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Path Analysis of Agile Methodology and Its Influence on Industrial Revolution 4.0 Adoption in IoT

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Abstract: The rapid advancement of Industrial Revolution 4.0 (IR 4.0) technologies, especially the Internet of Things (IoT), requires a flexible and adaptive implementation approach. Agile Methodology, recognized for its iterative and collaborative principles, offers a potential framework for effectively navigating these complexities. This research paper explores the intersection of Agile practices with IoT adoption within IR 4.0, focusing on psychological safety, leadership styles, team dynamics, and maturity models. Specifically, the study aims to assess the effectiveness of Agile methodology in enabling IoT adoption within the IT sector, analyze the influence of psychological safety, leadership styles, and team dynamics on the successful integration of Agile practices in IoT-driven projects, and explore the role of Agile leadership styles—such as transformational and servant leadership—in promoting innovation and adaptability. Furthermore, the paper investigates the challenges Agile teams face and their impact on business performance under disruptive conditions. By conducting a comprehensive literature review and using path analysis as the primary methodological approach, the findings identify critical gaps in existing research and propose a novel research problem to address these gaps. The paper concludes by suggesting future research directions, emphasizing the need for tailored maturity models and metrics to better support Agile adoption in IoT-driven environments.

Keywords: Agile Methodology, Industrial Revolution 4.0, Internet of Things (IoT), Psychological Safety, Leadership Styles, Team Dynamics, Maturity Models, Path Analysis

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1. Introduction

The onset of Industrial Revolution 4.0 (IR 4.0) transforms industries by integrating advanced technologies like the Internet of Things (IoT), artificial intelligence, big data analytics, and robotics into traditional manufacturing and business processes[1]. This revolution features the seamless interconnection of devices, systems, and people, enabling real-time data exchange and decision-making, significantly enhancing productivity, efficiency, and innovation across various sectors. However, organizations face significant challenges in successfully adopting and implementing these IR 4.0 technologies, particularly regarding organizational readiness, leadership, and team dynamics[2].Originally developed as a flexible and iterative approach to software development, Agile Methodology has gained recognition as a potential framework for managing the complexities associated with IR 4.0. Agile principles emphasize adaptability, cross-functional collaboration, customer-centric development, and continuous improvement, making them particularly relevant in the dynamic and rapidly evolving landscape of IR 4.0.[3]. Agile's iterative nature allows for frequent reassessment and strategy adjustment, which is crucial when dealing with the uncertainties and technological advancements inherent in IR 4.0.[4].However, integrating Agile practices into adopting IoT and other IR 4.0 technologies presents challenges. The success of this integration depends on several factors, including psychological safety within teams, leadership styles that promote innovation and adaptability, the maturity of Agile practices within the organization, and the use of appropriate tools and metrics to measure progress[5]. Psychological safety is essential for fostering an environment where team members feel safe to take risks, voice their ideas, and engage in innovative problem-solving, all of which are critical for successfully adopting new technologies[6].

Leadership plays a pivotal role in this context. Leaders must advocate for Agile practices and create a supportive culture that encourages experimentation and learning. Different leadership styles, such as transformational and servant leadership, have positively influenced the adoptionof Agile practices by promoting trust, empowerment, and continuous learning[7]. However, existing research lacks a comprehensive understanding of how these leadership styles interact with other factors, such as team dynamics and organizational culture, to influence the adoption of IoT technologies within an Agile framework.Moreover, the maturity of an organization's Agile practices is another critical factor influencing the success of IoT adoption. Maturity models, which assess the extent to which Agile principles are embedded within an organization, provide valuable insights into areas that require improvement[8]. However, existing maturity models and metrics are often not tailored to the specific challenges associated with IoT adoption in IR 4.0, highlighting the need for further research and Adaptation of these models[7], [9].Given these complexities, this paper explores the intersection of Agile Methodology and IoT adoption within the context of IR 4.0. The study identifies and analyses the key factors influencing this process, including psychological safety, leadership styles, team dynamics, and maturity models[10]. By conducting a comprehensive literature review and employing path analysis, the study seeks to uncover the direct and indirect relationships between these factors and their collective impact on the successful adoption of IoT technologies.The research also addresses significant gaps in the existing literature, particularly in understanding how these factors influence adoption[11]. The study proposes a novel research problem to provide a more holistic understanding of the complexities of adopting IoT within an Agile framework, particularly in IR 4.0. The findings of this research aim to contribute valuable insights to both academic research and practical applications, offering guidance for organizations seeking to navigate the challenges of digital transformation in the age of IR 4.0[12].By focusing on these critical areas, the paper sets the stage for a deeper exploration of how organizations can effectively integrate Agile practices to facilitate the adoption of IoT and other IR 4.0 technologies. This research is particularly relevant given the increasing importance of digital transformation in maintaining a competitive advantage in today's rapidly evolving industrial landscape. The insights gained from this study have the potential to inform both theory and practice, providing a roadmap for organizations to manage the complexities of IR 4.0 adoption successfully[13].

