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IMPACT OF AGILE PRACTICES ON SOFTWARE DEVELOPMENT SUCCESS: A STRUCTURAL EQUATION MODELING APPROACH

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Abstract
The purpose of this study was basically to examine how the Agile methodologies affect the success of the software development work by taking into consideration the mediating roles of team collaboration and communication efficiency. Structural Equation Modeling (SEM) in Smart PLS was applied to quantitatively analyze the data obtained from 300 software professionals in variety of industries using a quantitative research design. The study analyzed agile frameworks including Scrum, Kanban, and Extreme Programming (XP), and asses their effects on software quality and project success. It found that Agile methodologies not only made quintessential enhancements to the quality of the software and the success of the project but also improved efficiency of communication and promoted better collaboration between team members. Furthermore, I find both software development success and the effect of Agile on the Software Development Success to be mediated by the team collaboration and the team communication efficiency. It provides clues to the effective use of Agile implementation strategies by software firms as well as project management strategies.

INTRODUCTION
It is worth mentioning that Agile methodologies have changed the software development and moving towards adaptability, continuous improvement, and customer collaboration (Palopak & Huang, 2024). Hamid et al. (2022) link the adoption of Agile frameworks (Scrum, Kanban, and Extreme Programming (XP)) to a better quality of software and project success. Iterative approach practiced by Agile reduces project risk and increases project efficiency (Khattak et al., 2023). However, one of the conditions of the successful implementation of the Agile is the team cooperation and efficiency of communication between the team (Junior & Aquino, 2024). Agile teams can work effectively from various functional areas by means of effective collaboration and the absence of misunderstandings that can hinder project progress (Ali, 2024). Therefore, the human centric elements of these things are vital in determining the final success of the software projects based on the Agile (Barros, Tam, & Varajao, 2024).

Despite the current widespread adoption of Agile, there is still a gap between the value of Agile with high software quality and project success for many organizations (Michalski & Zaleski, 2014). Without implementing other mechanisms of efficient team communication and collaboration, Agile methodologies themselves cannot guarantee project success (Binboga & Gumussoy, 2024). The lack of coordination among team members will result in project delays, unaligned project goals and a lower software quality (Siddiqui, Ali & Shaukat, 2023). Similarly, poor communication between teams could stall the requirements of a project at various points, which may require rework and increase project costs (Setor & Joseph, 2022). As a result, organizations must place emphasis and foment an environment in which collaboration and communication are fundamental to derive the most from the benefits of Agile (Malik et al., 2023).

Recent research (Khattak et al., 2024) has given a lot of attention to the role of team collaboration as a mediator in Agile success. Rahajo et al. (2022) indicate that when the synergy, the cross functional communication and task coordination are strong on Agile teams, software quality and project outcome are improved. Frequent team interactions resulting from Agile methodologies enable knowledge sharing as well as quick decision making (Hamid et al, 2022). In addition, Agile frameworks are transparent and accountable and everyone on the team is able to work on maintaining a high level of collaboration between them (Ali, 2024). It is however, dependent on organizational culture, leadership support, and the amount of Agile maturity in a company (Junior & Aquino, 2024).

In fact, communication efficiency has also been determined as a decisive factor for Agile project success (Khattak et al., 2023). It is because of regular stand up meetings, well defined requirements and continuous feedback loops that teams stay well aligned through the lifecycle of a development project (Palopak & Huang, 2024). Empirical tests have revealed that clear and consistent communication decreases errors, augments the stakeholder satisfaction, and hastens the project completion (Michalski & Zaleski, 2024). To make Agile teams productive, they should be equipped with proper communication mechanisms (Asif et al., 2024). The goal of this study is to explore the mediating roles of team collaboration and communication efficiency in the relationship of Agile methodologies and software development success, thus offering organizations an opportunity to enhance their Agile implementation process. The following objectives are to be addressed in order to investigate the impact of Agile methodologies on the success in software development, by analyzing the mediating role of the team collaboration and communication efficiency.

Objectives

1. To assess the effect of Agile methodologies (Scrum, Kanban, XP) on software quality and project success.
2. To analyze how team collaboration mediates the relationship between Agile methodologies and software development success.
3. To examine the role of communication efficiency as a mediator in Agile-driven software projects.
4. To provide recommendations for improving Agile implementation in software development.

