cost-effectiveness, and fewer project failures (PMI, 2021). Regular training in leadership, risk management, and technical skills helps project managers stay flexible in the face of changing challenges and shifts in the industry (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 artificial intelligence and automation reshape project management, organizations must prepare their project managers to effectively utilize AI-driven tools, data analytics, and digital transformation methodologies (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).

Developing Leadership skills is critical to developing an engaging stakeholder relationship and enhancing the overall leadership impact. Strong leaders help project managers have everyone on board, build trust, include stakeholders and lead effective teams. Companies focusing on nurturing career leadership skillset for their project managers exhibit higher stakeholders engagement, less conflicts and more involvement in projects (Ghisetti et al., 2020).

Lastly, proper management of competency reduces project failures and uncertainty. Poor project management skills are the leading cause of budget overruns, missed deadlines, and failed projects. Organizations ensure project managers are equipped to address risks, effectively use resources and support post-mortem success (PMI, 2021) by establishing competency frameworks and initiatives focused on continual development. This progressive nurturing of project management capabilities is integral to meeting deadlines while staying within financial constraints and achieving specified outcomes.

2.8 Dimensions of Project Manager's Competencies

Technical Competencies

Technical skills include the specific knowledge, tools, and methods needed to plan, carry out, and monitor projects. These skills are essential for project managers to handle important project aspects like schedules, budgets, resources, risk management, and quality control (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 increasing use of AI in project management has expanded the range of technical skills needed. With AI tools, project managers can predict project timelines more accurately, automate risk assessments, and forecast costs more precisely. This improves the project management process and allows for better, data-driven decision-making (Agarwal & Kalmar, 2020).

Leadership & Behavioral Competencies

Leadership and behavioral skills are essential for managing teams, boosting collaboration, and ensuring good stakeholder engagement in project management. Project managers must inspire trust, communicate well, and resolve conflicts to keep a productive environment throughout the project lifecycle (Ghisetti et al., 2020). These skills are vital for building a harmonious and efficient team dynamic, helping keep the project on track.

Communication and negotiation is one of the core aspect under leadership and behavioral competencies. It builds the foundation for clear project objectives, well-defined stakeholder expectations and appropriate assignation of team responsibilities. "In addition, effective negotiation skills need to be applied while controlling contracts, managing budgets and achieving favorable 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).

Critical leadership skills also include problem-solving and decision-making. AI tools have a lot to offer in terms of the insights they can provide, but decision making ultimately must rely on the judgment, ethical reasoning and context awareness of project managers. Such human capabilities ensure that all decisions adhere to the broader goals and values of the project (Agarwal & Kalmar, 2020) Furthermore, in this age of fast technological developments and shifting market conditions, being adaptable to change becomes a necessary quality for project managers. Their capacity to drive change and adapt to emerging challenges is critical for successful project delivery over the long term (Ghisetti et al., 2020).

Although AI-powered instruments enhance leadership and team capabilities by streamlining administrative duties and facilitating collaboration via chatbots, the significance of human leadership endures. Project managers are indispensable for cultivating trust, mediating conflicts, and fostering team creativity—elements beyond AI's capacity. These human-centric attributes are vital to ensure that AI tools augment, rather than supplant, effective leadership, thereby contributing to the formation of 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. Project managers can effectively align project execution with corporate strategy by understanding these competencies, optimizing resource allocation and success through the system (Koppenjan & Enserik, 2020). They are also critical in ensuring that projects, when they do get executed, produce maximum organizational value.

One important aspect of strategic and business competencies is strategic thinking and vision. Project managers must clearly understand how individual projects fit into the larger business picture and how their outcomes contribute to the organization's growth (PMI, 2021). Financial and resource management is also crucial. Project managers need to handle budgets, procurement processes, and workforce allocation effectively to ensure that projects deliver value while keeping costs in check (Agarwal & Kalmar, 2020). Another key part is managing relationships with stakeholders and clients. Engaging effectively with stakeholders builds trust, sets

expectations, and encourages long-term collaboration, which is vital for ongoing project success (Ghisetti et al., 2020). Lastly, governance and compliance are important. Project managers must ensure that projects meet regulatory requirements, ethical standards, and corporate governance rules. This helps protect the organization from legal and operational risks (Koppenjan & Enserik, 2020).

AI-powered business intelligence tools can help project managers track project performance, measure return on investment (ROI), and find opportunities for strategic improvements. However, even with the advances in AI, human expertise is still vital for interpreting the insights generated by AI and making informed strategic decisions that fit with the organization's goals (PMI, 2021). The mix of AI tools and human judgment creates a balanced method for strategic decision-making and business management during project execution.

CHAPTER 3

PRACTICAL FRAMEWORK

3.1 Introduction

In this chapter, a full description of the research methodology implemented within this study that investigates the mediating effect of project manager's competencies between AI applications and Triple Constraints is provided. These decisions can be well aligned with what was outlined as research problem, objectives of the study and possible hypotheses in Chapter One for methodology, sampling strategy, data collection instrument and statistical analysis tools to help determine meaningful results.

In the first chapter, it was noted that the use of AI technologies in project management processes varies widely among contracting companies, particularly in areas like the Eastern Province of Saudi Arabia. There is also a gap in understanding how project managers' skills affect the effectiveness of AI in addressing project constraints. This chapter presents a framework aimed at exploring these connections and providing evidence.

The chapter is structured as follows: Section 3.2 discusses the research design and reasons behind it. Section 3.3 defines the population and explains the sampling methods. Section 3.4 presents the development and structure of the research tool. Section 3.5 explains the validity and reliability procedures. Section 3.6 outlines the data collection steps. Section 3.7 details the statistical techniques used for data analysis and explains the purpose of each technique. Section 3.8 addresses the ethical considerations related to this study.

3.2 Research Methodology

This section discusses the philosophical basis, method, and specific research strategy used in this study. It aims to clearly explain and justify the research choices made, linking each decision to the study's overall goals, hypotheses, and framework. By outlining the philosophical approach, this section shows the theoretical foundations that guide the research, reflecting the values and beliefs that shape the design and execution of the study.

Additionally, this section explains the chosen methodology, describing how it supports the research questions and matches the study's goals. It also highlights how

the chosen strategy allows the research to produce meaningful, valid, and reliable results that add to the field of knowledge. The aim is to give a clear reason for the research design, ensuring transparency and consistency throughout the study.

3.2.1 Research Philosophy and Paradigm

The study is constructed on a positivist paradigm that implies an objective, measurable and empirical reality exists and can be observed through scientific inquiries. Positivism here assumes that knowledge is based on what is observable and hence the relationships between variables can be quantitatively measured with objectivity. This perspective complements quantitative techniques for studying relationships between variables and for hypothesis testing and statistical analysis.

In this study, which looks at the relationship between AI, project managers' skills, and project constraints, a positivist approach is highly suitable for several reasons. First, it serves as a ground for hypothesis-driven inquiry, allowing the study to test systematically the proposed relationships among the key concepts. Second, the approach is based on objective, numerical data that are collected using a standardised tool so that the findings can be derived from comparable information. Third, positivist methodology advocates replicability and generalizability principles essential to the contribution of a study in ensuring findings are reproducible and generalizable across different contexts [29], especially in management research. These properties justify the utilization of the positivist paradigm as a rich framework for this study. which promises a solid, objective input and claims to render credible and applicable outputs from this research oriented inquiry.

3.2.2 Type of Research Design

The present investigation employs a non-experimental, correlational, and explanatory design to examine the interrelationships among significant variables. The correlational dimension facilitates the examination of associations between diverse variables without necessitating manipulation. This characteristic renders it particularly appropriate for field research conducted within authentic organizational contexts. Through the analysis of these naturally occurring relationships, the study provides valuable perspectives on the interconnectedness of various elements, including the

utilization of artificial intelligence, the competencies of project managers, and project constraints.

In addition to its correlational nature, the explanatory orientation of the study allows it to go a step further by not only identifying these associations but also by seeking to explain the underlying causal pathways. More importantly, this approach can reveal the ways in which project managers competencies may or not mediate the relationship between their AI usage and project constraints. The study provides more than a mere description of relationships by elucidating the mediating effects involved, and therefore presents an - if not the most- important part likely to explain how competencies lead to project outcomes in those settings of AI-driven projects. By adopting a combination of correlational and explanatory design, the current study allows for a thorough exploration of the multitude of factors that contribute to project management effectiveness in an AI-integrated context.

3.2.3 Time Frame and Unit of Analysis

This study uses a cross-sectional time frame, meaning data will be collected at one specific moment instead of over a long period. This approach is effective because of the practical problems associated with field access and driving rapid insights that can feed directly back into management of a project. In focusing on data collected at a single point in time, the research seeks to provide an overview of the status quo regarding AI usage, project manager competencies, and project pain points within their organizations.

The research analyzes individual project management staff members. The key areas of interest AI use, project manager skills, and project challenges are experienced and interpreted on a personal level. This focus allows for a better understanding of how project managers see and use these factors. This in turn ensures that the research captures personal insights and experiences used to identify methods leading to more effective project management within an organization. The attention to those domains at an individual level is expected to shed new light on using AI technology and addressing challenges in project managers day-to-day work.

3.3 Study Population and Sampling

3.3.1 Study Population

The population studied included project management professionals working for large contracting companies. These companies were approved by the Saudi Contractors Authority and operated in the Eastern Province of Saudi Arabia. This specific group was chosen for important strategic reasons, which are explained in the context of the justification presented in Chapter One.

As previously mentioned, the contracting sector in Saudi Arabia is undergoing a profound transformation under the framework of Vision 2030. The Eastern Province, in particular, has become a focal point for large-scale megaprojects, infrastructure development, and industrial expansion. Despite this significance, many companies still face significant challenges in project delivery, especially in terms of time, cost, scope, and risk management. While integrating AI into project management is still a work in progress, how well project managers adopt and use these tools is a key factor in deciding whether projects succeed or fail.

Therefore, focusing on this population provides both practical value and theoretical insight. On a practical level, the findings can contribute to real-world improvements in organizational practices and project management strategies. Theoretically, the study fills a gap in the literature by expanding the empirical research on AI utilization and managerial competencies into a regional context that has not been extensively studied, thereby offering a unique perspective on AI's role in the Saudi contracting sector.

3.3.2 Sampling Frame and Criteria

According to Monsha'at, a division of the Saudi Ministry of Commerce, companies in Saudi Arabia are classified into four categories based on the number of full-time employees. Micro companies are defined as those with 1 to 5 employees; small companies employ 6 to 49 individuals; medium companies have between 50 and 249 employees; and large companies employ 250 or more individuals (Monsha'at, n.d.). The sampling frame for this study includes all large contracting companies in Saudi Arabia's Eastern Province that meet these criteria: they are registered with the Saudi Contractors Authority (SCA), have dedicated project management departments or

units, and employ qualified people in decision-making or operational roles related to project delivery.

Participants will be chosen from these organizations based on their involvement in managing, coordinating, or supporting project operations. This includes project managers, project engineers, planning and scheduling staff, and other professionals in similar roles. Based on these criteria, a total of 79 companies form the population for this study (Muqawil, n.d.).

3.3.3 Sampling Technique

For this study, a probability sampling method will be employed paying special attention to stratified random sampling as the preferred technique whenever feasible. This method ensures that different sub-segments of the population, like sizes of the company in "large" and types of projects and geographic locations in Eastern Province. If access to certain companies is limited, a simple random sampling method will be used among organizations that agree to participate. This will keep the sample valid while reducing selection bias.

3.3.4 Sample Size Determination

To determine the required sample size, the following Yamane (1967) formula for finite populations will be applied:

$$n = \frac{N}{1 + N (e)^2}$$

Where:

- n = Sample size
- N = Total population (estimated number of eligible employees)
- e = Margin of error (commonly set at 0.05 for 95% confidence)

Upon validation of the estimated total population (N) via the Saudi Contractors Authority database or through collaboration with the relevant companies, the sample size will be determined with precision, employing the Yamane formula. This methodology is designed to guarantee that the study possesses adequate statistical power for the effective testing of its hypotheses. Specifically, in the context of structural

equation modeling (SEM), which necessitates larger sample sizes to generate dependable and robust estimates, the calculated sample size will be crucial in ensuring the statistical significance and generalizability of the findings within the defined population.

3.3.5 Sample Size Justification for SEM

Since one of the primary analytical techniques in this study is Path Analysis using Structural Equation Modeling (SEM), the sample size needs to fulfill the minimum requirements for model complexity. Hair et al. (2017) suggest that for models with moderate complexity—comprising 3 to 5 latent variables, each with several indicators—a sample size of 200 to 300 respondents is typically considered sufficient, provided that the data quality is high. Therefore, this study aims to meet or exceed this threshold to ensure the reliability and robustness of the SEM analysis.

3.4 Instrumentation: Questionnaire Design and Development

3.4.1 Overview of Instrument Design

One of the most important aspects of designing a questionnaire is that it determines the reliability and precision of your data. Brace (2004) reminds us that a well-structured questionnaire should correlate with the research objectives and be developed to reduce errors as much as possible while acquiring authentic responses. To accomplish this, you have to carefully plan types of questions, the order, and how each question is phrased for clarity and to keep respondents engaged. Furthermore, the design should take into account the perspectives and needs of all stakeholders involved: respondents, interviewers and data analysts. A great questionnaire is, essentially, a directed conversation that allows us to collect direct, unbiased information that will help us achieve our research goals.

A structured questionnaire is the primary data collection tool of this study which has been painstakingly prepared to elicit broad, valid and reliable data that genuinely reflects the conceptual variables under investigation. The structure of the questionnaire is mapped directly to the conceptual model and theoretical framework discussed in Chapter 1 and Chapter 2, respectively. The operationalization uses the three main constructs of AI Usage, Project Manager's Competencies and Project Constraints and ensures that they can be measured using relevant dimensions and indicators for data analysis.

A 5-point Likert scale was used for all items relating to the constructs, with responses ranging from (1) Strongly Disagree to (5) Strongly Agree. The five-point Likert scale is used extensively in academic research to measure attitudes, perceptions and behaviours based on self-reports because we want the measurement of these variables to be consistent and reliable.

3.4.2 Questionnaire Structure

Based on the 5 research hypotheses that are:

H1: There is a significant relationship between the use of AI, Project Constraints, and Project Managers' Competencies.

H2: There is a positive impact of using AI on Project Managers' Competencies.

H3: There is a positive impact of using AI on Project Constraints.

H4: There is a positive impact of Project Managers' Competencies on Project Constraints.

H5: The significant impact of using artificial intelligence on project constraints increases when mediated by project managers' competencies.

The questionnaire is structured into four distinct sections, each organized in a logical sequence to ensure clarity and coherence in data collection. These sections are as follows:

Section A: Demographic and Organizational Information

This section gathers key background information to facilitate segmentation and enable comparative analysis. The variables covered include:

- Gender
- Age group
- Educational qualification
- Years of experience in project management
- Position or role

This data allows for descriptive profiling, comparison of groups using statistical tests (such as t-tests and ANOVA), and provides the context necessary to interpret the findings effectively.

Section B: Artificial Intelligence Usage

This section aims to evaluate the degree to which AI tools are adopted and integrated into project management activities. It includes 7 dimensions, each assessed through 3 to 5 items:

- Machine Learning (ML)
- Natural Language Processing (NLP)
- Chatbots and Visual Assistants
- Predictive Analytics
- Robotic Process Automation (RPA)
- Data Visualization Tools
- Decision Support Systems (DSS)

Each item in this section captures either the actual use or the perceived usefulness of AI tools within the project management context.

Section C: Project Manager's Competencies

This section focuses on the mediating variable of the study, which is based on internationally recognized competency frameworks (e.g., IPMA, PMI). The construct is operationalized into three key competency clusters:

Technical Competencies – e.g., planning, budgeting, software usage

Leadership and Behavioral Competencies – e.g., communication, team management

Strategic and Business Competencies – e.g., understanding of organizational strategy, business acumen

Each cluster includes specific indicators designed to assess perceived proficiency and effectiveness within the context of project management roles. These indicators provide a comprehensive measure of the competencies required to effectively navigate the complexities of AI integration and project constraints.

Section D: Project Constraints

This section looks at the dependent variable by examining how well projects meet the established constraints. The 10 dimensions, drawn from both traditional and modern project management theories, cover key factors that affect project performance. These dimensions are scope, time, cost, quality, risk, resources, stakeholder engagement, governance, benefits realization, and strategic alignment. Each dimension aims to evaluate the critical aspects of project constraints, offering an overview of how well projects stick to their defined boundaries and objectives.

Participants will be asked to share their views on how effectively these constraints are managed in their projects. Their feedback will give valuable insights into the effectiveness of project management practices and how various constraints influence project success. This assessment will help identify where project managers may struggle and where improvements can be made to better achieve project objectives.

3.4.3 Questionnaire Structure

Sections B (AI Usage), C (Project Manager's Competencies) and D (Project Constraints) items were tailored from existing validated instruments used in previous peer-reviewed studies and professional standards. Measurement items of the remaining scales found in literature relevant to the current study were reviewed; then, they were modified as necessary to fit large contracting companies operating in the Eastern Province of Saudi Arabia. This also ensures that the items accurately capture the particular conditions and challenges these organizations are working with while preserving conceptual integrity of origin instruments.

Technical terminology underwent linguistic and contextual modifications to align with prevailing local industry standards, while preserving its inherent meaning. As an illustration, terminology pertaining to artificial intelligence was revised to specify the particular tools and technologies currently utilized within Saudi project management contexts. This approach facilitated the relevance of the local language while simultaneously upholding the conceptual integrity.

Before full deployment, the questionnaire will undergo several testing phases:

- **Face validity testing:** To evaluate the clarity, wording, and overall comprehension of the questions.

- **Content validity review:** Conducted by a panel of academic and industry experts to ensure that the instrument adequately covers all relevant constructs.
- **Pilot testing:** A trial run with 20–30 project management professionals to assess the timing, consistency, and initial reliability of the questionnaire.

3.4.4 Language and Format

The questionnaire will first be developed in English because it is the main language used in most corporate project environments in Saudi Arabia. If needed, an Arabic version will be created to ensure that the meaning stays consistent in both versions. The survey will be conducted online, using secure platforms to make access easy, track responses, and manage data efficiently..

3.5 Validity and Reliability Testing

The credibility and accuracy of any quantitative study depend on the validity and reliability of its research instrument. This study will use several strong methods to confirm that the questionnaire accurately measures the intended concepts. Additionally, these methods will ensure that the instrument consistently produces reliable results, regardless of the participants or the specific situation.