2. Theoretical Overview of the Main Concepts

Agile methodology is an approach to project management and software development that prioritizes Flexibility, Collaboration, and customer feedback. Unlike traditional methodologies, which often involve long planning phases followed by execution, Agile focuses on iterative development. Projects are broken down into smaller, manageable parts, called iterations or sprints, developed and tested in cycles[14]. The core principles of Agile include adaptive planning, evolutionary development, early delivery, and continuous improvement. Agile methodologies are known for responding to changing requirements and delivering value incrementally[15]. The fundamental principles of Agile methodology revolve around five key concepts. First, Iterative Development encourages breaking projects into smaller cycles, enabling continuous development, testing, and refinement [16]. Each iteration aims to deliver a potentially shippable product, facilitating faster feedback and timely adjustments. Second, User-Centric Design ensures that the end-user remains at the core of the development process, with features defined through user stories that capture the user's perspective[17]. Third, collaboration is emphasized in Agile, fostering a cooperative environment where cross-functional teams closely engage with stakeholders to align the product with desired outcomes[18]. Fourth, flexibility is integral to Agile, requiring teams to adapt swiftly to changes in requirements, market conditions, or user needs[19]. Finally, Agile advocates for Continuous Improvement**,** promoting a culture where teams consistently reflect on their performance to enhance productivity and product quality[20]. Agile has transformed how software projects are managed and delivered. The methodology's iterative nature allows teams to release software frequently, deploying new features and updates as they develop. This approach contrasts sharply with traditional Waterfall models, where teams develop the entire product before releasing any part[21].Agile's focus on customer collaboration ensures that software products remain relevant to user needs by incorporating feedback throughout the development cycle. This alignment with market demands has led to higher customer satisfaction rates and fewer project failures.Agile's adaptability has been particularly beneficial in software development, where requirements often change or are unclear[22]. By embracing change rather than resisting it, Agile teams can quickly pivot, minimizing the impact of shifting priorities or unexpected challenges.

Initially designed for software projects, Agile has expanded into various industries due to its adaptability and core principles of Flexibility, Collaboration, and customer-centric development. Its value in managing complex projects in fast-changing environments has made it applicable to manufacturing, finance, healthcare, and education. Agile is used in product development in manufacturing, especially in innovation-driven sectors like automotive and consumer electronics, and it aligns with Lean Manufacturing principles such as waste elimination, process optimization, and rapid value delivery[23]. In the financial sector, Agile enhances the development of financial products and services, helping institutions swiftly adapt to regulatory changes, market shifts, and customer demands[24]. It also supports digital transformation efforts, especially in fintech development. In healthcare, Agile streamlines processes, improves patient care and accelerates medical technology development. Its iterative nature helps refine treatments and technologies more efficiently while adhering to regulatory requirements[25]. Finally, Agile is applied to curriculum design, instructional methods, and educational technologies, allowing institutions to adapt quickly to changing educational needs and innovations [26]. Despite its many benefits, implementing Agile practices in industries outside software development presents challenges. Adapting Agile principles to fit different industries' specific contexts and requirements is a primary difficulty[27]. For example, Agile teams in heavily regulated industries like healthcare and finance must navigate strict compliance requirements while maintaining flexibility in adapting.Another challenge involves the cultural shift required to embrace Agile practices fully. Organizations must abandon traditional hierarchical management structures and adopt a collaborative, team-oriented approach. Achieving this cultural shift sometimes requires significant changes in organizational culture, leadership styles, and employee mindsets, particularly in established industries with entrenched practices[28].Additionally, applying Agile in non-software environments often requires developing new tools and metrics to measure progress and success. Traditional Agile metrics, such as velocity and burn-down charts, may not directly apply in other contexts, necessitating the creation of industry-specific adaptations.

Industry 4.0, the Fourth Industrial Revolution, refers to the ongoing transformation in manufacturing and related industries by integrating digital technologies. This revolution is characterized by the fusion of physical and digital systems, advanced automation, and intelligent technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics. Critical Components of Industry 4.0 include various advanced technologies that shape modern manufacturing and other industries. Cyber-physical systems (CPS) arecrucial to managing physical operations with digital computing to create intelligent environments like autonomous factories[29]. Another essential element is IoT Integration, which connects machines, devices, and sensors to enable real-time monitoring and data exchange, facilitating advanced analytics and decision-making[30]. Advanced Analytics processes the vast amounts of data these systems generate, providing insights that optimize processes[31]. Automation and Robotics also significantly improve efficiency and accuracy by performing traditionally manual tasks 32]. Combining these technologies results in Smart Manufacturing, where production processes become more flexible, efficient, and responsive to changing demands[31].Agile and the Future of Industry 4.0 demonstrates that the principles of Agile methodology—Flexibility, iterative development, and continuous improvement—align perfectly with Industry 4.0's needs. The adaptability of Agile helps organizations swiftly incorporate new technologies and respond to market changes. As Industry 4.0

emphasizes interconnected systems, Agile's collaborative approach fosters teamwork in leveraging IoT, AI, and other technologies[33]. Agile's focus on customer-centric development also allows organizations to respond to evolving user expectations and ensure that products and services remain relevant[34]. The principle of Continuous Improvement supports ongoing Adaptation in Industry 4.0, where organizations must continuously assess and enhance their processes to stay competitive.The Expansion and Integration of Agile into Industry 4.0 involves supporting Digital Transformation by providing a structured way to manage complex projects[36]. Agile enables organizations to adopt technologies like IoT and AI in a phased manner, adjusting based on real-time feedback. It also aids Innovation Management, allowing organizations to test and refine new technologies before scaling them[35]. Agile's adaptability extends across industries such as manufacturing, healthcare, and finance, facilitating the integration of Industry 4.0 technologies in diverse sectors[37].However, Challenges and Considerations must be addressed when applying Agile in Industry 4.0. Contextual Adaptation requires modifying Agile practices to meet industry-specific needs, such as compliance with healthcare or finance regulations[39]. Cultural Shifts are also necessary as organizations move from traditional hierarchies to more collaborative, iterative approaches[38][40]. Finally, Scalability and Integration pose challenges, as organizations must align Agile practices with existing processes andtechnologies, often requiring new tools and metrics to track progress effectively[41].In conclusion, Agile methodology offers a valuable framework for navigating the complex and rapidly evolving landscape of Industry 4.0. Its adaptability, focus on collaboration and commitment to continuous improvement make it well-suited to managing innovation, driving digital transformation, and ensuring success in technologically advanced environments.

3. Objectives and Methodology

This paper proposes the following four objectives for further research based on the gap analysis derived from the literature review and discussions.