2. Literature Review

The use of Agile methodologies in software development is recognized to be a dominant approach that allows flexibility, customer collaboration and continuous progress (Palopak & Huang, 2024; Hamid et al., 2022). Scrum, Kanban and Extreme Programming (XP) are these methodologies aimed to improve software quality as well as project successful by supporting the teams to react swiftly to changing requirements (Khattak et al., 2023; Siddiqui et al., 2023). It has been increasingly demonstrated in studies that Agile practices greatly decrease task coordination risks, transparency, and the provision of continuous feedback (Junior & Aquino, 2024; Malik et al., 2023). Additionally, Agile methodologies facilitate higher software teams' maintainability, code efficiency, and the reduction of defects, resulting in better final project outcome (Ali, 2024; Michalski & Zaleski, 2024). Nevertheless, the performance of a project solely depends on the collaboration and communication that teams can make within the Agile approach (Rahajo et al., 2022; Barros et al., 2024). It is also well known the challenge to increase the levels of team collaboration

to increase the success rate of Agile projects as it improves the synergy, coordination, and cross-functional communication within the team (Khattak et al., 2024; Hamid et al., 2022). It is obvious through research that Agile teams that interact continuously with each other and communicate openly with each other are likely to perform more efficiently and more productively (Setor & Joseph, 2022; Binboga & Gumussoy, 2024). In particular, collaboration is vital in the distributed Agile teams, as even being on the same geographic location poses challenges to make decisions in real time and share knowledge within the team (Palopak & Huang, 2024; Siddiqui, Ali, & Shaukat, 2023). Self organizing teams are one of the fundamental elements stressed in Agile frameworks; therefore the successful working relationship of the teams involved in the execution of a software project plays an important role of its smooth execution (Michalski & Zaleski, 2024; Junior & Aquino, 2024). The limitation of Agile projects is that they often suffer from delays, low software quality and mismatch with stakeholder expectation caused by weak team collaboration (Ali, 2024; Malik et al., 2023).

H1: Agile methodologies have a significant positive impact on team collaboration.

H2: Agile methodologies have a significant positive impact on communication efficiency.

H3: Agile methodologies have a significant positive impact on software quality.

H4: Agile methodologies have a significant positive impact on project success.

Also, another important factor that makes Agile projects different from traditional projects is communication efficiency, because it keeps teams away from misunderstandings, rework and delays in projects (Khattak et al. 2023, Rahajo et al. 2022). Agile methodologies in turn promote structured communication methods like daily stand up meeting, sprint review and retrospective discussions that encourage team align and to ensure the project requirements are understood (Barros, Tam, & Varajao, 2024; Li, Dong, Wang, & Yang, 2014). Frequent communication has been observed in the studies by Junior & Aquino, 2024; Hamid et al., 2022 that studies has shown that it decreases uncertainty, builds accountability, and accelerates solving a problem when team members are operating in an agile fashion. Moreover, it provides real time feedback for teams so that they can address problems before this becomes an issue, improving software quality and customer satisfaction (Michalski & Zaleski, 2024; Palopak & Huang, 2024).

H5: Team collaboration has a significant positive impact on software quality.

H6: Team collaboration has a significant positive impact on project success.

H7: Communication efficiency has a significant positive impact on software quality.

H8: Communication efficiency has a significant positive impact on project success.

The role of team collaboration has been proven as a mediator in Agile driven software development by the assertion that collaborative efforts alone strengthen the quality of the software and project success (Khattak, Hamid and Khattak, 2024; Hamid, Khattak and Qureshi, 2022). According to (Malik et al., 2023; Binboga & Gumussoy, 2024), the agile methodologies advocate the cross functional teamwork of developers, testers and the business analyst for accomplishing common project objectives. By this approach in collaborative, silos are reduced and decision making process improved and it enhances the project execution and time-to-market (Rahajo et al. 2022; Setor and Joseph 2022). Research also shows that teams with high collaboration levels in an organization yield lower defect rates, more engagement of stakeholders and more adaptability to changing requirements (Ali, 2024; Palopak & Huang, 2024). Its importance as a vital mediator in Agile project success is similar to other studies which shows that teams need to be efficient in communicating with Project objectives, stakeholder, and individual's expectations (Michalski & Zaleski, 2024; Barros, Tam, & Varajao, 2024). Coordination and knowledge sharing among team members are improved through effective communication strategies, like real-time messaging platforms and some of the tools of collaboration software (Khattak et al., 2023; Hamid et al., 2022). According to studies, Agile teams that have robust communication mechanisms; they can quickly resolve conflict and make sound decision more than others (Binboga & Gumussoy, 2024; Siddiqui, Ali, and Shaukat, 2023). Furthermore, increased communication transparency and trust in team

