The Trajectory of Scaled Agile Research: A Bibliometric Analysis and Visualization Approach

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Abstract

Modern project management in organisations is moving towards Scaled Agile to achieve success. Scaled Agile refers to a set of organisational structures and processes for implementing agile practices that are applied on an enterprise scale. This study explores Scaled Agile growth and impact by analysing 238 publications obtained from the Scopus databases using bibliometric analysis. The results show that publications on Scaled Agile have steadily increased, with more contributions from developed nations than developing countries. In terms of the geographic distribution of publications, Germany is the leading followed by Sweden and the United States. The results also show that Scaled Agile is being applied across different fields, but is dominated by computer science, engineering, and business. We visualized the high-frequency terms using a word cloud and the keyword co-occurrence map, and a density map using VOSViewer. The h-index of 21 for the analysed articles indicates the significant scholarly impact of the publications. The study identified the following key themes: team dynamics, organisational structures, and practical applications of Scaled Agile. The study also identifies the major challenges associated with Scaled Agile, namely cultural issues and scalability issues, effective organisational design, and change management strategies. The findings of this study offer valuable insights into the current state of Scaled Agile that appeal to industry practitioners and academics interested in Scaled Agile research and implementation.

Keywords: Bibliometric analysis, Project management, Scaled Agile, Software project success, Visualization

1. INTRODUCTION

Modern project management has radically changed the project management ecosystem and software development companies. The most significant change that has revolutionised how projects are managed is the use of adaptive methodologies that enable a high rate of software project success. One of these adaptive methodologies is the Agile methodology [1]. Agile methods enable companies to manage change, deliver frequently, and remain flexible, all while ensuring

collaboration and communication by all stakeholders involved in a project, thus ensuring optimum customer satisfaction [2] [3]. Agile methodologies and scaling frameworks have become a go-to solution for software development companies looking to boost project success [4] [5]. However, moving Agile to large-scale contexts is a complex task with many challenges. Agile methodologies were created for small projects, but because of their benefits, large software development companies have embraced them to grow their projects [1]. Many large software development organisations undertake massive software projects, and it has been proven that large projects utilising the classic Waterfall approach are less effective than those employing Agile methodologies. Scaled Agile Framework (SAFe) adoption has therefore been viewed as a feasible approach to aid in the success of large projects [6]. SAFe is a framework and a collection of best practices of Agile development for large enterprises. The framework is built upon Agile development, lean product development, and systems thinking ideas. It supports companies of different sizes, from small ones with few employees to larger enterprises with thousands of people.

In its simplest form, Agile portfolio management allows organisations to respond more quickly to rapidly changing market conditions and ensures that strategic goals align with the market needs. Going Agile is not a one-time event; it's a journey that leads toward more Agile project portfolio management practices across organisations that depend on the strategic goals and the organisation's commitment to leading to Agile transformation [8] [9]. Being Agile means an organisation continuously delivers value for a project or product. It's a way of enabling an organisation to anticipate and adapt to changes. Different Agile scaling frameworks exist, including the SAFe introduced during the Agile 2013 conference, LeSS, and Disciplined Agile Delivery presented in May 2013 by Ambler at the International Conference of Software Engineering. SAFe and other Agile scaling frameworks are becoming hot topics within software-developing organisations [10]. Software-developing organisations that have already adopted SAFe have seen significant changes and improvements in the productivity and quality of their software products. Every organisation, including software development organisations, is concerned with improving the quality and productivity of software products [11]. Even though the Agile Manifesto for software development mainly defines Agile, these Agile methods are also used by other disciplines, such as construction, agriculture and others, depending on their goal [12]. For example, the portfolio level of SAFe can be used by other disciplines for investments, the programme level can be used for the execution of different initiatives, and the team level can be used for the management of various activities within the initiatives [12] [13].

The consensus indicates that the majority of small projects reap significant advantages with the use of Agile methods, and hence, the adoption of such

techniques to be Scaled by larger organisations and used for larger projects has seen increasingly more considerable interest [14] [1]. Modern project management within large organisations aims to adopt Agile methodologies to scale their projects and achieve success [14]. In smaller organisations, success is relatively more straightforward to measure under Agile practices, and thus, the perceived indicators for success are much simpler and fundamentally easier to identify [14]. Within Scaled Agile projects, the ability to measure success becomes a challenging task, as the sheer size of teams, the difference in mindsets and practices, and the lack of cross-functional coordination make it harder to manage projects in an Agile fashion [15] [1]. This current research focuses on the portfolio SAFe 5.1, which is depicted in Figure 1.
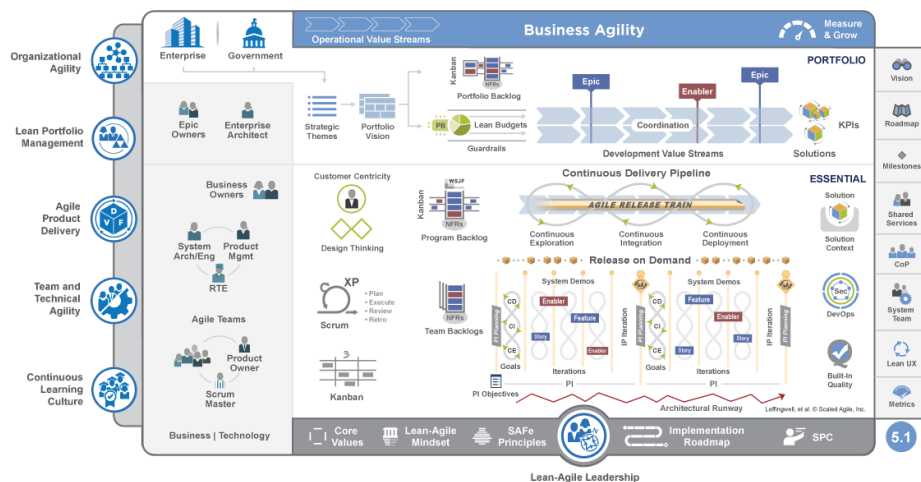

Figure 1. Scaled Agile Framework [7]

Nevertheless, no bibliometric study related to Scaled Agile exists to our knowledge. This study seeks to answer the following questions:

1) What are the publication trends and geographical distribution of research contributions in Scaled Agile?
2) Which are the research hotspots and emerging areas of research in this research area?