- To evaluate the effectiveness of Agile methodology in facilitating IoT adoption within the IT sector, especially concerning the challenges posed by Industrial Revolution 4.0 (IR 4.0) technologies.
- To analyze the influence of psychological safety, leadership styles, and team dynamics on successfully integrating Agile practices in IoT-driven projects.
- To explore the role of Agile leadership styles, such as transformational and servant leadership, in promoting innovation and adaptability within Agile teams involved in IR 4.0 technology adoption.
- To investigate the challenges Agile teams face and their impact on business performance under disruptive conditions.

This study uses the mixed-methods approach, incorporating a comprehensive literature review and quantitative path analysis. The comprehensive literature review will help identify all crucial factors influencing adoption in IoT environments. This path analysis approach examines the relationships among factors identified in the literature review.

4. Data Collection and Data Analysis

Fifty participants contributed to the survey, selected based on their active involvement in Agile projects, including project managers, software developers, and team leaders across various organizational levels. Data collection utilized a structured online survey distributed to IT professionals working on Agile practices and IoT-driven projects.The questionnaire was designed to gather quantitative and qualitative data that was aligned with the research objectives. Quantitative responses were measured using a 5-point Likert scale to assess perceptions of leadership styles, psychological safety, and Agile maturity. Qualitative responses were captured through open-ended questions. Google Forms facilitated the online survey over one month, with all participants providing informed consent and maintaining anonymity.The research team collected data using a structured questionnaire that captured quantitative and qualitative responses from IT professionals. The target population included individuals involved in Agile practices and IoT-driven projects across different organizational levels and roles. The questionnaire, developed to align with the five research objectives, ensured comprehensive coverage of all critical aspects. The questionnaire comprised several sections designed to collect comprehensive data. The Demographic Information section gathered details such as the size of the organization, the industry sector, and the respondent's role. The Agile Methodology and IoT Adoption section focused on the usage and effectiveness of Agile methodologies, including their implementation duration and role in facilitating IoT adoption. In the Leadership Styles and Team Dynamics section, questions assessed leadership behaviours, psychological safety, and team dynamics related to Agile practices. The Agile Maturity Models section required respondents to rate their organization's maturity in Agile practices and identify any perceived gaps or challenges. Lastly, the Challengesand Business Performance section addressed the difficulties encountered during Agile-IoT integration and evaluated its impact on business performance, particularly during disruptive conditions such as the COVID-19 pandemic.

5. Discussion on analysis of Data and Outcomes for Research Objectives

5.1. Effectiveness of Agile Methodology in Enabling IoT Adoption:

Against the challenges of IR 4.0 technologies, a quantitative and qualitative analysis of the responses showed how Agile practices facilitate IoT adoption within IT companies. Agile methodologies with customization provide essential efficiencies in IoT adoption by enhancing cross-functionality and iteration about the nature of development cycles. However, scalability became a challenge for larger organizations. In this scenario, regression analysis refers to the connection of independent variables as predictors with the dependent variable, how good leadership is for agile practices and the adoption of IoT. OLS refers to the Ordinary Least Squares Regression Results from the output produced after performing a linear regression using the OLS method. OLS is one of the most commonly used methods for assessing the relationship between a dependent variable (the response variable) and one or more independent variables (predictors). The main features of the OLS regression results establish an excellent comprehension of how effective leadership in Agile practices and IoT adoption works. In this research, the Dependent Variable was the "Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption," representing prognosticated outcomes. The R-squared value gives the proportion of variance in the dependent variable that is explained by the independent variables. The goodness of fit increases with higher values. Adjusted R-squared is adjusted by penalizing it for the number of predictors, which acts as a penalty term against the irrelevant addition to the model. The overall significance of a regression model is evaluated by its F-statistic and p-value. A low p-value indicates that the model fits significantly better than a model that includes no predictors. The Coefficients (coef) calculate the change in the dependent variable concerning one unit increase in independent variables, holding all other factors constant. The std err measures the variability of these estimates, with lower values indicating more precise results. The t-stat and its corresponding P-value ($P>|t|$) test whether each independent variable statistically affects the dependent variable. When $P>|t| < 0.05$ is considered a statistical significance. The confidence interval ([0.025, 0.975]) gives a 95% confidence range for the coefficients' true value. The Durbin-Watson Statistic: Tests for autocorrelation in the residuals. A value near two would give no correlation problem. The Omnibus and Jarque-Bera Tests determine if the residuals have a normal distribution. In such a case, non-normality may compromise the validity of hypothesis testing. Finally, it provides criteria for model selection with AIC and Bayesian Information Criterion (BIC), where lower values indicate a better fitting model that balances goodness of fit with the complexity of the model.

Based on the OLS regression in Table 1, model fit, and overall significance reveals several findings in this study. The R-squared value is 0.555, meaning that independent variables in the model explain approximately 55.5% of the variability in the dependent variable-effectiveness of leadership in support of Agile practices and IoT adoption. That suggests a moderate explanatory power. However, the Adjusted R-squared is very low at 0.246, accounting for the number of predictors. Only about 24.6% of the variance is explained after adjustment. The large difference between R-squared and Adjusted R-squared is quite significant, indicating that many of the predictors added may have little or no significance in this model, considering the high number of predictors relative to the sample size. The F-statistic is 1.794, and the accompanying p-value is 0.0978. The test checks whether a model with at least some predictors significantly improves on a model with no predictors. The p-value shows the model is marginally insignificant at the 0.05 level. However, it is approaching the significance threshold at 0.1, resulting in an inference that the set of predictors might have some weak explanatory power.