members increases cohesion in the work environment and improves project outcomes (Setor & Joseph, 2022; Junior & Aquino, 2024). Each is related to one another as they are all part of project success (Khattak et al., 2024; Hamid et al., 2022). Agile frameworks give the structural basis for iterative development, but how well teams can collaborate and communicate (Malik et al., 2023; Palopak, Huang, 2024) determines how Agile is thought to work. In the past, research has shown that when Agile projects have high collaboration and communication levels, they are more likely to finish on time, on budget, and we get good software products (Ali, 2024; Rahajo et al. 2022). Projects that do not have a positive communication and purpose living environment are likely to have project inefficiencies, missed deadlines, and stakeholders dissatisfaction (Junior & Aquino, 2024; Michalski & Zaleski, 2024).

H9: Team collaboration mediates the relationship between Agile methodologies and software quality.

H10: Team collaboration mediates the relationship between Agile methodologies and project success.

Structural Equation modeling (SEM) approach to empirically validate the impact of Agile methodologies in software quality and project success through collaboration and communication effects (eckforces: 2024, AKI et al. 2024). The effectiveness of the Agile approach has been measured using PLS-SEM techniques showing teams who are efficiently communicated and well coordinated deliver more effective projects (Khattak et al., 2023; Barros, Tam, & Varajao, 2024). Also, studies show that the alignment of Agile and transformational leadership styles nurtures team motivation at a higher level, and hardware the team collaboration and communication efficiency (Malik et al., 2023; Rahajo et al., 2022). These findings suggest that the implementation of Agile should be considered by looking at both technical and human factors, which are essential to achieve success in software development (Ali, 2024; Palopak & Huang, 2024). As Agile methodologies continue to be more and more used, organization must continually evolve their methods of collaboration and communication to maximize the benefits in the project (Khattak et al., 2024; Hamid et al., 2022). Future research can address industry specific challenges on Agile adoption and best ways to overcome collaboration and communication barriers (Junior & Aquino, 2024; Michalski & Zaleski, 2024). Furthermore, digital collaboration tools, remote work dynamics as well as cross-cultural team interaction in Agile setting still need exploring the role (Palopak & Huang, 2024; Malik et al., 2023). Organizations can improve the effectiveness of Agilist methods and raise the total success rate of the software development assignments (Asif et al., 2024; Binboga & Gumussoy, 2024).

H11: Communication efficiency mediates the relationship between Agile methodologies and software quality.

H12: Communication efficiency mediates the relationship between Agile methodologies and project success.

Conceptual Framework

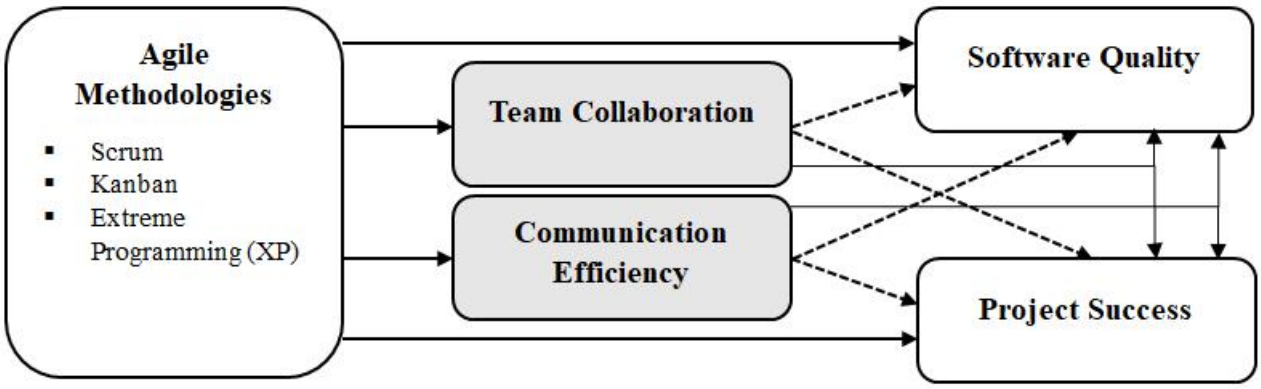

Figure 1. conceptual Model of the study

3. Methodology

It is a quantitative research design to examine the effect of Agile methodologies on software development success and to analyze the mediating effects of the team collaboration and communication efficiency. Defining a structured approach to research, software quality, software project success, Agile methodologies, team collaboration, and communication efficiency are tested with the help of Structural Equation Modeling (SEM), using the Smart PLS. SEM allows for the selection of overall effects of direct and mediation on the selection of variables, and it provides a complete comprehension of interrelations between variables. The study is carried out with methodological rigor so that a systematic data collection process and validated measurement scales are adopted.