3.5.1 Content Validity

Content validity assesses how well the items in a measurement tool represent the entire scope of the concept being measured. To ensure this, the initial questionnaire will be reviewed by a panel of experts in project management, artificial intelligence, and academic research methods. These experts will evaluate the relevance, clarity, thoroughness, and wording of each question. Based on their feedback, changes will be made. This may include rewording, adding, or removing items to better fit theoretical frameworks and practical uses. This step is especially crucial for the AI-related areas, as they change quickly and need to accurately reflect the latest industry practices and technologies.

3.5.2 Face Validity

The Face validity is a high-level confirmation that its items of the questionnaire should seem to assess what they need, in terms of the means that respondents see them. To accomplish this, a small pilot group of 10 to 15 project management professionals will be used to review the questionnaire. They will evaluate the ease of understanding, moat

to your culture, and sequence of the questions. The responses gathered will be used to answer any potential confusion or bias and ensure that the tool is user-friendly and accessible. Although face validity is not a statistical test per se, it has a major role in making the questionnaire more effective and accessible to enhance better response rate and accuracy.

3.5.3 Construct Validity – Confirmatory Factor Analysis (CFA)

To assess construct validity, the study will use Confirmatory Factor Analysis (CFA) with AMOS software or R (lavaan package). This method allows for the statistical confirmation that each item (indicator) is significantly linked to its intended latent construct (e.g., Machine Learning items load on AI usage). The measurement model will be evaluated using several fit indices to ensure it meets acceptable standards, including:

- CFI (Comparative Fit Index) ≥ 0.90
- RMSEA (Root Mean Square Error of Approximation) ≤ 0.08
- Chi-square/df ratio ≤ 3.0

CFA will also check convergent validity, which means that items measuring the same idea are closely linked. It will also look at discriminant validity, which verifies that the ideas are different from each other. This process improves the reliability and strength of the measurement model.

3.5.4 Reliability – Internal Consistency

To measure the reliability of each construct, we will calculate Cronbach's Alpha using SPSS. Constructs with alpha values of 0.70 or higher will be considered acceptable since this level shows enough internal consistency. If any construct shows weak reliability, we will identify problematic items and revise or remove them based on item-total correlations and alpha-if-item-deleted metrics. We will conduct this reliability testing for all AI sub-dimensions, competency clusters, and each project constraint dimension to ensure that the measures consistently reflect the intended constructs across respondents.

3.5.5 Pilot Testing

A pilot test will take place before the main data collection. It will involve 20 to 30 respondents from the target population who will not be included in the final sample. The goals of this pilot test are to check the response time and usability of the electronic questionnaire, confirm that data is captured and exported correctly, calculate preliminary Cronbach's Alpha values for each dimension, and uncover any logistical or technical problems that may arise during data collection. The feedback and initial results from the pilot will inform any needed changes to the questionnaire and data collection procedures before the full study is implemented.

3.6 Data Collection Procedures

One of the most important phases in order to improve integrity completeness and ethical soundness of study is data collection phase. This section details the questionnaire's administration, encompassing participant access and the procedural safeguards implemented during data collection. It elucidates the systematic and ethical approach to data acquisition, specifying the measures taken to uphold participants' rights and the organizational structure of the data collection process. Consequently, these protocols ensure the precision, reliability, and alignment of the acquired data with the research objectives.

3.6.1 Preparation Phase

Prior to launching into data collection, several steps will be completed in preparation for complete and thorough study execution. These consist of refining the questionnaire using suggestions from experts and findings from pilot testing. This questionnaire will then be translated into an electronic format, using tools like Google Forms, Qualtrics or SurveyMonkey that are secured and easy to use for our implementing sites. A formal cover letter will be prepared that specifies the full target of the study, duration, confidentiality measures taken to keep participants data confidential and an informed consent statement so participants know their rights and what they are partaking in. Formal approval will be sought from the institution of development, and any company representatives or ethics boards required by your local area.

3.6.2 Targeting and Access

According to section 3.3, the survey target respondents will be project management professionals employed in major classified contracting companies located in Eastern

Province of Saudi Arabia. The following steps will be taken to improve access to this population:

- Corporate offices of these companies will be contacted in the first instance to obtain permission and access for distribution of the survey to relevant project management personnel.
- Internal PMOs, HRs, or department heads will coordinate to facilitate the dissemination and collection of the surveys.
- Where central distribution channels do not exist, potential respondents will be reached directly through professional networks, industry-specific groups and online project management communities to encourage wide engagement

3.6.3 Distribution Process

The survey will be shared with you through a secure online link, and the following procedures will be in place to facilitate an easy and ethical approach to data collection:

- Formal invitations will be communicated through email or official places. This message will contain the following information:
 - The purpose of the study
 - The estimated time required to complete the survey (10–15 minutes)
 - Guarantees of confidentiality and data privacy
 - A statement confirming voluntary participation
 - Contact details of the researcher if subjects have any questions or concerns
- Respondents will have the flexibility to access the survey via desktop or mobile device, completing the questionnaire at their convenience.
- The system will be configured so that each voter can only cast a vote – either by limiting based on an I.P. address or requiring log in credentials, depending on the platform used. This will ensure the data stays in order, and duplicate submissions don't occur.

3.6.4 Data Monitoring and Follow-up

During the data collection period, which is expected to last between 4 and 6 weeks, the researcher will actively manage and monitor the process to ensure smooth and effective data gathering. The specific actions include:

- Monitoring response rates daily to track progress and spot any potential issues early.
- Sending reminder messages after one week and again after two weeks to encourage participation and improve response rates.
- Identifying and fixing any technical or access-related problems that may come up, making sure all participants can complete the survey easily.
- Logging any irregularities or incidents that happen during the data collection process for transparency and to keep a clear record of the data collection activities.

3.6.5 Data Cleaning and Preparation

Data will go through a series of steps to ensure that it is clean and ready for analysis after the data collection period is completed. These steps include::

- **Preliminary Check:** The data will be assessed for comprehensiveness, identifying missing or repeating respondents. This will help to make sure only valid entries are considered in the analysis.
- **Coding and Labeling:** Data will be coded and labeled in SPSS for consistency. Easier to analyze this way.
- **Addressing Missing Data:** Standard approaches for managing missing data, such as listwise deletion or imputation, will be applied based on the degree and nature of missingness. To sustain the dataset it is required.
- **Initial Frequency Checks:** You will perform checks to ensure that outliers or errors are addressed for further analysis.

These steps are a necessary prerequisite for a comprehensive statistical analysis of the dataset, covered in the next section.

3.7 Data Analysis Techniques

This section gives an overview of the statistical methods that will be used to analyze the data collected from the structured questionnaire. Each method was chosen to support the research goals and hypotheses presented in Chapter One. The selected techniques follow established best practices in quantitative data analysis, as advised by respected scholars in the field. These methods will allow for a detailed examination of how the variables are related. As a result, they will help answer the study's research questions and effectively test the proposed hypotheses.

3.7.1 Descriptive Statistics

Purpose:

The purpose of this analysis is to summarize and describe the basic characteristics of the sample and the collected data. This step will provide a clear understanding of the demographic and professional profile of the respondents, as well as offer an initial overview of the key study variables.

Methods:

For categorical variables, such as gender, education level, and years of experience, we will use frequencies and percentages to give an overview of the sample's distribution. For continuous variables, including AI usage scores, competency ratings, and project constraints, we will calculate means and standard deviations to summarize the data's central tendency and variability. This descriptive analysis will provide the basis for the next inferential statistical techniques.

Justification:

Descriptive statistics provide important insights into the respondents' profiles and the distribution of key variables. By summarizing the data on central tendency, variability, and frequency, these statistics help in understanding the findings more clearly. This basic understanding is crucial because it allows for meaningful comparisons and sets the stage for further analysis in the next stages of the study.

3.7.2 Reliability Analysis – Cronbach's Alpha

Purpose:

The purpose of this analysis is to evaluate the internal consistency of each construct in

the questionnaire to ensure that the items within each construct are reliably measuring the same underlying concept.

Methods:

Cronbach's Alpha coefficients will be calculated for each subscale, such as Machine Learning (ML), Natural Language Processing (NLP), Technical Competencies, and Project Schedule, among others. An acceptable threshold for Cronbach's Alpha is considered to be ≥ 0.70 , which indicates satisfactory internal consistency. Values below this threshold may prompt further investigation and revision of the respective items in the subscale.

Justification:

This ensures that the items within each construct are consistently measuring the same underlying concept, which is essential for maintaining the reliability and validity of the inferential statistics used in the study.

3.7.3 Confirmatory Factor Analysis (CFA)

Purpose:

To validate the dimensional structure of the measurement model and confirm construct validity.

Methods:

- It will be conducted using AMOS or R (lavaan) software.
- The model fit will be assessed using fit indices such as:
 - Chi-square/df ratio
 - RMSEA (≤ 0.08)
 - CFI (≥ 0.90)
 - TLI (≥ 0.90)
- Convergent validity will be evaluated, for example, using Average Variance Extracted (AVE), and discriminant validity will be assessed to ensure constructs are distinct from one another.

Justification:

Confirmatory Factor Analysis (CFA) verifies whether the observed variables accurately represent their corresponding latent constructs, which is a crucial step before proceeding with structural modeling.

3.7.4 Correlation Analysis**Purpose:**

To examine the strength and direction of linear relationships between the three main constructs.

Methods:

- Pearson's correlation coefficient (r)

Justification:

It provides initial insight into the associations among AI usage, project manager competencies, and project constraints, which guides the interpretation of SEM outcomes.

3.7.5 Structural Equation Modeling (SEM)**Purpose:**

To test the proposed causal relationships among the variables and evaluate the model.

Methods:

- Full SEM using AMOS or R (lavaan)
- Assessment of direct, indirect, and total effects
- Examination of model fit indices

Justification:

SEM allows for the simultaneous testing of multiple dependent relationships, making it ideal for models involving mediators like project manager competencies.

3.7.6 Mediation Analysis

Purpose:

To determine whether project manager competencies mediate the relationship between AI usage and project constraints.

Methods:

- **Bootstrapping method** (recommended for mediation in SEM)

Justification:

This test directly addresses Hypothesis H5 in the study and provides insights into how and why AI affects project outcomes through managerial capabilities.

3.7.7 Multiple Regression Analysis

Purpose:

To assess the predictive power of specific AI dimensions and competency factors on project constraints.

Methods:

- Hierarchical or stepwise regression models
- Assessment of standardized beta coefficients, R^2 values, and significance levels

Justification:

Complements SEM by showing which variables most strongly predict project constraints and helps validate theoretical assumptions with empirical data.

3.8 Ethical Considerations

The study adheres to the ethical standards set forth for academic research involving human participants. Upholding ethical responsibility is not just a regulatory necessity, but also an essential aspect of maintaining research integrity and fostering trust among participants. The following sections detail the primary ethical principles and procedures that will be followed throughout the study's design, data collection, analysis, and dissemination stages. These measures ensure that the study is conducted with the highest regard for the rights, privacy, and well-being of the participants.

3.8.1 Informed Consent

An informed consent statement that explains:

- The purpose of the study
- That responses will be kept anonymous and confidential
- That data will be used solely for academic purposes

3.8.2 Anonymity and Confidentiality

To protect participants' identities:

- No names, email addresses, or other personally identifiable information will be collected.
- All responses will be aggregated and analyzed at the group level.
- Data will be stored securely on a password-protected device accessible only to the researcher.
- In reporting findings, no data will be attributed to specific individuals or companies.

3.8.3 Voluntary Participation

Participation in the study will be strictly voluntary. No form of coercion, reward, or penalty will be associated with responding or choosing not to respond. Participants may opt out at any stage of the survey without consequence.

3.8.4 Institutional and Organizational Approval

Formal approval for conducting this study will be sought from:

- The academic research committee or ethics board at Midocean University
- Relevant stakeholders at the participating contracting companies, where applicable

Written permissions will be documented and archived for accountability.

3.8.5 Data Usage and Retention

The collected data will be:

- Used solely for this PhD research
- Stored securely for a limited retention period (e.g., 3–5 years)

- Deleted or anonymized permanently upon the expiration of the retention period, unless further use is approved

3.8.6 Transparency and Researcher Integrity

The researcher pledges to:

- Present findings honestly and transparently
- Avoid data manipulation or misrepresentation
- Disclose any potential conflicts of interest, though none are anticipated

These ethical safeguards are designed to protect participant rights and enhance the credibility and academic rigor of the research.

3.9 Questionnaire

Section A: Demographic Information

1- **Gender**

☐ Male ☐ Female

2- **Age Group**

☐ Under 25 ☐ 25–34 ☐ 35–44 ☐ 45–54 ☐ 55+

3- **Educational Qualification**

☐ Diploma ☐ Bachelor ☐ Master ☐ PhD ☐ Other: _____

4- **Job Title**

☐ Project Manager ☐ Site Engineer ☐ Coordinator ☐ Consultant ☐ Other:

5- **Years of Experience in Project Management**

☐ Less than 3 years ☐ 3–5 years ☐ 6–10 years ☐ More than 10 years

Scale Used (Sections B, C, D):

1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Section B: Artificial Intelligence Usage in Project Management

Machine Learning (ML)

- 1- Our project team uses machine learning models to identify patterns in past project data.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2- ML tools assist us in resource allocation decisions.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3- We use ML to predict project risks and delays.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

4- ML models are integrated into our project forecasting tools.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Natural Language Processing (NLP)

5- NLP tools are used to analyze project documents and communications.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

6- NLP helps summarize reports and technical documentation.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

7- We use voice-to-text or sentiment analysis features in project tools.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

8- NLP applications help us extract key information from contracts.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Chatbots and Visual Assistants

9- AI-powered assistants provide real-time support to project team members.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

10- Chatbots are used to answer standard project queries.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

11- AI assistants help guide project workflows and reminders.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

12- These assistants reduce the time spent on repetitive tasks.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Predictive Analytics

13- Predictive analytics tools are used to estimate project completion timelines.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

14- We use prediction models to evaluate cost overruns.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

15- Our project decisions are influenced by predictive analysis results.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

16- Predictive tools help us anticipate potential quality issues.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Robotic Process Automation (RPA)

17- RPA is used to automate administrative project tasks.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

18- Our team uses bots to generate reports automatically.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

19- RPA minimizes errors in document processing.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

20- Project communication is improved through automation.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Data Visualization Tools

21- Dashboards provide real-time project insights.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

22- Visual analytics help us detect trends and anomalies.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

23- Data visualization tools enhance stakeholder communication.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

24- We rely on visual reports for decision-making in project meetings

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Decision Support Systems (DSS)

25- DSS tools assist in selecting among project alternatives.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

26- These systems support data-driven decision-making.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

27- DSS integrates multiple data sources for better insights.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

28- Our DSS tools are regularly updated with new data inputs.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Section C: Project Manager's Competencies

Technical Competencies

29- I am proficient in using project management software tools (e.g., MS Project, Primavera).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

30- I have a strong understanding of project planning and scheduling techniques.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

31- I can effectively manage project budgets and cost estimations.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

32- I possess technical knowledge relevant to the nature of my projects.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

33- I ensure the application of standards and best practices in project execution.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Leadership and Behavioral Competencies

34- I can effectively lead cross-functional project teams.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

35- I communicate clearly and proactively with all stakeholders.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

36- I resolve conflicts in a constructive and timely manner.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

37- I motivate team members to achieve project objectives.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

38- I demonstrate resilience and adaptability in dynamic project environments.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Strategic and Business Competencies

39- I align project objectives with organizational strategy.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

40- I understand the business impact of project decisions.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

41- I analyze project performance in terms of benefits realization.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

42- I contribute to strategic planning in my organization.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

43- I evaluate risks and opportunities from a strategic perspective.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Section D: Project Constraints

Scope

44- Project scope is clearly defined and managed throughout execution.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

45- Scope changes are systematically evaluated and controlled.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

46- Stakeholders have a common understanding of the project scope.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Schedule

47- Projects are usually completed within the scheduled timeline.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

48- Time estimates are realistic and based on historical data.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

49- Schedule delays are managed through proactive planning.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Cost

50- Project budgets are well estimated and managed.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

51- We frequently monitor actual versus planned costs.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

52- Projects are typically completed within the allocated budget.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Quality

53- Quality standards are clearly defined at the project's start.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

54- Deliverables meet required specifications and customer expectations.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

55- Quality reviews are regularly conducted during project execution

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Risk

56- Project risks are identified and assessed early in the project.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

57- Risk response strategies are developed and implemented.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

58- Risk monitoring is an ongoing part of project control.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Resources

59- Projects are adequately staffed with the required competencies.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

60- Resource allocation is optimized across projects.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

61- We have access to the necessary tools, equipment, and infrastructure.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Stakeholders

62- Stakeholder needs and expectations are clearly identified.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

63- Stakeholders are engaged throughout the project lifecycle.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

64- Feedback from stakeholders is used to improve performance.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Governance

65- Projects are guided by a defined governance framework.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

66- Roles and responsibilities are clear across all levels.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

67- Decisions are taken based on structured escalation procedures.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Benefits

68- Project outcomes align with expected organizational benefits.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

69- Benefits realization is tracked beyond project closure.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

70- Project success is evaluated in terms of both output and outcomes.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Strategic Alignment

71- Projects contribute to the strategic goals of the organization.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

72- Project selection is aligned with strategic priorities.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

73- Performance indicators reflect strategic objectives

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

CHAPTER 4

RESULTS AND TESTING OF HYPOTHESIS

4.1 Introduction

This chapter presents the analysis of the data that were collected through the survey which was sent to 79 large scale contracting companies in the eastern province of Saudi Arabia to examine the role of the project manager competencies in the relationship between the use of AI and project constraints. The participants in this study were all employees that are working in the project management field with good experience.

The focus of the study is on the 3 variables with their dimensions. The first variable is AI and its use in the field of project management including the previously identified dimensions of AI that are Machine Learning, Natural Language Processing, Chatbots and Visual Assistants, Predictive Analytics, Robotic Process Automation, Data Visualization Tools, and Decision Support Systems. The second variable is project manager competencies which include Technical Skills, Leadership, and Behavioral Qualities. The third variable is project constraints which include Scope, Time, Cost, Quality, Risk, Resources, Stakeholder involvement, Governance, benefits Realization, and Strategic Alignment. The assessment of these variables and their dimensions was conducted through a questionnaire that has 73 questions.

As per the planned methodology, several statistical techniques were utilized in order to analyze the collected data. These techniques include descriptive statistics, correlation test, Confirmatory Factor Analysis (CFA), Reliability Analysis, Structural Equation Modeling (SEM), mediation analysis using bootstrapping. There are other tests that are included like T-tests, ANOVA, and Multiple regression.

The chapter provides an explanation of the sampling process and response rate, includes a description of the participants, presents the results of the data analysis, tests them against the research hypotheses, and concludes with a summary of the key findings.