Further computation of the coefficient for each independent variable brings in significant details that explain the degree of contribution each bears toward leadership effectiveness in support of Agile and IoT adoption. Organization size has a coefficient of 0.3962 with a p-value of 0.057, thus showing a positive contribution to leadership effectiveness, though borderline significant. This means that more prominent organizations have the advantage of improved leadership, which enables them to run smoothly.In contrast, the usage time of Agile methodology has a coefficient value of -0.3845 and a p-value of 0.012, meaning its adverse impact is significant. It indicates that the longer one uses Agile practices, the lower leadership effectiveness should be over time. The perceived impact on the efficiency of organizations has a positive and statistically significant coefficient of 0.4082 at a p-value of 0.017, indicating that a more significant perceived impact translates into leadership support, which is more effective for adopting Agile and IoT. In addition, this team's coefficient for ease in the idea and concern sharing is 0.4207 with a p-value of 0.068, which reflects a trend towards significance. With greater comfort levels in communications, the effectiveness of leadership becomes better. The cross-functional collaboration frequency accounts for a negative and significant coefficient of -0.3883 with a p-value of 0.027, which means that a more frequent collaboration may decrease leadership effectiveness because there may be inefficiencies due to overused collaboration. The number of several predictors is statistically insignificant because their p-values are more than 0.05, depicting that they do not play a significant role in predicting the dependent variable. These are the industry sector (p = 0.370), respondent role (p = 0.373), maturity of Agile practices in the organization (p = 0.220), current stage of IoT implementation (p = 0.899), IoT technologies currently being used (p = 0.125), style of leadership for Agile implementation (p = 0.421), level of Collaboration within Agile teams (p = 0.719), maturity model used to assess Agile practices (p = 0.555), and parameters used to measure the success of IoT initiatives (p = 0.239). From this study, these variables do not contribute substantially to the model, and their effect on the dependent variable is still unknown. Residual Diagnostics has information on Durbin-Watson - 1.595. The above statistic tests for autocorrelation in the residuals. A value close to 2 indicates no autocorrelation and a value of 1.595 suggests slight positive autocorrelation, but this is not a significant concern. The omnibus and Jarque-Bera tests check normality for the residuals. The probabilities are relatively high at 0.035 and 0.066, respectively. This is a cause for concern because that may suggest the residuals do not fit the normality assumptions; thus, the model inferences are likely to be off. Altogether, model interpretation presents a reasonable share of explained variation in leadership effectiveness: R-squared = 0.555. Some essential variables, such as organizational size, tenure of Agile's use, perceived effect of IoT, and cross-functional team collaboration, have significant or near-significant influences on support for Agile and IoT adoption by leadership.

Table 1: OLS Regression Results

OLS Regression Results						
Dep. Variable:	Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption				R-squared:	0.555
Model:	OLS				Adj. R-squared:	0.246
Method:	Least Squares				F-statistic:	1.794
Date:	Sat, 28-09-2024				Prob (F-statistic):	0.0978
Time:	15:04:40				Log-Likelihood:	-23.175
No. Observations:	40				AIC:	80.35

Df Residuals:	23				BIC:	109.1
Df Model:	16					
Covariance Type:	nonrobust					
	coef	**std**	**err**	**t**	**P>|t|**	**[0.025 , 0.975]**
const	0.2482	1.277	0.194	0.848	-2.394	2.89
Industry Sector	0.1033	0.113	0.913	0.37	-0.131	0.337
Size of the Organization	0.3962	0.198	2	0.057	-0.014	0.806
Respondent Role	0.0713	0.079	0.909	0.373	-0.091	0.234
Duration of Agile Methodology Use in the Organization	-0.3845	0.14	-2.738	0.012	-0.675	-0.094
Agile Framework Utilized	-0.0422	0.129	-0.326	0.747	-0.31	0.225
Agile Practices Maturity in the Organization	0.1309	0.104	1.261	0.22	-0.084	0.346
Current Stage of IoT Implementation in the Organization	-0.0115	0.089	-0.129	0.899	-0.197	0.174
IoT Technologies Currently Utilized	0.1813	0.114	1.593	0.125	-0.054	0.417
Perceived Impact of IoT Technologies on Organizational Efficiency	0.4082	0.158	2.581	0.017	0.081	0.735
Team Comfort Level in Sharing Ideas and Concerns	0.4207	0.22	1.913	0.068	-0.034	0.876
Frequency of Retrospective or Feedback Sessions on Team Performance	-0.1138	0.165	-0.692	0.496	-0.454	0.227
Leadership Style for Agile Implementation	-0.113	0.138	-0.819	0.421	-0.398	0.172
Level of Collaboration Within Agile Teams	0.0966	0.266	0.364	0.719	-0.453	0.646
Frequency of Cross-Functional Team Collaboration	-0.3883	0.164	-2.366	0.027	-0.728	-0.049
Maturity Model Utilized to Assess	-0.0546	0.091	-0.599	0.555	-0.243	0.134

Agile Practices						
Parameters Used to Measure the Success of IoT Initiatives	0.1531	0.127	1.21	0.239	-0.109	0.415

5.2. Influence of Psychological Safety, Leadership Styles, and Team Dynamics

The analysis reveals that psychological safety, transformational leadership, and strong team dynamics influence Agile integration in IoT projects. Employees become more empowered to share ideas and take ownership of tasks, driving successful Agile adoption. Organizations practising servant leadership experience higher levels of team collaboration and project success. This analysis is grounded in the correlation between dependent and independent variables.

Table 2: Correlation between dependent and independent variables.

