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EXPLORING THE IMPACT OF AGILE PROJECT MANAGEMENT PRACTICES ON SUPPLY CHAIN RESILIENCE AND SUSTAINABILITY: A CASE STUDY OF THE MANUFACTURING INDUSTRY

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ABSTRACT: This research investigates how agile project management practices have affected supply chain resilience and sustainable project management in China's manufacturing sector. Despite the expanding interest in Agile techniques and sustainable project management, there is a significant lack of research on their combined effects on supply chain resilience and sustainable project outcomes, particularly in China's manufacturing sector. Based on a comprehensive literature review, this study constructs hypotheses to investigate the relationships between Agile project management methods, supply chain resilience, and sustainable project management. Surveys are disseminated to 326 production workers from SMBs in the manufacturing industry to collect data. The acquired data are analyzed using PLS-SEM 4.0 (partial least squares structural equation modeling). The findings indicate that Agile project management methodologies significantly positively affect supply chain resilience and sustainable project management. The findings of this study contribute to the existing corpus of knowledge by shedding light on the importance of agile techniques for enhancing supply chain resilience and promoting sustainable project management in the Chinese manufacturing sector. The paper presents theoretical implications, practical recommendations, and future research directions, focusing on incorporating Agile approaches to improve SME supply chain resilience and project outcomes. These insights can assist industry practitioners and policymakers in developing strategies to enhance the competitiveness and sustainability of SME manufacturers.

Keywords: Supply Chain Resilience, Agile Project Management, Sustainable Project Management, Environmental, Economic Sustainability.

1. Introduction

In recent years, the project management literature has paid considerable attention to combining Agile Project Management Practices and sustainable techniques (Malik et al., 2023). Agile methods, which emphasize adaptability, collaboration, and adaptive planning, have been demonstrated to enhance project outcomes (Ismail & Wediawati, 2023; Ylinen, 2021). Sustainable project management, on the other hand, concentrates on integrating environmental, economic, and social concerns into project operations to ensure long-term viability (Larsson & Larsson, 2020; Stanitsas, Kirytopoulos, & Leopoulos, 2021). While these sectors have garnered considerable attention, their interaction and impact on the resilience and sustainability of supply chains remain unexplored (Marcucci et al., 2022).

Agile Project Management Practices research has primarily centered on measuring their impact on project success criteria such as time, cost, and quality (Bergmann & Karwowski, 2019; Odusanya et al., 2021). These studies demonstrate the benefits of Agile techniques in greater team cooperation, higher customer satisfaction, and quicker project completion (yaw Koi-Akrofi, Koi-Akrofi, & Matey, 2019; Žužek et al., 2020). Similarly, sustainable project management research has highlighted the importance of integrating sustainability concepts into project planning, implementation, and evaluation (Chofreh et al., 2019; Stanitsas & Kirytopoulos, 2023). Ki, Chong, and Ha-Brookshire (2020) These studies demonstrate that sustainability strategies positively affect resource efficiency, stakeholder engagement, and environmental stewardship.

In addition to the research mentioned above, the significance of field research cannot be overlooked (Goevert et al., 2019). Because China's manufacturing sector is vital to economic growth, but it faces unique challenges in sustainability, supply chain management, and project execution Liu et al. (2021). Moreover, China's SME sector is a vital driver of innovation, economic growth, and job creation (Chege & Wang, 2020). Nonetheless, SMEs frequently face obstacles, including limited technical capability, resource constraints, and the need for rapid market adaptation (Meng, Qamruzzaman, & Adow, 2021; Ritz, Wolf, & McQuitty, 2019). To fill these research gaps, it is essential to investigate the interaction between Agile practices, supply chain resilience, and sustainable project management in China's manufacturing landscape, providing valuable insights for SMEs to improve project outcomes and adopt sustainable practices (Sharma et al., 2022; Siegel et al., 2022).

Men et al. (2023) Investigating the correlation between Agile practices, supply chain resilience, and sustainable project management in this unique context can provide researchers and practitioners with valuable information. Dey et al. (2019); Khan, Godil, et al. (2021). Understanding the interaction between Agile methods, supply chain resilience, and sustainable project management in the context of Chinese SME performance enhancement potential will provide significant insight (AL-Shboul, 2023). Malek and Desai (2019) and Singh, Singh, and Khamba (2021) suggest that researchers and practitioners can design effective methods to improve project outcomes, mitigate risks, and promote sustainable practices in the manufacturing sector by investigating the connections between these elements.

As a result, this study aims to cover the abovementioned research by investigating the influence of Agile Project Management Practices on supply chain resilience and sustainable project management in China's manufacturing industry, focusing on small and medium-sized enterprises (SMEs). The findings of this research will contribute to the existing body of knowledge by providing empirical evidence of the relationship between Agile techniques, supply chain resilience, and long-term project outcomes. This study's findings will aid small and medium-sized enterprises (SMEs) in implementing effective project management techniques, enhancing supply chain resilience, and integrating sustainability concerns into their operations.

This research satisfies a need for research on converging Agile principles, supply chain resilience, and long-term project management. The Chinese manufacturing industry, particularly SMBs, presents unique performance development challenges and opportunities. By expanding on previous research findings, this study aims to increase understanding of the impact of Agile techniques on supply chain resilience and sustainable project management in the Chinese manufacturing sector.

2. Literature Review and Theoretical Background

In recent years, there has been an increase in the demand for adaptability and flexibility in supply chain management in order to navigate the dynamic commercial landscape successfully (Yang, Huo, & Gu, 2022). This trend has been driven by several factors, including rapidly changing client requirements, globalization, and the need for sustainable practices (Cavusgil et al., 2021). Consequently, traditional project management methodologies have inadequately addressed growing supply chain issues (Larsson & Larsson, 2020).

