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Advancing Sustainable Project Management: Interplay of Cost, Risk, and Schedule Management with AI and Knowledge Management Processes

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Abstract

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Keywords: Sustainable Project Management, Project Risk Management, Project Schedule Management, Project Cost Management, Artificial Intelligence

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Title

Advancing Sustainable Project Management: Interplay of Cost, Risk, and Schedule Management with AI and Knowledge Management Processes

Abstract

This study explores the nexus of project risk, cost and schedule management on sustainable project management in Pakistani manufacturing companies where knowledge management is considered a mediator and artificial intelligence moderator. Data from project management professionals were analysed. The results show that project cost and schedule management significantly influence sustainable project management and that knowledge management practices mediate this relationship. In addition, artificial intelligence modifies the impact of cost and schedule management on sustainability. The findings provide recommendations for companies to improve sustainable project management, focusing on economic and competitive advantages, stakeholder management and innovative sustainable business models.

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Introduction

In today's promptly changing business landscape, the incorporation of sustainability principles into project management has become mandatory as organizations aim to align their operational goals with global sustainability objectives. Organizations are integrating sustainability values into project management to ensure long-term success and alignment with sustainability goals (Mok et al., 2014). This shift helps to balance the short-term project deliverables with long-term sustainability goals. As the project complexity increases, the need for efficient methods to manage cost, risk, and schedule also increases while ensuring that sustainability objectives are also fulfilled.

Project cost, risk, and schedule management are the fundamental aspects of successful project execution. However, in today's volatile and uncertain environment, a deeper understanding is required to determine how they interrelate with sustainability goals. It is the concern of project managers to confirm that project cost, time, and risk trade-offs do not compromise sustainability outcomes (Fridgeirsson et al., 2023). The optimization of project schedules, minimizing risks, and controlling costs can allow organizations to reduce resource wastage and compliance with sustainability standards. This highlights the need for advanced tools and methodologies that can enhance decision-making in these areas.

One method could be the implementation of a knowledge management process as a mediator in project management. The knowledge management process enables the systematic handling of information and expertise across project teams, facilitating innovation, improving decision-making, and ensuring that lessons learned from past projects are effectively applied (Nonaka, 2009). The knowledge Management Process enables organizations to acquire and disseminate information from and among employees and groups that is helpful for strategic gains (Nisar et al., 2019; Martins et al., 2019). Knowledge management practices not only improve organizational learning but also contribute to project sustainability by facilitating collaboration and the reuse of knowledge across project teams (Osei-Kyei & Chan, 2017). Furthermore, knowledge management enhances collaboration across teams, which is essential for managing the intricacies of modern projects.

The increasing use of AI-based solutions in project management further amplifies the potential to meet sustainability goals. AI technologies, such as machine learning and predictive analytics, help project managers improve resource allocation, enhance risk assessment, and optimize schedules with unprecedented accuracy (Fridgeirsson et al., 2023). AI has invented the methods and techniques that help project managers perform their tasks and decision-making more easily and proficiently (Mohamed K.M.A, 2021). These tools act as moderators that support decision-making by providing real-time data insights and forecasts. This research explores how AI-based solutions moderate the association among project management practices as well as sustainable project management, alongside the mediating role of knowledge management processes. Understanding these dynamics can offer new perspectives on how projects can be designed and managed for long-term sustainability.

Literature Review

"Project is a transitory endeavour assumed to build a distinctive product or service" (PMI 2017) which says projects utilize resources and produce products or services while sustainability provides the criteria to utilize the resources properly (Armenia, Dangelico, Nonino & Pompei, 2019). Stakeholder management is the most imperative knowledge area of the project because the success of the project depends on the satisfaction of the stakeholders (Armenia, Dangelico, Nonino & Pompei, 2019; Freeman, 2001). The stakeholders demand ethicality, eco-friendliness and economic efficiency during the lifecycle of the project (Armenia et al., 2019; Abidin & Pasquire, 2006). According to the guidelines of ISO 26000, one of the basic principles of sustainability is the proactive engagement of stakeholders (Armenia et al., 2019; Robichaud & Anantatmula, 2010). One of the basic prerequisites for sustainable project management is the active participation of stakeholders (Chawla, Chanda, Angra & Chawla, 2018; ISO, 2010). In sustainable project management, it is mandatory for a joint, flexible, open and flexible negotiation which involves stakeholders (Larsson J., Larsson L., 2020).

