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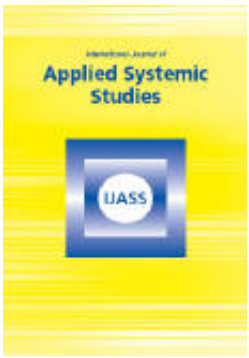

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Practical approaches for the implementation of distributed scrum teams

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Abstract: Scrum was originally projected for environments with small teams working in the same place, where collaboration and physical proximity are key for success. Accordingly, it becomes relevant to explore how scrum can be implemented in geographically distributed teams. This study aims to identify a set of different types of practical distributed scrum implementation using three case studies with Portuguese software companies. Furthermore, it explores the main motivations for this migration, the challenges posed by the geographical dispersion of teams, and the benefits brought by this approach to organisations. The findings reveal three approaches for implementing distributed scrum considering the geographical location of the employees and the challenges that are posed in terms of communication, collaboration and coordination. These approaches enhance the theoretical knowledge in the field and help software companies to migrate from traditional scrum environments to large-scale distributed environments.

Keywords: distributed agile; distributed teams; applied management; scaling; case study.

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1 Introduction

Agile software development methods have acquired great popularity over the past decades. Dissatisfaction with the traditional development model that required a lot of planning and documentation in the early stages of a project, extrapolation of software delivery times, increased costs above initial estimates, and little flexibility regarding changes in requirements are typically pointed out as the reasons for the increase in the number of agile projects in the software industry (Martin, 2002). At the same time, there is also an increase in distributed software development motivated by the organisational problems faced by companies and the scarcity of highly qualified human resources in software engineering. According to Prenner et al. (2021), this model of distributed software development contributes to increasing the development speed through geographically distributed teams.

Scrum is currently the most agile method used by software companies (Petrova, 2019). Several studies report its adoption in software development teams (Barbareschi et al., 2022; Rigby et al., 2016). However, this method was originally designed to be applied in small teams that share the same physical space. Therefore, the adoption of this model in geographically distributed teams is also expected to bring new challenges. Several challenges are pointed out in the literature in areas such as communication between teams, project and process management, knowledge management, and cultural issues (Almeida et al., 2019; Dikert et al., 2016).

This study aims to explore the phenomenon of the adoption of the scrum methodology in geographically distributed teams through the realisation of three case studies within software companies. Firstly, it intends to explore the different levels of team distribution and the causes that led to the choice of the distributed model. Next, an attempt is made to systematise a set of characteristics and practices corresponding to this type of development. Finally, it seeks to identify ways to mitigate the challenges that can be found in this distributed model of software development. This work essentially intends to offer practical contributions to software companies that are taking the first steps in the distribution of their development teams. Through this work, these companies will be better prepared to face the challenges posed by the adoption of scrum in a distributed environment.

The manuscript is organised as follows: initially, a literature review is performed on the software development processes in distributed teams. Next, the methodology and associated methods adopted in this study are presented. It is also in this section that the profile of the software companies participating in this study is presented. After that, the results of the study are presented and discussed considering the relevance of this evidence to the scientific community. Finally, the conclusions of the study are stated. Also, in this section, the theoretical and practical implications, limitations, and some indications of future work are presented.

2 Literature review

Distributed scrum teams, also known as virtual teams (Lumseyfai, 2020) or remote teams, are teams that have individual members working in different physical locations while working on the same project. The same applies to projects that have different teams, working together in different locations. Virtual team members may never

physically meet during the project or have very few interactions (Karunathilaka, 2022). This is increasingly happening in software development, where the different geographical locations and time zones of individual team members, or groups of team members, is a common scenario, leading to 'global virtual teams' (Caputo et al., 2022; Morrison-Smith and Ruiz, 2020). As software projects become more complex, they often require multi-disciplinary teams to develop them. The best-talented people to join the team can be anywhere in the world and are often not available to move to a common location. The developments in information and communications technologies (ICTs) enhanced the possibility of working from any place while keeping the connection with others working on the same project and assuring team cohesion. Therefore, distributed teams have become a new trend in workplace development. For software companies, distributed teams are a way to involve the best people in the project, without moving them, lowering the development costs. For team members is a way to avoid displacement, allowing them to work from the place of their choice, and reducing costs in terms of time, money and stress (Morrison-Smith and Ruiz, 2020). For both teams and companies distributed teams are considered a way to enhance productivity (El Idrissi and Fourka, 2022; Liska, 2022).