Agile Project Management Practices

The emergence of agile project management strategies has spurred interest as a potential option for enhancing supply chain resilience and sustainability (Sadeghi, Akbarpour, & Abbasianjahromi, 2022). Initially popularized in the software development industry, Agile approaches have extended to other industries due to their capacity to foster collaboration, adaptability, and speedy decision-making (Baran & Woznyj, 2020). According to Ahmed and Mohammed (2019), Agile project management is an iterative approach to planning and implementing project procedures. It is a compilation of tools and procedures used during the software development process. These tools and processes are required to collaborate and integrate all project participants through self-organization, planning, development, and early project delivery. In addition, it is the response to various situations (Zasa, Patrucco, & Pellizzoni, 2020).

Time Management

Time management is essential to agile project management strategies (Hayat et al., 2019). Agile techniques emphasize iterative planning, timeboxing, and time-bound iterations to facilitate efficient project execution (Anantatmula & Kloppenborg, 2021). According to Ismail and Wediawati (2023), time management in agile approaches permits rapid decision-making, frequent feedback loops, and flexible scheduling, allowing teams to adapt quickly to shifting customer requirements and market dynamics. Agile teams frequently use sprint planning, time estimations, and monitoring to increase project productivity and meet deadline-sensitive deliverables (Sojan & Ajayakumar, 2019).

Innovation

Bushuyeva, Bushuiev, and Bushuieva (2019) Innovation is a significant driver of agile project management approaches. Agile methodologies encourage a culture of innovation, experimentation, and continuous improvement (Javed, Bamford, & Abualqumboz, 2021). Agile teams can experiment with new techniques, technologies, and solutions throughout the project lifecycle if they embrace innovation (Sarangee et al., 2022). Li and Long (2022) state that agile methodologies encourage creativity by fostering collaboration, information exchange, and cross-functional team dynamics. This enables businesses to respond to changing trends, seize opportunities, and develop innovative products and services (Yuan & Cao, 2022).

Reliability

Bushuyeva et al. (2019) Innovation is a significant driver of agile project management approaches. Agile methodologies encourage a culture of innovation, experimentation, and continuous improvement (Javed et al., 2021). Agile teams can experiment with new techniques, technologies, and solutions throughout the project lifecycle if they embrace innovation (Sarangee et al., 2022). Li and Long (2022) state that agile methodologies encourage creativity by fostering collaboration, information exchange, and cross-functional team dynamics. This enables businesses to respond to changing trends, seize opportunities, and develop innovative products and services (Yuan & Cao, 2022).

Cooperation

Cooperation and collaboration are essential to agile project management approaches (Özkan & Mishra, 2019). Agile methodologies promote self-organizing teams, cross-functional collaboration, and open communication channels (Ozkan, Gök, & Köse, 2020). According to Thorgren and Caiman (2019), collaborative methods within agile teams foster shared knowledge, trust, and collective responsibility, enabling teams to work efficiently on challenging projects. Agile methodologies encourage collaboration, which enhances coordination, information sharing, and overall project success (Agbejule & Lehtineva, 2022).

Sustainable Project Management

According to Thacker et al. (2019), sustainable development is the form of development that satisfies the current generation's needs without depriving future generations of their needs. Frequently, the concept of sustainability is framed in terms of three dimensions, commonly referred to as the triple bottom line or Triple-P (People, Planet, Profit), which incorporate environmental, economic, and social aspects. Given their interdependence, Kemkaran-Thompson and West (2020) argue that sustainable development requires simultaneous consideration of all three pillars. Development in one dimension must not impede development in another. Publications on sustainable development frequently emphasize a single dimension, with the economic dimension and its relationship to the environmental dimension receiving the most attention. Sustainability has acquired popularity in supply chain management (Zhang, Yu, & Zhang, 2021). Organizations rapidly recognize the need to incorporate sustainable practices into their operations to reduce environmental impacts, increase social responsibility, and guarantee long-term profitability (Yuan & Cao, 2022).

Environmental Sustainability

Sustainability is essential to project management (Koke & Moehler, 2019). Armenia et al. (2019) Sustainable project management approaches aim to reduce negative environmental impacts throughout the project's lifetime. According to Zare Khafri, Sheikh Aboumasoudi, and Khademolqorani (2023), agile project management strategies may contribute to environmental sustainability by reducing waste, optimizing resource utilization, and facilitating adaptive planning. Agile methodologies emphasize iterative development, which permits more efficient resource utilization and eliminates unnecessary effort, thereby reducing the project's environmental footprint (Magano et al., 2021).

Economic Sustainability

Economic sustainability is another aspect of long-term project management (Sabini, Muzio, & Alderman, 2019). Agile methodologies can potentially increase economic sustainability by enhancing project efficiency, cost management, and return on investment (Yusuf et al., 2020). According to Munteanu and Dragos (2021), agile approaches encourage value delivery, customer participation, and regular feedback, which facilitates the modification of project scope and priorities in response to fluctuating market conditions. This agility and emphasis on customer value contribute to economic sustainability by optimizing resource allocation, reducing project costs, and maximizing business outcomes (Piyathanavong et al., 2022).

Social Sustainability

Goel, Ganesh, and Kaur (2020) define social sustainability in project management as the welfare of project stakeholders such as personnel, communities, and society. Agile project management approaches promote social sustainability by fostering stakeholder participation, communication, and inclusion (Gomes Silva et al., 2022). According to Olszewski (2023), agile approaches enhance project participants' social relationships and well-being by fostering cooperation, empowering team members, and promoting open communication. Agile approaches contribute to social sustainability in project management by addressing stakeholder needs and fostering a healthy work environment (Zakrzewska et al., 2022).

Supply Chain Resilience

Supply chain resilience is the capacity of an organization to adjust effectively to disruptions, maintain continuity, and recover rapidly (Wang et al., 2023). Agile project management strategies can enhance supply chain resilience in several ways (Sharma et al., 2021). According to Adana et al. (2023), agile techniques foster flexibility, adaptability, and rapid decision-making, enabling businesses to respond swiftly to unanticipated events and prevent supply chain disruptions. By implementing agile principles, businesses can enhance information sharing, supplier cooperation, and real-time decision-making, bolstering supply chain resilience (Oh, Moon, & Zhong, 2020).