4.2 Response Rate and Sampling Justification

The population of the study consist of 2,890 person that are considered professionals in project management field working in 79 large scale contracting companies located in the Eastern Province of Saudi Arabia. The classification of the 79 companies is identified as per the standard of the Saudi Contractors Authority (SCA).

In order to determine the sample size, Yamane's (1967) formula for finite populations was applied using a confidence level of 95% and a margin error of 5%

$$n = \frac{N}{1 + N (e)^2}$$

Where:

n = Required sample size

N = Total population = 2,890

e = Margin of error = 0.05

Therefore, n = 351

The total number of participants that completed the survey was 400. However, to stay aligned with the required sample size and ensure the results remain balanced and without any bias, only the first 351 responses were selected and included in the statistical analysis.

4.3 Statistical Analysis

4.3.1 Reliability and validity of the Instrument

Both reliability and validity are fundamental measures used to make a trustworthy judgment about the appropriateness of a research instrument ,Reliability refers to the extent to which an instrument can produce consistent and error-free results when re-administered or used under similar conditions, whereas validity refers to the degree to which the instrument accurately measures what it is intended to measure — that is, the degree of correspondence between the theoretical construct and the actual indicators.

Among the most common methods for measuring internal consistency, Cronbach's Alpha is one of the most widely used indicators, as it expresses the degree of interrelation among items measuring the same conceptual dimension. The higher the value of Cronbach's Alpha

(usually ≥ 0.70), the greater the indication that the items consistently measure the same construct.

In addition, the validity coefficient is an important statistical indicator used to estimate the accuracy of the research instrument in measuring the intended construct. This coefficient is often calculated using the Pearson Correlation Coefficient, which measures the degree of the linear relationship between the total score of the instrument and the score of each item, or between two tests assumed to measure the same conceptual dimension.

According to Phelan et al. (2005), reliability refers to the degree to which an assessment tool produces stable and consistent results, while validity refers to how well a test measures what it is intended to measure.

To ensure the validity and reliability of the data in this research, the questionnaires were designed to represent every aspect of the study objectives.

4.3.1.1 Reliability and validity for Independent Variables (Using Artificial Intelligence)

Variables	Validity coefficient (Pearson Correlation Coefficient)	Stability Coefficient (Cronbach alpha)	
ML1	0.907**	0.899	0.946
ML2	0.756**		
ML3	0.931**		
ML4	0.909**		
Machine Learning (ML)	0.679**		
NLP1	0.804**	0.882	
NLP2	0.805**		
NLP3	0.876**		
NLP4	0.963**		
Natural Language Processing (NLP)	0.884**		
CV1	0.892**	0.884	
CV2	0.759**		
CV3	0.888**		
CV4	0.902**		
Chatbots and Visual Assistants	0.760**		
PA1	0.908**	0.949	
PA2	0.961**		
PA3	0.918**		
PA4	0.944**		
Predictive Analytics	0.765**		
RPA1	0.789**	0.865	
RPA2	0.727**		

Variables	Validity coefficient (Pearson Correlation Coefficient)	Stability Coefficient (Cronbach alpha)	
RPA3	0.944**		
RPA4	0.914**		
Robotic Process Automation	0.579**		
DV1	0.971**	0.969	
DV2	0.938**		
DV3	0.968**		
DV4	0.947**		
Data Visualization Tools	0.618**		
DSS1	0.874**	0.885	
DSS2	0.939**		
DSS3	0.905**		
DSS4	0.763**		
Decision Support Systems	0.759**		

Table (4-1) Validity and stability coefficients for the study questionnaire variables

** A function at the level of significance less than (0.01)

The table presents the validity coefficients (Pearson Correlation Coefficients) and reliability coefficients (Cronbach's Alpha) for the questionnaire items and variables. It is evident that all values fall within statistically acceptable ranges, reflecting a high level of quality in the construction of the measurement instrument.

- **Validity Coefficients (Pearson Correlation Coefficient)**

The validity coefficients for all items indicate strong and statistically significant correlations at the 0.01 level with their corresponding variables, with correlation values ranging from 0.579 to 0.971. These high values suggest that the items effectively measure the same concept associated with their respective dimension. Such findings represent an important indicator of validity, supporting the appropriateness of using these items to measure the study variables.

- **Reliability Coefficients (Cronbach's Alpha)**

Cronbach's Alpha values for the main variables were remarkably high, ranging from 0.865 to 0.969. These values exceed the widely accepted minimum threshold of 0.70, "The overall Cronbach's Alpha value for the scale reached (0.946), which is higher than the acceptable threshold of 0.70, indicating that the scale demonstrates a high level of reliability."

4.3.1.2 Reliability and validity for Mediating Variables (Project Manager's Competencies)

Variables	Validity coefficient (Pearson Correlation Coefficient)	Stability Coefficient (Cronbach alpha)	
TC1	0.801**	0.900	0.967
TC2	0.894**		
TC3	0.880**		
TC4	0.885**		
TC5	0.791**		
Technical Competencies	0.863**		
LB1	0.947**	0.969	
LB2	0.979**		
LB3	0.939**		
LB4	0.973**		
LB5	0.884**		
Leadership & Behavioral	0.963**		
SB1	0.964**	0.959	
SB2	0.951**		
SB3	0.965**		
SB4	0.906**		
SB5	0.868**		
Strategic and Business	0.926**		

Table (4-2) Validity and stability coefficients for the study questionnaire variables.

** A function at the level of significance less than (0.01)

The table presents the validity coefficients (Pearson Correlation Coefficients) and reliability coefficients (Cronbach's Alpha) for the questionnaire items and variables. It is evident that all values fall within statistically acceptable ranges, reflecting a high level of quality in the construction of the measurement instrument.

- **Validity Coefficients (Pearson Correlation Coefficient)**

The validity coefficients for all items indicate strong and statistically significant correlations at the 0.01 level with their corresponding variables, with correlation values ranging from 0.791 to 0.979. These high values suggest that the items effectively measure the same concept associated with their respective dimension. Such findings represent an important indicator of validity, supporting the appropriateness of using these items to measure the study variables.

- **Reliability Coefficients (Cronbach's Alpha)**

Cronbach's Alpha values for the main variables were remarkably high, ranging from 0.900 to 0.969. These values exceed the widely accepted minimum threshold of 0.70, "The overall Cronbach's Alpha value for the scale reached (0.967), which is higher than

the acceptable threshold of 0.70, indicating that the scale demonstrates a high level of reliability.

4.3.1.3 Reliability and validity for Dependent Variables (Project Constraints)

Variables	Validity coefficient (Pearson Correlation Coefficient)	Stability Coefficient (Cronbach alpha)	
Scope1	0.891**	0.773	0.981
Scope2	0.875**		
Scope3	0.759**		
Scope	0.917**		
Schedule1	0.896**	0.865	
Schedule2	0.928**		
Schedule3	0.842**		
Schedule	0.916**		
Cost1	0.925**	0.911	
Cost2	0.950**		
Cost3	0.899**		
Cost	0.942**		
Quality1	0.942**	0.872	
Quality2	0.870**		
Quality3	0.880**		
Quality	0.888**		
Risk1	0.793**	0.723	
Risk2	0.842**		
Risk3	0.670**		
Risk	0.786**		
Resources1	0.949**	0.957	
Resources2	0.976**		
Resources3	0.954**		
Resources	0.876**		
Stakeholders1	0.887**	0.897	
Stakeholders2	0.907**		
Stakeholders3	0.949**		
Stakeholders	0.963**		
Governance1	0.906**	0.891	
Governance2	0.878**		
Governance3	0.946**		
Governance	0.925**		
Benefits1	0.863**	0.898	
Benefits2	0.935**		
Benefits3	0.935**		
Benefits	0.930**		
StrategicAlignment1	0.947**	0.902	
StrategicAlignment2	0.878**		
StrategicAlignment3	0.919**		
Strategic Alignment	0.859**		

Table (4-3) Validity and stability coefficients for the study questionnaire variables.

** A function at the level of significance less than (0.01)

The table presents the validity coefficients (Pearson Correlation Coefficients) and reliability coefficients (Cronbach's Alpha) for the questionnaire items and variables. It is evident that all values fall within statistically acceptable ranges, reflecting a high level of quality in the construction of the measurement instrument.

- **Validity Coefficients (Pearson Correlation Coefficient)**

The validity coefficients for all items indicate strong and statistically significant correlations at the 0.01 level with their corresponding variables, with correlation values ranging from 0.670 to 0.976. These high values suggest that the items effectively measure the same concept associated with their respective dimension. Such findings represent an important indicator of validity, supporting the appropriateness of using these items to measure the study variables.

- **Reliability Coefficients (Cronbach's Alpha)**

Cronbach's Alpha values for the main variables were remarkably high, ranging from 0.723 to 0.957. These values exceed the widely accepted minimum threshold of 0.70, "The overall Cronbach's Alpha value for the scale reached (0.981), which is higher than the acceptable threshold of 0.70, indicating that the scale demonstrates a high level of reliability."

4.3.2 Respondents' Demographic Information

Table (4-4) shows the Descriptive Analysis of demographic characteristics of the Study sample regarding the respondents' Gender.

Category		Freq.	Percent
Gender	Male	337	96.00
	Female	14	4.00
Total		351	100.00

Table (4-4) Descriptive Analysis of Demographic Characteristics of the Study Sample (Gender)

The table presents the characteristics of the study sample, revealing that:

- Regarding the Gender of the study sample, it was found that Male were slightly more represented, with a percentage of 96.00%, comprising 337 respondents, while Female represented 4.00%, comprising 14 respondents in the study sample.

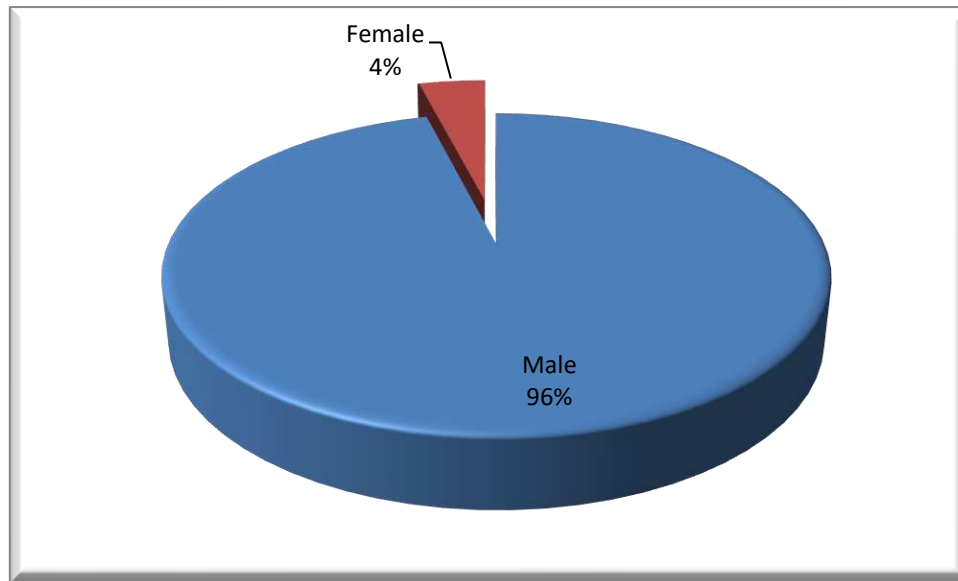


Figure (4-1) Demographic Characteristics of the Study Sample (Gender)

Table (4-5) shows the Descriptive Analysis of demographic characteristics of the Study sample regarding the respondents' Age group

Category		Freq.	Percent
Age group	25 – 34years	38	10.83
	35 – 44years	179	51.00
	45 – 54years	114	32.48
	55+ years	22	5.70
Total		351	100.00

Table (4-5) Descriptive Analysis of Demographic Characteristics of the Study Sample (Age group)

The table presents the characteristics of the study sample, revealing that:

- Regarding the Age group of the study sample, it was found that 35 – 44years were slightly more represented, with a percentage of 51.00%, comprising 179 respondents, while 55+ years represented 5.725%, comprising 22 respondents. in the study sample.

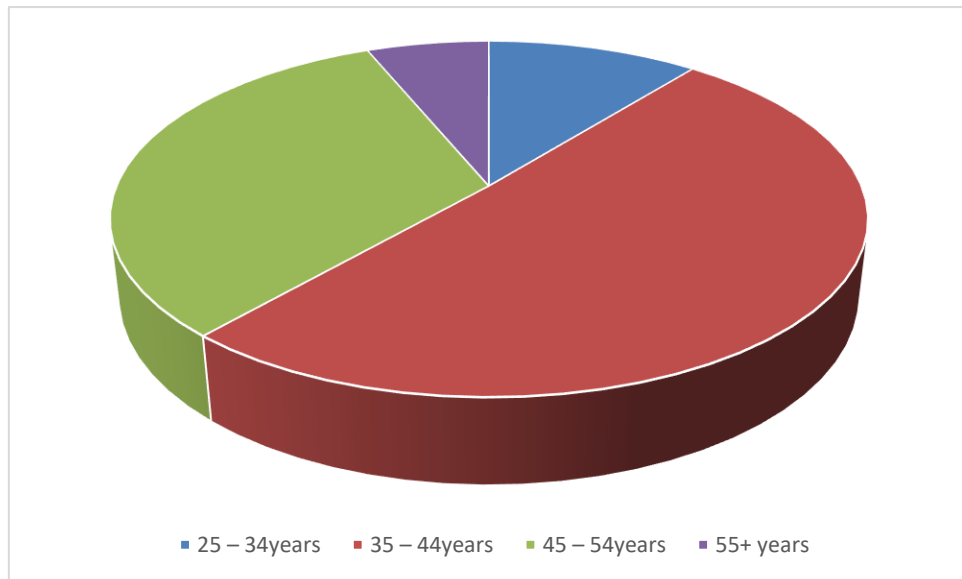


Figure (4-2) Demographic Characteristics of the Study Sample (Age group)

Table (4-6) shows the Descriptive Analysis of demographic characteristics of the Study sample regarding the respondents' Education.

Category		Freq.	Percent
Education	Diploma	15	4.27
	Bachelor	146	41.60
	Master	158	45.01
	PhD	32	9.12
Total		351	100.00

Table (4-6) Descriptive Analysis of Demographic Characteristics of the Study Sample (Education)

The table presents the characteristics of the study sample, revealing that:

- Regarding the Education of the study sample, it was found that Master were slightly more represented, with a percentage of 45.01%, comprising 158 respondents, while Diploma represented 4.27%, comprising 15 respondents in the study sample.

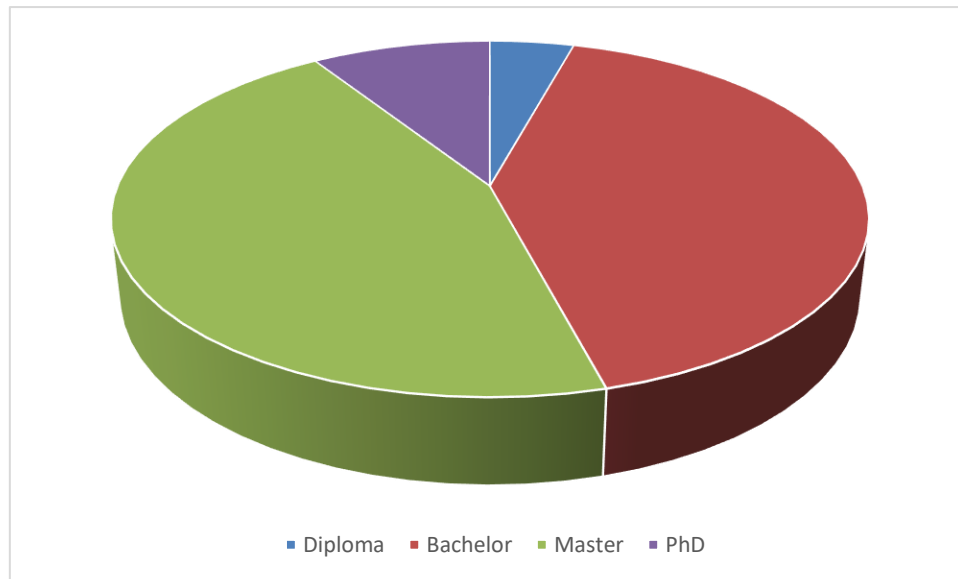


Figure (4-3) Demographic Characteristics of the Study Sample (Education)

Table (4-7) shows the Descriptive Analysis of demographic characteristics of the Study sample regarding the respondents' Job title

Category		Freq.	Percent
Job title	Project Manager	127	36.18
	Site Engineer	38	10.83
	Coordinator	69	19.66
	Consultant	73	20.80
	Other	44	12.54
Total		351	100.00

Table (4-7) Descriptive Analysis of Demographic Characteristics of the Study Sample (Job title)

The table presents the characteristics of the study sample, revealing that:

- Regarding the Job title of the study sample, it was found that Project Manager were slightly more represented, with a percentage of 36.18%, comprising 127 respondents, while Site Engineer represented 10.83%, comprising 38 respondents in the study sample.

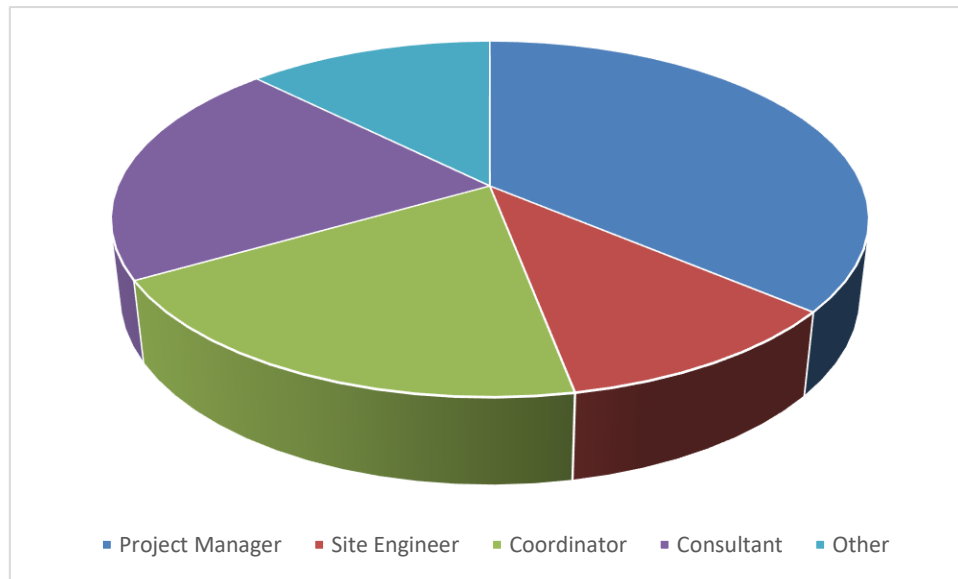


Figure (4-4) Demographic Characteristics of the Study Sample (Job title)

Table (4-8) shows the Descriptive Analysis of demographic characteristics of the Study sample regarding the respondents' Experience

Category		Freq.	Percent
Experience	Less than 3 years	13	3.70
	3 – 5 years	31	8.83
	6 – 10 years	77	21.94
	More than 10 years	230	65.53
Total		351	100.00

Table (4-8) Descriptive Analysis of Demographic Characteristics of the Study Sample (Experience)

The table presents the characteristics of the study sample, revealing that:

- Regarding the Experience of the study sample, it was found that more than 10 years were slightly more represented, with a percentage of 65.53%, comprising 230 respondents, while less than 3 years represented 3.70%, comprising 13 respondents in the study sample.