<table>
<tr><th>Dependent
Variables
=======>
Independent Variables
\||/</th><th>Agile Practices Maturity in the Organization</th><th>Perceived Impact of IoT Technologies on Organizational Efficiency</th><th>Team Comfort Level in Sharing Ideas and Concerns</th><th>Leadership Style for Agile Implementation</th><th>Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption</th><th>Level of Collaboration Within Agile Teams</th></tr>
<tr><td>Industry Sector</td><td>-0.009011258</td><td>-0.428622442</td><td>0.1115284</td><td>-0.326278</td><td>-0.15324579</td><td>0.143090952</td></tr>
<tr><td>Size of the Organization</td><td>0.108002498</td><td>0.330004853</td><td>-0.346552</td><td>0.2137988</td><td>0.177030798</td><td>-0.11433239</td></tr>
<tr><td>Respondent Role</td><td>-0.211802917</td><td>-0.206730541</td><td>0.0880167</td><td>-0.210982</td><td>0.109009473</td><td>-0.02540822</td></tr>
<tr><td>Duration of Agile Methodology Use in the Organization</td><td>0.181543324</td><td>0.456435465</td><td>0.0527046</td><td>-0.210561</td><td>-0.1177898</td><td>-1.34E-16</td></tr>
<tr><td>Agile Framework Utilized</td><td>0.003082701</td><td>-0.08267216</td><td>-0.035798</td><td>-0.098069</td><td>-0.06600439</td><td>-0.1033402</td></tr>
<tr><td>Current Stage of IoT Implementation in the Organization</td><td>0.205880325</td><td>0.357103009</td><td>-0.007448</td><td>-0.077789</td><td>-0.03870082</td><td>-0.09030191</td></tr>
<tr><td>IoT Technologies Currently Utilized</td><td>0.244843962</td><td>-0.182448626</td><td>0.076159</td><td>0.034773</td><td>0.106987896</td><td>0.037688918</td></tr>
</table>

Frequency of Retrospective or Feedback Sessions on Team Performance	0.01435226	0.052486388	-0.166667	0.0665852	-0.07449681	-0.11547005
Frequency of Cross-Functional Team Collaboration	0.022011857	0.131835398	0.0312997	-0.342983	-0.29642098	0.08131903
Maturity Model Utilized to Assess Agile Practices	-0.232054221	0.093880999	-0.051641	0.1479026	0.037247173	0.113839951
Parameters Used to Measure the Success of IoT Initiatives	-0.057960931	0.078397579	-0.225895	0.1994394	-0.17566865	-0.30342767

The correlation matrix reveals valuable insights into the relationships between various independent variables, including organizational factors and practices, and dependent variables, such as effectiveness and adoption metrics related to Agile methodologies and IoT technologies. The correlation values range from -1 to 1, where 1 indicates a perfect positive correlation, -1 denotes a perfect negative correlation, and 0 signifies no correlation.Agile Practices Maturity in the Organization shows a positive correlation with the duration of Agile methodology use (0.1815), suggesting that as Agile practices are utilized for a longer duration, their maturity tends to improve. Additionally, a higher current stage of IoT implementation (0.2059) and IoT technologies (0.2448) are associated with better maturity in Agile practices. Conversely, a negative correlation exists with the maturity model utilized to assess Agile practices (-0.2321), indicating that an increase in maturity model assessment may not align positively with Agile maturity.Perceived Impact of IoT Technologies on Organizational Efficiency has a strong positive correlation with the duration of Agile methodology use (0.4564), implying that more extended use enhances the perceived impact of IoT on efficiency. Similarly, a higher current stage of IoT implementation (0.3571) is associated with a more substantial perceived impact. However, the industry sector has a negative correlation (-0.4286), suggesting it may adversely affect perceptions of IoT effectiveness.Team Comfort Level in Sharing Ideas and Concerns shows a weak positive correlation with the industry sector (0.1115), indicating some comfort level varies by sector. However, it negatively correlates with the organization's size (-0.3466), suggesting that larger organizations may experience lower comfort levels when sharing ideas. Additionally, the parameters used to measure the success of IoT initiatives show a negative correlation (-0.2259), indicating that as these parameters increase, comfort in sharing may decrease.

Leadership Style for Agile Implementation positively correlates with the current stage of IoT implementation (0.1994), suggesting that leadership styles positively influence IoT implementation stages. Conversely, there is a negative correlation with the frequency of cross-functional team collaboration (-0.3430), indicating that certain leadership styles may hinder collaboration and a negative correlation with team comfort level in sharing ideas and concerns (-0.2110).Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption is positively correlated with the current stage of IoT implementation (0.1770), suggesting that effective leadership positively influences the implementation stage. However, it has a negative correlation with the frequency of cross-functional team collaboration (-0.2964) and the parameters used to measure the success of IoT initiatives (-0.1757), indicating that leadership effectiveness may not support collaboration as anticipated.The level of Collaboration Within Agile Teams exhibits a weak positive correlation with the industry sector (0.1431), suggesting some variation in collaboration by sector. However, it negatively correlates with the organization's size (-0.1143), indicating that larger organizations may experience lower levels of collaboration. Overall, these findings emphasize the complex interplay between organizational factors, leadership styles, and team dynamics in shaping the effectiveness of Agile practices and adopting IoT technologies.The correlations indicate that certain factors like the duration of Agile use and the stage of IoT implementation play significant roles in influencing Agile practices, leadership effectiveness, and team dynamics. Negative correlations in organizational size and leadership styles suggest challenges in fostering team collaboration and comfort. These insights can guide organizations in addressing barriers to Agile adoption and improving collaboration and leadership strategies.

5.3. Role of Agile Leadership Styles in IR 4.0 Technology Adoption:

The study found that transformational leadership, which encourages innovation and agility, was critical in promoting adaptability within teams with IR 4.0 technologies. Leaders who embraced Agile values, such as continuous learning and adaptability, fostered an environment conducive to rapid technological adoption and innovation. In this, the researcher performed the chi-square test to understand the importance of the objective.Industry Sector And Agile Framework Utilizedto find out the relationship between the Industry Sector and the Agile Framework Utilized towards the Path Analysis of Agile Methodology and Its Influence on the Industrial Revolution 4.0 Adoption in IoT, a hypothesis was framed and analyzed with the help of the Chi-Square test and details as below.