Overall, the research supports the notion that agile project management techniques, such as time management, creativity, dependability, and collaboration, positively impact sustainable project management and supply chain resilience (Levy, Hadar, & Aviv, 2021). By applying these principles, organizations can support environmental, economic, and social sustainability, resulting in more resilient supply chains and improved project outcomes (Daú et al., 2019).

Hypotheses Development

The first hypothesis investigates how agile project management approaches influence supply chain resilience (Centobelli, Cerchione, & Ertz, 2020). Alqudah et al. (2020); Sonar et al. (2022). For instance, Kadenic and Tambo (2023) conducted a comprehensive literature review and discovered that agile project management approaches to enhance a company's capacity to adapt to disruptions and recover quickly. This aligns with the concept of supply chain resilience, which emphasizes supply chain agility and adaptability in the face of ambiguity (Um & Han, 2021).

More evidence for H1 can be found in the work of Korimbocus, Towokul, and Nagowah (2020), who contend that agile techniques enable businesses to foster collaboration, knowledge sharing, and swift decision-making. These characteristics are essential for building resilient supply networks that can effectively adapt to disruptions while maintaining operational continuity. Consequently, based on the current research, we propose that agile project management approaches significantly impact supply chain resilience.

H1: Agile project management practices significantly influence supply chain resilience.

The second hypothesis examines the relationship between agile and long-term project management methodologies. Sustainable project management integrates environmental, economic, and social sustainability principles into project execution. Agile techniques have demonstrated potential for facilitating the administration of long-term projects in various facets. According to Altuwaijri and Ferrario (2022), Agile techniques emphasize value delivery, customer participation, and regular feedback. (Khan, Razzaq, et al., 2021). Agile approaches encourage adaptable planning and resource optimization, which are crucial to the economic sustainability of a project (Jiménez, Afonso, & Fernandes, 2020).

According to Uzwyshyn (2023), agile project management strategies may contribute to environmental sustainability by minimizing waste, optimizing resource utilization, and facilitating adaptive planning. Agile techniques' iterative nature enables continuous development, reducing the project's environmental impact via improved resource allocation and decreased wasteful effort (Al Jabri, 2023). Agile approaches encourage stakeholder participation, cooperation, and inclusive decision-making in terms of social sustainability (Neely et al., 2021). According to Stare (2015), these characteristics foster a healthy work environment, improve the well-being of project participants, and contribute to the social sustainability of project management (Hatipoglu, Ertuna, & Salman, 2019). Based on these findings, we argue that agile project management approaches significantly affect long-term project management. By implementing agile principles, organizations can enhance the economic, environmental, and social sustainability of project execution.

H2: Agile project management practices significantly influence sustainable project management.

The proposed hypotheses (H1 and H2) are supported by prior research demonstrating the positive impact of agile project management approaches on supply chain resilience and sustainable project management (see Figure 1). In the following chapters, these hypotheses will be evaluated experimentally to investigate the correlations between the variables and contribute to the existing corpus of knowledge on the topic.

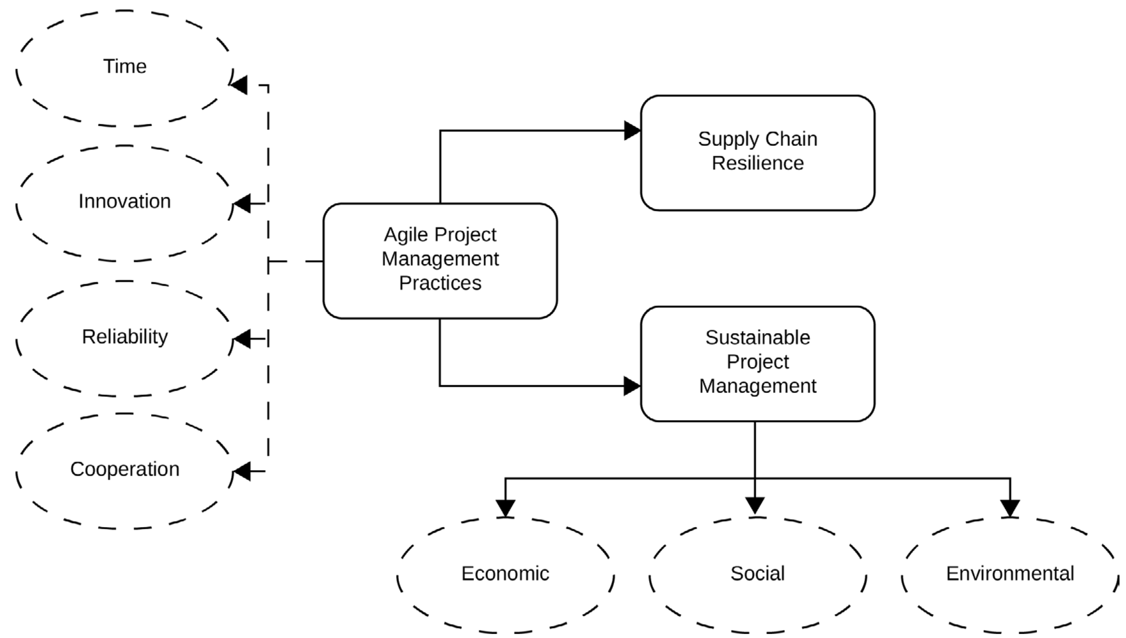

Figure 1: Conceptual Model

3. Methods

This study collected data from 326 manufacturing workers employed by Small and Medium-Sized Enterprises (SMEs). (See Table 1). These employees were recruited from various industrial companies in China based on their relevance to the research topic and availability as participants. Standardized questionnaires were distributed to the participants to capture their perspectives and experiences with agile project management approaches, supply chain resilience, and sustainable project management. Chow et al. (2021) developed a nine-item scale measuring sustainable project management. Soni, Jain, and Kumar (2014) used a scale with 14 items to assess the supply chain's resilience. The seven-item scale of Mohammed and Jasim (2018) was utilized to assess agile project management.