The rest of this paper is structured as follows: Section 2 outlines the methodology we observed and how we collected and analysed data. Section 3 presents the results using descriptive methods and the outcomes from analysis done on VOSviewer version 1.6.18. Section 4 discusses the results' implications. Finally, in Section 5, we summarise the main findings of the bibliometric analysis.

2. LITERATURE REVIEW

2.1. Portfolio Level

The portfolio level is the SAFe's highest level, which is intended to assist in aligning the development organisation with the company's business objectives. The value stream, which comprises all the work necessary to produce value, is how value is created for a client or company, and the Agile release train embodies the value stream [16] [18]. Agility necessitates an organisation's ability to recognise and adapt to unexpectedly changing circumstances holistically. As a result, Agile portfolio management is critical for connecting established independent, self-organising, cross-functional Agile service delivery teams to the strategic business goal while allowing for fast readjustment [19]. Agile portfolio management, in its most basic form, allows a company to react more quickly to rapidly changing market conditions. Being Agile entails producing value constantly, whether for a product, project, or program. Agile working styles enable businesses to anticipate and respond to change in near real-time on a corporate level [17] [7].

The portfolio level includes various projects and programs to ensure strategic goals are met by managing company investments [7]. Portfolios are designed to enhance, align and support project deployment through efficient resource allocation. Typically, portfolios will comprise a particular plan, strategy and associated risks [21][7]. A portfolio is entirely at the will of the company's strategic and overall goals; hence, when portfolios are being imagined, the available resources, current strategic roadmap, and overall governance play an integral part in their realisation and re-alignment [7]. The portfolio level involves the enablement of a company's strategic value. Thus, as indicated previously, several portfolio-level processes exist, including lean governance, value streams and alignment, program selection, portfolio optimisation, strategy and investment funding [7] [17].

2.2. Program Level

When using the SAFe, the program level refers to various Agile teams working independently [17] [22]. This level looks at certain variables involved in delivering a functioning system, such as the estimations and forecasted estimated time for each sprint to be implemented. This level also ensures alignment and assessment through cadence planning [18]. The resulting outcomes of these estimations enable the creation of the program backlog. This program backlog ensures that all Agile teams are coordinated in a synergetic fashion to provide the direction and guidance of the overall end goal of particular system solutions [17] [18]. Program backlogs define and prioritise business and architectural features [19]. An Agile release train focuses on synchronicity and cadence at this level, aiming to improve the quality of releases.

As part of a release train, teams follow a similar rhythm, including several iterations of work and one iteration of innovation and planning. Program Increments (PIs) are giant time boxes shared and examined by everyone at a PI planning session [22]. A typical Agile Release Train (ART) offers deliverables and possibly increments that can be shipped at a schedule set in advance, usually 2 to 4 months. All relevant stakeholders are involved in a 2-day event to plan the releases. Additionally, innovation and planning sprints are used to hold a review and adjust seminars to the PI planning. The progress of the entire PI is shown by reducing technical accounts, opening communication channels between the teams, and performing training. In the PI planning process, highlights are divided into stories and assigned to teams by teams and stakeholders [7]. Release train engineers (RTEs) serve as scrum masters for the whole train - they take responsibility for coordinating scrum masters and product owners, eliminating restrictions, and facilitating regular assemblies [17] [22] [7].

2.3. Team Level

Development teams now widely use Agile development methods like eXtreme Programming (XP), Scrum, and Kanban. A typical Agile team comprises a few cross-functional individuals able to deliver product increments frequently and accurately. They are capable of working independently and making decisions on their own. Unfortunately, this type of team setup is not always feasible [17] [7]. Agile teams, particularly small ones, cannot provide the specialised skills needed to develop large, complex products. These roles are part-time and usually provide support through certain stages of product evolution. Agile teams are, therefore, required to work with many people [17]. Agile teams dominate the framework at the team level [7]. These teams are responsible for designing, developing, and testing software in iterations with a fixed duration. In this level of SAFe, Agile project management (Scrum) is blended with Agile practices. The idea of user narratives originates based on XP, whereas planning sprints and everyday stand-ups is integral to Scrum.

The Team Level contains the roles, activities, events, and processes that Agile teams build and deliver value [18]. The team level is vital in Scaled Agile, as it involves the immense processes surrounding providing quality products and services. SAFe is similar to other Agile software development approaches at the team level. It comprises a cross-functional and self-organised Agile team comprising 3 to 9 engineers, scrum masters, and product owners [25] [22]. In SAFe nomenclature, the ScrumXP team's methods and responsibilities are derived from Scrum and XP. Along with the team, the product owner maintains a backlog, and the Scrum master works as a team steward, clearing bottlenecks and promoting the improvement of the collaborative process [17] [7].