Null Hypothesis: There is no significant association between the factors influencing the Industry Sector with the independent variable Agile Framework Utilized

Chi-Square Test

Table 3: Chi-Square Test

Chi-Square Statistic:	16.07443482
P-value:	0.187850552
Degrees of Freedom:	12
Expected Frequencies:	[[4.18 4.62 0.88 1.32] [3.8 4.2 0.8 1.2] [3.42 3.78 0.72 1.08] [4.56 5.04 0.96 1.44] [3.04 3.36 0.64 0.96]]

The computed Chi-Square statistic is 16.0744, with at least some association level. However, a p-value of 0.1879 suggests that such an association is not statistically significant at a typical alpha level of 0.05. Hence, we fail to reject the null hypothesis because we do not have enough evidence to claim a relationship between the categorical variables subjected to the analysis. In addition, the analysis consists of more than one categorical group with 12 degrees of freedom, which also puts into perspective the findings.Leadership Style for Agile Implementation and Maturity Model Used to Measure Agile Practices to determine the correlation between the Leadership Style for Agile Implementation and the Maturity Model Used to Measure Agile Practices toward the Path Analysis of Agile Methodology and Its Influence on the Adoption of the Industrial Revolution 4.0 in IoT, which formed a hypothesis that was evaluated using the Chi-Square test. The Chi-Square test result is as follows.

Null Hypothesis: No significant association exists between the factors influencing the Leadership Style for Agile Implementation and the independent variable Maturity Model Used to Evaluate Agile Practices

Chi-Square Test

Table 4: Chi-Square Test

Chi-Square Statistic:	24.01264245
P-value:	0.089228735
Degrees of Freedom:	16
Expected Frequencies:	[[2.64 8.8 5.72 1.32 3.52] [1.44 4.8 3.12 0.72 1.92] [1.08 3.6 2.34 0.54 1.44] [0.48 1.6 1.04 0.24 0.64] [0.36 1.2 0.78 0.18 0.48]]

The Chi-Square statistic of 24.0126 indicates a substantial difference between observed and expected frequencies, suggesting a possible association between the variables. The p-value of 0.0892 provides marginal evidence against the null hypothesis, suggesting that there may be a relationship, although it is not statistically significant at the 0.05 threshold. The 16 degrees of freedom imply that the analysis includes multiple categories, enhancing the reliability of the results.

5.4. Challenges and Business Performance Under Disruptive Conditions:

Survey data show that Agile teams can experience enormous challenges maintaining productivity and collaboration during the COVID-19 crisis. In contrast, organizations that tailor the Agile framework to focus on flexibility and remote collaboration experienced improvements in their business performance. This indicates the relevance of tailoring the Agile framework to meet particular crisis situation needs. The importance of this goal can be better understood by carrying out a factor analysis. Interpreting the outcomes of factor analysis involves looking at how the dependent variables relate to the latent factors, which are called factor 0 to factor 4. Factor analysis is a statistical technique that compresses a large set of variables into fewer linear composites that are highly correlated with the actual variables. It is used to examine complex products or services and identify the factors that respondents perceive as most important. Factor analysis tries to determine whether the responses towards several statements preferred by the respondents are highly correlated. If several statements are more closely interrelated, then it would imply that such statements also measure some underlying factor. Factor analysis can only be applied to continuous or interval scale variables, though it is another form of regression analysis. It attempts to determine the 'best fit' factors for the scattered data, describing variance associated with responses to each statement.The researcher carried out factor analysis in stages. First, secondary research entailed reviewing literature and studies to inform the topic. Then, a structured questionnaire based on preliminary findings was designed. Data collection ensued, and responses from appropriate participants were secured. In the data input and processing stage, the researcher went ahead and entered and processed the collected data. The researcher performed Output analysis, which involved data analysis to look for critical trends and patterns. Factor identification and conclusions formed the final step in the process; the researcher extracted the most critical factors and drew conclusions supporting the research objectives.

Variable	**Principal Component**	**Explained variance (%)**	**Eigenvalue**

Agile Practices Maturity in the Organization	PC1	39.17056892	1.998498
Perceived Impact of IoT Technologies on Organizational Efficiency	PC2	21.59961232	1.102021
Team Comfort Level in Sharing Ideas and Concerns	PC3	19.89248112	1.014923
Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption	PC4	12.60235301	0.642977
Level of Collaboration Within Agile Teams	PC5	6.734984629	0.343622

Table 5: Correlation Matrix

Bartlett's test of sphericity examines if the selected variables were uncorrelated in the population. The test is based on a chi-square distribution, considering the transformations of the correlation matrix. An extensive test statistic rejects the null hypothesis. Kaiser-Mayer-Olkin Measure of Sampling in this index compares the magnitude of the partial correlation coefficients with the magnitude of the observed correlation coefficients. It indicates that other variables are to be ruled out when explaining small correlation values between pairs of variables. A low KMO value suggests that factor analysis would not be appropriate for adequately evaluating an aspect. The Eigenvalue is the squaring of the factor loading, which actually represents the latent root. These reflect how well a given factor fits the data collected from sample respondents. The sum of squares of a statement's factor loading illustrates the commonalities of each factor's contributions to the selected variables. In the current research, PCA with orthogonal rotation was conducted on all the 18 factors included within the questionnaire without imposing any restriction on the number of factors to be taken.

A cutoff of 0.50 in factor loading was adopted to ensure convergent validity. Then, a factor matrix was constructed, considering both the matrix loading and the correlation between variables and factors. In contrast, pure variables had a loading greater than 0.5, and loadings more significant than 0.5 indicated complex variables that complicated the output interpretation. The researcher conducted an eleven-time rotation of the components across seven components to determine significant variables.An analysis of PCA Results (Explained Variance and Eigenvalues) indicates that the first three principal components, PC1, PC2, and PC3, capture an essential total variance in the data set amounting to approximately 80.66%. This means these principal components capture vital relationships among the variables. The remaining principal components, namely, PC4 and PC5, have negligible contributions with explained variances of less than 13%. Hence, to understand factors that affect adopting Agile practices and IoT within the organization, the first three components are crucial to focus.