Sustainability has become the key indicator for business success (Gholamzadeh and Ariani, 2019; Goni et al., 2017). Hence, sustainability should be embedded into project management concepts as SPM, to support the organizations in order to achieve competitive advantage (Gholamzadeh & Ariani, 2019). SPM concepts and applications are mandatory to sustainably estimate risk, and plan, organise and control the projects (Gholamzadeh & Ariani, 2019). SPM can be viewed as an opportunistic platform for companies to survive competently with current and future sustainability issues. SPM helps organizations to interlock sustainability principles in the way projects are managed, reported and measured which will ultimately contribute to success (Gholamzadeh & Ariani, 2019). Sustainability and project management should be assimilated to update project management so that it is ready to face sustainability-related problems (Kivilä, Martinsuo & Vuorinen, 2017).

Project Risk Management (PRM)

The processes which identify and analyse the uncertain circumstances that can have a negative impact on the project are involved in project risk management such as quantitative risk analysis, qualitative risk analysis, monitoring risks, planning risk

responses and implementing risk responses. It also includes mitigation strategies that help to reduce the negative effect of the risk (Holzman & Lechiara, 2022). This includes risk assessment and strategy development. Risk mitigation is a systematic activity aimed at addressing potential risks associated with uncertainty. Analysis of transactional and wholesale relationships between analytical departments of risk management; financial valuation and modelling; or risk assessment and allocation (Guerrero-liquet et al., 2016; Burgherr & Hirschberg, 2014).

Project Schedule Management (PSM)

The PSM implicates a process which permits them to accomplish the project timely (PMI, 2017). This duration of the project, develop a schedule, control schedule, and plan schedule management (Holzman & Lechiara, 2022). It remains a significant challenge to accurate time estimation because of unpredictable risks and resource constraints (Flyvbjerg, 2007). Project schedule management involves six major processes including schedule planning, among others (PMI, 2021).

Project Cost Management (PCM)

Economic and financial aspects involved in project cost management such as estimating the cost, controlling cost, determining a budget, and planning cost management (Holzman & Lechiara, 2022). Effective cost management practices are directly associated with the project's success because they help to maintain financial control and prevent budget overruns (Mir & Pinnington, 2013). Despite the fact that there are several tools and techniques available but still project cost management face several challenges. The main challenge is the accuracy of initial cost estimation. Many projects suffer from cost overruns due to optimistic estimations and unforeseen risks (Flyvbjerg, 2006). These challenges require a proactive approach to handle them efficiently.

Knowledge Management Process (KMP)

It is analysed that the core competency and value creation for the firms is knowledge (Liu et al., 2018; Martins, Rampasso, Anholon, Quelhas, and Filho, 2019). There should be a proper knowledge management process but still, there are companies that have difficulty properly managing it due to cultural barriers of the organization (Martins et al, 2019). The researchers agreed on the concept that KM is an integrated approach that helps to capture, share and utilize the intellectual asset (knowledge) for sustainable management and strategic benefits of firms. Due to the increasing demand for sustainability aspects of project management, there is a growing need to find solutions for the improvement of knowledge management processes and practices Bucci & El-Diraby, 2018). This complex nature concept demands proper utilization of knowledge in order to enhance the concept of sustainability (Bucci & El-Diraby, 2018; Spangler et al., 2014; Martins, Rampasso, Anholon, Quelhas & Filho, 2019).

KMP helps the firms to react to market variations quickly (Cillo et al., 2019; Shahzad, Zafar, Ying Qu, Rehman and Islam; 2020) enhance the operations of sustainability (Abbas, 2019; Shahzad et al., 2020) and helps to attain competitiveness (Del-Giudice et al., 2017, Shahzad et al., 2020). KMP is considered as the premeditated and systematized effort to utilize the knowledge which will further help to enhance the performance of the organization (Syed Ikhsan & Rowland, 2004; Shahzad et al., 2020). Knowledge management is an intangible asset for an organization. It has been recognized that sustainable competitive advantage can be achieved through knowledge management. The economic and production level of the company depends on invisible competencies rather than physical assets (Rahimli, 2012). It is mandatory for organizations to develop such capabilities which help them in the management of change and quickly learn from the changing market trends (Rahimli, 2012). Organizations can gain a competitive advantage when they have the capability to obtain, disseminate and apply the knowledge throughout the organization and use that knowledge to build core competencies. These core competencies help the organizations to achieve competitive advantage (Rahimli, 2012).