3.   METHODOLOGY

Including meta-analysis in a review article will improve the level of evidence and significantly increase its citability [20]. We chose the Scopus database because it is the most extensive citation and abstract database of peer-reviewed publications. Scopus is a reputable and widely used database that is easily accessible, providing a basis for answering the research questions posed in the previous sections. On 4 January 2024, we searched the titles, abstracts and keywords and collected data with the search string, selecting articles focused on Scaled Agile. The string used is:

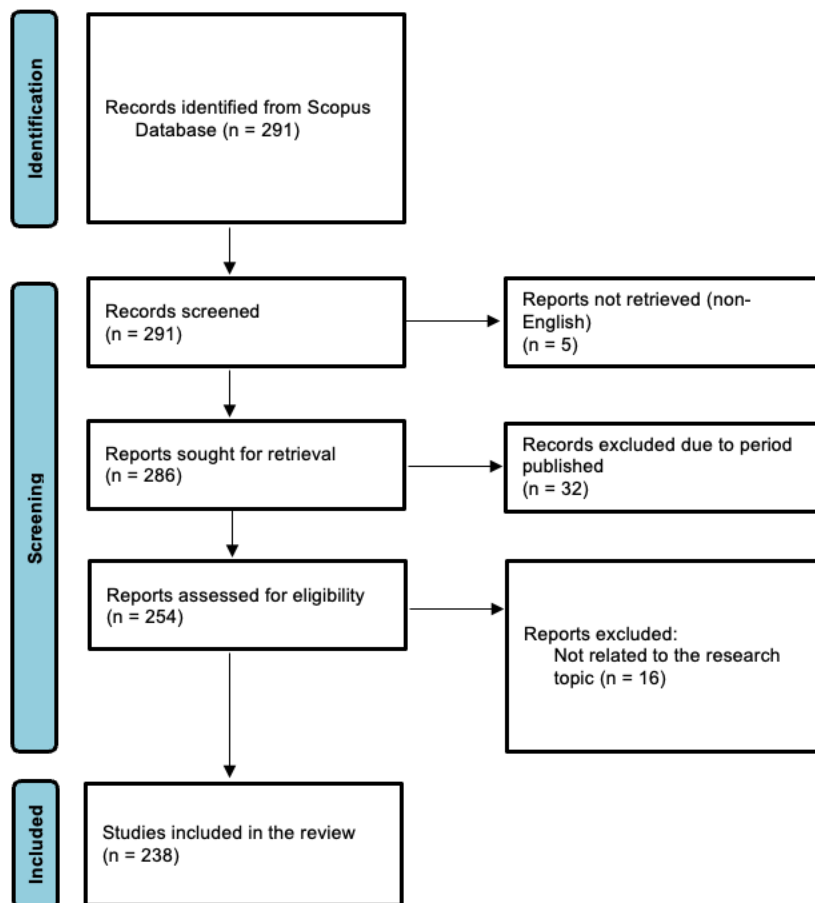TITLE-ABS-KEY (("Scaled Agile Framework") OR ("Scaled Agile") OR ("Scaling Agile"))

Figure 2. PRISMA Flowchart

A systematic process following the PRISMA framework was employed to identify, screen, and select relevant studies for this review. Figure 2 summarises the process followed. The initial search yielded 291 articles, but five of these were excluded as they were non-English. The remaining 286 articles were refined further by limiting the publication to the decade (2014–2023), resulting in 254 articles. These articles, and their abstracts, were exported to Microsoft Excel for detailed analysis. During the screening phase, each of the two researchers independently reviewed the titles and abstracts of the articles. In cases where there were discrepancies in the articles to be excluded, both researchers re-evaluated the articles together. Consensus was reached through discussion, ensuring that only studies meeting the inclusion criteria were retained for the final review. After this, 16 articles were excluded, leaving 238 relevant articles.

4. RESULTS AND DISCUSSION

This study demonstrates the state of the art of research in Scaled Agile research by exploring the authors, institutions and countries that have contributed the most to it in the corpus. This is accomplished by analysing the publication and citation trends and the geographic distribution of publications. The study aimed to explore the trajectory of Scaled Agile research and to identify the research hotspots and emerging areas. Table 1 shows the distribution of the types of publications analysed. Over two-thirds of the publications analysed were conference proceedings (68%), followed by journal articles accounting for almost a quarter (24%) of the publications. Book chapters accounted for 4% of the publications, reviews, almost 3% and books just over 1% of the publications. The dominance of conference proceedings suggests a growing interest in Scaled Agile, with conferences accepting papers on it.

Table 1. Distribution of Publications Analysed

Publication Type	Count	Percentage of 238
Conference Proceeding	162	68.1
Article	57	23.9
Book Chapter	10	4.2
Review	6	2.5
Book	3	1.3

4.1. Publications trends

Figure 3 plots the publication trends. From 2014 to 2015, the annual publication count was consistently below ten, with seven articles in 2014 and eight in 2015. The publications then increased, reaching 11 in 2016 and 17 in 2017. In 2018, there was a further increase to 29 articles, but in 2019, the count slightly decreased to 28.