Managing distributed teams brings new challenges. Takkunen (2014) reports social and communication issues (lack of informal conversation, loss of non-verbal cues, establishing consensus and shared meaning at distance, fewer opportunities to build strong ties between members, different cultures, and different work processes), time zone differences and inadequate ICT. Dikert et al. (2016) pointed out that, when dealing with large-scale agile, coordination problems arise when teams are distributed on many geographical sites. Besides project management problems, some other issues were stressed, like missing kick-off meetings, lack of a sense of proximity, and difficulty in scheduling meetings when distributed teams operate in different time zones, which is also reported by Shah (2016). Despite these problems, Dikert et al. (2016) stated that agile and distributed teams must still be used together. Ockerman (2020) also notes that lack of information, or an overload of information causes transparency challenges. Scrum masters must deal with transparency assuring that the team gets all the needed information. Address conflict management is another issue identified by Ockerman (2020). Scrum masters must allow team members to engage in conflict productively and creatively. With virtual teams, this issue can be hard to address and requires different techniques. Finally, Almeida et al. (2019) addressed several challenges in knowledge management in large-scale scrum teams by analysing two projects from a software company. Cultural and time zone differences among team members were also discussed along with the importance of using collaborative digital platforms to manage virtual teams. The study also pointed out the importance of having team members connected to the culture of the projects' target market.

These challenges have been approached by several researchers and professionals aiming to find how to overcome them and seek new ways to better manage virtual teams and increase their performance. Some best practices to cope with communication challenges in virtual scrum teams were discussed by Walimbe (2016) and revealed a list of issues related to communication within teams: effective use of communication tools, how to manage daily scrum meetings, working under different time zones, overcome language barriers, and deal with lack of trust and coordination. Remote leadership challenges emerge that have been exacerbated by the COVID-19 pandemic (Kashive et al., 2022; Krehl and Büttgen, 2022). Chai and Park (2022) add that communication

challenges in virtual teams have increased with psychological implications for employee well-being in the course of the COVID-19 pandemic.

Table 1 Main challenges and solutions in scrum distributed teams

Challenges	*Authors*
Communication issues	Chai and Park (2022), Takkunen (2014), Walimbe (2016)
Conflict management	Lumseyfai (2020), Ockerman (2020)
Coordination issues	Dikert et al. (2016), Lumseyfai (2020), Shah (2016), Walimbe (2016)
Cultural issues	Almeida et al. (2019), Morrison-Smith and Ruiz (2020), Walimbe (2016)
Distance and time zone differences	Almeida et al. (2019), Caputo et al. (2022), Karunathilaka (2022), Morrison-Smith and Ruiz (2020), Takkunen (2014), Walimbe (2016)
Inadequate ICT	Lumseyfai (2020), Morrison-Smith and Ruiz (2020), Takkunen (2014)
Information/knowledge management issues	Almeida et al. (2019), Ockerman (2020), Shah (2016)
Lack of sense of proximity	Dikert et al. (2016)
Project management issues	Dikert et al. (2016), Morrison-Smith and Ruiz (2020), Lumseyfai (2020), Shah (2016), Walimbe (2016)
Social issues	Takkunen (2014)
Solutions	*Authors*
Collaborative digital technologies	Almeida et al. (2019)
Cultural alignment	Almeida et al. (2019)
Governance methodology	Kashive et al. (2022), Krehl and Büttgen (2022), Lumseyfai (2020)
Human interaction	Dikert et al. (2016), Lumseyfai (2020), Morrison-Smith and Ruiz (2020)
Organisational environment	Lumseyfai (2020), Morrison-Smith and Ruiz (2020), Walimbe (2016)
Technology management	Lumseyfai (2020), Morrison-Smith and Ruiz (2020), Walimbe (2016)
Transparent process	Ockerman (2020)

Morrison-Smith and Ruiz (2020) conducted a literature review, with 255 relevant studies, most of them in the last two decades, to highlight the collaboration challenges experienced by virtual teams. They also addressed existing mitigation strategies. Those relevant studies primarily focused on technology use. Morrison-Smith and Ruiz (2020) separated challenges into five categories: geographical distance, temporal distance, perceived distance, the configuration of dispersed teams, and diversity of workers. The authors also described four implications for designing groupware that better supports the work of virtual teams. It is advocated that technology must support conversations to establish a common project-specific technical language, methodologies and best practices. It is also revealed that since ICT varies across organisations, some virtual team members may face limitations in accessing sophisticated collaboration technology and technologies may vary within a virtual team. Therefore, the team must use lightweight

technology, maximising the number of potential users. It should also deal with team members' different levels of technical competence.