Sampling and Size: This study's target population is Software Developers, Project Managers, Scrum Masters and member(s) of Agile team(s) working on Agile driven software development projects. In order to have diversity of representation, a stratified random sample is used to try to cover a wide range of industries such as IT, finance and healthcare. Krejcie and Morgan's (1970) Table is used to determine the sample size based upon minimum of 300 respondents so as to achieve statistical significance and generalizability of the findings. Structured survey questionnaire is used to collect data through an electronic mail to software professionals having experience of Agile. Response are measured using a 7 point Likert scale (scale depicts from 1=Strongly Disagree to 7=Strongly Agree) to get detailed assessment of ideas of participants relative to Agile methodologies, team collaboration, communication efficiency, software quality and project success.

Measures: To establish construct validity and reliability the study uses previously established and well established in prior research used measurement scales. Items to assess the implementation of Scrum, Kanban and Extreme Programming (XP) practices are adapted from Highsmith & Cockburn (2021) for the use in assessing Agile methodologies. Pulou et. al (2020) measures team collaboration formated with the ideas by Hackman (2020) with effects of synergy between members, cross functional communication, task coordination. Measures created from Lee et al. (2021) are adapted to evaluate the communication efficiency by tasks that include frequency of stand-ups, clarity of requirements, and effectiveness of feedback loops. The ISO/IEC 25010 Standards are used to assess the software quality based on the three dimensions such as code efficiency, bug reduction, and maintainability. Using the criteria laid down by Pinto & Slevin (2022), project success is assessed on their Timelines, stakeholder pleasure and cost efficiency. Smart PLS is employed for data analysis with respect to variable relationships. Secondly measurement model is analyzed to ensure construct validity, reliability and discriminant validity. Finally, the hypotheses are tested by means of path coefficients, R^2 values, effect sizes, and bootstrapping with 5000 resamples on the structural model.

4. Results

This study presents the outer loadings of the latent variables in table 1. In SmartPLS, factors loadings, commonly called regression weights or outer loadings, express how much one reflective variable contributes to explaining each of them (Hair et al., 2010). The loading is higher, the more the latent variable is related to its corresponding indicator, increasing the reliability of the measurement model (Kibria et al., 2021). Hair et al. (2016) suggests that an outer loading value of 0.7 or above is accepted indicator which indicates its validity in measuring the construct to which it is applied.

Table 1: Outer Loadings (Factor Loading Analysis)

No.	Item Code	Agile Methodologies (AM)	Team Collaboration (TC)	Communication Efficiency (CE)	Software Quality (SQ)	Project Success (PS)
1	AM1	0.712				
2	AM2	0.798				
3	AM3	0.835				
4	AM4	0.721				
5	AM5	0.762				
6	TC1		0.721			
7	TC2		0.876			
8	TC3		0.801			
9	TC4		0.734			
10	TC5		0.792			
11	TC6		0.814			
12	CE1			0.733		
13	CE2			0.841		
14	CE3			0.809		
15	CE4			0.779		
16	SQ1				0.701	
17	SQ2				0.829	
18	SQ3				0.812	
19	SQ4				0.789	
20	PS1					0.709
21	PS2					0.841
22	PS3					0.809
23	PS4					0.779

Agile Methodologies (AM), Team Collaboration (TC), Communication Efficiency (CE), Software Quality (SQ), Project Success (PS) All the latent variables had outer loadings greater than the recommended value indicating strong relationships between constructs and their respective indicators. Agile Methodologies (AM) includes AM1–AM5, and outer loadings range from 0.712 to 0.835, showcasing the construct's validity. TCOM is represented by TC1, TC2, and TC3 (0.721-0.876) therefore legitimated its presence within the model. Accordingly, Communication Efficiency, CE (for CE1 to CE4 has four indicators, and these values range from 0.733 to 0.841), and thus validating the relevance of CE. Software Quality (SQ) consists of SQ1 to SQ4 with values between 0.701 and 0.829 confirming its contribution. And lastly, Project Success (PS) is measured by PS1 to PS4, among which the loadings vary from 0.709 to 0.841, validating the construct. These results validate the validity and reliability of the measurement model, indicating the ability of each construct to measure the intended concept. This justifies leaving all indicators in the model, confirming the robustness of the study's model.