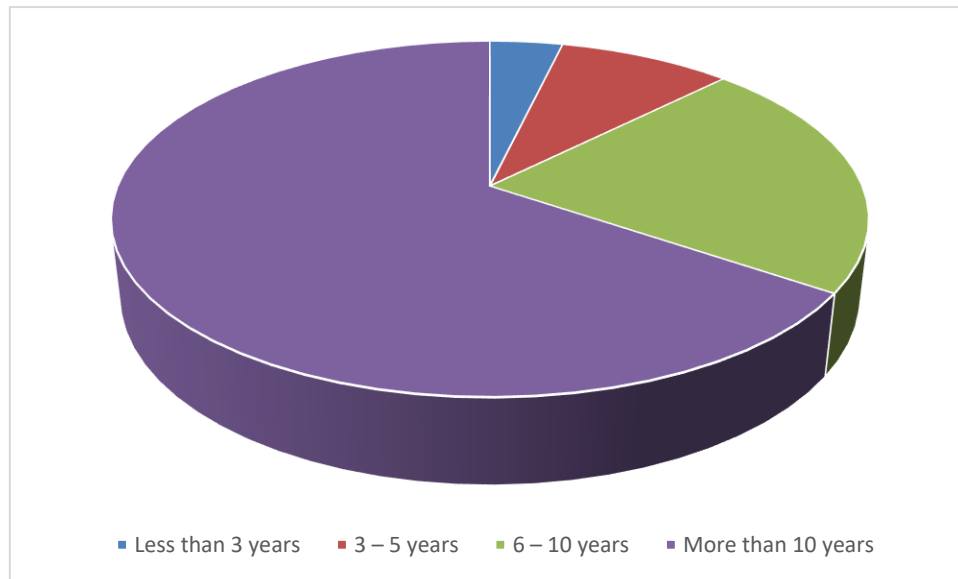


Figure (4-5) Demographic Characteristics of the Study Sample (Experience)

4.3.3 Distribution of the Study Subjects

4.3.3.1 Distribution of the Study Subjects according to Using AI

Using AI		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent
Machine Learning (ML)							
Our project team uses (ML) models to identify patterns in past project data.	Strongly Disagree	91	22.8	1-5	2.77±1.30	3.00	55.35%
	Disagree	91	22.8				
	Neutral	70	17.5				
	Agree	116	29.0				
	Strongly Agree	32	8.0				
ML tools assist us in resource allocation decisions	Strongly Disagree	71	17.8	1-5	3.39±1.29	4.00	67.80%
	Disagree	11	2.8				
	Neutral	69	17.3				
	Agree	189	47.3				
	Strongly Agree	60	15.0				
We use ML to predict project risks and delays	Strongly Disagree	102	25.5	1-5	2.96±1.32	3.00	59.10%
	Disagree	21	5.3				
	Neutral	100	25.0				
	Agree	147	36.8				
	Strongly Agree	30	7.5				
ML models are integrated into our project forecasting tools	Strongly Disagree	91	22.8	1-5	2.87±1.38	3.00	57.35%
	Disagree	75	18.8				
	Neutral	91	22.8				
	Agree	82	20.5				
	Strongly Agree	61	15.3				
Natural Language Processing (NLP)							
NLP tools are used to analyze project documents and communications	Strongly Disagree	100	25.0	1-5	2.82±1.33	3.00	56.30%
	Disagree	62	15.5				
	Neutral	86	21.5				
	Agree	116	29.0				
	Strongly Agree	36	9.0				
NLP helps summarize reports and technical documentation.	Strongly Disagree	80	20.0	1-5	3.16±1.43	3.00	63.15%
	Disagree	59	14.8				
	Neutral	62	15.5				
	Agree	116	29.0				
	Strongly Agree	83	20.8				
Using AI		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent

We use voice-to-text or sentiment analysis features in project tools	Strongly Disagree	124	31.0	1-5	2.77±1.47	3.00	55.35%
	Disagree	65	16.3				
	Neutral	44	11.0				
	Agree	114	28.5				
	Strongly Agree	53	13.3				
NLP applications help us extract key information from contracts	Strongly Disagree	80	20.0	1-5	2.90±1.35	3.00	57.95%
	Disagree	95	23.8				
	Neutral	64	16.0				
	Agree	108	27.0				
	Strongly Agree	53	13.3				
Chatbots and Visual Assistants							
AI-powered assistants provide real-time support to project team members	Strongly Disagree	39	9.8	1-5	3.88±1.28	4.00	77.55%
	Disagree	28	7.0				
	Neutral	37	9.3				
	Agree	135	33.8				
	Strongly Agree	161	40.3				
Chatbots are used to answer standard project queries	Strongly Disagree	50	12.5	1-5	3.51±1.26	4.00	70.20%
	Disagree	33	8.3				
	Neutral	62	15.5				
	Agree	173	43.3				
	Strongly Agree	82	20.5				
AI assistants help guide project workflows and reminders	Strongly Disagree	63	15.8	1-5	3.24±1.40	4.00	64.80%
	Disagree	82	20.5				
	Neutral	32	8.0				
	Agree	142	35.5				
	Strongly Agree	81	20.3				
These assistants reduce the time spent on repetitive tasks.	Strongly Disagree	63	15.8	1-5	3.70±1.38	4.00	74.00%
	Disagree	11	2.8				
	Neutral	46	11.5				
	Agree	143	35.8				
	Strongly Agree	137	34.3				
Predictive Analytics							
Predictive analytics tools are used to estimate project completion timelines	Strongly Disagree	39	9.8	1-5	3.62±1.16	4.00	72.40%
	Disagree	21	5.3				
	Neutral	78	19.5				
	Agree	177	44.3				
	Strongly Agree	85	21.3				
We use prediction models to evaluate cost overruns	Strongly Disagree	47	11.8	1-5	3.35±1.30	4.00	67.05%
	Disagree	62	15.5				
	Neutral	85	21.3				
	Agree	115	28.8				
	Strongly Agree	91	22.8				
Our project decisions are influenced by predictive analysis results	Strongly Disagree	47	11.8	1-5	3.30±1.39	4.00	65.90%
	Disagree	97	24.3				
	Neutral	54	13.5				
	Agree	95	23.8				
	Strongly Agree	107	26.8				
Predictive tools help us anticipate potential quality issues	Strongly Disagree	47	11.8	1-5	3.26±1.33	3.00	65.15%
	Disagree	86	21.5				
	Neutral	73	18.3				
	Agree	105	26.3				
	Strongly Agree	89	22.3				
Robotic Process Automation (RPA)							
RPA is used to automate administrative project tasks.	Strongly Disagree	56	14.0	1-5	3.24±1.29	3.00	64.80%
	Disagree	57	14.3				
	Neutral	93	23.3				
	Agree	123	30.8				
	Strongly Agree	71	17.8				
Our team uses bots to generate reports automatically.	Strongly Disagree	65	16.3	1-5	2.93±1.37	3.00	58.50%
Using AI		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent

	Disagree	120	30.0				
	Neutral	69	17.3				
	Agree	72	18.0				
	Strongly Agree	74	18.5				
RPA minimizes errors in document processing.	Strongly Disagree	45	11.3	1-5	3.50±1.38	4.00	70.00%
	Disagree	62	15.5				
	Neutral	72	18.0				
	Agree	90	22.5				
	Strongly Agree	131	32.8				
Project communication is improved through automation.	Strongly Disagree	45	11.3	1-5	3.62±1.42	4.00	72.45%
	Disagree	62	15.5				
	Neutral	51	12.8				
	Agree	83	20.8				
	Strongly Agree	159	39.8				
Data Visualization Tools							
Dashboards provide real-time project insights	Strongly Disagree	25	6.3	1-5	3.93±1.19	4.00	78.65%
	Disagree	39	9.8				
	Neutral	28	7.0				
	Agree	154	38.5				
	Strongly Agree	154	38.5				
Visual analytics help us detect trends and anomalies	Strongly Disagree	25	6.3	1-5	3.73±1.16	4.00	74.50%
	Disagree	39	9.8				
	Neutral	70	17.5				
	Agree	153	38.3				
	Strongly Agree	113	28.3				
Data visualization tools enhance stakeholder communication	Strongly Disagree	25	6.3	1-5	3.89±1.14	4.00	77.80%
	Disagree	39	9.8				
	Neutral	17	4.3				
	Agree	193	48.3				
	Strongly Agree	126	31.5				
We rely on visual reports for decision-making in project meetings	Strongly Disagree	25	6.3	1-5	3.84±1.15	4.00	76.80%
	Disagree	38	9.5				
	Neutral	37	9.3				
	Agree	176	44.0				
	Strongly Agree	124	31.0				
Decision Support Systems (DSS)							
DSS tools assist in selecting among project alternatives	Strongly Disagree	42	10.5	1-5	3.27±1.21	4.00	65.45%
	Disagree	73	18.3				
	Neutral	71	17.8				
	Agree	162	40.5				
	Strongly Agree	52	13.0				
These systems support data-driven decision-making	Strongly Disagree	42	10.5	1-5	3.73±1.18	4.00	74.60%
	Disagree	11	2.8				
	Neutral	63	15.8				
	Agree	181	45.3				
	Strongly Agree	103	25.8				
DSS integrates multiple data sources for better insights	Strongly Disagree	42	10.5	1-5	3.63±1.22	4.00	72.55%
	Disagree	11	2.8				
	Neutral	115	28.8				
	Agree	118	29.5				
	Strongly Agree	114	28.5				
Our DSS tools are regularly updated with new data inputs.	Strongly Disagree	62	15.5	1-5	3.34±1.38	4.00	66.70%
	Disagree	66	16.5				
	Neutral	29	7.3				
	Agree	162	40.5				
	Strongly Agree	81	20.3				

Table (4-9) Distribution of the study subjects according to Using AI

The table presenting the distribution of the study participants according to their use of artificial intelligence techniques shows varying levels of adoption across the different dimensions. The values of the arithmetic means and the percentage scores indicate a

general trend toward moderate to high use for most of the examined applications. The data further reveal that participants tend to adopt tools that are more closely related to direct operational support—such as data visualization tools, decision support systems, visual assistants, and chatbots—more than the more complex analytical techniques such as machine learning and natural language processing.

- **Machine Learning (ML)**

The results indicate that the use of machine learning remains at moderate levels, with arithmetic means ranging between (2.77–3.39), suggesting that the adoption of this technique is still relatively limited despite its importance in risk prediction and data analysis. The Mean score percent ranged between (55.35%–67.80%).

- **Natural Language Processing (NLP)**

The table shows that the use of NLP techniques also tends toward the moderate level, with arithmetic means ranging between (2.77–3.16), and Mean score percent ranging between (55.35%–63.15%).

- **Chatbots & Visual Assistants**

This dimension emerged as one of the highest in terms of usage, with item means ranging between (3.24–3.88), and Mean score percent ranging between (64.80%–77.55%).

- **Predictive Analytics**

The results point to a moderate-to-high level of use, with arithmetic means between (3.26–3.62), and Mean score percent ranging between (65.15%–72.40%).

- **Robotic Process Automation (RPA)**

The data indicate that the use of RPA falls within the moderate level, with means ranging between (2.93–3.62), and Mean score percent ranging between (58.50%–72.45%).

- **Data Visualization Tools**

This dimension recorded the highest levels of adoption, with elevated arithmetic means between (3.73–3.93), and Mean score percent ranging between (74.50%–78.65%).

- **Decision Support Systems (DSS)**

The results reveal good levels of use, with means ranging between (3.27–3.73), and Mean score percent ranging between (65.45%–74.60%).

4.3.3.2 Distribution of the Study Subjects according to Project Manager's Competencies

Project Manager's Competencis		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent
Technical Competencies							
I am proficient in using project management software tools (e.g., MS Project, Primavera)	Strongly Disagree	36	9.0	1-5	3.40±1.17	4.00	68.05%
	Disagree	46	11.5				
	Neutral	112	28.0				
	Agree	133	33.3				
	Strongly Agree	73	18.3				
I have a strong understanding of project planning and scheduling techniques	Strongly Disagree	16	4.0	1-5	3.60±1.01	4.00	71.90%
	Disagree	40	10.0				
	Neutral	102	25.5				
	Agree	174	43.5				
	Strongly Agree	68	17.0				
I can effectively manage project budgets and cost estimations	Strongly Disagree	36	9.0	1-5	3.72±1.24	4.00	74.40%
	Disagree	33	8.3				
	Neutral	63	15.8				
	Agree	143	35.8				
	Strongly Agree	125	31.3				
I possess technical knowledge relevant to the nature of my projects	Strongly Disagree	16	4.0	1-5	4.04±1.00	4.00	80.70%
	Disagree	24	6.0				
	Neutral	26	6.5				
	Agree	198	49.5				
	Strongly Agree	136	34.0				
I ensure the application of standards and best practices in project execution	Strongly Disagree	16	4.0	1-5	4.18±0.94	4.00	83.55%
	Disagree	0	0.0				
	Neutral	52	13.0				
	Agree	161	40.3				
	Strongly Agree	171	42.8				
Leadership & Behavioral							
I can effectively lead cross-functional project teams	Strongly Disagree	16	4.0	1-5	4.25±0.93	4.00	84.90%
	Disagree	0	0.0				
	Neutral	41	10.3				
	Agree	156	39.0				
	Strongly Agree	187	46.8				
I communicate clearly and proactively with all stakeholders	Strongly Disagree	16	4.0	1-5	4.19±0.92	4.00	83.75%
	Disagree	0	0.0				
	Neutral	41	10.3				
	Agree	179	44.8				
	Strongly Agree	164	41.0				
I resolve conflicts in a constructive and timely manner	Strongly Disagree	16	4.0	1-5	4.09±0.96	4.00	81.80%
	Disagree	24	6.0				
	Neutral	0	0.0				
	Agree	228	57.0				
	Stronglyv Agree	132	33.0				

Project Manager's Competencis		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent
I motivate team members to achieve project objectives	Strongly Disagree	16	4.0	1-5	4.18±0.86	4.00	83.55%
	Disagree	0	0.0				
	Neutral	24	6.0				
	Agree	217	54.3				
	Strongly Agree	143	35.8				
I motivate team members to achieve project objectives	Strongly Disagree	16	4.0	1-5	4.16±0.84	4.00	83.15%
	Disagree	0	0.0				
	Neutral	19	4.8				
	Agree	235	58.8				
	Strongly Agree	130	32.5				
Strategic and Business							

I align project objectives with organizational strategy	Strongly Disagree	16	4.0	1-5	4.15±0.93	4.00	82.95%
	Disagree	0	0.0				
	Neutral	52	13.0				
	Agree	173	43.3				
	Strongly Agree	159	39.8				
I understand the business impact of project decisions	Strongly Disagree	16	4.0	1-5	4.06±0.99	4.00	81.15%
	Disagree	0	0.0				
	Neutral	90	22.5				
	Agree	133	33.3				
	Strongly Agree	161	40.3				
I analyze project performance in terms of benefits realization	Strongly Disagree	16	4.0	1-5	3.93±1.10	4.00	78.50%
	Disagree	41	10.3				
	Neutral	39	9.8				
	Agree	165	41.3				
	Strongly Agree	139	34.8				
I contribute to strategic planning in my organization	Strongly Disagree	25	6.3	1-5	3.68±1.20	4.00	73.50%
	Disagree	52	13.0				
	Neutral	68	17.0				
	Agree	138	34.5				
	Strongly Agree	117	29.3				
I evaluate risks and opportunities from a strategic perspective	Strongly Disagree	16	4.0	1-5	3.95±0.94	4.00	78.95%
	Disagree	17	4.3				
	Neutral	39	9.8				
	Agree	228	57.0				
	Strongly Agree	100	25.0				

Table (4-10) Distribution of the study subjects according to Project Manager's Competencies

The table presenting the distribution of the study participants according to Project Manager's Competencies reflects a general trend toward high levels of competencies across the technical, leadership, and strategic domains. This is clearly demonstrated by the elevated arithmetic means and percentage scores, which were as follows:

- **Technical Competencies**

The results of this dimension indicate that participants possess a good to high level of technical skills, with mean scores ranging between (3.40–4.18) and Mean score percent ranging between (68.05%–83.55%).

- **Leadership & Behavioral Competencies**

This dimension emerges as the strongest among the competency dimensions, with mean scores ranging between (4.09–4.25), reflecting a high level of leadership proficiency and Mean score percent ranging between (81.80%–84.90%).

- **Strategic & Business Competencies**

The results of this dimension are at a good to high level, with means ranging between (3.68–4.15). These values highlight the participants' ability to understand the strategic aspects of projects and align them with organizational objectives and Mean score percent ranging between (73.50%–82.95%).