Lumseyfai (2020) proposed a model for enabling successful virtual project team performance built around four pillars: governance methodology (the methodology used to govern teams, including practices for ensuring coordination, tracking, and communication across team members), human interaction (practices centred on engaging and motivating team members, fostering a comfortable environment, instilling a sense of purpose, and facilitating collaboration), technology management (dealing with ICT tools used by teams) and organisational environment (factors that can impact team's performance within the organisation). Agile techniques were incorporated into this model, particularly scrum techniques. A research experiment was conducted to evaluate the relationship between each of the four model pillars and virtual teams' performance. The experiment found that there was a significant, positive correlation between those four pillars and the virtual team's performance.

The literature review demonstrates that distributed scrum teams face many challenges, and an additional effort must be made to manage and implement them. Table 1 summarises the challenges and solutions we can find to address distributed scrum. Some authors even argue that a group of geographically distributed people cannot even be considered as a scrum team (Sabine, 2016). Therefore, the literature review shows that the adoption of the scrum methodology with distributed teams is a phenomenon that needs to be addressed.

3 Materials and methods

This study applies a qualitative approach through the realisation of three case studies with software development companies using the scrum distributed methodology. According to Yin (2017), qualitative analysis has an emphasis on processes and meanings and allows an in-depth analysis of the phenomena in the real environment where they occur. The case study inherits the general properties of the qualitative methodology and enables the use of available theories to explain a given contemporary phenomenon in the business context in which it becomes useful to explore a situation that is not well defined. One of the essential aspects of adopting case studies is to ensure reliability and validity. For this, Yin (2017) considers it essential to look at four perspectives:

1 construction validity

2 internal validity

3 external validity

4 reliability.

In the construction validity dimension, it was ensured the realisation of multiple case studies that allow understanding how distributed scrum is adopted by different companies; as internal validity was considered a framework that allows exploring the way teams and processes are organised in a distributed scrum environment; as external validity was sought to find case studies that represent different organisation structure and distribution of work; and as reliability interviews were conducted with three members of each company to include three perspectives on the same phenomenon.

Table 2 briefly presents the profile of the companies involved in the case studies analysis. A total of eight Portuguese companies in software engineering were contacted for the case studies. However, four of them were excluded because they were not available for the interviews under the requested conditions. Another company was also excluded because it presents an identical and redundant profile concerning CS2. In the end, a total of three companies in the software solutions and services development area were considered. For each company, three members with different roles in scrum development were interviewed, respectively: the product owner, scrum master, and a member of the scrum team. The product owner is responsible for providing a business vision and requirements for the service and/or product; the scrum master is responsible for managing the scrum processes and removing any barriers or impediments that arise during the project; while the scrum team member is primarily responsible for implementing the user stories. It is recognised that the scrum team member in the three companies has the freedom of execution and decision within the project guidelines to achieve the sprint goal.

Table 2 Profile of the companies

	Case study 1 (CS1)	*Case study 2 (CS2)*	*Case study 3 (CS3)*
Established year	2015	2006	1998
No. of employees	8	121	278
Size	Micro company	SME	Large enterprise
No. of scrum teams	1	6	23
No. of distributed scrum teams	1	2	16
Distribution level	Collocated	Distributed with full overlapping hours	Distributed with partial overlapping hours

CS1 is a micro company that develops games for online platforms on social networks. It was a company made up of two colleagues from a master's degree course in multimedia. CS2 is a small and medium-sized enterprise (SME) providing services in the IT area that simplifies the process of infrastructure management and reduces expenses associated with equipment and IT staff from the implementation of the device as a service (DaaS) model. CS3 is a large company with more than 20 years of experience, and it is dedicated to the development of e-commerce solutions for the African market. The size of the company follows the OECD framework, in which the three different types of companies are considered:

1 micro company: 1 to 9 employees

2 SME: 10 to 249 employees

3 large enterprise: 250 employees or more.