Table 1: Information on Participants' Demographics

Demographic Variable	Frequency	Percentage
Gender		
Male	182	55.80%
Female	144	44.20%
Age		
18-25 years	65	19.90%
26-35 years	126	38.70%
36-45 years	88	27.00%
46-55 years	35	10.70%
56 years and above	12	3.70%
Education Level		
High School	48	14.70%
Bachelor's Degree	172	52.80%
Master's Degree	86	26.40%
Doctorate Degree	20	6.10%
Years of Experience		
Less than 1 year	32	9.80%
1-5 years	112	34.40%
6-10 years	100	30.70%
11-15 years	54	16.60%
More than 15 years	28	8.60%
Company Size		
Small (Less than 50 employees)	138	42.30%
Medium (50-249 employees)	120	36.80%
Large (250 or more employees)	68	20.90%

PLS-SEM 4.0 was used to analyze the collected data and evaluate the study's hypotheses. PLS-SEM is a statistical analytic instrument utilized in social science research to analyze complex interactions between latent variables. PLS-SEM is ideally adapted for exploratory research because it permits a comprehensive evaluation of measurement and structural models. Using a comprehensive and rigorous strategy, PLS-SEM 4.0 was used to investigate the relationships between the independent variable (agile project management techniques) and the dependent variables (supply chain resilience and sustainable project management). This type of analysis permitted the evaluation of the significance and extent of the correlations and the investigation of any potential mediating or moderating effects. After data collection, the obtained responses were coded and entered into the PLS-SEM 4.0 program for analysis. Several procedures were performed during the analysis to confirm the accuracy and reliability of the results.

Initially, the collected data were examined for completeness, accuracy, and consistency to ensure they were suitable for further analysis. The absence or inconsistency of data points was dealt with using appropriate methods, such as mean imputation or exclusion. The measurement model was evaluated to ascertain the dependability and validity of the investigation's measurement instruments. This involved investigating the factor loadings, composite reliability, convergent validity, and discriminant validity of the measuring items.

Examining the structural model to determine the relationships between the variables of interest consisted of calculating path coefficients, determining statistical significance, and assessing the model's explanatory power. Other analyses were conducted to examine the potential mediating or moderating effects of other variables on the relationships of interest. This study determined whether an intermediate variable mediated the influence of the independent variable on the dependent variable. According to moderation analysis, incorporating a third variable changed the associations.

4. Results

Table 2 displays the Cronbach's Alpha values for the variables encompassed by the study. Cronbach's Alpha is an internal consistency statistic that indicates the reliability of each construct's measuring scales.

The Cronbach's Alpha values for most variables are greater than the conventionally accepted threshold of 0.70, indicating high reliability. With a Cronbach's Alpha score of 1, the construct "Cooperation" demonstrates outstanding reliability, as demonstrated by the consistency of responses across assessment items. "Agile Project Management Practices" (=0.855), "Economic" (=0.792), "Environment" (=0.719), "Innovation" (=0.721), "Reliability" (=0.763), "Social" (=0.752), "Supply Chain Resilience" (=0.899), "Sustainable Project Management" (=0.849), and "Time."

These high Cronbach's Alpha values indicate that the measuring scales used in this study are reliable and generate consistent results over time. This reliability ensures that the data obtained accurately reflect the evaluated constructs, increasing confidence in the subsequent analysis and interpretation of the findings. Overall, the reliability analysis results indicate that the measuring instruments utilized in this study were reliable and suitable for assessing the variables of interest. This establishes a solid foundation for future examination and interpretation of the relationships between agile project management methods, supply chain resilience, and sustainable project management (Zaman, 2023).

Table 2: Reliability Estimations for Cronbach's Alpha

Construct	Cronbach's Alpha
Agile Project Management Practices	0.855
Cooperation	1.000
Economic	0.792
Environment	0.719
Innovation	0.721
Reliability	0.763
Social	0.752
Supply Chain Resilience	0.899
Sustainable Project Management	0.849
Time	1.000

The assessment of measurement reliability and validity for the investigated constructs is summarized in Table 3. The reliability of measuring instruments is evaluated using two key indicators: Composite Reliability and Average Variance Extracted (AVE). These indicators provide information regarding the constructs' internal consistency and convergent validity (see Figure 2).