4.3.3.3 Distribution of the Study Subjects according to Project Constraints

Project Constraints		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent
Scope							
Project scope is clearly defined and managed throughout execution	Strongly Disagree	25	6.3	1-5	3.94±1.09	4.00	78.80%
	Disagree	17	4.3				
	Neutral	48	12.0				
	Agree	177	44.3				
	Strongly Agree	133	33.3				
Scope changes are systematically evaluated and controlled	Strongly Disagree	16	4.0	1-5	4.11±0.92	4.00	82.15%
	Disagree	9	2.3				
	Neutral	28	7.0				
	Agree	210	52.5				
	Strongly Agree	137	34.3				
Stakeholders have a common understanding of the project scope	Strongly Disagree	45	11.3	1-5	3.67±1.24	4.00	73.40%
	Disagree	24	6.0				
	Neutral	52	13.0				
	Agree	176	44.0				
	Strongly Agree	103	25.8				
Schedule							
Projects are usually completed within the scheduled timeline	Strongly Disagree	45	11.3	1-5	3.20±1.31	3.00	63.90%
	Disagree	103	25.8				
	Neutral	56	14.0				
	Agree	121	30.3				
	Strongly Agree	75	18.8				
Time estimates are realistic and based on historical data	Strongly Disagree	45	11.3	1-5	3.50±1.15	4.00	69.90%
	Disagree	11	2.8				
	Neutral	112	28.0				
	Agree	165	41.3				
	Strongly Agree	67	16.8				
Schedule delays are managed through proactive planning	Strongly Disagree	25	6.3	1-5	3.75±1.09	4.00	75.00%
	Disagree	30	7.5				
	Neutral	59	14.8				
	Agree	192	48.0				
	Strongly Agree	94	23.5				

Project Constraints		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent
Cost							
Project budgets are well estimated and managed	Strongly Disagree	25	6.3	1-5	3.67±1.11	4.00	73.40%
	Disagree	31	7.8				
	Neutral	92	23.0				
	Agree	155	38.8				
	Strongly Agree	97	24.3				
We frequently monitor actual versus planned costs	Strongly Disagree	25	6.3	1-5	4.01±1.01	4.00	80.20%
	Disagree	11	2.8				
	Neutral	20	5.0				
	Agree	223	55.8				
	Strongly Agree	121	30.3				
Projects are typically completed within the allocated budget	Strongly Disagree	25	6.3	1-5	3.59±1.24	4.00	71.75%
	Disagree	76	19.0				
	Neutral	44	11.0				
	Agree	149	37.3				
	Strongly Agree	106	26.5				
Quality							
Quality standards are clearly defined at the project's start	Strongly Disagree	25	6.3	1-5	3.93±1.21	4.00	78.50%
	Disagree	28	7.0				
	Neutral	74	18.5				
	Agree	98	24.5				

	Strongly Agree	175	43.8				
Deliverables meet required specifications and customer expectations	Strongly Disagree	9	2.3	1-5	4.04±0.86	4.00	80.85%
	Disagree	0	0.0				
	Neutral	87	21.8				
	Agree	173	43.3				
	Strongly Agree	131	32.8				
Quality reviews are regularly conducted during project execution	Strongly Disagree	25	6.3	1-5	3.99±1.08	4.00	79.85%
	Disagree	15	3.8				
	Neutral	38	9.5				
	Agree	182	45.5				
	Strongly Agree	140	35.0				
Risk							
Project risks are identified and assessed early in the project	Strongly Disagree	9	2.3	1-5	3.88±0.97	4.00	77.60%
	Disagree	35	8.8				
	Neutral	56	14.0				
	Agree	195	48.8				
	Strongly Agree	105	26.3				
Risk response strategies are developed and implemented	Strongly Disagree	9	2.3	1-5	3.85±0.80	4.00	76.95%
	Disagree	0	0.0				
	Neutral	108	27.0				
	Agree	209	52.3				
	Strongly Agree	74	18.5				
Risk monitoring is an ongoing part of project control	Strongly Disagree	16	4.0	1-5	4.10±0.92	4.00	81.95%
	Disagree	0	0.0				
	Neutral	57	14.3				
	Agree	183	45.8				
	Strongly Agree	144	36.0				
Resources							
Projects are adequately staffed with the required competencies	Strongly Disagree	45	11.3	1-5	3.67±1.21	4.00	73.30%
	Disagree	15	3.8				
	Neutral	65	16.3				
	Agree	179	44.8				
	Strongly Agree	96	24.0				
Resource allocation is optimized across projects	Strongly Disagree	45	11.3	1-5	3.68±1.26	4.00	73.60%
	Disagree	17	4.3				
	Neutral	79	19.8				
	Agree	139	34.8				
	Strongly Agree	120	30.0				

Project Constraints		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent
We have access to the necessary tools, equipment, and infrastructure	Strongly Disagree	45	11.3	1-5	3.54±1.24	4.00	70.85%
	Disagree	26	6.5				
	Neutral	92	23.0				
	Agree	141	35.3				
	Strongly Agree	96	24.0				
Stakeholders							
Stakeholder needs and expectations are clearly identified	Strongly Disagree	25	6.3	1-5	3.77±1.07	4.00	75.30%
	Disagree	17	4.3				
	Neutral	85	21.3				
	Agree	173	43.3				
	Strongly Agree	100	25.0				
Stakeholders are engaged throughout the project lifecycle	Strongly Disagree	25	6.3	1-5	3.80±1.20	4.00	76.05%
	Disagree	55	13.8				
	Neutral	18	4.5				
	Agree	178	44.5				
	Strongly Agree	124	31.0				
Feedback from stakeholders is used to improve performance	Strongly Disagree	25	6.3	1-5	3.96±1.02	4.00	79.20%
	Disagree	0	0.0				
	Neutral	67	16.8				
	Agree	182	45.5				
	Strongly Agree	126	31.5				

Governance							
Projects are guided by a defined governance framework	Strongly Disagree	25	6.3	1-5	3.78±1.09	4.00	75.60%
	Disagree	15	3.8				
	Neutral	96	24.0				
	Agree	151	37.8				
	Strongly Agree	113	28.3				
Roles and responsibilities are clear across all levels	Strongly Disagree	25	6.3	1-5	3.65±1.12	4.00	73.05%
	Disagree	46	11.5				
	Neutral	54	13.5				
	Agree	193	48.3				
	Strongly Agree	82	20.5				
Decisions are taken based on structured escalation procedures	Strongly Disagree	25	6.3	1-5	3.94±0.97	4.00	78.70%
	Disagree	0	0.0				
	Neutral	51	12.8				
	Agree	224	56.0				
	Strongly Agree	100	25.0				
Benefits							
Project outcomes align with expected organizational benefits	Strongly Disagree	25	6.3	1-5	3.99±1.01	4.00	79.70%
	Disagree	15	3.8				
	Neutral	13	3.3				
	Agree	235	58.8				
	Strongly Agree	112	28.0				
Benefits realization is tracked beyond project closure	Strongly Disagree	25	6.3	1-5	3.71±1.13	4.00	74.15%
	Disagree	43	10.8				
	Neutral	52	13.0				
	Agree	184	46.0				
	Strongly Agree	96	24.0				
Project success is evaluated in terms of both output and outcomes	Strongly Disagree	25	6.3	1-5	3.91±1.02	4.00	78.25%
	Disagree	11	2.8				
	Neutral	44	11.0				
	Agree	214	53.5				
	Strongly Agree	106	26.5				
Strategic Alignment							
Projects contribute to the strategic goals of the organization	Strongly Disagree	16	4.0	1-5	3.94±0.99	4.00	78.75%
	Disagree	35	8.8				
	Neutral	9	2.3				
	Agree	238	59.5				
	Strongly Agree	102	25.5				

Project Constraints		Frequency	Percent	Min-Max	Mean ± SD	Median	Mean Score Percent
Project selection is aligned with strategic priorities	Strongly Disagree	25	6.3	1-5	3.85±1.08	4.00	76.90%
	Disagree	15	3.8				
	Neutral	72	18.0				
	Agree	173	43.3				
	Strongly Agree	115	28.8				
Performance indicators reflect strategic objectives	Strongly Disagree	16	4.0	1-5	3.72±0.97	4.00	74.35%
	Disagree	20	5.0				
	Neutral	105	26.3				
	Agree	179	44.8				
	Strongly Agree	80	20.0				

Table (4-11) Distribution of the study subjects according to Project Constraints

The table presenting the distribution of study participants according to Project Constraints illustrates a comprehensive overview of how various constraints are perceived and managed within the projects under investigation. Overall, the results indicate a generally high level of awareness and adherence to project management

practices across multiple constraint dimensions, as reflected by the elevated mean scores and percentage agreement levels.

- **Scope Constraints**

The results show that the scope is clearly defined and managed, with mean scores ranging between 3.67 and 4.11 and Mean score percent ranging between (73.40%-82.15%). This indicates that participants recognize the importance of well-defined project boundaries and systematic control of scope changes, reflecting a strong alignment among stakeholders regarding project objectives.

- **Schedule Constraints**

Schedule management appears to be moderately robust, with mean scores between 3.20 and 3.75 and Mean score percent ranging between 63.90% to 75.00%. While projects are generally completed within planned timelines, some variability suggests opportunities for improving time estimation accuracy and proactive scheduling measures.

- **Cost Constraints**

The management of project budgets and costs shows a good level of control, with means ranging from 3.59 to 4.01 and Mean score percent ranging between 71.75% and 80.20%. The results suggest that participants actively monitor actual versus planned costs and aim to complete projects within allocated budgets, highlighting effective financial oversight.

- **Quality Constraints**

Quality standards are consistently applied, with mean scores between 3.93 and 4.04 and Mean score percent ranging between 78.50% to 80.85%. This demonstrates that participants prioritize delivering outputs that meet required specifications and customer expectations, supported by regular quality reviews during project execution.

- **Risk Constraints**

Project risk management reflects a proactive approach, with means from 3.85 to 4.10 and Mean score percent ranging between 76.95% and 81.95%. Participants identify and assess risks early, develop mitigation strategies, and continuously monitor risks, indicating a mature risk management practice.

- **Resource Constraints**

Resource allocation and availability are managed at a moderate to good level, with mean scores ranging from 3.54 to 3.68 and Mean score percent ranging between

70.85% to 73.60%. The results suggest that projects are generally staffed appropriately, with adequate tools and infrastructure, though there may be room for optimization.

- **Stakeholder Constraints**

Stakeholder engagement and feedback utilization are strong, with means between 3.77 and 3.96 and Mean score percent ranging between 75.30% to 79.20%. This highlights the recognition of stakeholders' critical role in project success and the use of their input to enhance performance.

- **Governance Constraints**

Project governance is effectively established, with mean scores ranging from 3.65 to 3.94 and Mean score percent ranging between 73.05% to 78.70%. Participants indicate that roles, responsibilities, and decision-making procedures are clearly defined and structured, supporting accountability and control.

- **Benefits**

Projects demonstrate high alignment with organizational benefits, with mean scores between 3.71 and 3.99 and Mean score percent ranging between 74.15% to 79.70%. Participants emphasize tracking outcomes beyond project closure and ensuring that project objectives support broader organizational priorities, reflecting strategic project management maturity.

- **Strategic Alignment**

Projects demonstrate high alignment with organizational strategic Alignment, with mean scores between 3.72 and 3.94 and agreement percentages from 74.35% to 78.75%. Participants emphasize tracking outcomes beyond project closure and ensuring that project objectives support broader organizational priorities, reflecting strategic project management maturity.

4.3.4 Distribution of the Study Subjects

4.3.4.1 Descriptive Statistics of Independent Variables (Using AI)

Variables	Mean±SD	Skewness	Kurtosis	Mean score percent
Machine Learning (ML)	11.98±4.70	-0.448	-0.763	59.90%
Natural Language Processing (NLP)	11.64±4.96	-0.163	-0.967	58.19%
Chatbots and Visual Assistants	14.33±4.51	-0.936	0.173	71.64%
Predictive Analytics	13.53±4.75	-0.495	-0.561	67.63%
Robotic Process Automation	13.29±4.77	-0.530	-0.629	66.44%
Data Visualization Tools	15.39±4.39	-1.185	0.791	76.94%
Decision Support Systems	13.97±4.46	-0.950	0.218	69.83%
Using Artificial Intelligence	94.11±24.64	-0.356	-0.642	67.22%

Table (4-12) Descriptive Statistics of Independent Variables

Table (4-12) shows Descriptive Statistics of Independent Variables (Using Artificial Intelligence) the following Machine Learning (ML) 11.98±4.70 Mean score percent 59.90%, Natural Language Processing (NLP) 11.64±4.96 Mean score percent 58.19%, Chatbots and Visual Assistants 14.33±4.51 Mean score percent 71.64%, Predictive Analytics 13.53±4.75 Mean score percent 67.63%, Robotic Process Automation 13.29±4.77 Mean score percent 66.44%, Data Visualization Tools 15.39±4.39 Mean score percent 76.94%, Decision Support Systems 13.97±4.46 Mean score percent 69.83%, Using Artificial Intelligence 94.11±24.64 Mean score percent 67.22%.

4.3.4.2 Descriptive Statistics of Mediating Variables (Project Manager's Competencies)

Variables	Mean±SD	Skewness	Kurtosis	Mean score percent
Technical Competencies	18.93±4.45	-1.012	1.711	75.72%
Leadership & Behavioral	20.86±4.21	-2.072	5.656	83.43%
Strategic and Business	19.75±4.70	-1.215	1.693	79.01%
Project Manager's Competencies	59.54±12.17	-1.873	4.891	79.39%

Table (4-13) Descriptive Statistics of Mediating Variables

Table (4-13) shows Descriptive Statistics of Mediating Variables (Project Manager's Competencies) the following Technical Competencies 18.93±4.45Mean score percent 75.72%, Leadership & Behavioral 20.86±4.21Mean score percent 83.43%, Strategic and Business 19.75±4.70Mean score percent 79.01%, Project Manager's Competencies 59.54±12.17Mean score percent 79.39%.

4.3.4.3 Descriptive Statistics of Dependent Variables (Project Constraints)

Variables	Mean±SD	Skewness	Kurtosis	Mean score percent
Scope	11.72±2.79	-1.508	2.747	78.12%
Schedule	10.44±3.14	-0.675	-0.087	69.60%
Cost	11.27±3.05	-1.095	1.183	75.12%
Quality	11.96±2.86	-1.091	1.201	79.73%
Risk	11.83±2.09	-0.095	-0.460	78.83%
Resources	10.89±3.49	-1.035	0.378	72.58%
Stakeholders	11.53±3.00	-1.213	1.636	76.85%
Governance	11.37±2.91	-1.304	1.985	75.78%
Benefits	11.61±2.87	-1.569	2.622	77.37%
Strategic Alignment	11.50±2.74	-1.240	1.898	76.67%
Project Constraints	114.10±25.94	-1.227	2.042	76.07%

Table (4-14) Descriptive Statistics of Dependent Variables

Table (4-14) shows Descriptive Statistics of Dependent Variables (Project Constraints) the following Scope 11.72±2.79Mean score percent 78.12%, Schedule 10.44±3.14Mean score percent 69.60%, Cost 11.27±3.05Mean score percent 75.12%, Quality 11.96±2.86Mean score percent 79.73%, Risk 11.83±2.09Mean score percent 78.83%, Resources 10.89±3.49Mean score percent 72.58%, Stakeholders 11.53±3.00Mean score percent 76.85%, Governance 11.37±2.91Mean score percent 75.78%, Benefits 11.61±2.87Mean score percent 77.37%, Strategic Alignment 11.50±2.74Mean score percent 76.67%, Project Constraints 114.10±25.94Mean score percent 76.07%.

4.3.3 Correlation Matrix between Variables (Pearson Correlation)

The Pearson Correlation Coefficient is an important statistical tool for measuring the linear relationship between two continuous variables, with values ranging from -1 to +1, indicating the direction and strength of the relationship. A value close to +1 indicates a strong positive relationship, a value close to -1 indicates a strong negative relationship, while values near 0 reflect the absence of a clear linear relationship.

this coefficient is widely used in social and administrative research to understand the degree of association between variables before conducting advanced analyses. Its use requires that the variables be continuous, the relationship approximately linear, the data roughly normally distributed, and extreme values avoided.

The purpose of the Pearson coefficient is to determine whether a significant relationship exists between variables and to estimate the amount of shared variance through the

squared value of r (r^2). However, the coefficient indicates correlation only, not causation, and is therefore often used alongside additional analyses such as regression or structural equation modeling. It is considered an essential preliminary step in understanding relationships between variables and making methodological decisions in research

H1: There is a significant relationship between the use of AI, Project Constraints, and Project Managers' Competencies.

Variables		Machine Learning (ML)	Natural Language Processing (NLP)	Chatbots and Visual Assistants	Predictive Analytics	Robotic Process Automation	Data Visualization Tools	Decision Support Systems	Using Artificial Intelligence	Technical Competencies	Leadership & Behavioral	Strategic and Business	Project Manager's Competencies
Machine Learning (ML)	r	1											
	p												
Natural Language Processing (NLP)	r	0.774**	1										
	p	0.000											
Chatbots and Visual Assistants	r	0.444**	0.657**	1									
	p	0.000	0.000										
Predictive Analytics	r	0.410**	0.646**	0.703**	1								
	p	0.000	0.000	0.000									
Robotic Process Automation	r	0.293**	0.492**	0.445**	0.672**	1							
	p	0.000	0.000	0.000	0.000								
Data Visualization Tools	r	0.250**	0.489**	0.432**	0.283**	0.217**	1						
	p	0.000	0.000	0.000	0.000	0.000							
Decision Support Systems	r	0.547**	0.724**	0.444**	0.422**	0.475**	0.669**	1					
	p	0.000	0.000	0.000	0.000	0.000	0.000						
Using Artificial Intelligence	r	0.707**	0.907**	0.779**	0.787**	0.684**	0.621**	0.805**	1				
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.000					
Technical Competencies	r	0.314**	0.323**	-0.021	-0.179**	-0.085	0.367**	0.508**	0.228**	1			
	p	0.000	0.000	0.682	0.000	0.090	0.000	0.000	0.000				
Leadership & Behavioral	r	0.351**	0.360**	0.102*	-0.059	-0.157**	0.492**	0.448**	0.285**	0.742**	1		
	p	0.000	0.000	0.041	0.236	0.002	0.000	0.000	0.000	0.000			
Strategic and Business	r	0.504**	0.509**	0.220**	0.068	0.038	0.457**	0.648**	0.458**	0.627**	0.868**	1	
	p	0.000	0.000	0.000	0.172	0.449	0.000	0.000	0.000	0.000	0.000		
Project Manager's Competencies	r	0.431**	0.440**	0.113*	-0.059	-0.071	0.481**	0.591**	0.359**	0.865**	0.953**	0.916**	1
	p	0.000	0.000	0.024	0.235	0.159	0.000	0.000	0.000	0.000	0.000	0.000	
Scope	r	0.229**	0.411**	0.323**	-0.074	-0.076	0.624**	0.515**	0.361**	0.659**	0.609**	0.631**	0.696**