Artificial intelligence (AI)

Nils J. Nilson demarcated Artificial Intelligence (AI) as "the process of making machines intelligent, enabling them to function appropriately and learn from their environment." Introduced by Allen Turing and John McCarthy, AI is now understood (Kaplan & Haenlein, 2019). This study adopts a modern perspective on AI, viewing it as a tool that performs human-like tasks by analyzing data, learning, and interpreting the environment. In project management, AI supports project managers by providing recommendations for optimal decisions and actions (Holzman & Lechiara, 2022). Research by Fridgeirsson et al. (2021) highlights AI's significant impact on cost management, particularly in cost estimation, as well as on project schedule management processes like activity sequencing, duration estimation, and

schedule control. AI also greatly influences project risk management, with the highest impact observed in quantitative risk analysis and risk monitoring.

Hypothesis Development:

Project Risk Management and Sustainable Project Management

Effective RM can help project managers minimize negative impacts and maximize positive impacts on sustainability objectives (Gambatese et al., 2016). A study by Nygaard and Marshall (2014) demonstrated that integrating risk assessment and management processes into sustainability planning can improve project success rates, reduce the potential for harm to the environment, and enhance social equity. Moreover, risk management techniques, such as risk mapping and scenario planning, can help project teams identify and address sustainability risks and opportunities more effectively (Schmidt et al., 2019). Finally, effective risk management can help to prevent project failure, which is critical for ensuring long-term sustainability benefits (Chapman, 2003).

H1: PRM and SPM are positively associated.

Sustainable Project Management and Project Schedule Management

Effective PSM also enhances communiqué and alliance among team members, stakeholders, and clients. Effective schedule management entails adapting to changing project requirements, which can lead to cost savings through optimized resource utilization. Finally, the use of technology tools in PSM has been cited as a key driver of project success. The integration of sustainability into project schedule management improves risk management by equipping projects to handle uncertainties related to environmental regulations and social expectations (Martens & Carvalho, 2016).

H2: Sustainable Project Management and Project Schedule Management are positively associated.

Sustainable Project Management and Project Cost Management

Several research has been conducted on the affiliation among this nexus. PCM plays a crucial role in stakeholder engagement which can support project teams to involve with stakeholders and address their concerns. Projects that incorporate sustainable practices could have better cost performance due to enhanced resource efficiency and reduced waste (Hwang, Zhu, & Ming, 2017).

H3: Project cost management and Sustainable Project Management are positively associated.

Knowledge Management Process and Project Risk Management

The risk of the project will cause cost overrun and project delays (Gunnarsodottir, 2021). Risk management is a critical part of project management because unmanaged risks can cause project failure (Lyons & Skitmore, 2003). According to Neef (2005), organizations cannot manage the risks without the management of knowledge. He believes that risk management (RM) can only be handled through knowledge management (KM).

H4: The Knowledge Management Process and Project Risk Management have a significant and positive association.

Knowledge Management Process and Project Cost Management

Effective cost management, such as budgeting, resource allocation, and scheduling, can help in reducing the costs associated with knowledge management. For example, by utilizing cost-effective tools and technologies, organizations can optimize their knowledge management process, resulting in lower expenses. Proper allocation of resources plays a significant role in both knowledge management and cost management. By using the right mix of people, skills, tools, and technologies, organizations can optimize both of these processes. Cost management can help in developing effective performance metrics that line up with the organizational objectives.

H5: Project cost management has a significant and positive effect on the Knowledge management process.

Project Schedule Management and Knowledge Management Process

Various researchers have explored the connection between project schedule management and knowledge management. It's crucial to capture knowledge from project activities for continuous improvement through knowledge repositories (Ajmal & Koskinen, 2008). Projects with effective knowledge management practices face fewer schedule overruns and are better able to meet deadlines (Park & Lee, 2013). Hanisch et al., (2009) also prove that knowledge integration and sharing can improve project outcomes specifically in terms of time management and schedule reliability. In addition, the process of knowledge transfer is also crucial during the schedule development and control phases. Effective knowledge sharing among stakeholders can facilitate the timely identification and resolution of schedule variances (Argotr & Ingram, 2000). The knowledge sharing allows the project managers to address issues such as resource constraints or

unforeseen delays thus helping to confirm that the project rests on schedule (Alavi & Leidner, 2001).

