Critical Success Factors of Agile Software Projects: A Review

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ABSTRACT

Most organizations have begun to adopt agile methods to pursue successful software development. However, the adoption and implementation of agile approaches are facing various challenges. The success of agile software development depends on Critical Success Factors (CSFs), which this study aims to identify and classify based on their relative importance. Through an extensive literature review, these factors are summarized, screened, and categorized into six dimensions. Their evolution is also outlined and analyzed. Then, the factors are illustrated through a bubble chart. Furthermore, this study determines the relevant CFSs that have a significant impact on how effectively can agile software development be implemented in China. The findings suggest certain recommendations to ensure that agile software projects are efficiently implemented in China, maximizing the chances of project success, providing valuable insights and practical guidance.

Keywords-critical success factors; agile; software development; bubble chart; China

I. INTRODUCTION

With the increasing market competition, cost pressure, and software complexity, people are gradually realizing that traditional methods cannot adapt to their complex and changeable needs and the frequency of rapid software iteration. Consequently, agile development methods emerged in the 1990s to respond to these challenges [1, 2], with the agile method series starting receiving attention. Agile Software Manifesto was issued 20 years ago, and accordingly that was the first time agile computing had been introduced to the world. However, given that the recognition and acceptance of agile software in China are far lower than in other foreign countries, no influential research results regarding this software have been formed [3, 4]. The key issue is that the success of agile software development depends on certain Critical Success Factors (CSFs). Therefore, their identification will provide important references for the successful implementation of agile software projects in China [4, 5].

In the past decade, researchers from various countries have conducted research on the CFSs of agile software projects. People-related factors are the first ones mentioned, which explains the success of agile software development [6]. These constitute survey studies conducted on the CSFs for agile software development projects through quantitative research techniques. Other studies have identified the CSFs for agile software development projects using Systematic Literature Review (SLR) [7, 8]. However, the existing research strives in identifying and prioritizing CSFs for agile software development, considering their relative importance to the success of software projects. There is no structured model to

specify the key factors that could contribute to bringing success in agile software development [9, 10].

This paper collected CSFs from literature and consolidated them through reliability and factor analysis into six categories, namely: Organization, People, Process, Project, Team, and Customer.

II. METHOD

The review consists of three stages: planning, conducting, and reporting [21, 22]. This section discusses the planning and conducting phases. The reporting phase is discussed in the Results section.

A. Planning the Review

In the planning phase, the research questions, search strategy, inclusion criteria, exclusion criteria, and quality assessment procedure were defined to ensure a systematic and comprehensive approach. [21]. This review aims to identify and classify the CFCs for agile software development based on their relative importance. The following Research Questions (RQs) were established:

- What are the CSFs that influence the success of agile software development in the local software industry of China?
- How are these CSFs classified?
- Which factors are more important for successful agile software development in China?

After determining the research questions, the search strategy was planned. The primary studies were identified by conducting a search using a specific set of keywords in digital databases. Subsequently, a thorough manual search was carried out by individually browsing through pertinent journal articles and conference proceedings. This dual strategy ensures thorough coverage, allowing for the inclusion of relevant research papers in the field of computer science.

An effective literature review should be based on a reliable search strategy that is fair, impartial, comprehensive, and accurate to ascertain research reliability [21, 22]. Therefore, five well-regarded digital libraries were utilized: CNKI, IEEE, Science Direct, Scopus, and Springer. Search keywords were derived from the RQs. The next step is determining the review protocol, which consists of inclusion and exclusion criteria. It is essential to make the search result to be more specified because the abstracts of the papers were reviewed based on these criteria. In the inclusion criteria, only scientific materials, written in English or Chinese were included. The publication date ranged from 2019 to March 2023. This review excluded publications that do not contain the search keywords. Based on the abstract, if the words agile and software were not mentioned in the paper, this was excluded.