Variables		Machine Learning (ML)	Natural Language Processing (NLP)	Chatbots and Visual Assistants	Predictive Analytics	Robotic Process Automation	Data Visualization Tools	Decision Support Systems	Using Artificial Intelligence	Technical Competencies	Leadership & Behavioral	Strategic and Business	Project Manager's Competencies
Schedule	p	0.000	0.000	0.000	0.139	0.131	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	r	0.297**	0.435**	0.193**	-0.072	-0.026	0.500**	0.405**	0.323**	0.472**	0.377**	0.456**	0.479**
	p	0.000	0.000	0.000	0.153	0.601	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cost	r	0.265**	0.431**	0.170**	-0.087	-0.116*	0.464**	0.463**	0.295**	0.648**	0.478**	0.521**	0.604**
	p	0.000	0.000	0.001	0.081	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Quality	r	0.263**	0.563**	0.509**	0.208**	0.245**	0.665**	0.682**	0.586**	0.622**	0.587**	0.657**	0.685**
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Risk	r	0.377**	0.583**	0.273**	0.250**	0.069	0.596**	0.616**	0.518**	0.465**	0.522**	0.638**	0.597**
	p	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Resources	r	0.275**	0.465**	0.152**	-0.107*	0.028	0.369**	0.505**	0.316**	0.761**	0.417**	0.427**	0.588**
	p	0.000	0.000	0.002	0.032	0.583	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stakeholders	r	0.392**	0.682**	0.429**	0.163**	0.247**	0.645**	0.670**	0.606**	0.654**	0.566**	0.597**	0.666**
	p	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Governance	r	0.175**	0.459**	0.277**	-0.001	0.039	0.618**	0.557**	0.395**	0.678**	0.644**	0.652**	0.723**
	p	0.000	0.000	0.000	0.985	0.438	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Benefits	r	0.252**	0.483**	0.408**	0.045	0.016	0.606**	0.498**	0.430**	0.532**	0.490**	0.513**	0.563**
	p	0.000	0.000	0.000	0.366	0.752	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Strategic Alignment	r	0.438**	0.531**	0.115*	-0.106*	-0.071	0.453**	0.438**	0.337**	0.661**	0.608**	0.545**	0.663**
	p	0.000	0.000	0.021	0.033	0.156	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Project Constraints	r	0.327**	0.559**	0.315**	0.014	0.039	0.612**	0.593**	0.459**	0.693**	0.586**	0.622**	0.697**
	p	0.000	0.000	0.000	0.774	0.442	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table (4-15) Correlation Matrix between Variables Independent Variables, Mediatomg Variables and Dependent Variables

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

* Pearson correlation test

Variables		Scope	Schedule	Cost	Quality	Risk	Resources	Stakeholders	Governance	Benefits	Strategic Alignment	Project Constraints
Scope	r	1										
	p											
Schedule	r	0.815**	1									
	p	0.000										
Cost	r	0.871**	0.914**	1								
	p	0.000	0.000									
Quality	r	0.889**	0.706**	0.749**	1							
	p	0.000	0.000	0.000								
Risk	r	0.689**	0.688**	0.730**	0.729**	1						
	p	0.000	0.000	0.000	0.000							
Resources	r	0.717**	0.742**	0.772**	0.730**	0.590**	1					
	p	0.000	0.000	0.000	0.000	0.000						
Stakeholders	r	0.815**	0.813**	0.795**	0.892**	0.727**	0.857**	1				
	p	0.000	0.000	0.000	0.000	0.000	0.000					
Governance	r	0.915**	0.797**	0.832**	0.891**	0.637**	0.746**	0.869**	1			
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
Benefits	r	0.868**	0.865**	0.849**	0.831**	0.590**	0.710**	0.856**	0.878**	1		
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
Strategic Alignment	r	0.664**	0.744**	0.716**	0.651**	0.582**	0.791**	0.828**	0.753**	0.760**	1	
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
Project Constraints	r	0.922**	0.907**	0.922**	0.900**	0.766**	0.866**	0.947**	0.932**	0.921**	0.841**	1
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Table (4-16) Correlation Matrix between Variables Independent Variables (Using Artificial Intelligence), Mediating Variables (Project Manager's Competencies) and Dependent Variables (Project Constraints)

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

* Pearson correlation test

The table presents the correlation coefficients between the independent variables related to the use of Artificial Intelligence (AI) technologies, the mediating variable (Project Manager's Competencies), and the dependent variable (Project Constraints), providing a comprehensive view of the statistical relationships among these variables. The results reveal several key points:

- **Relationship between AI usage and Project Manager's Competencies**

The correlations indicate significant positive relationships between most AI technologies and project managers' competencies. For instance, Machine Learning ($r = 0.431, p < 0.01$), Natural Language Processing ($r = 0.440, p < 0.01$), Data Visualization Tools ($r = 0.481, p < 0.01$), and Decision Support Systems ($r = 0.591, p < 0.01$) show moderate to strong correlations with project managers' competencies. Meanwhile, Chatbots and Visual Assistants show a weak correlation ($r = 0.113, p < 0.05$), whereas Predictive Analytics ($r = -0.059, p > 0.05$) and Robotic Process Automation ($r = -0.071, p > 0.05$) do not exhibit statistically significant correlations, suggesting that some advanced technologies are not yet fully leveraged to enhance managerial competencies.

- **Relationship between AI usage and Project Constraints**

The results indicate that most AI tools and technologies are positively and moderately to strongly correlated with project constraints, with correlation coefficients ranging from ($r = 0.315$ to $0.612, p < 0.01$), except for Predictive Analytics ($r = 0.014, p > 0.05$) and Robotic Process Automation ($r = 0.039, p > 0.05$), which show no significant correlation. These findings reflect the role of AI in improving control over certain project constraints, such as quality and resources, while highlighting that some technologies have yet to be fully exploited to impact these constraints.

- **Relationship between Project Manager's Competencies and Project Constraints**

The table shows that project managers' competencies serve as a crucial mediating variable, with all three competency dimensions (technical, leadership & behavioral, and strategic & business) displaying strong and significant correlations with project constraints, ranging between ($r = 0.586$ – $0.693, p < 0.01$). This indicates that high managerial competencies enhance the ability to manage various constraints effectively and achieve project objectives.

- **Implications of the Results**

Based on the above, it can be concluded that the relationship between AI usage and project constraints is not always direct; project managers' competencies play a

central mediating role that strengthens the effect of AI technologies on managing constraints efficiently. This also implies that investing in training and enhancing managerial capabilities can maximize the practical benefits of AI adoption in project management.

H2: There is a positive impact of using Artificial Intelligence on Project Manager's Competencies.

To test the main study Hypothesis H2, the researcher used simple linear regression analysis of the effect of using Artificial Intelligence on Project Manager's Competencies.

Model	df	Sum of Squares	Mean Square	(R)	(R2)	B	B1	F test		T test	
								F	Sig	T	Sig
Regression	1	7612.60	7612.60	0.359	0.129	42.86	0.18	58.849	0.000*	7.671	0.000*
Residual	398	51484.76	129.36								
Total	399	59097.36									
a. Dependent Variable: Project Manager's Competencies											
b. Predictors: (Constant), using Artificial Intelligence											

Table (4-17) Test of using AI effect on Project Manager’s Competencies

*A function at the level of significance less than (0.05).

The table presents the results of a simple linear regression analysis examining the effect of using Artificial Intelligence (AI) on Project Manager’s Competencies. The model shows a significant positive relationship between the independent variable (AI usage) and the dependent variable (Project Manager’s Competencies).

Model Fit and Explained Variance:

The coefficient of determination ($R^2 = 0.129$) indicates that approximately 12.9% of the variance in project managers’ competencies can be explained by the level of AI usage. Although this represents a modest proportion, it is statistically significant, suggesting that AI adoption contributes meaningfully to enhancing managerial competencies. The multiple correlation coefficient ($R = 0.359$) reflects a moderate linear association between the variables.

Regression Coefficients:

The regression coefficient ($B = 0.18$, $t = 7.671$, $p < 0.01$) is positive and highly significant, indicating that increased use of AI tools is associated with higher levels of project managers’ competencies. In practical terms, this suggests that for every unit increase in AI usage, there is a corresponding increase in the competency score of project managers, highlighting the positive role of AI in supporting managerial effectiveness.

Statistical Significance:

The F-test for the regression model ($F = 58.849$, $p < 0.01$) confirms that the model as a whole is statistically significant, meaning that AI usage significantly predicts variations in project managers' competencies.

Implications:

These results underscore the importance of integrating AI technologies in project management practices. By leveraging AI tools, organizations can enhance the technical, leadership, and strategic competencies of their project managers, ultimately leading to more effective project planning, decision-making, and execution. However, given that R^2 is 0.129, it also indicates that other factors beyond AI usage contribute to managerial competencies, suggesting the need for complementary strategies such as training, experience, and organizational support.

Summary:

In conclusion, the regression analysis confirms a significant positive effect of AI usage on project managers' competencies, validating the role of AI as a supportive factor in developing managerial skills while acknowledging that additional variables influence competency levels.

To test the main study Hypothesis H2, the researcher used Multiple linear regression analysis of the effect of using Artificial Intelligence on Project Manager's Competencies

Coefficient ^a										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	F	Sig.	R square	R square change
		B	Std. Error	Beta						
1	(Constant)	46.157	1.508		30.613	0.000*	90.855	0.000*	18.59%	
	Machine Learning (ML)	1.117	0.117	0.431	9.532	0.000*				18.59%
2	(Constant)	44.958	1.517		29.632	0.000*	54.019	0.000*	21.39%	
	Machine Learning (ML)	0.587	0.182	0.226	3.222	0.001*				18.59%
	Natural Language Processing (NLP)	0.649	0.172	0.265	3.765	0.000*				2.81%
3	(Constant)	51.134	1.922		26.611	0.000*	46.549	0.000*	26.07%	
	Machine Learning (ML)	0.466	0.178	0.180	2.609	0.009*				18.59%
	Natural Language Processing (NLP)	1.205	0.201	0.491	5.998	0.000*				2.81%
	Chatbots and Visual Assistants	-0.781	0.156	-0.290	-5.006	0.000*				4.68%
4	(Constant)	55.682	1.798		30.976	0.000*	65.771	0.000*	39.98%	
	Machine Learning (ML)	0.252	0.163	0.097	1.548	0.122				18.59%
	Natural Language Processing (NLP)	1.824	0.192	0.743	9.478	0.000*				2.81%

	Chatbots and Visual Assistants	-0.060	0.160	-0.022	-0.374	0.708				4.68%
	Predictive Analytics	-1.444	0.151	-0.564	-9.566	0.000*				13.91%
5	(Constant)	57.466	1.902		30.209	0.000*	54.907	0.000*	41.06%	
	Machine Learning (ML)	0.217	0.162	0.084	1.343	0.180				18.59%
	Natural Language Processing (NLP)	1.902	0.193	0.775	9.848	0.000*				2.81%
	Chatbots and Visual Assistants	-0.104	0.159	-0.039	-0.653	0.514				4.68%
	Predictive Analytics	-1.207	0.174	-0.471	-6.955	0.000*				13.91%
	Robotic Process Automation	-0.364	0.135	-0.143	-2.697	0.007*				1.09%
6	(Constant)	45.888	2.158		21.265	0.000*	68.615	0.000*	51.16%	
	Machine Learning (ML)	0.546	0.152	0.211	3.596	0.000*				18.59%
	Natural Language Processing (NLP)	1.223	0.191	0.498	6.387	0.000*				2.81%
	Chatbots and Visual Assistants	-0.388	0.149	-0.144	-2.608	0.009*				4.68%
	Predictive Analytics	-0.975	0.160	-0.381	-6.082	0.000*				13.91%
	Robotic Process Automation	-0.361	0.123	-0.141	-2.930	0.004*				1.09%
	Data Visualization Tools	1.067	0.118	0.385	9.014	0.000*				10.10%
7	(Constant)	44.551	1.991		22.376	0.000*	79.876	0.000*	58.79%	
	Machine Learning (ML)	0.384	0.141	0.148	2.727	0.007*				18.59%
	Natural Language Processing (NLP)	0.668	0.188	0.272	3.560	0.000*				2.81%
	Chatbots and Visual Assistants	-0.225	0.138	-0.083	-1.631	0.104				4.68%
	Predictive Analytics	-0.791	0.149	-0.309	-5.308	0.000*				13.91%
	Robotic Process Automation	-0.712	0.121	-0.279	-5.910	0.000*				1.09%
	Data Visualization Tools	0.424	0.132	0.153	3.198	0.001*				10.10%
	Decision Support Systems	1.395	0.164	0.511	8.516	0.000*				7.62%

Table (4-18) Test of using Artificial Intelligence effect on Project Manager's Competencies

a. Dependent Variable: Project Manager's Competencies

*A function at the level of significance less than (0.05).

The table presents the results of a series of Multiple linear regression models aimed at examining the impact of different dimensions of Artificial Intelligence (AI) usage on project managers' competencies. Independent variables were introduced progressively to evaluate the contribution of each technology individually, while considering changes in the explanatory power of the model (R^2) at each step.

General Observations:

The results indicate that most AI technologies positively contribute to enhancing project managers' competencies, with variations in the magnitude of the effect across different technologies. The unstandardized coefficient (B) represents the direct effect, while the standardized coefficient (Beta) shows the relative impact of each technology compared to the other variables.

Detailed Observations by Technology:**Machine Learning (ML):**

Demonstrates a consistent positive effect on project managers' competencies across all models, with Beta ranging from 0.084 to 0.431 and highly significant p-values ($p < 0.01$). This indicates that using ML enhances both the technical and strategic competencies of managers.

Natural Language Processing (NLP):

Shows a strong positive effect, particularly in models including multiple AI dimensions. Beta ranges from 0.265 to 0.775, with high t-values ($p < 0.01$), indicating a critical role for NLP technologies in improving managers' analytical, communication, and knowledge management skills.

Chatbots & Visual Assistants:

Exhibits negative effects in some models, with Beta ranging from -0.039 to -0.290, and statistically significant in certain cases. This suggests that these tools may not directly enhance core managerial competencies and are likely more supportive of routine operational tasks.

Predictive Analytics:

Shows a negative effect in advanced models, with Beta ranging from -0.309 to -0.564 ($p < 0.01$), which may indicate that reliance on predictive analytics alone reduces the need for some traditional managerial skills or highlights differences in expertise required to interpret results effectively.

Robotic Process Automation (RPA):

Demonstrates a moderate negative effect, with Beta between -0.141 and -0.279, statistically significant in most models, suggesting that heavy automation may reduce the performance of some traditional tasks but still serves as a supporting tool for other competencies.

Data Visualization Tools:

It shows a notable positive impact, with Beta ranging from 0.153 to 0.385, highly significant, reflecting the strong role of these tools in supporting decision-making and enhancing managers’ analytical capabilities.

Decision Support Systems (DSS):

It shows a strong positive effect in the final model (Beta = 0.511, $p < 0.01$), indicating that integrating DSS into daily work directly strengthens strategic decision-making ability and overall managerial competencies.

Model Explanatory Power (R^2):

R^2 increases from 18.59% to 58.79% as all variables are included, demonstrating that combining multiple AI tools substantially improves the model’s ability to explain variance in project managers’ competencies, highlighting the importance of using an integrated set of technologies for a comprehensive positive effect.

H3: There is a positive impact of using Artificial Intelligence on Project Constraints.

To test the main study Hypothesis H3, the researcher used simple linear regression analysis of the effect of using Artificial Intelligence on Project Constraints.

Model	df	Sum of Squares	Mean Square	(R)	(R2)	B	B1	F test		T test	
								F	Sig	T	Sig
Regression	1	56615.75	56615.75	0.459	0.211	68.61	0.48	106.330	0.000*	10.312	0.000*
Residual	398	211915.45	532.45								
Total	399	268531.20									
a. Dependent Variable: Project Constraints											
b. Predictors: (Constant), using Artificial Intelligence											

Table (4-19) Test of using Artificial Intelligence effect on Project Constraints

*A function at the level of significance less than (0.05).

The table presents the results of a regression analysis examining the effect of using Artificial Intelligence (AI) on project constraints, with project constraints as the dependent variable and AI usage as the independent variable.

Model Overview:

The regression model demonstrates a statistically significant positive relationship between the use of AI and project constraints, as indicated by the F-test value of 106.330 ($p < 0.001$). The model’s correlation coefficient ($R = 0.459$) suggests a moderate relationship, while the coefficient of determination ($R^2 = 0.211$) indicates

that approximately 21.1% of the variance in project constraints can be explained by AI utilization.

Interpretation of Coefficients:

- The unstandardized regression coefficient ($B = 68.61$) and standardized coefficient ($B1 = 0.48$) indicate that increased use of AI is associated with a significant improvement in managing project constraints. Specifically, higher levels of AI adoption contribute to better handling of scope, schedule, cost, quality, risk, resources, and stakeholder-related constraints.
- The t-test value ($t = 10.312$, $p < 0.001$) confirms that the effect of AI on project constraints is statistically significant, supporting the hypothesis that AI can serve as a critical tool for mitigating project limitations and enhancing overall project performance.

To test the main study Hypothesis H3, the researcher used Multiple linear regression analysis of the effect of using Artificial Intelligence on Project Constraints

Coefficient ^a										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	F	Sig.	R square	R square change
		B	Std. Error	Beta						
1	(Constant)	92.444	3.366		27.465	0.000*	47.728	0.000*	10.71%	
	Machine Learning (ML)	1.807	0.262	0.327	6.909	0.000*				10.71%
2	(Constant)	85.071	2.962		28.720	0.000*	102.539	0.000*	34.06%	
	Machine Learning (ML)	-1.455	0.355	-0.263	-4.092	0.000*				10.71%
	Natural Language Processing (NLP)	3.992	0.337	0.763	11.858	0.000*				23.35%
3	(Constant)	90.766	3.842		23.622	0.000*	70.881	0.000*	34.94%	
	Machine Learning (ML)	-1.566	0.357	-0.284	-4.389	0.000*				10.71%
	Natural Language Processing (NLP)	4.504	0.402	0.861	11.212	0.000*				23.35%
	Chatbots and Visual Assistants	-0.721	0.312	-0.125	-2.308	0.021*				0.88%
4	(Constant)	104.022	3.091		33.653	0.000*	154.071	0.000*	60.94%	
	Machine Learning (ML)	-2.190	0.279	-0.396	-7.836	0.000*				10.71%
	Natural Language Processing (NLP)	6.309	0.331	1.206	19.063	0.000*				23.35%
	Chatbots and Visual Assistants	1.383	0.275	0.241	5.034	0.000*				0.88%
	Predictive Analytics	-4.209	0.260	-0.771	-16.216	0.000*				26.00%
5	(Constant)	105.409	3.295		31.990	0.000*	123.694	0.000*	61.09%	
	Machine Learning (ML)	-2.217	0.280	-0.401	-7.911	0.000*				10.71%
	Natural Language Processing (NLP)	6.369	0.334	1.218	19.042	0.000*				23.35%

	Chatbots and Visual Assistants	1.349	0.276	0.235	4.886	0.000*				0.88%
	Predictive Analytics	-4.025	0.301	-0.737	-13.387	0.000*				26.00%
	Robotic Process Automation	-0.283	0.234	-0.052	-1.210	0.227				0.14%
6	(Constant)	83.217	3.650		22.799	0.000*	147.490	0.000*	69.25%	
	Machine Learning (ML)	-1.586	0.257	-0.287	-6.174	0.000*				10.71%
	Natural Language Processing (NLP)	5.068	0.324	0.969	15.650	0.000*				23.35%
	Chatbots and Visual Assistants	0.805	0.251	0.140	3.202	0.001*				0.88%
	Predictive Analytics	-3.580	0.271	-0.656	-13.203	0.000*				26.00%
	Robotic Process Automation	-0.276	0.208	-0.051	-1.327	0.185				0.14%
	Data Visualization Tools	2.044	0.200	0.346	10.213	0.000*				8.16%
7	(Constant)	82.147	3.601		22.809	0.000*	132.697	0.000*	70.32%	
	Machine Learning (ML)	-1.716	0.255	-0.311	-6.727	0.000*				10.71%
	Natural Language Processing (NLP)	4.624	0.340	0.884	13.617	0.000*				23.35%
	Chatbots and Visual Assistants	0.935	0.250	0.163	3.746	0.000*				0.88%
	Predictive Analytics	-3.432	0.270	-0.629	-12.734	0.000*				26.00%
	Robotic Process Automation	-0.558	0.218	-0.102	-2.558	0.011*				0.14%
	Data Visualization Tools	1.530	0.240	0.259	6.383	0.000*				8.16%
	Decision Support Systems	1.116	0.296	0.192	3.769	0.000*				1.08%

Table (4-20) Test of using Artificial Intelligence effect on Project Constraints

a. Dependent Variable: : Project Constraints

*A function at the level of significance less than (0.05).