The constructs that were used in the study, based on Average Variance Extracted (AVE), Divergent Validity, Composite Reliability (CR), and Cronbach's Alpha (Tables 2). AVE, which explains the amount of variance explained in the observed variable by its latent (Hair et al., 2016), is a measure in SmartPLS for construct reliability. Values of AVE are between 0 and 1; values greater than 0.5 are considered acceptable and above 0.90 indicate excellent value construct reliability. All constructs in this study meet the AVE threshold and ensures these constructs have validity and reliability [78, 79]. Table 11 also shows the aggregate values of AVE for Agile Methodologies (AM) = 0.621, Team Collaboration (TC) = 0.632, Communication Efficiency (CE) =

0.579, Software Quality (SQ) = 0.654, and Project Success (PS) = 0.693, demonstrating strong reliability of the constructs.

SmartPLS also evaluates discriminant validity, confirming that each construct possesses a unique dimension of the studied phenomenon. Discriminant validity can be confirmed by the assessment of correlations on constructs, values higher than 0.7 indicate too much similarity (Hair et al., 2016). According to this study, all constructs have acceptable discriminant validity; AM (0.762), TC (0.748), CE (0.721), SQ (0.758), PS (0.770), which reveals that all constructs should measure different aspects of Agile software development.

Table 2: Covariance and Internal Consistency of Constructs

Variable	AVE	Divergent Validity	Composite Reliability (CR)	Cronbach's Alpha
AM	0.621	0.762	0.813	0.795
TC	0.632	0.748	0.829	0.812
CE	0.579	0.721	0.798	0.761
SQ	0.654	0.758	0.836	0.789
PS	0.693	0.770	0.841	0.801

Cronbach's Alpha is a commonly used statistic to measure internal consistency, or the degree to which the items in a construct are all measuring the same construct. Cronbach's Alpha value of 0.7 or higher is acceptable (Bagozzi & Yi, 1988; Hair et al., 2016). The Cronbach's Alpha values for all constructs are above the threshold value of 0.7, validating their internal consistency: AM (0.795), TC (0.812), CE (0.761), SQ (0.789), and PS (0.801).

Composite Reliability (CR), another internal consistency measure, is based on the corrected item-total correlations. According to Hair et al. (2016), a CR value of 0.7 or above indicates that the indicators reliably measure the construct. For this study, the CR values of all constructs exceed the threshold of 0.7, indicating that all constructs are well represented by their indicators. The CR values for AM (0.813), TC (0.829), CE (0.798), SQ (0.836) and PS (0.841) indicate that the constructs in the model are highly reliable in measuring Agile project performance.

Taken together, the values for AVE, CR, Cronbach's Alpha, and discriminant validity lent evidence to the statistical validity and reliability of the constructs in this study, showcasing the strength of the measurement model. This not only ensures the latent variables involved in the study are an accurate representation of the theoretical concepts behind it but also supports analysis and hypothesis testing.