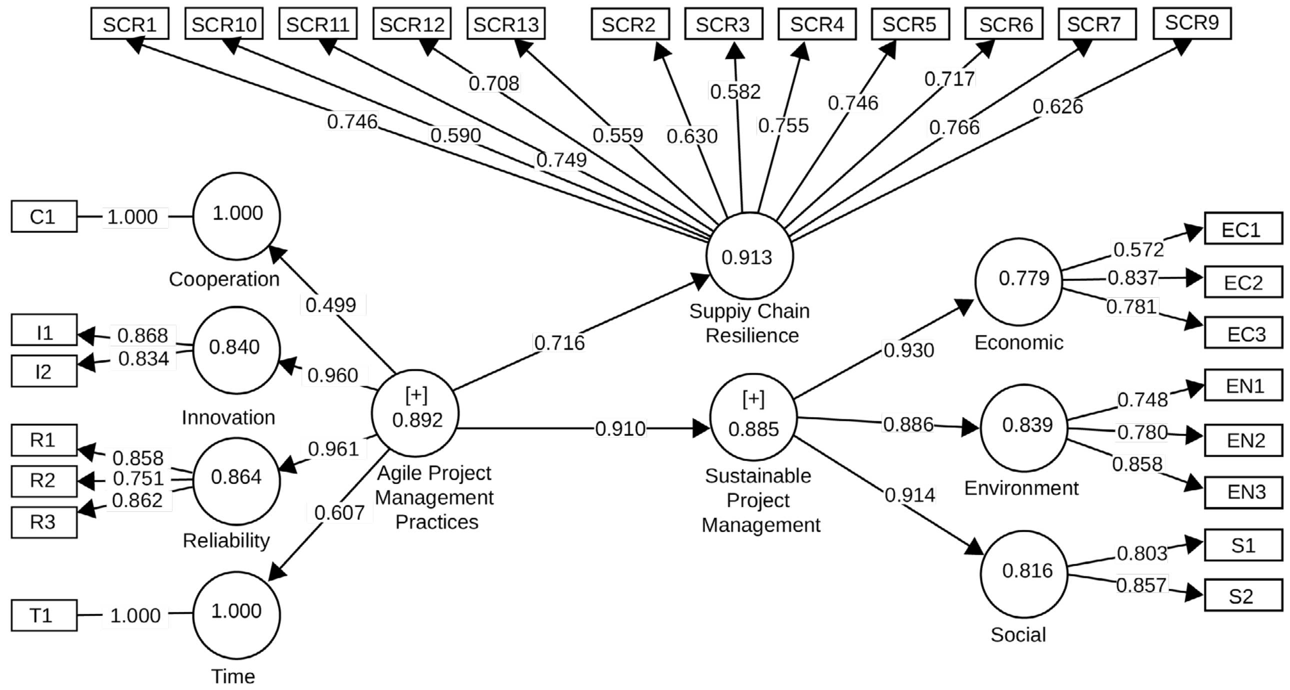

Figure 2: Structural Model

The Composite Reliability of the Agile Project Management Practices construct is 0.892, indicating high internal consistency. The Average variation Extracted (AVE) value of 0.548 indicates that the concept explains 54.8% of the variation in the measurement items, indicating satisfactory convergent validity. Cooperation's measuring elements have a high reliability of 1.000, indicating perfect internal consistency. The AVE score of 1.00 indicates that the construct explains all of the variances in the assessment items, indicating that it has high convergent validity.

With a Composite dependability of 0.868, the Innovation construct demonstrates outstanding dependability and high internal consistency. The AVE score of 0.840 indicates that the construct satisfactorily explains 84.0% of the variance in the measurement items, demonstrating adequate convergent validity. The Composite Reliability of the Reliability construct is 0.864, indicating excellent internal consistency. The construct accounts for 68.1% of the variance in the measurement items, indicating satisfactory convergent validity. The Time construct has a Composite Reliability of 1.000, indicating perfect internal consistency. The AVE score of 1.00 indicates that the construct explains all of the variances in the assessment items, indicating that it has high convergent validity.

With a Composite dependability score of 0.88, indicating excellent internal consistency, the Sustainable Project Management construct demonstrates excellent dependability. The AVE score of 0.502 indicates that the construct satisfactorily explains 50.2% of the variance in the measurement items, demonstrating adequate convergent validity. With a Composite dependability of 0.816, the Social construct has a high level of dependability, indicating high internal consistency. The AVE score of 0.69 indicates that the construct explains 69.0% of the variance in the measurement items, indicating acceptable convergent validity.

With a Composite dependability of 0.779, the Economic construct has a high degree of dependability, indicating high internal consistency. The AVE score of 0.546 indicates that the construct satisfactorily explains 54.6% of the variance in the measurement items, demonstrating adequate convergent validity. With a Composite dependability of 0.839, the Environment construct has a high level of dependability, indicating high internal consistency. The AVE value of 0.635 indicates that the construct explains 63.5% of the variance in the measurement items, indicating satisfactory convergent validity (Zaman, Aktan, et al., 2023).

High internal consistency is demonstrated by the Supply Chain Resilience construct's Composite Reliability of 0.913%. The AVE score of 0.569 indicates that the construct satisfactorily explains 56.9% of the variance in the measurement items, demonstrating adequate convergent validity. The majority of the study's constructs have acceptable reliability and convergent validity, as determined by the results of the reliability and validity analyses. These results validate the measuring equipment used to evaluate the variables of interest for the subsequent analysis and interpretation of the study.

Table 3: Assessment of Measurements for Reliability and Validity

	Factor	Original Sample	Composite Reliability	Average Variance Extracted (AVE)
Agile Project Management Practices			0.892	0.548
Cooperation	C1	0.599	1.000	1.000
Innovation	I1	0.868	0.840	0.724
	I2	0.834		
Reliability	R1	0.858	0.864	0.681
	R2	0.751		
	R3	0.862		
Time	T1	0.607	1.000	1.000
Sustainable Project Management			0.885	0.502
Social	S1	0.803	0.816	0.690
	S2	0.857		
Economic	EC1	0.572	0.779	0.546
	EC2	0.837		
	EC3	0.781		
Environment	EN1	0.748	0.839	0.635
	EN2	0.780		
	EN3	0.858		
Supply Chain Resilience	SCR1	0.746	0.913	0.569
	SCR10	0.590		
	SCR11	0.749		
	SCR12	0.708		
	SCR13	0.559		
	SCR2	0.630		
	SCR3	0.582		
	SCR4	0.755		
	SCR5	0.746		
	SCR6	0.717	0.516	
	SCR7	0.766		
	SCR8	0.626		

Using the Fornell-Larcker criteria, the discriminant validity of the assessment scales used in the study is determined. The numbers in the table represent the square root of the extracted average variance (AVE) for each construct, indicating the relationship between the construct and the other research constructs. The square root of the AVE for the Cooperation construct is not included in the table.

The square root of the AVG for the Economic construct is 0.457, indicating a moderate relationship with other components. The AVE square root of the Environment construct is 0.535%. It has a moderate correlation with the Economic construct (0.705) but none with the other constructs.

0.351 is the square root of the AVE for the Innovation build. It is moderately associated with the Economic (0.851) and Environment (0.671) constructs. The AVE square root of the Reliability construct is 0.356.0. It has a moderate correlation (0.838) with the Economic construct and a high correlation (0.650) with the Environment construct. The average square root of the Social concept is 0.347%. It has a moderate relationship with the Economic (0.841), Environment (0.686), and Reliability (0.902) constructs.

The square root of the Supply Chain Resilience AVE is 0.682%. It has a moderate relationship with the Economic (0.713), Environment (0.49), Innovation (0.600), Reliability (0.664), and Social (0.563) constructs. The Time construct provides the AVE with a square root of 0.245. Economic (0.417), Environment (0.595), innovation (0.504), Reliability (0.448), Social (0.443), and Supply Chain Resilience (0.388) are moderately associated with it.

According to the results of the Fornell-Larcker criteria, the AVE's square root for most constructs is greater than the correlations with other constructs, indicating outstanding discriminant validity. In a few instances, however, correlations between constructs are relatively strong, indicating overlap. These correlations should be meticulously evaluated when assessing the connections between the components in the subsequent analysis of the study's findings.