2020 marked the highest point with 41 articles, followed by 35 in 2021. Subsequently, both 2022 and 2023 had 31 articles each.
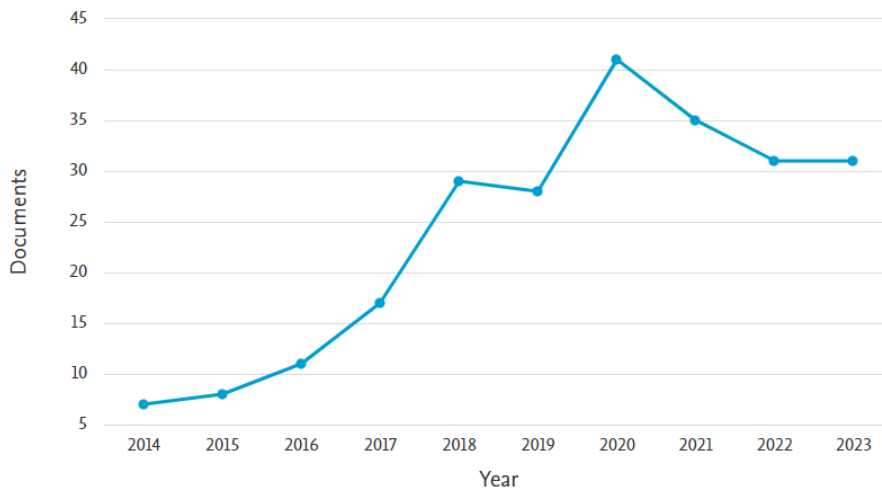

Figure 3. Publications trends

4.2.   Geographical distribution of articles

Figure 4 shows the geographical distribution of articles. Examining the data unveils the quantity of research contributions and highlights the global diversity of efforts in the specified field. The distribution of articles across different countries indicates a predominant interest in research within developed nations. Furthermore, the dominance of authors affiliated with institutions from the Global North is evident, with significantly fewer contributions from the Global South. During the period of analysis, authors affiliated with institutions from Germany have a total of 50 publications.

Sweden, the United States and Finland have significant contributions with 28, 26 and 25 publications, respectively. India, the Netherlands, Ireland, South Africa, Norway and France complete the top 10 countries, contributing to publications. There is a concern in the publications by authors affiliated with institutions from developing countries. Another concern is the fact that authors affiliated with institutions from Germany contributed more than authors affiliated with institutions from the bottom 21 countries in Figure 4. Authors affiliated with institutions from the top 10 countries have more publications than authors affiliated with institutions from the rest of the countries. This disparity raises questions about the varying levels of research output across countries.
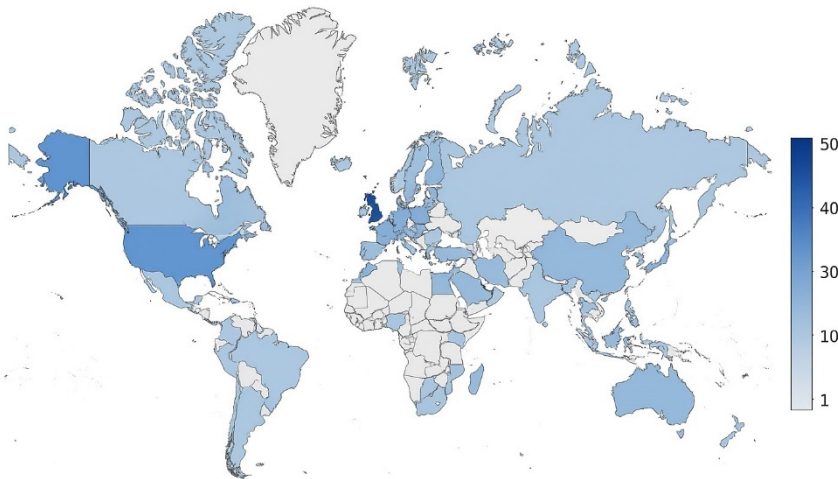
Figure 4. Geographical distribution of articles (Created using MS Excel)

Research output between the Global North and Global South stems from several structural challenges, such as unequal access to research databases. These databases are often unaffordable for institutions in the Global South because of limited funding [27]. In addition, the dominance of English in academic publishing creates a language barrier for non-English speakers, who may face difficulties in writing for high-impact journals and cannot afford language editing services [28].

The article processing charges for open access publishing are high for researchers in low- and middle-income countries. Although some publishers offer fee waivers, these are inconsistently applied, and many top journals prioritise the Global North outputs over the Global South [29]. Biases in the peer review processes and publishing standards may contribute to the underrepresentation of Global South research [30].

4.3.   Analysis of Publications by Field

Scopus allows the analysis of publications by the main research fields. The 238 articles were classified into 15 research fields as shown in Figure 5. As can be seen, computer science is the most dominant field, with 197 publications, followed closely by engineering, with 88. The dominance of computer science can be attributed to the roots of agile project management – software development, a subfield of computer science. "Business, management, and accounting" has 71 publications showing the adaptability of Scaled Agile for different research fields.
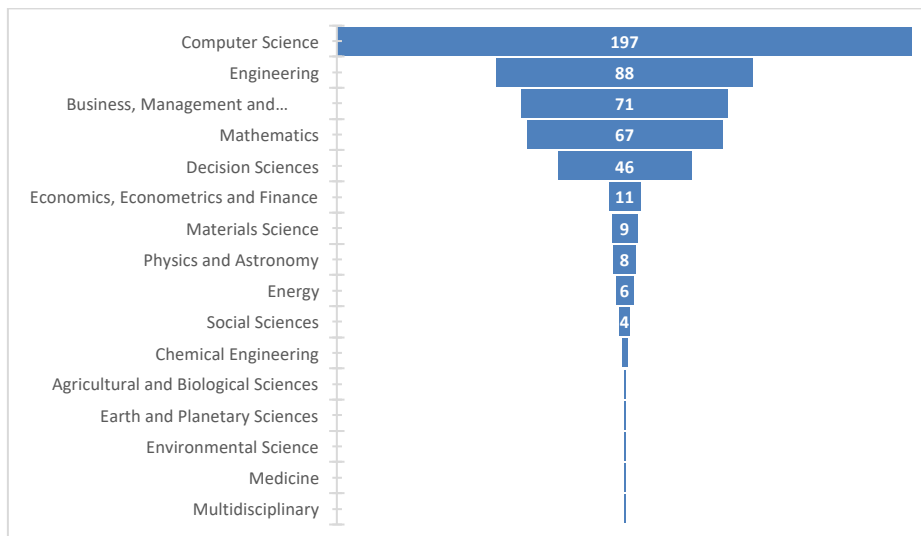
Figure 5. Publications per field