H_6: Project schedule management has a significant and positive effect on the Knowledge management process.

Knowledge Management Process and Sustainable Project Management

In today's globalizing world, knowledge is a vital asset for organizations and effective management is needed to realize its benefits (Jalil et al., 2018). Proper knowledge management enables organizations to innovate, grow, sustain their operations and gain competitive advantage (Calvo et al., 2016; Chen and Huang, 2009). Researchers believe that in order to achieve sustainability and strategic advantages in knowledge management, intellectual assets should be used within a consistent strategy (Martens et al., 2019; Al-Sefi, 2015; Hosseinki et al., 2017).

With the increasing interest in sustainability, it is important to improve the quality of knowledge transfer (Martens et al., 2019; Bucci and Al-Derabi, 2018). These processes ensure the creation and sustainable use of knowledge resources (Abbas and Sajsan, 2019; Lim et al., 2017). The management of non-material knowledge enables companies to adapt to market changes and create core competencies by providing sustainable competitive advantage (Rahimli, 2012). Competitive advantages, corporate capabilities and innovation are based on the effective acquisition, sharing and application of knowledge (Rahimli, 2012). It also improves knowledge management, knowledge exchange among employees and the production of new products (Martens et al., 2019). Knowledge sharing improves corporate resources, generates new ideas and expands innovation capabilities (Shehzad et al., 2019; Ganguly et al., 2019). Companies can maintain their competitive position and increase productivity by effectively managing project-related knowledge (Jalil et al., 2018; Shehzad et al., 2020).

H7: The knowledge management process has a significant and positive effect on sustainable project management.

Mediating Effect of the Knowledge Management Process

This research study is conducted to examine whether project management knowledge areas affect sustainable project management directly and Knowledge management process acts as a mediator between them. Knowledge management plays an important role in the performance of organizations or projects (Yang et al., 2011). The knowledge management process improves the assimilation of sustainability into project management by ensuring that relevant knowledge is accessible and utilized throughout the project lifecycle (Ahern, Leavy & Byrne, 2014). Projects that have robust knowledge management practices can better anticipate and manage risks of environmental and social factors (Jia et al., 2011).

H8: The knowledge management process mediates the relationship between Project management knowledge areas and sustainable project management.

Moderating Effect of Artificial Intelligence (AI)

Artificial Intelligence-based applications such as expert systems, decision support systems, knowledge management and recommendation agents have supported users in knowledge acquisition, dissemination and application processes (Coombs et al., 2020). Research shows processes of cost management would have a high effect. Of all the four processes, estimation of costs has the highest effect. Similarly, AI has an influence on the processes of the projects. Processes include schedule management planning, defining activities, sequence of activities, estimation of activities duration, and developing and controlling schedules. Moreover, AI can cope with multifarious analytics which helps to rack the project movement and make expectations about the future of the project (Gunnarsodottir, 2021). Artificial Intelligence systems can help project managers estimate costs, manage schedules, monitor progress, and planning of resources (Fridgeirsson et al., 2021). Previous studies show that IT is beneficial because it is helpful for mutual knowledge sharing and also supports well-organized data assimilation, sharing and management. It plays an imperative role in knowledge management (Yang et al., 2011).

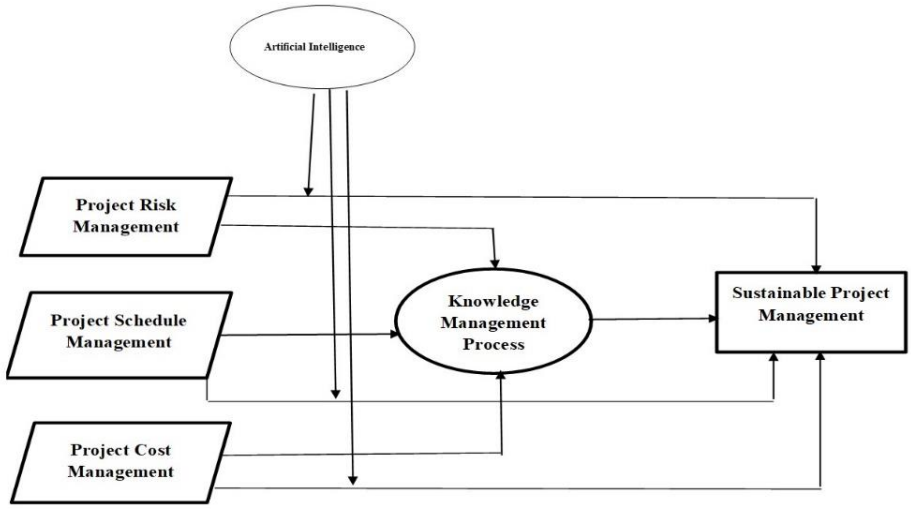
H9a: AI-used solutions moderate the nexus between PRM and SPM.