The distribution level considered the various distribution models of scrum teams as proposed by Rothman and Kilby (2019), in which the organisation of distributed scrums should be analysed according to the models of collaboration with remote workers. In CS1, team members share the same physical office, but some members occasionally work in a distributed way; CS2 has two distributed teams but all of them are in compatible time zones (e.g., less than three hours difference); and in CS3, 16 out of 23 (close to 70%) of

the teams are distributed in quite different time zones, like the development teams in India, Egypt and Portugal (e.g., between 2 and 6 hours).

Table 3 Research dimensions

Dimension	*Description*	*Interview questions*	
Contextual	The aim is to know the needs of the company to adopt scrum's distributed model and to explore the composition of these teams considering the profile and experience of the human resources involved.	Q1	What has been the main motivation for distributed adoption of scrum?
		Q2	What is the profile of these teams?
Model	This dimension seeks to evidence the distribution model adopted and to understand the reasons for its adoption. It is also important to know whether this model has been reformulated or corrected over time.	Q3	What has been the typology of the scrum distributed model adopted?
		Q4	How has this model been defined?
Challenges	The implementation of scrum distributed team management incorporates a set of risks and limitations that becomes relevant to know. Equally relevant is to explore the mitigation strategies implemented by companies.	Q5	What are the risks and limitations of the adopted model?
		Q6	What mitigation strategies have been implemented?
Benefits	Benefits also arise from the inclusion of distributed team management models. It becomes relevant to know the good practices implemented by companies and explore the benefits that these approaches can offer.	Q7	What have been the benefits achieved for the company?
		Q8	What are the good practices that can be identified?

Table 4 Findings of thematic analysis

Dimension	*Final theme*
Contextual	All: Involvement in all software development lifecycle (FT1)
	All: Experience in scrum (FT2)
	All: Business needs (FT3)
	CS2 and CS3: Cost reduction (FT4)
	CS1: Capture of new talent (FT5)
	CS3: Knowledge of local market (FT6)
	CS3: Experience in distributed team structure (FT7)
Model	All: Dynamic adaptation (FT8)
	CS1: Mostly local teams (FT9)
	CS2: Distributed in close time zone (FT10)
	CS3: Distributed in different time zones (FT11)
Challenges	All: Communication, collaboration, and coordination issues (FT12)
	All: Lack of visibility (FT13)
	All: Shared components (FT14)
	All: Keep team spirit (FT15)
	CS3: Cultural differences (FT16)
	CS2 and CS3: Regional holidays (FT17)

Table 4 Findings of thematic analysis (continued)

Dimension	*Final theme*
Benefits	All: Better technological infrastructure (FT18)
	All: Monitor work progress (FT19)
	All: Knowledge management (FT20)
	CS2 and CS3: Creation of cross-functional teams (FT21)
	CS2 and CS3: Decentralise decision making (FT22)
	CS2 and CS3: Documentation of processes (FT23)

The interviews were conducted between 6th September and 17th December 2020. Due to the restrictions imposed by the COVID-19 pandemic and to avoid potential contagion risks with the presence of people outside the companies, the meetings were held via Google Meet and Zoom. These two videoconferencing platforms were chosen by the participating companies and offer similar conditions for the study. The questions for the interviews were sent 48 hours before each interview. After the interviews, an individual report of each interview was created and then sent by email to each company for validation.

The analysis of the implementation processes of distributed agile software engineering teams followed the framework established by Rizvi et al. (2015) in which it is suggested to explore the practices of distribution models according to four dimensions (i.e., contextual, model, challenges and benefits) as shown in Table 3. A total of eight questions were formulated. From these four dimensions, it is possible to have a sufficiently comprehensive perception of the various practical approaches followed by organisations in the implementation of distributed scrum teams.

4 Results

The analysis of the results was carried out using thematic analysis. This is an interpretative method of data analysis that through the identification, analysis and description of patterns or themes, allows presenting and organising the data in a synthetic but rich way. According to Miles et al. (2019), the thematic analysis is flexible by allowing the use of different epistemological positioning and is suitable for different types of qualitative data like interviews and focus groups. The webQDA software was adopted to perform the thematic analysis, which allowed grouping the identified themes by each research dimension. The individual reports of each interview were uploaded to the webQDA and the most cited words were identified. After that, it was analysed which case studies support each individual theme, and similar themes were aggregated to provide the final list of themes presented in Table 4. The common and specific themes for each case study were identified. Most of the identified themes are common to several case studies. However, some specific to each company emerge, namely in the contextual dimension and that allows us to identify different motivations for the implementation of distributed scrum. Also, in the 'model' dimension, there are notable differences in the models implemented by the participating companies in the case study. This was a strategic decision that resulted from the choice of three companies with different approaches to implementing the distributed scrum model. There are also remarkable

synergies between CS2 and CS3, which result from similar approaches in the implementation of distributed scrum, despite the size of the teams and the distributed model being more extensive and complex in CS3.