The table presents the results of regression analysis examining the effect of using artificial intelligence (AI) technologies on project constraints. Each AI technology was tested individually and then integrated progressively in sequential models to clarify their relative contributions.

Overview of the Model:

The results indicate that all regression models were statistically significant ($p < 0.001$), with varying explanatory power (R^2) ranging from 10.71% in the first model to 70.32% in the final model when all AI technologies were combined. This indicates that the integration of different AI technologies explains a substantial portion of the variance in project constraints, highlighting the important role of AI in enhancing project management.

Analysis of Each Technology's Effect:

Machine Learning (ML):

Shows a negative effect in most models when combined with other technologies, which is statistically significant. This suggests that relying on ML alone or within a set may reduce certain constraints if it is not integrated with supporting technologies.

Natural Language Processing (NLP):

Exhibits a strong positive effect across all models with the highest standardized coefficient (Beta), indicating that adopting NLP significantly improves the management of project constraints, particularly in communication, requirement understanding, and stakeholder management.

Chatbots and Visual Assistants:

Shows a relatively positive effect in the later models with statistical significance ($p < 0.05$), suggesting that these tools enhance the team's ability to interact with information and stakeholders, though they are not the most influential factor.

Predictive Analytics:

Exhibits a large negative effect in most models, which is statistically significant. This indicates that applying predictive analytics without comprehensive support from other technologies may reveal constraints or challenges that remain unresolved, though it remains an important tool for strategic decision-making when integrated.

Robotic Process Automation (RPA):

Shows a limited negative effect in some models with statistical significance in certain cases, suggesting that process automation alone may not reduce all constraints but contributes to operational efficiency when combined with other technologies.

Data Visualization Tools:

Demonstrates a clear positive and statistically significant effect, reflecting their importance in simplifying complex information and enabling project managers to make faster and more accurate decisions.

Decision Support Systems:

Show a relatively positive effect in the final model, indicating that integrating these systems with other technologies enhances the ability to make strategic decisions and reduce project constraints.

H4: There is a positive impact of Project Manager's Competencies on Project Constraints.

To test the main study Hypothesis H4, the researcher used simple linear regression analysis of the effect of Project Manager's Competencies on Project Constraints.

Model	df	Sum of Squares	Mean Square	(R)	(R2)	B	B1	F test		T test	
								F	Sig	T	Sig
Regression	1	130445.85	130445.85	0.697	0.486	25.64	1.49	375.981	0.000*	19.390	0.000*
Residual	398	138085.35	345.95								
Total	399	268531.20									
a. Dependent Variable: Project Constraints											
b. Predictors: (Constant), Project Manager’s Competencies											

Table (4-21) Test of Project Manager's Competencies effect on Project Constraints

*A function at the level of significance less than (0.05).

The table presents the results of a regression analysis examining the effect of Project Manager's Competencies on Project Constraints. The findings reveal a strong and statistically significant relationship between these two variables.

Model Fit and Variance Explained:

The regression model shows a high coefficient of determination ($R^2 = 0.486$), indicating that approximately 48.6% of the variance in project constraints can be explained by project managers' competencies. This demonstrates the substantial impact that managerial skills have on mitigating or managing project-related constraints.

Strength and Significance of the Relationship:

The correlation coefficient ($R = 0.697$) indicates a strong positive relationship, suggesting that higher levels of competencies in project managers are associated with better control and reduction of project constraints.

The F-test ($F = 375.981$, $p < 0.001$) confirms the overall statistical significance of the regression model, indicating that the model reliably predicts project constraints.

The t-test for the regression coefficient ($t = 19.390$, $p < 0.001$) demonstrates that the effect of project managers' competencies on project constraints is highly significant.

To test the main study Hypothesis H4, the researcher used Multiple linear regression analysis of the effect of Project Manager's Competencies on Project Constraints

Model		Unstandardized Coefficients		Standardize d Coefficients	t	Sig.	F	Sig.	R square	R square change
		B	Std. Error	Beta						
1	(Constant)	37.654	4.092		9.202	0.000*	368.272	0.000*	48.06%	

	Technical Competencies	4.038	0.210	0.693	19.190	0.000*				48.06%
2	(Constant)	30.143	4.756		6.338	0.000*	192.417	0.000*	49.22%	
	Technical Competencies	3.344	0.311	0.574	10.770	0.000*				48.06%
	Leadership & Behavioral	0.990	0.328	0.161	3.014	0.003*				1.16%
3	(Constant)	31.174	4.466		6.981	0.000*	163.888	0.000*	55.39%	
	Technical Competencies	3.457	0.292	0.593	11.846	0.000*				48.06%
	Leadership & Behavioral	-1.782	0.485	-0.289	-3.673	0.000*				1.16%
	Strategic and Business	2.767	0.374	0.501	7.399	0.000*				6.17%

Table (4-22) Test of Project Manager's Competencies effect on Project Constraints
a. Dependent Variable: Project Constraints
*A function at the level of significance less than (0.05).

The table presents the results of regression analysis examining the effect of Project Manager's Competencies (technical, leadership & behavioral, and strategic & business) on Project Constraints. The results indicate that each competency dimension has a distinct impact on project constraints, with varying strength across different models.

Model 1 – Technical Competencies only:

Technical competencies of project managers show a strong positive effect on project constraints, with a standardized coefficient (Beta = 0.693) and statistically significant ($t = 19.190$, $p < 0.001$).

This model explains approximately 48.06% of the variance in project constraints, highlighting the critical role of technical skills in managing constraints related to scope, cost, schedule, and quality.

Model 2 – Adding Leadership & Behavioral Competencies:

When leadership & behavioral competencies are added, the effect of technical competencies remains strong (Beta = 0.574), while leadership & behavioral competencies contribute an additional positive effect (Beta = 0.161, $p = 0.003$).

The explained variance slightly increases to 49.22%, indicating that leadership & behavioral skills contribute positively, but to a lesser extent compared to technical competencies.

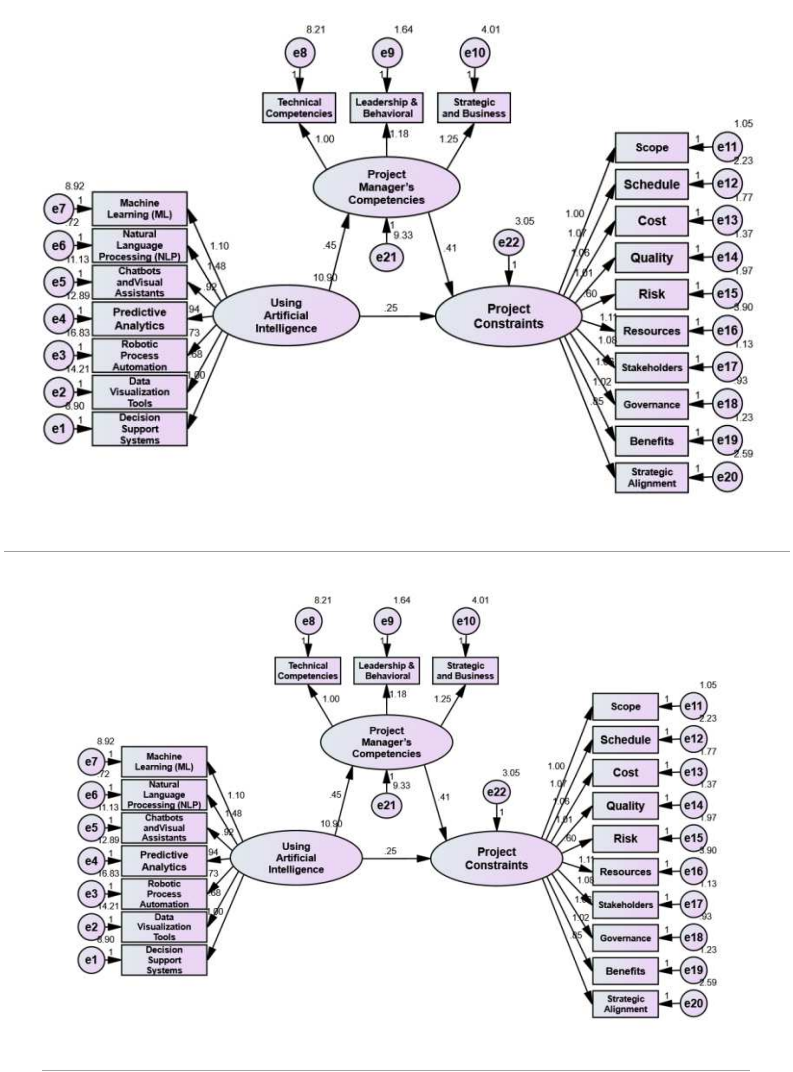
Model 3 – Adding Strategic & Business Competencies:

With the inclusion of strategic & business competencies, this dimension also shows a strong positive effect (Beta = 0.501, $p < 0.001$), whereas the effect of leadership & behavioral competencies becomes negative (Beta = -0.289, $p < 0.001$), possibly due to interaction effects or adjustment when controlling for other dimensions.

This model explains 55.39% of the variance in project constraints, suggesting that combining all three competency dimensions provides a more comprehensive prediction of project constraints.

H5: The significant impact of using artificial intelligence on project constraints increases when mediated by project managers' competencies.

Initial model values:



Variables			Estimate	S.E.	C.R.	P
Project.Manager'sCompetencies	<---	UsingArtificial.Intelligence	.454	.056	8.049	***
Project.Constraints	<---	Project.Manager'sCompetencies	.410	.036	11.240	***
Project.Constraints	<---	UsingArtificial.Intelligence	.251	.034	7.380	***
DecisionSupportSystems	<---	UsingArtificial.Intelligence	1.000			
DataVisualizationTools	<---	UsingArtificial.Intelligence	.680	.066	10.339	***
RoboticProcessAutomation	<---	UsingArtificial.Intelligence	.731	.071	10.242	***
PredictiveAnalytics	<---	UsingArtificial.Intelligence	.940	.070	13.432	***
ChatbotsandVisualAssistants	<---	UsingArtificial.Intelligence	.917	.066	13.830	***
NaturalLanguageProcessingNLP	<---	UsingArtificial.Intelligence	1.478	.072	20.449	***
MachineLearningML	<---	UsingArtificial.Intelligence	1.095	.068	16.097	***
TechnicalCompetencies	<---	Project.Manager'sCompetencies	1.000			
LeadershipBehavioral	<---	Project.Manager'sCompetencies	1.177	.057	20.602	***
StrategicandBusiness	<---	Project.Manager'sCompetencies	1.249	.063	19.823	***
Scope	<---	Project.Constraints	1.000			
Schedule	<---	Project.Constraints	1.067	.036	29.409	***
Cost	<---	Project.Constraints	1.060	.034	31.470	***
Quality	<---	Project.Constraints	1.006	.031	32.865	***
Risk	<---	Project.Constraints	.598	.030	19.961	***
Resources	<---	Project.Constraints	1.111	.045	24.903	***
Stakeholders	<---	Project.Constraints	1.083	.030	35.919	***
Governance	<---	Project.Constraints	1.058	.028	37.140	***
Benefits	<---	Project.Constraints	1.021	.030	34.122	***
StrategicAlignment	<---	Project.Constraints	.853	.036	23.808	***
CMIN (6990.453) CMIN/DF(41.859) GFI(0.473) RMSEA(0.320)			NFI(0.516) AGFI(0.337) CFI(0.521)			

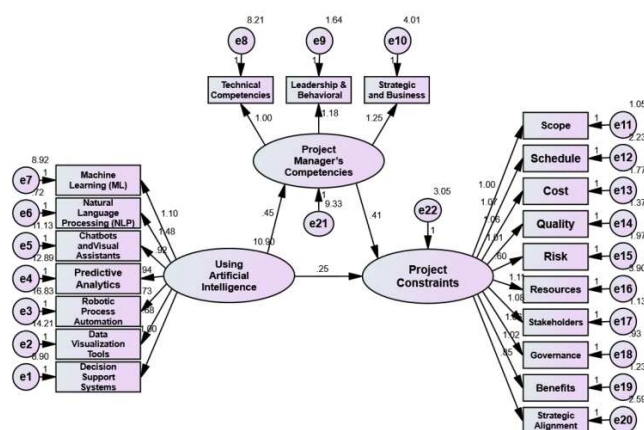


Figure (4-6): Structural Equation Model – Initial Model

Table (4-23) Results of the Initial Structural Equation Model with Standardized Path Coefficients

The table reflects the results of the initial Structural Equation Model (SEM) with standardized path coefficients, providing a detailed view of the relationships between the use of Artificial Intelligence (AI), Project Manager's Competencies, and Project Constraints. The scientific academic commentary can be presented as follows:

The initial SEM indicates a significant positive effect of using AI on Project Manager's Competencies ($\beta = 0.454$, $p < 0.001$), suggesting that higher adoption of AI technologies contributes notably to enhancing the technical, leadership, and strategic competencies of project managers.

The model also shows a significant positive effect of Project Manager's Competencies on Project Constraints ($\beta = 0.410$, $p < 0.001$), highlighting the pivotal role of managerial capabilities in handling challenges related to project scope, schedule, cost, quality, risks, resources, stakeholders, governance, benefits, and strategic alignment.

The direct effect of using AI on Project Constraints is also positive and significant ($\beta = 0.251$, $p < 0.001$), indicating that AI has a direct impact on improving project constraint management, in addition to its indirect effect mediated through project managers' competencies, emphasizing the mediating role of competencies in the relationship between AI adoption and project constraints management.

Regarding AI components, all technologies, including Machine Learning (ML), Natural Language Processing (NLP), Chatbots and Visual Assistants, Predictive Analytics, Robotic Process Automation, Data Visualization Tools, and Decision Support Systems, show strong significant associations with the AI usage variable, reflecting wide adoption of these tools.

For Project Manager's Competencies, all dimensions (Technical, Leadership & Behavioral, and Strategic & Business) show significant path coefficients, indicating the model's consistency in representing the relationship between competencies and project management.

For Project Constraints, all core dimensions (Scope, Schedule, Cost, Quality, Risk, Resources, Stakeholders, Governance, Benefits, and Strategic Alignment) have significant path coefficients, suggesting the model comprehensively represents all aspects of project constraints.

However, model fit indices indicate that the initial model requires improvement:

CMIN/DF = 41.859 (very high),

NFI = 0.516, AGFI = 0.337, GFI = 0.473, CFI = 0.521, RMSEA = 0.320,

These values suggest relatively poor overall fit, indicating a need to refine the model, such as improving relationships between variables or introducing additional factors to enhance accuracy and statistical adequacy.

Conclusion: The model confirms the positive importance of AI adoption in enhancing Project Manager’s Competencies, which in turn positively affects the management of Project Constraints, while emphasizing the necessity to improve model fit to achieve more reliable results.

Independent Variable	Dependent Variable	Effect	Effect Percentage
Using Artificial Intelligence	Project Constraints	Direct Effect	32.00%
		Indirect Effect	23.70%
		Total Effect	55.70%

Table (4-24) Percentages of Direct, Indirect, and Total Effects in the Model of the Study

Table (4-24) illustrates the percentages of direct, indirect, and total effects in the study model. It is evident that the use of artificial intelligence has a direct effect of 32.00% on project constraints, indicating a tangible and independent influence of AI in enhancing the management of project-related constraints. Moreover, there is an indirect effect of 23.70%, suggesting that part of the impact of AI is transmitted through the mediating variable—Project Managers’ Competencies, which strengthens the influence of AI on project constraints. Consequently, the total effect reaches 55.70%, reflecting the overall strength of the relationship between the use of artificial intelligence and the reduction or better management of project constraints. This underscores the pivotal role of artificial intelligence as a strategic tool in modern project management.