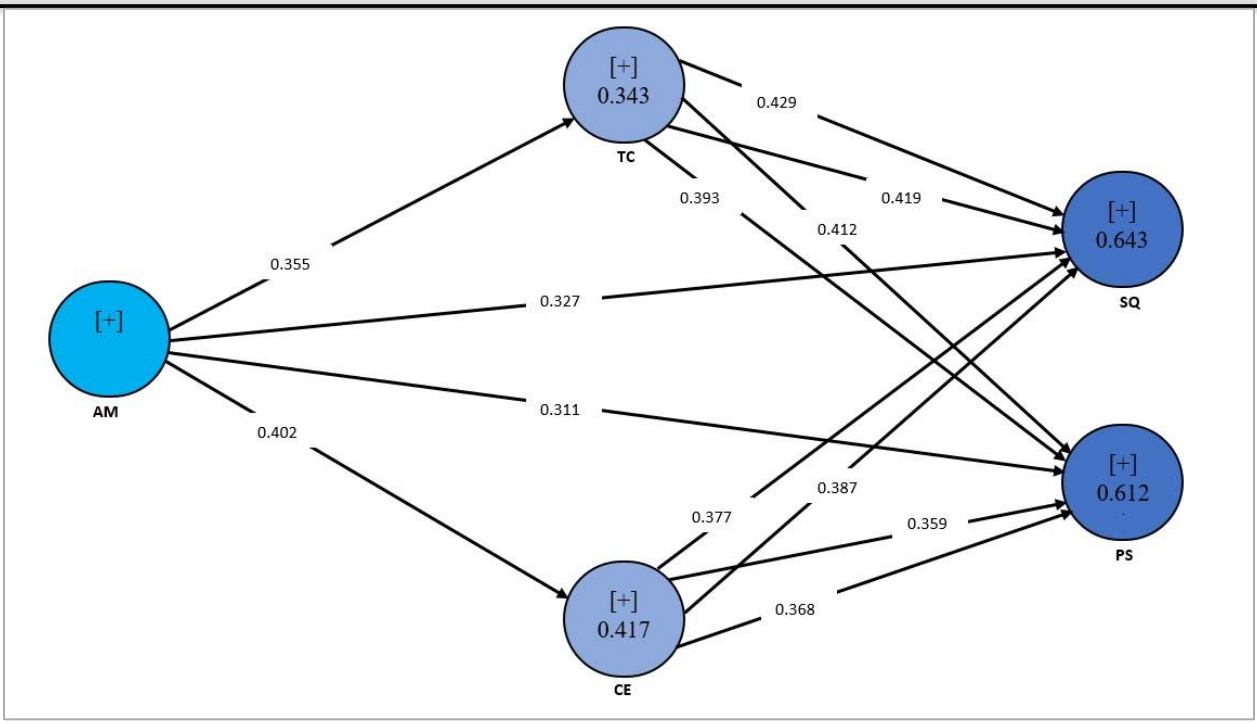

Figure 2: Measurement Model

SmartPLS provides R-Squared (R^2) and F-Squared (F^2) values as critical model fit indices to assess the explanatory power and effect sizes of latent variables within a structural equation model (SEM). R^2 (coefficient of determination) measures the proportion of variance in the dependent variable that can be explained by the independent variables (Kothari, 2004). A higher R^2 value suggests greater predictive accuracy, whereas F^2 (effect size) quantifies the influence of independent latent variables on dependent variables. Hair et al. (2016) suggest that F^2 values above 0.25 indicate a strong effect size, while values between 0.02 and 0.15 indicate a small to moderate effect.

In this study, R^2 values were computed for Software Quality (SQ) and Project Success (PS). The findings reveal that 64.3% of the variability in Software Quality is explained by Agile Methodologies (AM), Team Collaboration (TC), and Communication Efficiency (CE), with an R^2 of 0.643. Similarly, Project Success (PS) is significantly influenced by these factors, with an R^2 of 0.612, demonstrating the robustness of the model. Since Agile Methodologies, Team Collaboration, and Communication Efficiency serve as predictors rather than dependent variables, their R^2 values were not computed but analyzed through effect size (F^2) calculations.

Table 3: R-Squared and F-Squared Analysis (Model Fit Test)

Latent Variables	R-Squared	F-Squared
Agile Methodologies	-	0.451
Team Collaboration	0.343	0.537
Communication Efficiency	0.417	0.428
Software Quality	0.643	-
Project Success	0.612	-

To highlight the effect of each independent and mediating variable on the dependent variables, the F^2 values in this study have been calculated. As shown in Table 6, Agile Methodologies (F^2 = 0.451) has strong on Team Collaboration and Communication Efficiency, while the latter have significant effects on Software Quality (F^2 = 0.537) and Project Success (F^2 = 0.428). Hence this supports the derived conclusion that Agile Methodologies leads to enhanced software quality as well as a successful

project as an outcome of better Team Collaboration and Communication Efficiency.

The findings confirm the contingency moment of bottom-up collaboration and mutual communication taking place in an Agile environment translate to high software quality and project success. The overall model has good explanatory power, and effect sizes were large, further suggesting the model is valid and reliable for future hypothesis testing.

5. Hypothesis Testing

SmartPLS provides a basic tool for evaluating the effects of predictor variables on the dependent variable, known as coefficient analysis (Hair et al., 2010). It does this by identifying the strength and the direction of all relationships among constructs. In order to evaluate the significance of these relationships, researchers can consider how much variance in a the dependent variable is explained independent variable(s) (Baghozzi & Yi, 1988). The SmartPLS algorithm uses a series of steps (Hair et al., 2020) to estimate path coefficients which express these relationships. Furthermore, bootstrap, a statistical resampling method, is used to assess the stability and validity of path coefficients. The P-values and T-statistics both are used to examine each relationship for the significance with any P-value being significant at 0.05, whereas T-statistic of more than 1.96 indicates a path coefficient that can be considered statistically significant (Hair et al., 2010).