Table 4: Fornell-Larcker Criterion

	1	2	3	4	5	6	7	8
Cooperation								
Economic	0.457							
Environment	0.535	0.705						
Innovation	0.351	0.851	0.671					
Reliability	0.356	0.838	0.650	0.934				
Social	0.347	0.841	0.686	0.902	0.883			
Supply Chain Resilience	0.682	0.713	0.496	0.600	0.664	0.563		
Time	0.245	0.417	0.595	0.504	0.448	0.443	0.388	

The numbers in the table represent the HTMT ratios between construct combinations. The HTMT ratio for the Cooperation construct is not reflected in the table. The Economic construct has an HTMT ratio of 0.619%, indicating a high level of discriminant validity. The Environment and Economic constructs have an HTMT ratio of 0.612, indicating acceptable discriminant validity. The HTMT ratio for the Environment construct is 0.817%, demonstrating outstanding discriminant validity.

The Innovation and Economic constructs have outstanding discriminant validity, as evidenced by their HTMT ratio of 0.442. The Innovation and Environment constructs have an HTMT ratio of 0.620, indicating acceptable discriminant validity. The HTMT ratio for the Innovation construct is 0.770, demonstrating outstanding discriminant validity. The HTMT ratio between the Reliability and Economic constructs is 0.408, indicating strong discriminant validity. Good discriminant validity is indicated by the HTMT ratio of 0.48 between the Reliability and Environment constructs. The HTMT ratio between the Reliability and Innovation constructs is 0.824, indicating a high degree of discriminant validity. The HTMT ratio for the Reliability construct is 0.652, indicating high discriminant validity.

The HTMT ratio between the Social and Economic constructs is 0.46, indicating a high level of discriminant validity. The Social and Environment HTMT ratio is 0.66, indicating acceptable discriminant validity. The HTMT ratio between the Social and Innovation constructs is 0.873, indicating that they are highly discriminant. The HTMT ratio between the Social and Reliability constructs is 0.836, indicating a high degree of discriminant validity. The Social concept has an HTMT ratio of 0.647%, indicating strong discriminant validity.

The HTMT ratio between the Supply Chain Resilience and Economic constructs is 0.71, indicating that the constructs have outstanding discriminant validity. The Supply Chain Resilience and Environment HTMT ratio are 0.298, indicating adequate discriminant validity. The Supply Chain Resilience and Innovation HTMT ratios are 0.551, indicating high discriminant validity. The Supply Chain Resilience and Reliability constructs have an HTMT ratio of 0.707%, indicating high discriminant validity. The HTMT ratio between the Supply Chain Resilience and Social constructs is 0.702, indicating that the constructs have outstanding discriminant validity. The Supply Chain Resilience construct demonstrates high discriminant validity with an HTMT ratio of 0.694%.

The HTMT ratio between the Time and Economic construct is 0.245, indicating high discriminant validity. The HTMT ratio 0.52 between the Time and Environment constructs indicates acceptable discriminant validity. The Time and Innovation constructs have an HTMT ratio of 0.73, indicating a high level of discriminant validity. The Time and Reliability constructs have an HTMT ratio of 0.641, indicating a high level of discriminant validity. The HTMT ratio between the Time and Social constructs is 0.513, indicating that they are highly discriminant. The Time and Supply Chain Resilience constructs have an HTMT ratio of 0.59, indicating a high level of discriminant validity. High discriminant validity is exhibited by the Time construct's HTMT ratio of 0.385%.

The HTMT ratios indicate that most concept pairings have acceptable discriminant validity. However, the HTMT ratios are relatively high in a few instances, indicating possible overlap between the constructs. These cases should be considered when evaluating the relationships between the constructs in the subsequent study analysis.

Table 5: HTMT Criterion

	1	2	3	4	5	6	7	8
Cooperation								
Economic	0.619							
Environment	0.612	0.817						
Innovation	0.442	0.620	0.790					
Reliability	0.408	0.483	0.824	0.652				
Social	0.467	0.666	0.873	0.836	0.647			
Supply Chain Resilience	0.714	0.298	0.551	0.707	0.702	0.694		
Time	0.245	0.525	0.733	0.641	0.513	0.599	0.385	

Q2predict, RMSE, and MAE were utilized to assess the model's fitness for the investigation. Table 6 demonstrates that the model has a Q2predict value of 0.541, indicating moderate predictive value. In addition, the RMSE value of 0.078 represents the average difference between the observed and predicted values, with smaller values indicating a superior model fit. In addition, the MAE value of 0.084 represents the average absolute difference between the observed and projected values, with smaller values indicating greater precision. These results indicate that the model's fitness is satisfactory, indicating that its predictions are reasonable and correspond to the observed data.

Table 6: Model Fitness Measurements

Q^2predict	RMSE	MAE
0.541	0.078	0.084

As shown in Table 7, the fitness of the research model was evaluated using R-square values for each variable. The results demonstrate varying levels of explained variance between variables. The R-square value of 0.866 for the Economic variable indicates that the model explains a substantial proportion of the variance in economic factors. Similarly, the Innovation and Reliability variables have R-square values of 0.922% and 0.924%, respectively, indicating a significant relationship between these variables and the model. The Environment and Social variables had R-square values of 0.78 and 0.83, respectively, indicating that these constructs fit the model well. The R-square value of 0.829 for the Sustainable Project Management variable indicates that the model accounts for a substantial proportion of the variance in sustainable project management. However, the R-square values for Cooperation, Supply Chain Resilience, and Time are much lower, at 0.249, 0.512, and 0.368, indicating that the model explains a smaller proportion of the variance in these variables. Overall, the model's fitness is adequate, capturing a substantial variance in most variables; however, additional research or predictors may be necessary for a few variables (Zaman, Naeni, et al., 2023).