Modified model values:

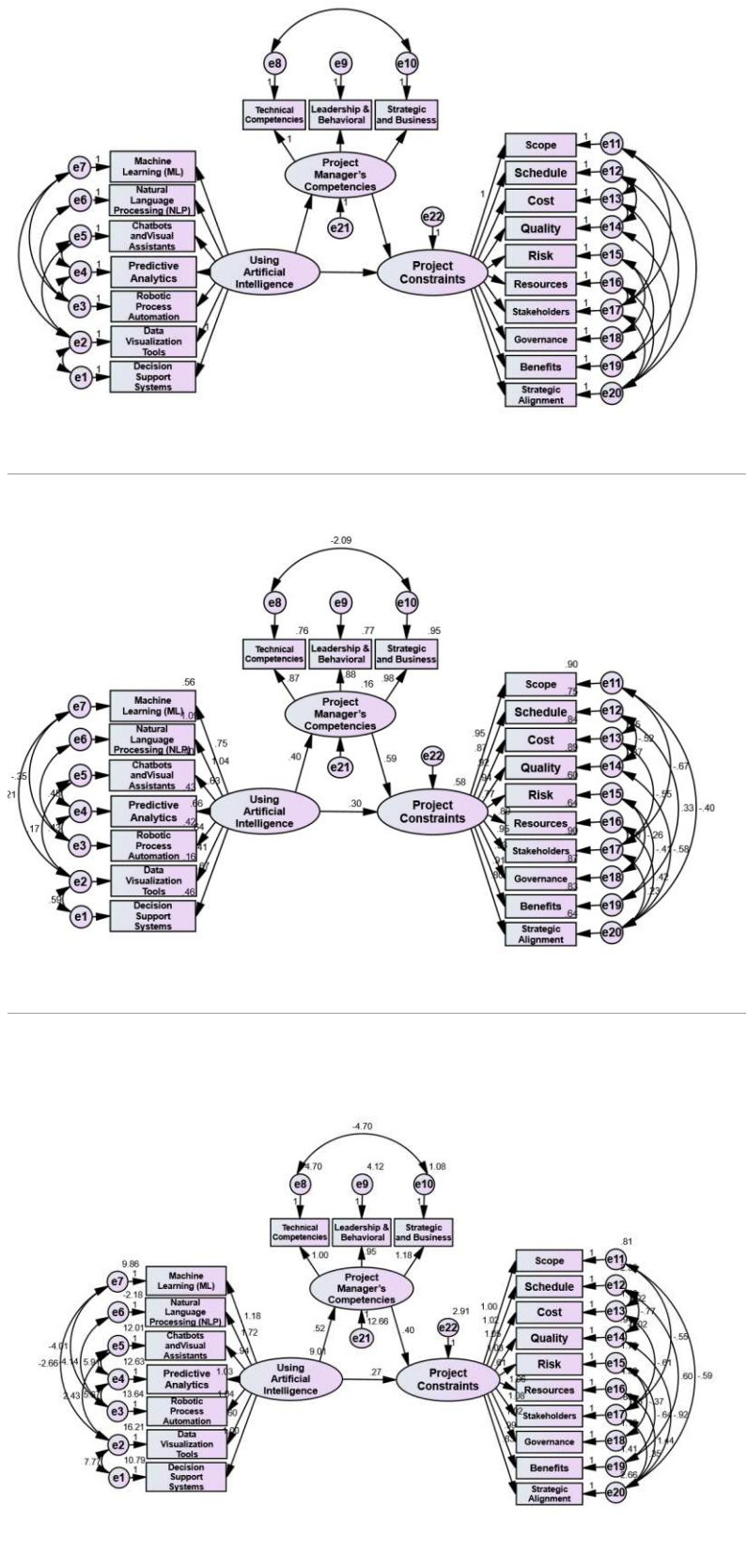


Figure (4-7): Structural Equation Model Modified model

Variables			Estimate	S.E.	C.R.	P
Project.Manager'sCompetencies	<---	UsingArtificial.Intelligence	.519	.062	8.431	***
Project.Constraints	<---	Project.Manager'sCompetencies	.399	.030	13.341	***
Project.Constraints	<---	UsingArtificial.Intelligence	.267	.031	8.500	***
DecisionSupportSystems	<---	UsingArtificial.Intelligence	1.000			
DataVisualizationTools	<---	UsingArtificial.Intelligence	.595	.051	11.669	***
RoboticProcessAutomation	<---	UsingArtificial.Intelligence	1.037	.097	10.712	***
PredictiveAnalytics	<---	UsingArtificial.Intelligence	1.029	.077	13.296	***
ChatbotsandVisualAssistants	<---	UsingArtificial.Intelligence	.943	.073	12.944	***
NaturalLanguageProcessingNLP	<---	UsingArtificial.Intelligence	1.722	.095	18.085	***
MachineLearningML	<---	UsingArtificial.Intelligence	1.182	.079	14.995	***
TechnicalCompetencies	<---	Project.Manager'sCompetencies	1.000			
LeadershipBehavioral	<---	Project.Manager'sCompetencies	.948	.046	20.712	***
StrategicandBusiness	<---	Project.Manager'sCompetencies	1.179	.062	19.081	***
Scope	<---	Project.Constraints	1.000			
Schedule	<---	Project.Constraints	1.021	.034	29.814	***
Cost	<---	Project.Constraints	1.048	.029	35.656	***
Quality	<---	Project.Constraints	1.031	.026	40.266	***
Risk	<---	Project.Constraints	.610	.027	22.719	***
Resources	<---	Project.Constraints	1.059	.044	24.148	***
Stakeholders	<---	Project.Constraints	1.081	.033	32.668	***
Governance	<---	Project.Constraints	1.025	.027	38.340	***
Benefits	<---	Project.Constraints	.994	.028	35.254	***
StrategicAlignment	<---	Project.Constraints	.828	.039	21.113	***
CMIN (5244.923)			NFI(0.637)			
CMIN/DF(35.924)			AGFI(0.408)			
GFI(0.589)			CFI(0.642)			
RMSEA(0.296)						

Table (4-25) Results of the Modified Structural Equation Model with Standardized Path Coefficients

The table presents the results of the modified Structural Equation Model (SEM) with standardized path coefficients, showing the refined relationships between Using Artificial Intelligence (AI), Project Manager's Competencies, and Project Constraints. The scientific academic commentary can be formulated as follows:

The modified SEM demonstrates that Using AI has a significant positive effect on Project Manager's Competencies ($\beta = 0.519$, $p < 0.001$), suggesting that the adoption of AI tools and technologies strongly enhances managers' technical, leadership, and strategic capabilities. This effect is slightly stronger than in the initial model, reflecting improved explanatory power after model refinement.

The path from Project Manager's Competencies to Project Constraints remains significant and positive ($\beta = 0.399$, $p < 0.001$), highlighting the critical role of managerial competencies in mitigating and managing project constraints, including scope, schedule, cost, quality, risks, resources, stakeholders, governance, benefits, and strategic alignment.

The direct effect of AI on Project Constraints is also positive and significant ($\beta = 0.267$, $p < 0.001$), which, along with the indirect effect mediated through Project Manager's Competencies, confirms that AI adoption improves project outcomes both directly and indirectly.

Individual AI components, including Machine Learning (ML), Natural Language Processing (NLP), Chatbots and Visual Assistants, Predictive Analytics, Robotic Process Automation, Data Visualization Tools, and Decision Support Systems, continue to show strong, statistically significant associations with the overall AI construct, confirming their collective importance in project management applications.

For Project Manager's Competencies, all three dimensions (Technical, Leadership & Behavioral, Strategic & Business) remain significant, confirming the robustness of the model in capturing the impact of AI on different managerial skill sets.

Similarly, Project Constraints dimensions show strong significance, confirming the model's effectiveness in representing all critical aspects of project performance limitations.

Regarding model fit indices, the modification improved the overall fit compared to the initial SEM, although it still indicates moderate fit:

CMIN/DF = 35.924 (still high),

NFI = 0.637, AGFI = 0.408, GFI = 0.589, CFI = 0.642, RMSEA = 0.296,

These indices suggest that while the model better captures the relationships among variables, further refinements—such as including additional mediators, latent variables, or adjusting paths—may be necessary to achieve a fully satisfactory fit.

Conclusion: The modified SEM confirms the positive and significant influence of AI adoption on Project Manager's Competencies, which in turn significantly enhances

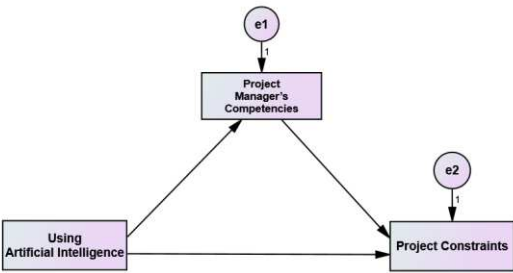
Project Constraints management. The model highlights both direct and indirect pathways through which AI improves project outcomes, providing valuable insight for organizations seeking to integrate AI into project management practices, while also indicating room for further model optimization.

Independent Variable	Dependent Variable	Effect	Effect Percentage
Using Artificial Intelligence	Project Constraints	Direct Effect	30.40%
		Indirect Effect	23.60%
		Total Effect	54.00%

Table (4-26) Percentages of Direct, Indirect, and Total Effects in the Model of the Study

Table (4-26) presents the percentages of direct, indirect, and total effects in the study model. It is evident that the use of artificial intelligence has a direct effect of 30.40% on project constraints, indicating that AI significantly contributes to improving the management of project constraints through its direct influence on planning, execution, and monitoring processes. Moreover, there is an indirect effect of 23.60%, suggesting that part of AI’s influence operates through Project Managers’ Competencies as a mediating variable that enhances and reinforces this impact. Consequently, the total effect reaches 54.00%, reflecting the overall strength of the relationship between the use of artificial intelligence and its ability to reduce or effectively manage project constraints. This emphasizes the importance of integrating AI technologies into modern project management practices to achieve more efficient and sustainable performance.

Path Analysis Model



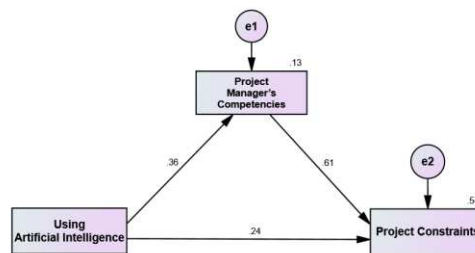
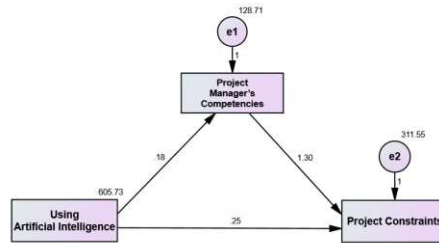


Figure (4-8): Path Analysis Model

Variables			Estimate	S.E.	C.R.	P
ProjectManagersCompetencies	<---	UsingArtificialIntelligence	.177	.023	7.681	***
ProjectConstraints	<---	ProjectManagersCompetencies	1.302	.078	16.718	***
ProjectConstraints	<---	UsingArtificialIntelligence	.253	.038	6.566	***
CMIN (0.000)			CFI(1.000)			
GFI(1.000)			RMSEA(0.547)			
NFI(1.000)						

Table (4-27) Standardized Path Estimates Showing the Effects of Using Artificial Intelligence on Project Managers' Competencies and Project Constraints

The table presents the standardized path estimates for the relationships among the use of artificial intelligence, project managers' competencies, and project constraints, showing statistically significant and positive direct effects at the $p < 0.001$ level. The results indicate that the use of artificial intelligence has a direct positive impact on project managers' competencies (Estimate = 0.177, C.R = 7.681, $p < 0.001$), suggesting that adopting AI technologies enhances managers' technical, leadership, and strategic capabilities.

The table also shows a strong effect of project managers’ competencies on project constraints (Estimate = 1.302, C.R = 16.718, $p < 0.001$), indicating that higher levels of managerial competence lead to improved management of project constraints such as scope, schedule, cost, quality, risk, and resources.

In addition, the results reveal a direct effect of using artificial intelligence on project constraints (Estimate = 0.253, C.R = 6.566, $p < 0.001$), demonstrating that AI contributes directly to improving the management of these constraints, alongside its indirect influence through enhancing managers’ competencies.

The model fit indices show relatively strong performance, with CFI, NFI, and GFI = 1.000, whereas RMSEA = 0.547, indicating that although the model displays excellent fit on several indices, the RMSEA value suggests some deviation from an ideal model.

Independent Variable	Dependent Variable	Effect	Effect Percentage
Using Artificial Intelligence	Project Constraints	Direct Effect	24.00%
		Indirect Effect	21.90%
		Total Effect	45.90%

Table (4-28) Percentages of Direct, Indirect, and Total Effects in the Model of the Study

The results presented in Table (4-28) indicate that the use of artificial intelligence has both direct and indirect significant effects on project constraints. The direct effect, which reached 24.00%, reflects the positive and immediate impact of AI technologies on improving the management of project constraints. Additionally, the findings reveal an indirect effect of 21.90% through project managers’ competencies, emphasizing the mediating role of managerial and technical competencies in enhancing the effectiveness of AI on overall project performance. Consequently, the total effect amounted to 45.90%, demonstrating the strong integrative relationship between artificial intelligence and project managers’ competencies in mitigating project constraints and improving project outcomes.

CHAPTER 5

CONCLUSION OF THE STUDY

5.1 Introduction

The purpose of this Chapter is to give a summary of the key findings and interpret them into practical recommendations. The main objective of this study was to explore the mediating role of the Project Manager's Competencies in the relationship between using AI in Project Management and Project Constraints, applying to the large-scale contracting companies in the eastern province of Saudi Arabia.

Based on the statistical analysis, which was presented in the previous chapter, the proposed hypotheses were tested, and the relationships between the variables were identified. Derived from the findings, this chapter presents the key findings and proposes practical recommendations for the organizations that look to enhance their performance in the field of Project Management by adopting AI. It also proposes recommendations for future studies to expand the knowledge and cover any possible research gaps.

5.2 Findings and Recommendations

Results	Recommendations	Implementation	Implementing Entity	Timeframe
Using AI has a significant positive effect on the Project Manager's Competencies. (Technical –Leadership & Behavioral – Strategic & Business).	Integrating AI with the functions of Project Management	Adopting the use of AI tools and applications that are supported by AI and integrating them with the processes and workflow of the organization.	IT Department – PMO – Executives	6 – 12 months
	Providing a Technical Training and Certification program that is based on AI, and making it part of the employees' development plan	Building a well-structured program covering all the required skills and tools that employees need to perform their functions at work.	HR / Training Department – PMO	6 months
	Initiating AI supporting tools as part of the Leadership Development Program	Conducting Workshops about AI and how it can be utilized in analyzing data, forecasting, and supporting decision-making.	HR / Training / Career Development Department	3 – 6 months
	Applying AI to the Organization's Strategy and Portfolio Management	Making automated dashboards supported by AI, which support in making decisions during the process of selecting projects and provide live information with reports and monitoring the status for the executives.	Executives.	3 months
Project Manager's Competencies have a significant effect on Project Constraints (Scope – Schedule – Cost – Quality – Risk – Resource – Stakeholder – Governance – Benefits realization – Strategic alignment).	Utilizing systems/applications that are AI-based to monitor and control the scope	Configuring the monitoring system or dashboard to give an alert for any scope creep or deviation.	IT Department - PMO	3 – 6 months
	Using tools for predicting the schedule	Adopting systems that have automated forecasting for the delays, milestones monitoring, and tracking	Planning Department – PMO	6 – 12 months
	Using AI-based systems for cost control	Utilizing a real-time dashboard for the expenses, predicting costs, and giving alerts whenever there is a variance between the planned budget and the actual budget.	Finance Department – PMO	6 – 12 months
	Enhancing quality by utilizing AI tools	Applying AI analytic tools to support detecting any defect and transforming from a preventive approach to a predictive approach.	Quality Department	6 – 8 months
	Adopting AI-based systems for predicting Risks.	Using automated Risk monitoring tools and integrating them with the project management software to give an early alert of any predicted Risk.	PMO – Risk Management	6 – 12 months
	Using AI for optimizing resources (Manpower – Tools – Equipment) allocations	Integrating AI tools with resource planning systems will give more flexibility and agility in moving resources between projects based on the requirements, activities, and milestones.	HR – PMO	3 – 6 months
	Utilizing AI-based systems to analyze and monitor Stakeholders.	Applying analytic tools with an automated monitoring dashboard that shows the engagement of stakeholders based on the milestones, activities, and communications.	PMO	3 – 6 months
	Establishing an analytic approach based on AI to monitor the performance and strategic benefits of the project	Applying an analysis to all the recorded events and performance after completing the project to link it with the organization's strategic plan and see the contribution towards achieving the organization's goals	PMO – Executives	3 months
Using AI has a significant effect on Project Constraints.	Implementing AI on all the organization's projects	Utilization of AI tools and software should be on certain projects as a first phase. An evaluation of the results with the performance is to be done, and comparing it with records of previous similar projects, and after that, applying it to all the organization's projects.	PMO – IT - Executives	12 months
Project Manager's Competencies significantly mediate the relationship between using AI and Project Constraints.	AI should be implemented within the organization step by step.	An assessment of the competencies of the employees should be done to evaluate their capabilities. After that, provide them with the required training based on their demographic characteristics, then provide AI tools and software to be utilized, and then evaluate them again in order to enhance and optimize their performance.	HR – PMO	3 – 6 months
There are significant differences based on certain demographic characteristics.	Developing AI and Competencies programs based on the demographic characteristics	Multiple Training programs should be implemented based on the position, qualifications, and experience to enhance the capabilities of the human capital.	HR – Training Department	3 – 6 months

Table (5-1) Findings & Recommendations

5.3 Recommendations for Future Research

This study examined the mediating role of the Project Manager's Competencies in the relationship between using AI and Project Constraints. It also investigated the impact of using AI on both the Project Manager's Competencies and Project Constraints. The study was conducted on the large-scale contracting companies in the Eastern Province of Saudi Arabia. Despite the findings generated by this research, several areas remain open for further exploration by future studies in this field.

First, the scope of this study was geographically limited to the Eastern Province. It is recommended for future studies to replicate the study on different geographical locations within Saudi Arabia, like Western Province and Central Province, in order to verify if there are variances based on the geographical locations. The findings will provide insight into the impact of the environment and culture on AI adoption in project management.

Second, this study was conducted on contracting companies. Future studies may extend the study to manufacturing companies or service companies like Facility Management (FM) Companies. Examining the model across different industries would broaden the understanding of the effect of AI adoption on the competencies of project managers and project constraints.

Third, since this study investigated all the dimensions of the Project Manager's Competencies and Project Constraints, future studies may examine each dimension individually with respect to AI adoption. Such focused studies would provide stronger empirical foundations for implementing AI in Project Management.

Finally, future researchers may consider assessing the long-term impact of integrating AI on project outcomes, as well as incorporating moderating variables like the culture of the organization, digital maturity, or leadership style.

5.4 Conclusion

This study investigated the mediating role of the Project Manager's Competencies in the relationship between using AI and Project Constraints as an application in the large-scale contracting companies in the eastern province of Saudi Arabia. It examined the relationship between adopting AI, Project Manager's Competencies, and Project Constraints using a quantitative approach.

The findings of this study significantly confirm the relationship between the variables, emphasizing the enhanced role of AI in project management, resulting in better outcomes. The results showed the important role that the competencies of the project managers play in boosting the relationship between adopting AI and the effective management of project constraints. The findings underline the importance of adopting AI technologies and the development of competencies for managers to enhance project performance.

In general, this study is a contribution to grow the Scientific Community and increase knowledge about the applications of AI in the field of Project Management, and provides a practical overview to the organizations that intend to enhance the efficiency of their projects alongside decision-making. The recommendation of this study provides a direction to the organizations and practitioners intending to adopt AI, besides strengthening the project managers' competencies. Researchers are encouraged to explore further areas in different industries and geographical locations to broaden the understanding of AI-driven project management.

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