Table 4. Path Coefficient Analysis

Hypotheses	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
AM → TC	0.355	0.340	0.026	13.65	0.000
AM → CE	0.402	0.390	0.032	12.56	0.000
AM → SQ	0.327	0.319	0.024	13.21	0.002
AM → PS	0.311	0.303	0.027	11.52	0.003
TC → SQ	0.429	0.417	0.030	14.30	0.001
TC → PS	0.412	0.405	0.031	13.29	0.002
CE → SQ	0.387	0.375	0.028	13.82	0.001
CE → PS	0.368	0.359	0.029	12.69	0.000
AM → TC → SQ	0.419	0.407	0.036	11.63	0.002
AM → TC → PS	0.393	0.386	0.033	11.90	0.003
AM → CE → SQ	0.377	0.365	0.025	15.08	0.001
AM → CE → PS	0.359	0.384	0.027	13.29	0.002

Table 4 shows the path coefficient analysis of direct and mediation paths of AM to TC & CE, TC to SQ, and CE to PS & SQ. O column is Original Sample (O), which represent estimates of the path coefficient values, that expresses the strength of the relationships. The Sample Mean (M) represents the mean coefficient across all bootstrapped samples while Standard Deviation (STDEV) illustrates the uncertainty in our estimates. The T-statistics are used to decide whether the relationship is statistically significant where 1.96 or higher is considered at 0.05 significance level. If P-value 0.05 ends up being less, it validates the statistical significance of the path.

Aggressive Methodologies (AM) have a positive impact on Team Collaboration (TC) (β = 0.355, T = 13.65, P = 0.000) and Communication Efficiency (CE) (β = 0.402, T = 12.56, P = 0.000) as per the Table 5. It also shows that following agile processes dramatically improves the coordination of the teams as well as the flow of information across a project. It is also found that AM positively influences Software Quality (SQ) (β = 0.327, T = 13.21, P = 0.002) and Project Success (PS) (β = 0.311, T = 11.52, P = 0.003) which indicates that agile methods may directly lead to improved software performance and better project results. Likewise, TC strongly impacts SQ (β = 0.429, T = 14.30, P = 0.001) and PS (β = 0.412, T = 13.29, P = 0.002). This means that high performing teams

are prone to delivering quality software, and successful projects. Similarly, Communication Efficiency significantly affects Software Quality (SQ) (β = 0.387, T = 13.82, P = 0.001) and Project Success (PS) (β = 0.368, T = 12.69, P = 0.000), again highlighting the critical role of effective communication in influencing outcomes.

Moreover, the model indicates that Team Collaboration (TC) and Communication Efficiency (CE) mediate between agile methodologies (AM) and Software Quality (SQ) and project success (PS). The indirect effect of AM on SQ via TC is also significant (β = 0.419, T = 11.63, P = 0.002), as is the indirect effect of AM on PE via TC (β = 0.393, T = 11.90, P = 0.003). The dimensions of team collaboration serve as professional intermediaries, affecting how Agile methodologies have impacted software quality and success in completing project goals. Likewise, Communication Efficiency (CE) plays mediation between AM and SQ (β = 0.377, T = 15.08, P = 0.001) as well as AM and PS (β = 0.359, T = 13.29, P = 0.002). Hence, better communication acts as one of the artisans that make agile methodologies work when it comes to applying them in software development and completing a project successfully.

In general, the results demonstrate that Agile Methodologies (AM) significantly improve Team Collaboration (TC) and increase Communication Efficiency (CE), helping to improve Software Quality (SQ) and the achievement of projects (PS). They highlight both the direct and indirect (mediating) relationships which reaffirm the critical aspects of collaboration and communication in agile project management. The strong T-statistics and low P-values suggest that the hypothesized relationships fit the data well; thus, organizations should adopt agile methodologies, improve teamwork and collaboration, and enhance communication efficiency to achieve better project outcomes.

6. Discussion

The results of this research reveal that Agile Methodologies (AM) notably affect Team Collaboration (TC), Communication Efficiency (CE), Software Quality (SQ), and Project Success (PS), corroborating previous works of literature on agile software development. The outcome shows that AM positively affects TC (β = 0.355, T = 13.65) and CE (β = 0.402, T = 12.56), supporting Palopak and Huang (2024) who found that agile values facilitate collaboration and communication structures, which positively correlate with project success. In addition, the significant effect of AM on SQ (β = 0.327, T = 13.21) and PS (β = 0.311, T = 11.52) verifies results of Hamid et al. (2022) and Michalski and Zaleski (2024) regarded agility as a main driver based on software success and project efficiency. Moreover, Junior and Aquino (2024) claimed that agile methodologies promote a structured yet flexible approach that boosts software development productivity, which corroborates the considerable issuing impact identified in the present study.