Table 7: R-Square Statistics

Construct	R-square
Cooperation	0.249
Economic	0.866
Environment	0.785
Innovation	0.922
Reliability	0.924
Social	0.836
Supply Chain Resilience	0.512
Sustainable Project Management	0.829
Time	0.368

According to Table 8, the results of the route analysis indicate substantial correlations between the variables. The path from Agile Project Management Practices to Supply Chain Resilience has a substantial positive effect, with a value of 0.716%. This indicates that Agile Project Management Practices have a considerable impact on enhancing supply chain resilience. The significance of this association is supported by the t-statistic of 21.294 and the p-value of 0.000.

Similarly, the path from Agile Project Management Practices to Sustainable Project Management demonstrates a substantial positive effect with a coefficient of 0.910. This indicates that Agile Project Management Practices contribute positively to achieving long-term project management goals. With a p-value of 0.000, indicating a highly significant finding, the accompanying t-statistic of 40,736, which emphasizes the significance of this correlation, emphasizes the significance of this correlation.

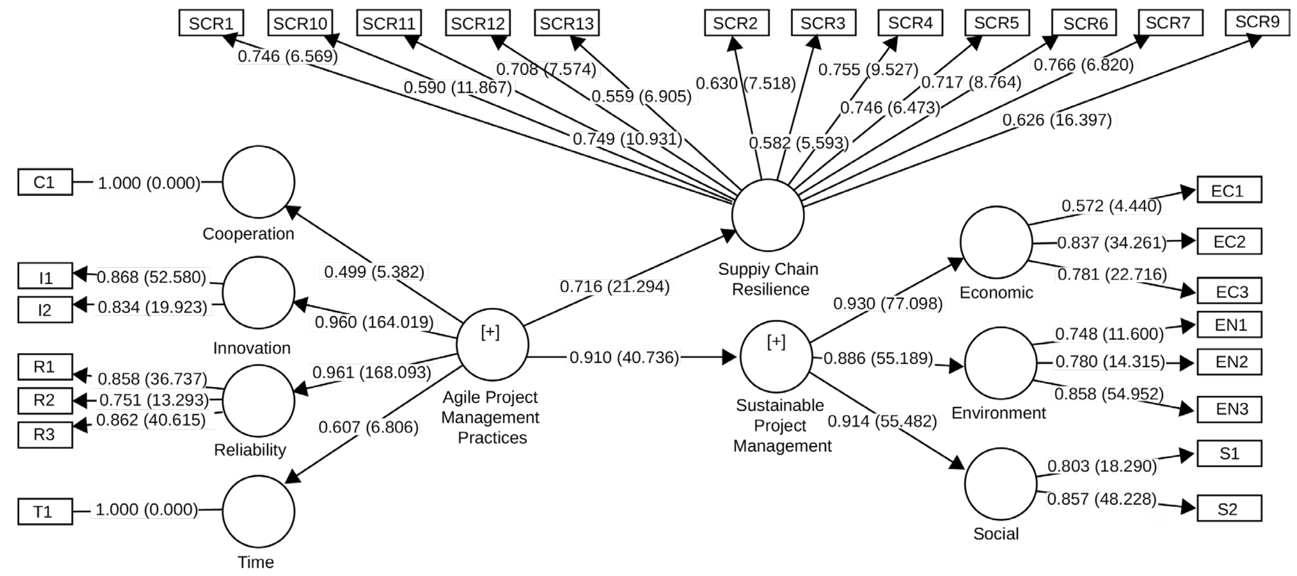

Figure 3: Path Analysis Model

These results prove that Agile Project Management Practices benefit Supply Chain Resilience and Sustainable Project Management. The high coefficients and statistically significant values indicate a strong relationship between the variables, highlighting the need to employ agile principles to improve supply chain resilience and project management sustainability (see Figure 3).

Table 8: Path Analysis Statistics

Hypotheses	Original Sample	Standard Deviation	T Statistics	P Values
Agile Project Management Practices->Supply Chain Resilience	0.716	0.034	21.294	0.000
Agile Project Management Practices->Sustainable Project Management	0.910	0.022	40.736	0.000

5. Discussion

This study's discussion chapter analyzes the findings in light of prior literature and aims to understand the study's contributions and implications comprehensively. The following discussion connects pertinent findings from the literature to the results of this study.

Agile Project Management Practices are widely acknowledged as an effective strategy for enhancing project outcomes and organizational performance (Goodison, Borycki, & Kushniruk, 2019; Papadakis & Tsironis, 2020). Our research corroborates these findings by demonstrating the positive influence of Agile Project Management Practices on Supply Chain Resilience and Sustainable Project Management. Previous research has demonstrated a positive correlation between Agile methods and project success (Lukusa et al., 2020); Radhakrishnan et al. (2022). The results support these findings.

According to our research, Agile Project Management Practices correlate strongly with Supply Chain Resilience. Alqudah et al. (2020); Ahmed and Rashdi (2021); Alqudah et al. (2020) have highlighted the significance of agile techniques in enhancing supply chain resilience, as agile practices enable organizations to respond to disruptions swiftly and effectively. Adopting agile concepts enables businesses to proactively manage risks, collaborate with supply chain partners, and respond to shifting market demands, enhancing their overall resilience.

Moreover, our findings demonstrate a strong positive correlation between Agile Project Management Practices and Sustainable Project Management. This result is consistent with previous findings that Agile techniques enhance sustainability performance (López-Alcarria, Olivares-Vicente, & Poza-Vilches, 2019; Tripathi et al., 2021). Agile techniques emphasize iterative and adaptive processes that permit continuous development, stakeholder participation, and the incorporation of environmental and social concerns throughout the project.

Our findings contribute to the corpus of knowledge by providing empirical evidence regarding the connection between Agile Project Management Practices, Supply Chain Resilience, and Sustainable Project Management. This study sheds light on the potential synergies between agile techniques, supply chain management, and sustainability practices by demonstrating the positive influence of Agile practices on both constructs.

Our findings have numerous repercussions. Implementing Agile Project Management Practices could enhance supply chain resilience and sustainability performance for manufacturing organizations, particularly small and medium-sized enterprises (SMEs). Organizations can respond to disruptions, manage risks, and achieve greater project success by adopting agile methodologies. Moreover, incorporating sustainability into agile processes enables businesses to align project outcomes with environmental, economic, and social objectives, thereby contributing to long-term sustainable growth. Nevertheless, significant limitations of this investigation must be recognized. Due to the study's focus on the Chinese manufacturing industry, its applicability to other industries and situations may be limited.