H9b: AI-based solutions moderate the nexus between PCM and SPM.

H9c: AI-based solutions moderates the nexus between PSM and SPM.

Figure 1

Conceptual Framework



The Research Design

This research study is acquitted by means of quantitative design based on a survey experiment and using adaptations of current scales based on the proposed framework. The respondents of this research are project management professionals who hold managerial positions in manufacturing organizations in Pakistan. Among 350 respondents, 42.6% were project managers, 28.3% were project team members, 12.9% were managers, 10.9% were senior managers and 5.4% were top management.

Table 1

Sources of Scale

Constructs	No. of items	Sources
Project Risk Management	8 items	(Omondi and Muchelule, 2022)
Project Schedule Management	5 items	Binuyo & Ogenberu (2020)
Project Cost Management	6 items	Gitonga, Muchelule & Nyang'au (2022)
Knowledge Management Process	16 items	Darroch (2003)
Artificial Intelligence	4 items	Srinivasan and Swink, 2018; Bubey et al. (2019)
Sustainable Project Management	14 items	Martens and Carvalho (2016)

Reliability measures consistency among the measurements. As shown in the following table all the values are within the acceptable limits as suggested by Nunnally and Bernstein (1994)

Table2

Construct Validity & Reliability

	Alpha	rho_A	R						
1. AI	0.727	0.728	0.830	0.74					
2. KMP	0.749	0.764	0.806	0.48	0.61				
3. PCM	0.737	0.742	0.827	0.38	0.50	0.70			
4. PRM	0.718	0.726	0.814	0.17	0.29	0.28	0.68		
5. PSM	0.781	0.782	0.851	0.36	0.49	0.56	0.18	0.73	
6. SPM	0.758	0.744	0.804	0.42	0.58	0.57	0.28	0.53	0.48

For Construct Validity & Reliability, discriminant validity is usually considered a necessity in analysing relationships. The values of HTMT are shown below in Table 3.

Table 3

HTMT ratio of Correlations

	1	2	3	4	5	6
AI						
KMP	0.653					
PCM	0.520	0.630				
PRM	0.245	0.391	0.382			
PSM	0.481	0.620	0.731	0.235		
SPM	0.538	0.673	0.672	0.342	0.646	

Table 4 displays the cross-loadings for each indication. According to the table, each item loads on its own construct and does not depend on any other constructions.

Table 4

Cross-Loadings

	AI	KMP	PCM	PRM	PSM	SPM
AI1	0.716					
AI2	0.751					
AI3	0.738					
AI4	0.761					
KMP1		0.524				
KMP10		0.580				
KMP11		0.541				
KMP12		0.629				
KMP13		0.604				
KMP14		0.653				
KMP15		0.501				
KMP16		0.634				
KMP2		0.519				
KMP3		0.516				
KMP4		0.656				
KMP5		0.525				
KMP6		0.797				
KMP7		0.680				
KMP8		0.599				
KMP9		0.667				
PCM1			0.550			
PCM2			0.732			
PCM3			0.740			
PCM4			0.745			
PCM5			0.720			
PRM1				0.718		
PRM2				0.703		
PRM3				0.648		
PRM4				0.652		
PRM5				0.692		
PSM1					0.765	
PSM2					0.689	
PSM3					0.783	
PSM4					0.722	
PSM5					0.691	
SPM1						0.698
SPM10						0.515

	AI	KMP	PCM	PRM	PSM	SPM
SPM11						0.655
SPM12						0.589
SPM13						0.714
SPM14						0.685
SPM2						0.653
SPM3						0.524
SPM4						0.523
SPM5						0.576
SPM6						0.570
SPM7						0.611
SPM8						0.569
SPM9						0.775