Mathematics and decision sciences maintain a notable presence with 67 and 46 articles; others, like Medicine, environmental science, and multidisciplinary, have a lower representation, each with only one article. This variation in research output across fields suggests differing levels of focus and emphasis within the academic community. Specialised fields, such as chemical engineering, materials science, physics and astronomy, have a lower count, possibly reflecting the niche nature of these disciplines. The figure provides a quantitative overview of research output and offers insights into the distribution and emphasis of academic contributions across diverse fields.

4.4.　Word Cloud of Keywords

A word cloud is a graphical representation of the most occurring keywords from the titles and abstracts of the publications analysed. Figure 6 shows the word cloud for the high-frequency terms captured in the abstracts of the articles, which use a larger font size for the most frequent terms. As depicted in the Figure 6, the keyword 'team' is the most common, which means that this is one of the main themes covered in Scaled Agile research. The next keyword is 'organisation' which emphasizes the importance of the internal operating environment for the success of Scaled Agile projects. The keyword 'project' also appears frequently suggesting an indication that Scaled Agile is being applied more and more in projects. The keyword 'challenge' suggests that many publications focus on addressing the difficulties in adopting Scaled Agile frameworks. 'Practice', suggests a practical orientation indicating a solid connection between theoretical insights and real-world application.

Figure 6. Word cloud showing high-frequency keywords

4.5. h-index analysis

The h-index is a widely used technique that evaluates the academic scientific achievement of scholarly articles and authors [21]. The h-index is reliable and authentic in measuring scientific achievement [22]. The values of the h-index can be calculated manually or automatically on most subscription-based databases such as Scopus or Web of Science [23]. For this study, the Scopus database analysis calculated the h-index for the 238 articles analysed. Figure 7 shows the h-index graph. An h-index means that h papers have been cited at least h times within a set of activities [24]. The articles have an h-index of 21. Of the 238 research articles, 21 have received at least 21 citations.
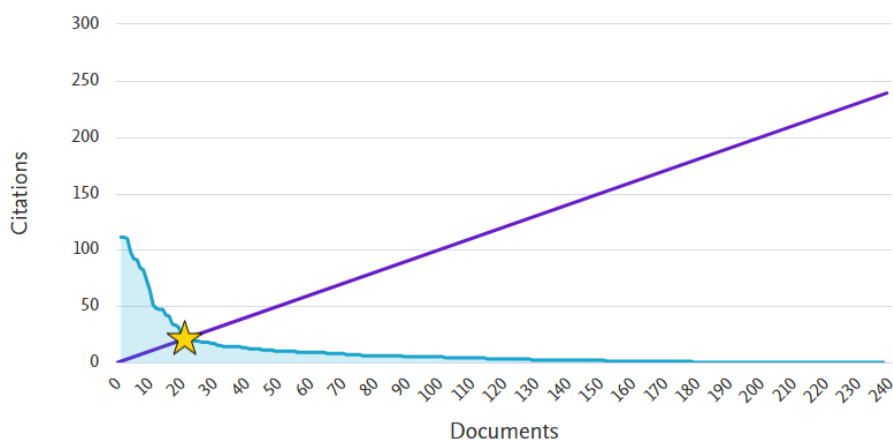

Figure 7. h-index (source: Scopus database)

4.6.　Keyword analysis

Using VOSviewer, we created a co-occurrence map using the author keywords based on bibliographic data downloaded from the Scopus database. The co-occurrence analysis shows the relatedness of items as determined by the number of articles in which they occur together [25]. We used binary counting instead of full counting as the counting method. Binary counting means that the weight of a link is fractionalised [25].

4594 keywords were extracted from the titles and abstracts of the 238 publications. On VOSviewer, we set the minimum occurrence of each keyword to ten, resulting in 124 keywords. Using VOSviewer, we calculated a relevance score for each of these 124 keywords. The top 60% of these keywords, determined by their relevance scores, were selected, resulting in 74 keywords. Upon analysis, it was observed that specific keywords were associated with the research methodology rather than the subject area, which is Scaled Agile. The excluded keywords are as follows: systematic literature review, researcher, gap, literature, survey, topic, article, year, methodology, and interview. Furthermore, synonym words were removed after removal, and 63 keywords remained. For each of the 63 keywords, VOSviewer calculated the co-occurrence links with other keywords. Figure 8 shows the keyword co-occurrence network map. The distance between two nodes reflects their associative strength. A shorter distance reveals a stronger relationship between the two keywords. The line between two keywords represents that they have appeared together in an article. Nodes with similar colours belong to the same cluster [25].

Cluster 1 (red) is the largest cluster, with 23 keywords and focuses on various facets of Agile practices. Agile practices are the activities used in agile projects to improve quality and adapt to changes that may occur throughout a project [32]. In this cluster, the most frequently occurring keywords are "Agile organisation," "Agile software development," "Agile team," and "Agile way,". These keywords suggest that research in the field is focused on the importance of agility in organisational structures, software development processes, and team dynamics.