6. Conclusion

This study examined the influence of Agile Project Management Practices on Supply Chain Resilience and Sustainable Project Management in China's manufacturing sector. Our findings revealed significant positive associations between Agile techniques and Supply Chain Resilience and Sustainable Project Management. These results contribute to the existing literature by providing empirical evidence of the significance of Agile techniques in enhancing project resilience and sustainability. The findings demonstrated that organizations utilizing Agile Project Management Practices are better equipped to respond to supply chain disruptions and uncertainty. Organizations that adopt Agile principles can enhance their capacity to adapt, collaborate, and innovate, thereby bolstering the overall resilience of their supply chains. This finding is consistent with previous research emphasizing the benefits of Agile supply chain management techniques. In addition, our investigation revealed a connection between Agile methodologies and Sustainable Project Management. By incorporating sustainability considerations into Agile techniques, organizations can efficiently address environmental, economic, and social issues throughout the project lifecycle. This study concludes that Agile Project Management Practices can facilitate positive change within the manufacturing industry. By recognizing the interdependence of supply chain resilience and sustainable project management, organizations can implement proactive strategies, respond to shifting market demands, and contribute to the long-term health of their projects and the environment. When coupled with future research and practical application, the study's findings indicate a promising future for project management techniques prioritizing resilience and sustainability in an increasingly dynamic and challenging corporate environment.

7. Theoretical and Managerial Implications

This study's theoretical and practical implications chapter examines the significance of the findings in both academic and practical contexts, shedding light on the study's contributions and applications. The following discussion emphasizes the potential benefits and applicability areas of the research findings and includes theoretical and practical implications. The relationship between Agile Project Management Practices, Supply Chain Resilience, and Sustainable Project Management is empirically demonstrated in this study. These findings corroborate and expand upon previous research demonstrating that Agile methodology improves project outcomes. Examining the interdependence between Agile methodologies, supply chain management, and sustainability within the context of a manufacturing company adds to our understanding of the relationship between these three factors.

This study bridges the divide between research on resilience and sustainability in project management. This study demonstrates the positive impact of Agile techniques on Supply Chain Resilience and Sustainable Project Management, emphasizing the importance of simultaneously considering both factors. Incorporating resilience and sustainability perspectives enhances understanding of project management techniques and their implications for long-term success and sustainable development. This study highlights the significance of Agile principles in resolving complex project management challenges. In addition, the findings highlight the significance of iterative and adaptable methods, stakeholder participation, and ongoing development for achieving resilience and sustainability goals. The research contributes to the theoretical comprehension of Agile methodologies by demonstrating their practical application in supply chain resilience and long-term project management. In addition, the research findings provide firms, notably SMEs in the manufacturing industry, with actionable recommendations for enhancing supply chain resilience. By implementing Agile Project Management Practices, organizations can increase their ability to respond swiftly to disruptions, collaborate effectively with supply chain partners, and manage risks proactively. Implementing agile concepts can help businesses develop resilience and ensure continuity amid uncertainty and obstacles.

Incorporating sustainability concerns into Agile methodologies yields tangible benefits for businesses pursuing long-term project goals. By aligning project objectives with environmental, economic, and social factors, organizations can contribute to sustainable development objectives while delivering effective projects. The findings highlight the importance of incorporating sustainability techniques throughout a project, developing responsible project management practices, and producing positive social and environmental outcomes. Market advantage accrues to businesses that adopt Agile Project Management Practices and demonstrate supply chain resilience and sustainability performance. Such businesses are better positioned to meet shifting customer requirements, adhere to regulatory mandates, and engage with stakeholders who value sustainability.

8. Limitations and Future Recommendations

In the chapter titled "Limitations and Future Research Directions," this paper acknowledges the limitations and prospective future research directions. To advance the discipline, it is essential to recognize the research's limitations and identify areas that need further investigation. The subsequent discussion outlines the limitations and suggests future research directions. Due to the study's limited scope, the findings may only apply to the Chinese manufacturing industry, not other industries or regions. Future investigations on the connections between Agile techniques, supply chain resilience, and sustainable project management should not be limited to a single industry or culture.

Even though well-known assessment scales were used in this study, there is still a possibility that their validity and reliability influenced the results. Future research should investigate the feasibility of developing and evaluating enhanced measuring tools for Agile practices, supply chain resilience, and sustainable project management to enhance the credibility of the results. Moreover, temporal and causal associations: The study employed a cross-sectional design, making drawing conclusions about cause and effect challenging. Future studies utilizing longitudinal designs or experimental methodologies could investigate the temporal dynamics and causal connections between Agile practices, supply chain resilience, and sustainable project management.

Agile methods, supply chain resilience, and sustainable project management are poorly understood, but this could change with cross-industry, cross-organizational, and cross-geographic comparative studies. Using data from comparative analyses, it is possible to understand better how Agile approaches perform in various contexts. Mediators and Moderators of the Relationship Between Agile Methodologies, Supply Chain Resilience, and Sustainable Project Management Examining these causal relationships will shed light on the complexity at play. The outcomes of Agile project management may be substantially impacted by organizational culture, leadership style, and technological capability.

Longitudinal research into the effects of Agile techniques on supply chain resiliency and sustainable project management would yield significant insights. Longitudinal studies could reveal the complete scope of Agile's influence on the long-term viability of businesses by capturing the nature of these concepts' evolution. Future research may wish to incorporate stakeholder perspectives in project management, including those of consumers, suppliers, and community members. From a broader stakeholder perspective, the effects of Agile techniques on supply chain resilience and sustainable project management can be better understood. Future research could be fruitful if it investigates how AI, ML, and other emergent technologies can be incorporated to enhance Agile practices, supply chain resilience, and environmentally responsible project management. It would be advantageous for academia and practice to investigate how these technologies can be applied to maximize project outcomes while addressing sustainability issues.

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