A quality assessment of each paper, which is complementary to the inclusion or exclusion process, was also conducted [21, 22]. The assessment criteria are derived from the Critical Appraisal Skills Program (CASP) checklist for qualitative assessment. This checklist encompasses the evaluation of methodological rigor, relevance, and contribution to the field. After planning, the review was initiated on the basis of the RQs, search terms, inclusion and exclusion criteria, and qualitative assessment.

B. Conducting the Review

To conduct the review, the study began with finding the papers using the selected search keywords. Initially, there were a total of 2659 papers. After filtering the duplicates and removing the irrelevant papers, 1357 papers remained. Then, the time range was filtered by being limited to the period from 2019 to 2023. After screening, this reduced the number to 768 papers. Next, the terms "critical success factors", "key success factors", "agile", "software projects", and "literature review" were deployed to filter the abstracts of these papers. At the end, there were 483 papers left within the research scope. Subsequently, a manual search was performed to examine the relevant journal articles and conference proceedings. Finally, a comprehensive review and a quality assessment of the papers were carried out. It was found that only 56 papers were completely relevant to the review topic and objective.

III. RESULTS AND DISCUSSION

The important CSFs from the selected papers were determined and categorized into six dimensions, which are Organization (6 CSFs), People (10 CSFs), Process (4 CSFs), Project (4 CSFs), Team (5 CSFs), and Customer (5 CSFs).

A. Organization Dimension

The Organization dimension includes Management support, Team distribution/co-located teams, Facility with agile style work environment, Leadership, Risk Management, and Culture.

- Management support: The reform of any company must involve management support, which can provide the implementation conditions and environment or the project itself, especially when the latter enters the bottleneck. Offering key support can significantly improve the probability of project success [7, 9, 10, 13, 16, 17, 24-26].
- Team distribution/co-located teams: A communication friendly office working environment and a cross team agile development common tool set should be established. The team should be allowed to sit together or cross regional team communication tools should be provided to facilitate real-time communication and improve efficiency [7, 9-11, 27-30].
- Facility with agile style work environment: An agile project and development release environment should be built, communication and connection problems between teams should be reduced through tools, and the team's synergy and creativity should be enhanced [8, 31, 32].
- Leadership: Team leadership for agile teams. In this era of rapid development, developers are under increased development pressure, but most managers lack this expertise, making it difficult for them to understand their condition, which will damage team leadership [5, 12, 13, 33, 34].

- Risk management: There are various risks in the process of project development, such as capital overdraft, extension of construction period, etc. Therefore, good Risk management will facilitate the reduction of development risks and ensure development quality [4, 9, 28, 35].
- Culture: Everyone should be respected, while the company's system and Culture should be leveraged to grow the team. Close cooperation allows members to learn from and trust each other, jointly promoting project implementation and recognition. Additionally, each member will realize self-worth, recognize the team, strengthen the sense of belonging, and make project development more efficient [3, 5, 9, 13, 26, 36].

The Organization dimension is crucial in China because top-level management directly impacts project success. Management can assign necessary resources to a project. Strong leadership, a good work environment, team culture, and risk management can help the software project run successfully.

B. People Dimension

The People dimension entails Capable and motivated team members, Knowledgeable and experienced agile coach, Managers having knowledge of the agile process, Staff agile experience, Good client relationship, Customer involvement, Training and education, Staffing culture, Agile values, and Active communication.