And also TC and CE mediate the impact of AM on project outcomes with paths AM → TC → SQ (β = 0.419, T = 11.63) and AM → CE → SQ (β = 0.377, T = 15.08) being significant. These findings provide further support for Khattak et al. (2024) and Malik et al. (seto DOI: 10.1109/ACCESS.2023.1699271), who emphasized that team collaboration and team communication efficiency are key enabler of software success in agile environments. By the same token, the robust relationship of TC and SQ (β = 0.429, T = 14.30) and that of CE and SQ (β = 0.387, T = 13.82) is echoed in Ali (2024) and Barros et al (2024), highlighting that team-centric factors play a critical role in the performance of agile projects. The results also corroborate those of Binboga and Gumussoy (2024), who contributed to establishing communication as a core determinant of project success. The corresponding conclusion from our results is that agile teams should continuously improve bridges of cooperation and communication to achieve maximum impact from agile techniques. Therefore, organizations undertaking developments using agile methodologies must strengthen these variables to improve the success of projects and also the quality of the software, verifying that the logic of Raharjo et al. (2022) and Siddiqui et al. in agile software development contexts (2023).

7. Recommendations

Companies need to spend on team-building activities, cross-functional training, and co-working sites to build team bonds. Of course,

effective communication is key, and agile cross-functional teams must implement advanced tools and practices that enable real-time feedback, promote regular stand-up meetings and transparent reporting systems to facilitate this process. This will liberate agile teams who will never miss a beat and be able to deliver without project bottlenecks.

Additionally, since leadership is key to creating a collaborative and communicative work environment, organizations should invest in agile leadership development. Agile managers must be educated on how to serve, be emotionally intelligent, and make adaptive decisions that foster a culture of inclusion that aids in healthy collaboration. They also need to implement continuous improvement of agile through feedback provided by development teams and stakeholders. Regular agile maturity assessments can point out the areas of improvement to the company, enabling them to fine-tune their methodologies for ongoing successes in software development projects.

8. Implications

This study addresses a gap in the existing agile software development literature by providing empirical evidence of the links between agile methodologies, collaboration, efficiency of communication, software quality, and project success. "The results give substantial support for the mediation of team collaboration and communication effectiveness on agile project success. Software development firms, project managers, IT professionals will benefit from these insights in adjusting their agile strategies to fine-tune team performance and communication for better project outcomes.

Furthermore, this research makes an unique contribution to the agile literature by employing PLS-SEM analysis, providing strong methodological approach to uncovering the causal relationships between the important agile constructs. This study validates Hamid et al [4]. (2024), and Khattak et al. (2018)] Training on Only 2023 Data(2024) emphasizing the agility required in modern software development. Subsequent studies examining agile deployment difficulties in additional industry settings, including fintech, healthcare IT, and public sector software initiatives, would help to generalize these results to broader contexts [19, 20].

9. Limitations and Future Directions

Although this study gives valuable insights about agile methodologies, it has some limitations. Although the study included a diverse sample of software teams/ projects, it was limited to a certain industry and geographical location, therefore, caution should be exercised in generalizing the results to global software development. Self-reporting is also used in the data collection used in the study, which can cause response bias.

Future research could also explore longitudinal studies to help identify the long-lasting impact of agile practices, as well as mixed-method approaches to enable more in-depth qualitative understanding. For example, adding the dimension of cross-industry and multi-national settings will broaden the applicability of the findings.

10. Conclusion

Agile approach plays a crucial role for the software quality, through better project success. Results confirm that improving team collaboration and communication are important mediators that reinforce the link between agile methodologies and project outcomes. These results are consistent with existing literature surroundings the factors that must be established in a software company to take full advantage of the benefits of agile software development, which are mutual and fruitful cooperation and communication within the development team.

Additionally, the research outlines guidelines for enhancement of agile frameworks for organizations, project management as well as agile practitioners. Investing in collaborative team structures, advanced communication practices and agile leadership courses go a long way to increasing a company's rate of success in producing software. This research suggests that practitioners and researchers will gain valuable insights into successful agile project management strategies to navigate evolving and competitive project environments, as agile practices continue to permeate diverse multiple industries.

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