Keywords like "large organisation" and "large-scale Agile development" indicate a move to applying Agile principles in large organisations. This is in line with an earlier study that showed that to grow projects and achieve success, modern project management in large organisations seeks to implement Agile approaches [14]. The cluster also includes keywords "collaboration," "communication," "coordination," and "transparency" which indicate the crucial role of effective communication and collaboration within Agile teams. Keywords "dependency," "enterprise," and "domain" show the importance of understanding the relationships and dependencies within Scaled Agile projects.
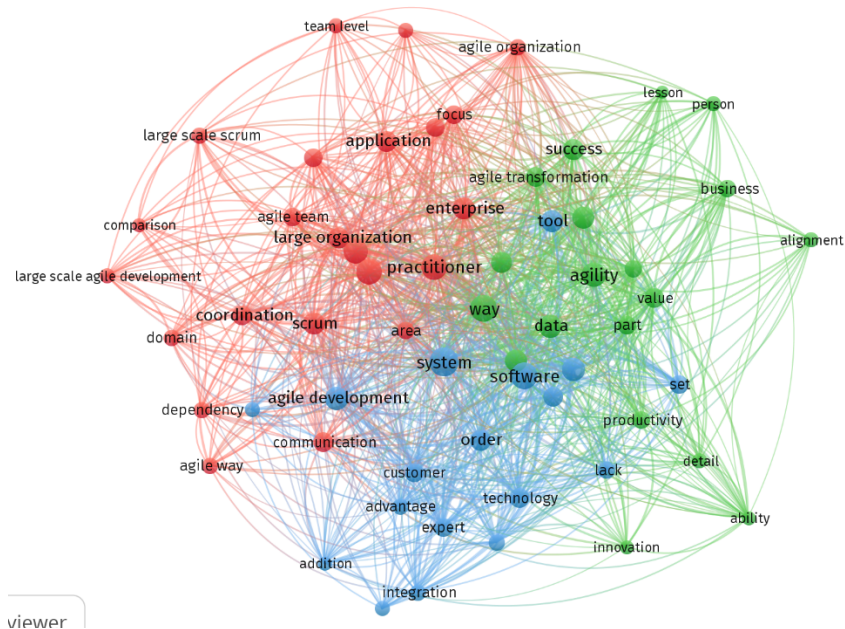
Figure 8. Keyword co-occurrence map of high-frequency terms in titles and abstracts

Cluster 2 (green) has 19 keywords centred around the theme of Agile development and organisational agility. Organisational agility refers to an organisation's ability to respond to change, while also addressing its customer demands [26]. Furthermore, organisational agility is an important tool for achieving competitiveness and a crucial business paradigm of the twenty-first-century organisation, serving as the primary vehicle for competition [27]. Achieving organisational agility means organisations should be able to find the right balance between flexibility and stability. Stability, while important, can sometimes limit variability [28]. Keywords "ability," "Agile development," and "agility" indicate the core characteristics associated with the adoption of Scaled Agile. The green cluster also includes keywords "alignment," "business," and "transformation," which emphasise the importance of aligning Scaled Agile practices with the business objectives and goals.

 The cluster also has the following keywords - "data," "detail," and "innovation" underscoring the significance of data-driven decision-making, and attention to detail. Innovation within Scaled Agile fosters the encouragement of innovation within Agile environments. Managing innovative projects can be challenging due to unclear objectives. Therefore, before initiating such initiatives, organisations should aim to define project objectives, even if broadly, to clarify requirements and guide the project team, thus facilitating risk assessment by experts [29]. The cluster

also has keywords "experience," "lesson," and "success", suggesting that Scaled Agile supports elements of learning from experiences and leveraging those lessons for success. The keywords "market," "impact," and "value" suggest a consideration of market dynamics, the impact of Scaled Agile practices, and the value delivered through their adoption.

The blue cluster has 18 keywords focusing on Agile transformation. Organisations undergo agile transformations to reduce the time to market and responsiveness to change, driven by increasing competition and the need to maintain or improve competitiveness in a rapidly evolving market, and deficiencies in project management [30]. An earlier study proposed the need for Agile transformation to provide a solution to the need for flexibility, yet their implementation can be challenging; therefore, a need for transformation [31]. Keywords like "addition," "advantage," and "integration" suggest a consideration of the benefits and challenges associated with incorporating Scaled Agile practices into existing systems and processes.
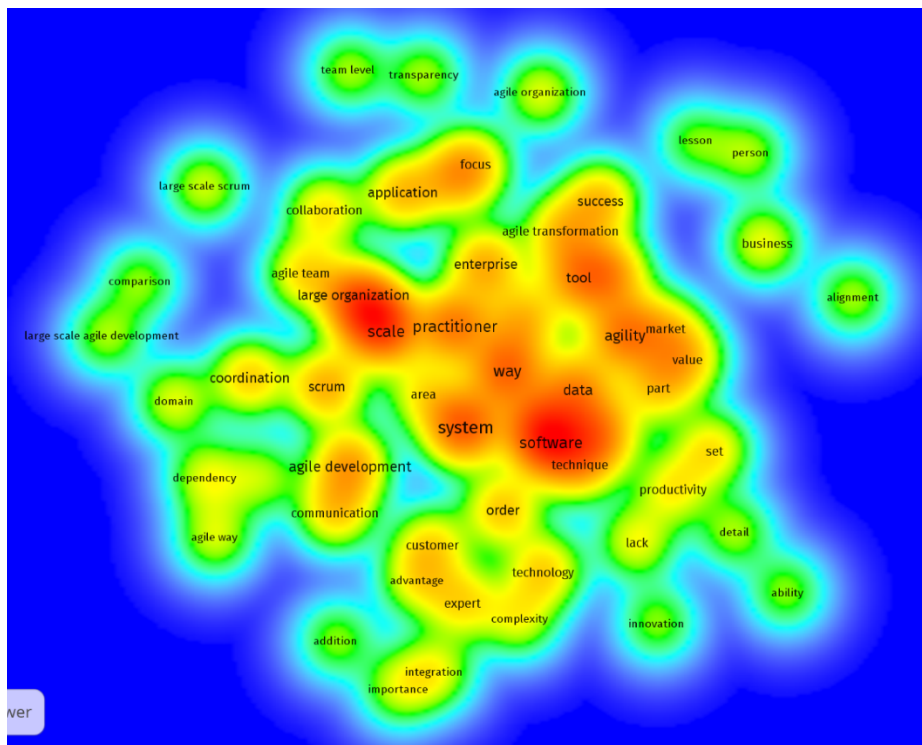