- Capable and motivated team members: The ability and motivation of team members will seriously affect the progress of the project. Societal culture and personal characteristics impact team capability. The agile software development team should be highly competent, technically sound, and greatly motivated to get the job done [20, 26, 37].
- Knowledgeable and experienced agile coach: A Knowledgeable and experienced agile coach will point out the direction for the company to implement agile development, formulate the rules of the whole team, observe the performance of the team, and make timely adjustments in case of abnormalities [3, 7, 9, 13, 38].
- Managers having knowledge of the agile process: The development of agile software has very high technical requirements, and someone must be very proficient to be able to handle it. The Managers should be aware of the agile methodologies and possess leadership qualities to effectively coordinate with the entire development team as well as develop a good working relationship with the customer [9, 13, 26].
- Staff agile experience: Experience is always very important, and experience in agile development is especially significant. Experienced staff is familiar with daily working methods and can point out problems and beneficial practices [26, 36, 39].
- Good client relationship: A Good client relationship promotes the understanding of the latest client needs in a timely manner, while developing products with high client satisfaction is essential [7, 9, 13, 26, 36, 39-41].
- Customer involvement: Customers or users should be allowed to participate and fully understand the user experience. Like in the case of Xiaomi's products, fans should participate in the design of the products, which users really need. The advantages include accelerating the speed of product development, enhancing the sense of belonging, and improving the product sales [5, 7, 9, 13, 15, 17, 26, 34, 36, 39, 41, 42].
- Training and education: By providing training courses and knowledge to employees, they can successfully achieve the expected results. After training, team members have consistent agile values, thinking and skills. They receive agile training, learn agile ideas, ideas are infiltrated into the members of each R and D team, transforming it into an agile team [5, 7, 9, 14, 16, 17, 20, 25, 26, 36, 39, 43, 44].
- Staff culture: An efficient Staff culture makes the project objectives of the team consistent. The integration of project interests, department interests, and personal interests can enhance the agile team's awareness of customer orientation [3, 7, 9, 13, 16, 20].
- Agile values: Successful agile implementation requires Agile values. Agile values must be taught to employees to increase team agility and accelerate agile transformation. People can only maximize the agile development value by following the Agile values [7, 13, 16, 26, 36].
- Active communication: Communication is one of the main factors that influence the success of agile methodologies. Building agile barrier free communication means that the team members and the team and customers share the same cognition and understanding of requirements [7, 9, 26, 30, 39, 45].

The People dimension is crucial for agile software projects in China because emotional intelligence is valued in the traditional Chinese culture. Communication, managerial support, and leadership are important to project implementation. People are extremely significant in any project. Agile software development makes modification performance difficult at any point, depending on the credibility of the project staff.

C. Process Dimension

Process dimension includes agile-oriented requirement management and regular working schedule. The project scope involves a well-defined project scope/project complexity and regular software delivery. The Process dimension is crucial to the agile software project in China. In recent years, different enterprises in different regions of China, including internet enterprises, telecommunication service providers and product suppliers, enterprise application providers, platform enterprises, and outsourcing service enterprises, have actively tried agile development, but the success rate of the projects was not high, mostly owing to the insufficient Process dimension factor knowledge. Agile software development requires scientific and

effective process management, well-defined project scope, and regular software delivery to maximize quality and productivity.

- Agile-oriented requirement management: Agile-oriented requirement management and market information data collection are the most important factors. The person in charge of the product needs to fully understand the customers' needs and transfer them to the R and D team without obstacles to ensure that these customer needs are transmitted without loss [31, 46].
- Regular working schedule: During the implementation of the project, the project team should monitor the project progress, give regular work progress, let team members know the progress of all tasks, and form a task progress burnout chart to promote the smooth completion of the project [26, 31, 36, 47].
- Well-defined project scope/project complexity: Determining the project scope is the basis for the smooth progress of the project, including determining the project scope and determining the project team. The functional scope and time scope of the project, as well as the members of the project team should be identified [7, 9, 13, 15, 26, 48].
- Regular delivery of software: An effective strategy should be devised to deliver software at regular intervals so that customer satisfaction can be achieved. Regular software delivery allows customers to experience, give feedback, and adjust in time, which further strengthens the stability of the system and ensures the quality of product delivery [7, 9, 13, 15, 26, 47-49].

D. Project Dimension

The Project dimension includes the factors Budget, Plan and schedule, Objective planning, and Project change management. The project dimension is important to Agile Software Projects in China because there is not much experience in the successful implementation of such projects in the Chinese market. Agile software development is challenging since it accelerates software development and allows adjustments at any point. Therefore, a proactive risk management approach should be an integral part of iteration in the agile software development cycle.