The final outcomes are presented in Table 5. It can be realised from the table that the hypothesis stating the positive effect of AI on sustainable project management is supported at a 0.01 level of significance (=0.119, t= 4.049, p≤0.01). This shows that by increasing 1 unit AI would increase SPM by 0.119 units. The second hypothesis is also accepted which states that KMP has a positive impact on SPM at 0.01 level of significance (b=0.291, t=5.319, p<0.01). This tells us that a 1-unit increase in KMP would increase 0.291 units of SPM. The third hypothesis is also accepted which states that PCM has a positive impact on KMP at 0.01 level of significance (b=0.293, t=4.259, p<0.01). This tells us that a 1-unit increase in PCM would increase 0.293 units of KMP. The fourth hypothesis is also accepted which states that PCM has a positive impact on SPM at 0.01 level of significance (b=0.210, t=3.575, p<0.01). This tells us that a 1-unit increase in PCM would increase 0.210 units of SPM. The fifth hypothesis is also accepted which states that PRM has a positive impact on KMP at 0.01 level of significance (b=0.156, t=2.756, p<0.01). This tells us that a 1-unit increase in PCM would increase 0.156 units of KMP. Furthermore, the sixth hypothesis H3 is rejected which states the positive relationship between PRM and SPM at a significance level of 0.01 (b=0.066, t=1.485, p>0.01). The seventh hypothesis is also accepted at a significance level of 0.01 (b=0.304, t=4.442, p<0.01) which means that PSM has a positive impact on KMP. So, a 1-unit increase in PSM would increase 0.304 units of KMP. The eighth hypothesis is also accepted at a significance level of 0.01 (b=0.224, t=3.978, p<0.01) which means that PSM has a positive impact on SPM. So, a 1-unit increase in PSM would increase 0.224 units of SPM.

Table 5

Hypothesis-Testing Results

	( )	(STDEV)	T Statistics	P Values
AI -> SPM	0.11	0.05	2.35	0.01
KMP -> SPM	0.29	0.05	5.31	0.00
PCM -> KMP	0.29	0.06	4.25	0.00
PCM -> SPM	0.21	0.05	3.57	0.00
PRM -> KMP	0.15	0.05	2.75	0.00
PRM -> SPM	0.06	0.04	1.48	0.13
PSM -> KMP	0.30	0.06	4.44	0.00
PSM -> SPM	0.22	0.05	3.97	0.00
PRM -> KMP -> SPM	0.045	0.018	2.499	0.013
PSM -> KMP -> SPM	0.088	0.026	3.402	0.001
PCM -> KMP -> SPM	0.085	0.027	3.174	0.002
PCM*AI -> SPM	-0.135	0.062	2.192	0.029
PRM*AI -> SPM	0.057	0.045	1.266	0.206
PSM*AI -> SPM	0.101	0.050	2.041	0.042

There is a mediating effect when two variables are intervened by a third variable (Hair et al. 2013). A bootstrapping method is used to identify the mediating effect, which is slightly rigorous. The KMP also mediates between PCM, PSM, project cost management and SPM as shown in the table.

It is proved from the table that the Knowledge Management Process mediates between PCM and SPM, PRM and SPM, and PSM and SPM. Decision has been taken on the basis of T values which are greater than 1.96. In our case, sustainable competitive advantage is playing the role of mediation between PCM and SPM, PRM and SPM, and PSM and SPM.

In this research, we are using AI as a moderator between PCM and SPM, PRM and SPM, and PSM and SPM. In this table, we can see that AI moderates between PCM and SPM, PSM and SPM. However, AI does not moderate between PRM and SPM.

Discussion

The core goal of this research was to conclude how SPM can be improved in Pakistan. This research refers to the mediating influence of KMP (KMP) between determinants namely PRM(PRM), PCM(PCM), and PSM(PSM) towards SPM(SPM). The moderation effect of AI (AI) is also determined by the relationship of PCM, PSM, PRM and SPM. This study develops a research framework that describes how the determinants (PCM, PRM, PSM) relate to achieving SPM with the help of KMP and AI. Questionnaire adopted from the previous studies. Data has been collected from 350 respondents via an online survey through Google Forms and respondents belong to the project management professionals of the manufacturing industry. Demographic characteristics are explained with the help of collected data. The validation of the scale was based on consistent reliability. Smart PLS3 was used to analyse the results of factor loading, composite reliability, coefficient of determination, and discriminant validity. A path model has been developed or studied to test the hypothesis.