Figure 9. Density map of high-frequency terms in titles and abstracts

"Customer" and "quality" as keywords underscore the important role of customer satisfaction and product quality in Scaled Agile. The keywords "order," "set," and

"lack" hint at the need for well-defined structures, sets of practices, and the potential pitfalls of inadequate planning that Scaled Agile seeks to address. "Technique," "technology," and "tool" suggest a technological aspect, pointing to the tools and techniques employed in Scaled Agile development to enhance efficiency and effectiveness.

Figure 9 shows the research hotspots in the study field. In VOSviewer, colours indicate the density of terms, ranging from blue (lowest density) to red (highest density) [25]. As can be seen, the density distribution across the map reveals distinctive patterns and focal points. The highest densities are in the middle, where the 21 keywords form a central research hotspot. This hotspot includes publications focusing on the following: "software," "scale," "system," "scale," "large organisation," "way," "data," "agility," "tool," "enterprise," "practitioner," "technique," "collaboration," "application," "focus," "market," "agile transformation," "success," "Agile team," "area," "part," and "value". This hotspot indicates that these keywords play a significant role within Scaled Agile research.

Around the central hotspot, there are three developing hotspot areas with yellow-shaded areas with average densities. The first is at the bottom of the figure and covers the following keywords: "customer," "advantage," "expert," "complexity," "technology," "order," "integration," and "importance." The second one is to the left and contains the following keywords: "Agile development," "communication," "scrum," "coordination," "Agile way," "dependency," and "domain." The third is to the right and has four keywords - "productivity," "set," "lack," and "detail." The green areas on the map's outer edges represent uncharted territories where there are no research hotspots. These areas are characterised by single keywords and represent potential future hotspot areas. These areas are "innovation," "ability," "alignment," "business," "large organisation," "large-scale scrum," and "addition".

4.7. Discussion

Scaled Agile has impacted not only the software development industry but project management as well. This approach has evolved to meet the demands of large-scale projects, ensuring that agile principles are applied effectively in complex organisational environments. This paper uses bibliometric analysis to track the trajectory of research in Scaled Agile. It specifically aims to achieve two main objectives: Firstly, to ascertain the publication trends and geographical distribution of research contributions in this field. Secondly, to identify research hotspots and emerging areas within the Scaled Agile domain.

The results show that in terms of publication trends, there was a steady increase in publications from 2014 onwards, with the highest output achieved in 2020. This growth in publications indicates a growing interest and scholarly activity in Scaled

Agile research. Regarding the geographical distribution of publications, the results show that Scaled Agile research is dominated by developed countries and those from the Global North. Institutions based in Germany, Sweden, the United States, and Finland lead research output, reflecting their prominence in academic contributions. However, notable participation from countries in the Global South - India, China, Brazil, and Pakistan highlights a diverse landscape of Scaled Agile research.

The distribution of articles across fields provides insights into the interdisciplinary nature of Scaled Agile research, with computer science as the most dominant research field, followed by engineering. This finding is linked to the origins of Agile and Scaled Agile methodologies in software development, a core area of computer science. Additionally, business, management, and accounting show significant adaptability to Scaled Agile practices, while fields like mathematics, decision sciences, and specialised disciplines such as medicine and environmental science have a varied but lower representation.

The h-index analysis provides a quantitative measure of scholarly impact, indicating the influence of research articles within the Scaled Agile domain. The h-index of 21 suggests that Scaled Agile research has a significant impact and scholarly influence. This underscores the relevance and contribution of Scaled Agile to the academic community, highlighting key studies that have resonated widely with researchers and practitioners alike.

The analysis of the word cloud showed that the keyword 'team' is widely used in Scaled Agile research publications. Scaled Agile frameworks rely on teams working together towards common goals, promoting adaptability and responsiveness. The occurrence of this keyword suggests a recognition of the role teams play in the success of Scaled Agile implementations. This is in line with previous studies on the impact of teams on successful Agile adoption. One study found that team autonomy allows for self-organisation, fostering grassroots empowerment within teams [1] and ultimately Scaled Agile success.

Furthermore, the keyword 'organisation' emerges prominently in the word cloud, indicating the importance of the operating environment for the success of Scaled Agile projects. Organisations undergoing Agile transformations often encounter challenges related to restructuring, governance, and cultural shifts [39] all focusing on the organisation. Understanding how Scaled Agile practices intersect with organisational structures is crucial for successful Scaled Agile adoption [39]. It is important to consider organisational factors and personnel working on software development projects in adopting and implementing agile practices [32].