- Budget: Project development budget is an essential comprehensive work. Controlling the cost within a reasonable budget can ensure the success of a project. If there is a budget problem, the former will miss the best time to enter the market, which allows competitors to take advantage of this opportunity [3, 4, 9, 13, 15-17, 20, 26, 36, 40, 50, 51].
- Plan and schedule: Project planning and arrangement guide project implementation and control, allowing executives and customers to track project status. With the development of the project, the content of the overall schedule needs to be further refined, to form a more specific schedule [9, 13, 15-17, 26, 40, 50, 51].
- Project objective planning: Clear Project objective planning is the primary task of the project start-up and requires going through an analysis stage. It is necessary to clarify the expected results of the project and the various indicators and standards that must be completed to achieve the expected results [13, 15, 17, 23].
- Project change management happens throughout the whole life cycle of software development. The repair content can be as large as the redesign of program modules or as small as the variable change of a source file, which shows the leading role of management change in actual development [7, 9, 14, 16-17, 26, 33, 40, 50-52].

E. Team Dimension

The Team dimension entails Project team skills, Project team commitment, Internal project communication and cooperation, Project team participation, and Team incentive mechanism. The team dimension is crucial to the Agile Software Project in China because agile software development teams need high abilities, sound technology, smooth communication, a spirit of cooperation, a strong sense of responsibility and belonging, great motivation to finish the work, and a complementary people dimension.

- Project team skills: Agile team members must have all the professional skills required for the product increment to transform the task list into the actual function increment. The skills and abilities of the project team are key factors for the success of the project [9, 27, 28, 33].
- Project team commitment: It considers the behavior and outcomes of the project team, emphasizing communication among team members to assist better understanding, and thus implementing the project [7, 9, 26, 36, 39, 41].
- Internal project communication and cooperation: It is the most critical factor of project success. Face to face communication is a rapid communication form aiming to avoid wasting time during information transmission [17, 26, 30, 39, 41, 44, 48, 51, 52].
- Project team participation: Business professionals, especially marketing, sales, operators, and customers, must be involved in product R and D to help designers understand product needs. Business staff and clients should be informed about the product development progress. After learning the product's R and D plan, the salesperson can market its functionalities. After understanding that plan, the customer can submit comments and thus improve the product value [7, 9, 16, 17, 26, 30, 39, 41, 44, 48, 51, 52].
- Team incentive mechanism: An effective incentive system will not only contribute to the success of the project, but will also have a positive impact on the project management. It can promote the progress management of the project, clarify the objectives, ensure the stability of the project team, and mobilize the enthusiasm of team members [39, 41, 48, 51-52].

F. Customer Dimension

The Customer dimension encompasses Customer involvement, Knowledgeable customers, Customer support education, Customer experience, and Customer training. The

Customer dimension is significant because market competition has made real-time software delivery requirements more difficult. The delivered results must have market value, customer involvement, and knowledge-based users who can accurately express their needs.

- Customer involvement: Customers should be guided to involve more deeply in the project. Too little customer participation will lead to a big difference between the project results and customer expectations. It is necessary to reach an agreement with customers, guide users to accept multiple ways and scenarios to participate, and communicate project problems in real time, which can also make customers have an intuitive grasp of the progress of the project [7, 16, 26, 34, 36, 39, 41, 42].
- Knowledgeable customer: If the cultural level of the users is relatively high, they will have a strong ability to acquire relevant knowledge during the process of project participation, and may participate in relevant discussions and meetings, which will be of great assistance to the smooth implementation of the project.
- Customer support education: By providing an experience beyond the expectations of the users, they can refresh their previous understanding of similar services or product experiences, and be therefore attracted, especially for a long time [16, 26, 36, 53].
- Customer experience: Many agile project managers are technically sufficient but do not know much about product design or business. Success requires including user experience. Insufficient time to consider the business and user environment and apply this information to build the design vision will make the designer's delivery process difficult [26, 36, 53].
- Customer training can effectively improve the accurate expression of user needs and efficiently complete the collection of these needs and changes [26, 36, 53].