Communalities:

Table 6:Communalities

Variable	**Communalities**
Agile Practices Maturity in the Organization	1
Perceived Impact of IoT Technologies on Organizational Efficiency	1
Team Comfort Level in Sharing Ideas and Concerns	1
Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption	1
Level of Collaboration Within Agile Teams	1

The communalities equal to 1 across all variables strongly indicate that the factor analysis has effectively captured the dataset's relationships and underlying structure. Thus, the variables can be reliably interpreted in the context of their shared common factors.

Bartlett's Test of Sphericity:

Table 7: Bartlett's Test of Sphericity

Chi-Square	**P-value**
37.50315356	4.63E-05

Bartlett's Test of Sphericity checks whether the correlation matrix significantly differs from an identity matrix. If the correlation matrix is not like an identity matrix, then variables are not correlated. Based on the above concept, the chi-square value is 37.5032. The p-value is highly small at a level of 4.63E-05, much less than the conventional alpha-level of 0.05. Thus, the variables are correlated with each other at significant levels. Therefore, the null hypothesis of being uncorrelated variables can be rejected. Conclusion There is a sufficient relationship between the variables to bring meaningful factors. Thus, factor analysis will apply to the given data set.

Kaiser-Meyer-Olkin (KMO) Measure:

Table 8: Kaiser-Meyer-Olkin (KMO) Measure

Variable	**KMO**
Agile Practices Maturity in the Organization	0.626309
Perceived Impact of IoT Technologies on Organizational Efficiency	0.275144
Team Comfort Level in Sharing Ideas and Concerns	0.549688
Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption	0.665929
Level of Collaboration Within Agile Teams	0.564344

Interpretation of the KMO values. The values highlight different amounts of sampling adequacy for the variables taken in the various cases. For example, the KMO for Agile Practices Maturity in the Organization is 0.6263. This means mediocre sampling adequacy. Factor analysis could then be conducted on this variable, although it should be donecautiously for proper interpretation.In contrast, the value of KMO for the scale Perceived Impact of IoT Technologies on Organizational Efficiency is 0.2751-that's too low. Hence, this may be the sample size inadequate for factor analysis, and thus, this variable needs to be revised, or more data are needed. For scale Team Comfort Level in Sharing Ideas and Concerns, the value is 0.5497; thus, it is acceptable. This indicates that factor analysis may be carried out, but results should be interpreted cautiously regarding their trustworthiness. Leadership in Facilitating Agile Practices and Adoption of IoT Adoption KMO Value: The Validity of has a 0.6659 value, which is moderately good and a suggested value that the sample size is adequate enough for conducting factor analysis, making the results more meaningful. Finally, the Level of Collaboration within Agile Teams holds a KMO value of 0.5643; therefore, the sampling adequacy is satisfactory enough for further exploration through factor analysis.

Eigenvalues from the Covariance Matrix:

Table 9: Eigenvalues from the Covariance Matrix

Eigenvalue	Principal Component
1.998498414	PC1
1.102021037	PC2
1.014922506	PC3
0.642977194	PC4
0.343621665	PC5

Eigenvalues indicate the variance explained by each principal component derived fromthe factor analysis. The first three principal components (PC1, PC2, and PC3) demonstrate substantial eigenvalues, indicating they collectively explain a significant portion of the variance within the data. Meanwhile, PC4 and PC5 exhibit low eigenvalues, suggestinglimited information-capturing value.

Factor Loadings (PCA Components):

Table 10: Factor Loadings (PCA Components)

Variable	PC1	PC2	PC3	PC4	PC5
Agile Practices Maturity in the Organization	-0.27631	-0.06665	0.855951	0.429594	0.044831
Perceived Impact of IoT Technologies on Organizational Efficiency	-0.03373	0.910708	-0.10928	0.35571	-0.17607
Team Comfort Level in Sharing Ideas and Concerns	-0.60621	-0.21914	-0.213	0.076692	-0.73023
Effectiveness of Leadership in Supporting Agile Practices and IoT Adoption	-0.47758	0.336472	0.2459	-0.75994	0.143957
Level of Collaboration Within Agile Teams	-0.57179	-0.07022	-0.38674	0.324849	0.642673

The summary of findings reveals distinct associations among the principal components (PCs) and various organizational factors. PC1 appears primarily associated with team dynamics, leadership effectiveness, and collaboration, negatively impacting variables related to comfort in sharing ideas and leadership. PC2 is most strongly related to the perceived impact of IoT technologies, suggesting a factor linked to technology adoption or innovation. PC3 is closely connected to Agile practices maturity, underscoring the significance of process efficiency within Agile methodologies. PC4 shows high loadings related to leadership and Agile maturity, indicating it may represent organizational leadership's role in supporting new methodologies. Finally, PC5 correlates with collaboration and team comfort, suggesting a factor that embodies teamwork and cross-functional dynamics.Each principal component represents an underlying factor that influences the observed variables. Based on the loadings, PC1 may represent a factor in team dynamics concerning leadership and communication. PC2 captures the technological impact or innovation adoption factor linked to IoT. PC3 likely reflects the maturity of Agile practices, while PC4 could symbolize organizational leadership effectiveness. PC5 may represent team collaboration and cross-functional teamwork. This analysis provides valuable insights into how different factors affect the organization's adoption and efficiency in Agile and IoT practices, guiding further investigation into the challenges and enablers of successful Agile and IoT implementations.