This study developed 13 hypotheses from which 11 hypotheses are significant while 2 hypotheses show insignificant results. The statistical results of the first hypothesis show insignificant relationship between PRM (PRM) and SPM (SPM). Schmidt et al. (2019) and several other studies show a positive relationship between PRM and SPM. However, it is rejected in the culture of Pakistan. Smith & Merritt (2017) and other studies also approve of the positive link between PSM and sustainable project management. Aibinu and Jagboro (2002) and other authors support the positive results of PCM and sustainable project management.

The results of hypothesis 4 show the positive association between PRM (PRM) and KMP (KMP). Neef (2005) and other authors also approve of the positive relationship between PRM and KMP. The fifth hypothesis suggested a positive relationship between PCM (PCM) and KMP (KMP). Zhang, Wu, and Wang (2018) also approve of the positive correlation between PCM and KMP. The sixth hypothesis outcome shows a positive association between PSM and KMP. It is also supported by the previous literature. The findings of the 7th hypothesis show a positive correlation between KMP and sustainable project management. Jaleel et al., 2018; Calvo, Navarro, Rey & Perian, 2016; and Chen & Huang, 2009 also approve the positive liaison between KMP and sustainable project management.

The findings of the eighth, ninth and tenth hypotheses show that KMP positively mediates the relationship of PCM, PRM, PSM and SPM. The previous studies also approve the positive impact of KMP. Hypothesis 11 depicts the insignificant impact of AI as a moderator between PRM and sustainable project management. It might be possible that AI-based solutions are not properly utilized for PRM or it could be possible that proper risk management techniques are not fully utilized in Pakistan. The results of 12 and 13 hypotheses show that AI positively moderates the relationship of PCM, PSM and SPM. Fridgeirsson et al. (2021) Also approve of the positive impact of AI on PCM and PSM.

Theoretical and Practical Implications

This research provides significant theoretical and practical insights into sustainable project management, advancing both academic understanding and professional practices.

The study highlights how improvements in project risk, cost and schedule management collectively increase sustainable development outcomes. By presenting knowledge management as a tool, it highlights the importance of knowledge transfer and its use in linking traditional project management with sustainable development goals. The results show that knowledge management increases the positive impact of risk, cost and schedule management on sustainable outcomes and integrates sustainability into core project practices. In addition, the study examines the regulatory role of artificial intelligence, demonstrating how advanced technologies are improving project management practices, making them more adaptable and responsive to sustainable development challenges. This unified method offers a vigorous context for understanding the interplay between project management, knowledge management and artificial intelligence in achieving sustainability.

Practitioners can use this information to guide risk, schedule, and cost management with a focus on sustainability. We have a greater risk of distortion, but the plan can also use a device to verify the data. The projector also works on the performance of the artist and the artist who will perform the art in the future and also emphasizes the strengthening of the system.

There is a lot of news from the old days, a lot of old things, old things are old and old things are still alive and well. Under the line, AI asset analytics provides a proactive response to risks, program deviations, and cost overruns, enabling more adaptive and effective strategies. By integrating risk, schedule, and cost management with information management and AI, this study provides a comprehensive roadmap for achieving sustainable project management.

Conclusion

This research examines the major changes affecting sustainable project management, with a focus on achieving economic and competitive benefits, stakeholder management, and innovative sustainable business models. This study investigates project cost, risk management, and schedule as independent variables, knowledge management practices as mediators, and artificial intelligence as mediators. The data collected through the survey were analysed using PLS software.

The findings show that project cost and schedule management have a positive effect on project sustainability and that knowledge management practices mediate these relationships. Artificial intelligence also moderates the effect of project cost and schedule on sustainability. However, project risk management does not significantly impact sustainable project management, and artificial intelligence does not change their relationship. The study provides valuable insights for manufacturing industries in Pakistan such as textiles, pharmaceuticals, and food, and suggests the use of artificial intelligence and advanced knowledge management processes to improve sustainable project management practices.

This research definitely has some limitations like this research is taken in the manufacturing industry of Pakistan by using an instrument tool questionnaire. Therefore, the other knowledge areas can be included to get a clear picture. It is advisable for Pakistani manufacturing industries like textile and pharmaceutical to pay utmost focus on artificial intelligence for sustainable project management.

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