G. Agile Principles

Agile methodology is based on the collaboration among team members [54]. The Agile Manifesto provides 12 principles, which help software development teams create value for all stakeholders (users, investors, and sponsors). Integrating agile software development principles into the Software Development Life Cycle (SDLC) can improve adaptation, flexibility, performance, and value for consumers, organizations, and investors. The six dimensions and CFCs which follow these 12 principles are illustrated in Table I.

H. Discussion

The mentioned CFCs vary depending on the scope, object, time, and progress. This paper conducts an extensive literature review, combined with reliability analysis and validation factors, to identify, screen, and classify the CFCs of the agile software development projects in China that are worth studying. As mentioned above, 34 CSFs and six dimensions were determined, which include Organization dimension (6 CSFs), People dimension (10 CSFs), Process dimension (4 CSFs), Project dimension (4 CSFs), Team dimension (5 CSFs), and Customer dimension (5 CSFs). The frequency of each CFC factor is recorded based on the literature review.

TABLE I. AGILE PRINCIPLES

Agile Principle	Label
The highest priority is to satisfy the customer through early and continuous delivery of valuable software.	P1
Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.	P2
Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter time scale.	P3
Businessmen and developers must work together daily throughout the project	P4
Build projects around motivated individuals. Give them the environment and support they need and trust them to get the job done.	P5
The most efficient and effective method of conveying information to and within a development team is face-to-face communication.	P6
Working software is the primary measure of progress.	P7
Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.	P8
Continuous attention to technical excellence and good design enhances agility.	P9
Simplicity – the art of maximizing the amount of work not done – is essential.	P10
The best architecture, requirements, and designs emerge from self-organizing teams.	P11
At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.	P12

The importance of each CSF can be determined according to its frequency. In addition, the setting of critical factors and dimensions follows agile principles, thus emphasizing the degree of technical compatibility between each factor and dimension and agile principles. This paper uses a bubble chart to display the corresponding relationships among various factors. The left side of Figure 1 lists each agile principle, the right side shows six dimensions, and the vertical axis represents the CFCs corresponding to each dimension. The data in the bubble denote the frequent weights of CFCs and their corresponding agile principles. Figure 1 demonstrates that the dimensions of People, Project, Team, and Organization play an important role in the success of agile development projects. Training and education and Budget are the most frequently occurring factors. This means that regular training and education of new professional skills are crucial for the improvement of project participants. In addition, Reasonable cost control should be given top consideration in the implementation of agile development. Customer involvement and Participation of the project team are factors that occur frequently and are relatively high. During the process of agile software development, it is necessary to consider the participation of project personnel and especially the participation of customers, who can timely provide the project team with feedback on the delivered software according to the latest requirements and market demands. This plays a substantial part in the success of the agile software development. Moreover, among all the CSFs, Management support and Active communication are very special, as these two factors have significant differences in the results in China and outside of China and are worthy of further research and exploration.