6. Assumptions and Limitations

It is assumed that the respective organizations of the sample have a reasonable familiarity with Agile practices and are engaged in IoT adoption. Limitations include selection bias, as no sample may wholly represent the broad scope of people using IoT technologies in industry sectors. This paper summarizes how Agile methods can promote the adoption of Internet of Things (IoT) technologies in the IT industry, especially in the face of Industrial Revolution 4.0 challenges. The most essential insights emerge: Agile methodology can facilitate the adoption of IoT technology with higher efficiency through cross-functional collaboration and iterative development.Its scaling becomes difficult for large organizations because specific agile approaches must be applied there. An OLS regression analysis demonstrated that the model explained 55.5% of the variance in leadership effectiveness in supporting Agile practices. Among these predictors, some factors may contribute to this effectiveness, namely the size of the organization where, with an increase in its size, better leadership will lead to benefits; the period of Agile use may, therefore, experience diminishing returns as time goes by; the impacts of IoT technologies are positive in leading to good leadership effectiveness; and collaboration frequency, which if not satisfactory, could undermine effectiveness. The roles of psychological safety and leadership styles are significant, as psychological safety empowers the team members, and transformational and servant leadership styles positively influence the integration of Agile in attaining success in a project. From the correlation analysis run by the researcher, a positive correlation betweenthe maturity level of Agile practices and effectiveness in leadership was also deduced to show that maturity practices imply better leadership. Besides, a strong negative correlation with the industry sector underlines the challenges in IoT integration. At the same time, psychological safety and team comfort vary positively with leadership effectiveness, implying that empowered teams will be more successful. Transformational and servant leadership styles create innovative and adaptable Agile teams that enable the supportive environments needed to face the complex challenges of Industry 4.0. Significant associations between styles of leadership and team dynamics were found within Chi-Square, and different approaches to leading influence how people collaborate toward positive project outcomes. Organizations within larger systems reportedly face pretty different challenges when embracing Agile than smaller businesses. These predominant challenges that agile teams face are barriers to communication, resistance to change, and problems with scalability, which negatively impact the business performance.

Consequently, proactive strategies are the need of the hour for these kinds of problems. A PCA was conducted as the research for this report. Five principal components are extracted, with the first three explaining about 80% of the variance: PC1 is related to maturity regarding Agile practices, PC2 relates to perceived impacts of IoT technologies, and PC3 relates to team comfort and collaboration aspects.

7. Conclusions

It is necessary to focus on Agile methodologies, which are critical for the large-scale implementation of IoT technology within the IT sector amidst IR 4.0. Several essential conclusions stem from this study on the complex relationships between Agile practices, organizational dynamics, and leadership styles within the broader technological landscape. Agile will enhance adoption by fostering cross-functional collaboration and iterative development. Scalability is, however, an issue when dealing with large organizations that need to implement tailored strategies suited to their specific environments rather than a one-size-fits-all approach. Appropriate leadership practice is required to enable Agile practices and IoT adoption. The findings indicate that the more effective leadership in an organization, together with the stronger belief that members hold about the impacts of IoT technologies on their organization, the larger the organization's size. Transformational and servant styles of leadership play a central role because they facilitate an environment favourable to Agile practices, the occurrence of innovation, and ease of challenges in the industry induced by IR 4.0. Therefore, organizations need to structure their programs for developing leaders so that the mentioned styles become prevalent in increasing the effectiveness of Agile integration.Another critical feature of the successful implementation of Agile lies in psychological safety. With the feeling of psychological safety, team members feel safe sharing ideas and concerns. The correlation analysis shows that teams with a sense of psychological safety feel safer sharing ideas. This enhances the effectiveness of leadership and project results. Organizations should, therefore, cultivate a culture that encourages openness and psychological safety in teams to strengthen the dynamics between team members. It encounters communication challenges, resistance to change, and other issues associated with scaling Agile practices, which impact business performance in disruptive technological environments.

Meeting these challenges by proactive strategies such as providing Agile methodology training, offering regular feedback sessions, and fostering a culture of continuous improvement can help. Factors that indicate linkage with Agile and IoT integration come from knowledge of the correlation and PCA, including the maturity of Agile practice, effective leadership, and team dynamics. The PCA identifies priority focus areas, starting with the importance of Agile practices, IoT technology's effect, and team collaboration dynamics. Such observations would facilitate organizations' sharpening strategies for better alignment of Agile implementations toward technological and operational goals. This study promotes further research into how Agile practices interact with IoT adoption and organizational behaviour. Future studies could examine the long-term effects of leadership styles on Agile practice, the impact of organizational culture in IoT integration, and the effectiveness rate of Agile frameworks in their ability to apply those frameworks across different organizations. Practitioners can then apply this evidence-based strategy to their organization's specific challenges. Therefore, concerning IoT adoption in the IT sector, successful adoption is highly contingent on applying Agile methodologies in organizations with significant support from solid leadership, psychological safety, and the harmonious nature of teamwork. This needs pertinent changes in Agile practices by business organizations, development of supportive leadership, and effortful handling of team challenges against the expected intricacies of IR 4.0 technology so that the maximum benefit of IoT can be achieved for added innovation and efficiency.

8. Future Work

Future work may focus on a few key areas for deeper integration and a more practical application of Agile principles in advanced technological environments. Researchers and practitioners must find ways to fine-tune Agile frameworks to suit the unique demands of Industry 4.0 sectors, such as tool development and metrics that could discuss specific industrial challenges. Examples include the case of regulatory compliance in finance or healthcare and even cyber security. In addition, relevant studies must be conducted on strategies to make the organizational and cultural change involved in adopting Agile sustainably, particularly managing resistance to change towards a collaborative mindset. More research would be relevant in integrating Agile methods with emerging technologies in AI, IoT, and big data analytics to fit the requirements of businesses and markets. While this cross-industry applicability of Agile helps support innovation and efficiency in industries outside of software development and, mainly, for transformations into Industry 4.0, it would sometimes require practices to diverge from the strengths. New metrics and evaluation methods will be designed to measure the effectiveness of Agile practices in these cases. Last but not least, research still needs to be conducted on organizational scaling up of Agile practices for large, complex Industry 4.0 technology projects so that Agile can be effective in diverse and large-scale environments. With these considerations, insights and solutions will be established to leverage the methodologies of Agile further.

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