'Challenge' denotes an understanding of the complexity that comes with working with scaled agile. Scaling up agile implementation requires overcoming several obstacles, including cultural issues, scalability problems, and cross-team alignment. These challenges include change resistance, lack of investment, agile difficulty in implementation, coordination challenges in a multi-team environment, hierarchical management, and organisational boundaries [15]. Resistance to change, a tight rollout schedule, concerns about quality assurance, and integration with existing non-agile business processes are some of the challenges identified in previous studies [32].

The keyword "practice" in the word cloud underscores its practical orientation, prioritising the translation of theoretical concepts into tangible, real-world applications within Scaled Agile research. While theoretical frameworks lay the groundwork for understanding Scaled Agile frameworks, their impact lies in their implementation in industry by practitioners. These frameworks can be categorised into three groups: those used at the team level, those specifically designed for scaling Agile, and those adaptable for both team-level operations and scaling Agile methodologies [33].

The keyword co-occurrence map of high-frequency terms in titles and abstracts identified three distinct clusters of Scaled Agile research, while the density map of high-frequency terms in titles and abstracts offered insights into research hotspots and uncharted territories. The first cluster centred on various facets of Agile practices, highlighting how crucial they are for allowing teams to produce software quickly and adjust to project needs that change. The second cluster focused on focusing on Agile development and organisational agility such as organisational agility and Agile development, stressing the necessary skills for implementing Agile approaches, and the third cluster focused on Agile transformation.

The density map of high-frequency terms in titles and abstracts revealed research hotspots and uncharted territories in Scaled Agile research. The research hotspots are centred around the keywords - "software," "scale," "system," "large organisation," "data," and "agility," highlighting their importance in the field. The developing hotspots are focused on "customer," "complexity," "Agile development," "communication," "productivity," and "lack.". The emerging areas with lower research activity feature keywords such as "innovation," "ability," "alignment," and "large-scale scrum," suggesting potential future research areas.

Our study has some limitations. Firstly, we relied on the Scopus database to collect data, which means that publications not indexed by Scopus were excluded. Secondly, non-English-language articles were excluded from the analysis, so publications in other languages that could have enhanced the analysis were not considered. Thirdly, the expensive subscription fees for open-access journals listed

in Scopus might have discouraged researchers from developing countries from submitting their articles. Additionally, the exclusion of non-open-access journals may have omitted contributions from authors in countries without financial assistance for publishing in top open-access journals. Nonetheless, since Scopus is a prominent database, our findings represent the current situation. Future studies can consider using multiple databases. This approach would increase the size of publications, providing a more comprehensive and robust dataset for analysis.

5.   CONCLUSION

Scaled Agile methodologies have influenced both the software development industry and project management practices, addressing the demands of large-scale projects by effectively applying Agile frameworks in complex organisational environments. This study employed bibliometric analysis techniques to trace the trajectory of Scaled Agile research, focusing on publication trends and geographical distribution and identifying key research hotspots and emerging areas within the field. The study reveals a growing interest in Scaled Agile, marked by a steady increase in publications since 2014, peaking in 2020. This trajectory underscores the increasing relevance of Scaled Agile methodologies in academic discourse and practical applications across diverse global contexts.

The geographical distribution of Scaled Agile research is dominated by developed countries, particularly Germany, Sweden, the United States, Finland, and countries in the Global North. There is notable participation from countries in the Global South such as India, China, Brazil, and Pakistan, indicating a diverse research landscape. This geographical spread reflects the global relevance and adaptability of Scaled Agile practices across different organisational contexts and highlights the contribution of various regions to the development and dissemination of Scaled Agile knowledge.

The distribution of articles across various fields reveals that Scaled Agile research is interdisciplinary, with computer science as the leading domain, followed by engineering. This aligns with the origins of Agile and Scaled Agile methodologies in software development/software engineering subfields of computer science and engineering. Other fields such as business, management, and accounting also show significant engagement, demonstrating the versatility and applicability of Scaled Agile practices beyond their traditional roots. Although fields like mathematics, decision sciences, and specialised disciplines such as medicine and environmental science have lower representation, their inclusion points to the broadening scope of Scaled Agile research.

Challenges associated with Scaled Agile adoption - 'cultural' opposition, scalability issues, and cross-team alignment, were identified as key to improving Scaled Agile.

Addressing these challenges requires an understanding of organisational design, leadership models, and change management strategies tailored to Agile principles. The keyword 'practice' indicates a strong emphasis on the practical application of theoretical concepts, with research exploring various Agile practices at both team and organisational levels to ensure effective scaling and implementation.

The study identified research themes and priorities focusing on Agile practices, Agile development and organisational agility, and Agile transformation. These findings emphasise the role of Agile in team dynamics, software development processes, and organisational structures. The study's h-index of 21 signifies a substantial scholarly impact of Scaled Agile research, indicating influential contributions that resonate within the academic community. The study found that keywords such as 'team', 'organisation', 'challenge', and 'practice' are central themes in Scaled Agile research. The study identified the research hotspots centred on "software," "scale," "system," "large organisation," "data," and "agility". Developing research hotspots focus on "customer," "complexity," "Agile development," "communication," "productivity," and "lack," while emerging areas with lower research activity, featuring keywords such as "innovation," "ability," "alignment," and "large-scale scrum," suggest potential future research directions.

Future bibliometric studies should explicitly expand their scope by incorporating multiple databases to enhance coverage and inclusivity. Relying solely on a single database can lead to biased representations of research outputs. Incorporating multiple databases will lead to a comprehensive mapping of publications without the inherent biases of using a single database.

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