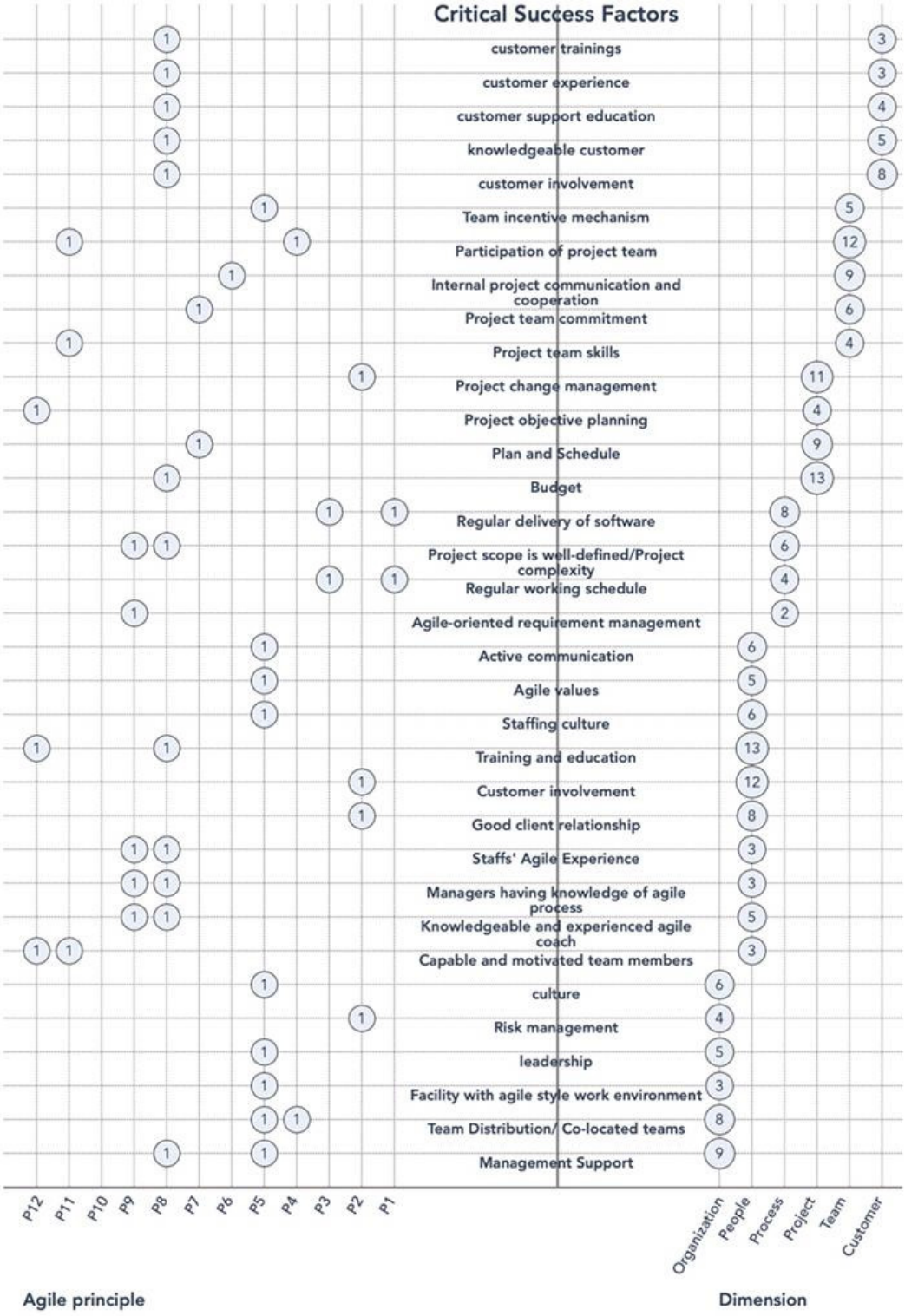

Fig. 1. CSF models in a bubble chart.

IV. CONCLUSION

The current paper identifies, analyzes, and categorizes the Critical Success Factors (CFCs) of the agile software development based on their relative importance. Through an extensive literature review, 34 CSFs worth studying were summarized and divided into six dimensions: Organization, People, Process, Project, Team, and Customer. These CSFs have a greater impact on the successful implementation of agile software development.

The complete identification and classification of CSFs, which address potential challenges, makes this work significant. Understanding these characteristics allows practitioners to adapt agile approaches to the organizational and cultural environment, improving their efficacy. This research fills a critical gap in the literature on agile practices in China contexts and provides a robust framework for agile software development research and practice in China and other regions with similar socio-cultural dynamics.

The practical implications of this research are substantial. The CSF model provides guidance in implementing agile software projects in China. It will maximize the chances of project success and provide valuable insights and practical guidance for the significant implementation of agile software development in China. This model facilitates organizations in comprehending the key elements that require focus, such as management support, team allocation, and customer engagement, which are essential for the efficient adoption and implementation of agile methodologies.

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