5 Discussion

5.1 Contextual

In all case studies, the distributed scrum implementation model is implemented in the several development phases of a project (e.g., planning, design, development, quality assurance and testing). This finding is not surprising considering the results of the study conducted by Rizvi et al. (2015) which highlights the difficulties of implementing an agile strategy only in a specific area of software engineering. In all companies, employees already had experience in scrum development. It was mentioned in CS3 (product owner): "it is necessary that at least part of the group has experience to assist in the implementation and deployment to facilitate the dissemination of knowledge in the teams." Therefore, it is evident that in CS3 it is essential the previous practical experience in the involvement in agile projects for the integration in distributed and large-scale agile teams.

The needs of the business present themselves as the main factor that led these organisations to adopt a distributed model of software development. CS1 highlights the integration of software engineering professionals from Brazil into their teams due to the existence of new business in this market and the difficulties of hiring new talent locally. This seems to be an emerging factor as European companies, particularly from the UK, seek the Portuguese market for outsourcing their activities in search of talent and less impact on the daily management of their business (Cleverti, 2018). However, in CS2 and CS3 other motivational factors for this paradigm shift are also mentioned, such as cost reduction. As Choudhury et al. (2019) state, information technologies play a key role in the inclusion of remote work teams. This approach can be a regular structure or serves as an adaptation in a given period, motivated by economic crisis factors. COVID-19 has emerged as an external factor that has made companies' digitalisation efforts even more relevant (Almeida et al., 2020). With the emergence of COVID-19 came a greater willingness of employees to work in a remote environment but posed challenges in terms of capacity management. CS3 highlights that it had to make an additional investment in its teams in India to ensure acceptable access conditions to its remote test platforms in the face of the exponential increase in traffic.

The composition of the teams follows several principles such as maturity, diversity and technical skills. In distributed teams, it is essential to value diversity (Vergini, 2018). The team must be open-minded and appreciate the differences of ideas, perspectives, origins, and personalities of its members. In CS3, the importance of knowledge of the local market is also mentioned. The e-commerce solutions developed in CS3 are aimed at specific markets with specific convictions and beliefs. For example, in Nigeria, the existence of colourful solutions and alerts that are not acceptable to users in the European market is highly valued. Having team members with knowledge of this reality is essential for the commercial success of the applications. Also, in CS3, knowledge about team distribution practices is valued. Therefore, scrum masters are chosen with this criterion as a fundamental reference.

5.2 Model

Regardless of the adopted model, in all the case studies the importance of dynamic adaptation to the characteristics of projects and teams was mentioned. In the companies participating in the study, it was reported the existence of sprints lasting two weeks. This is the most used period as mentioned in Weinreich et al. (2015) and it enables us to follow the evolution of the development phase without too many context breaks. However, in CS3, it is also mentioned the existence of sprints with 3 and 4 weeks in larger projects. Despite the knowledge about large-scale agile frameworks that have both product owner and scrum master, none of the frameworks is adopted because they generate excessive bureaucracy in a process that is intended to be agile.

In CS1, most scrum teams are local, although all members can potentially work in a distributed way. Team members are usually in the same physical location, with some members occasionally working in a distributed way. The exception to this rule was mainly visible in the period from March to May when due to COVID-19 all members were distributed. However, all members were in the same time zone. Even with members of other nationalities (i.e., Brazil) the time zone is not significant to create constraints. Therefore, various scrum meetings are facilitated (i.e., daily scrums, scrum meetings). The challenges emerge essentially in terms of interactivity since the meetings must be held by teleconference. We positively note the impact of COVID-19 in increasing the interactivity and robustness of these solutions that have now become widespread in the industry.

In CS2, there are two teams distributed but in which there is a relatively long and comprehensive period to interact. Daily scrum and sprint planning have a specific slot for their occurrence to allow the participation of all members. The model in CS3 is similar, but the teams are distributed in different time zones. This makes it difficult for employees to interact during working hours. In this regard, the scrum master of CS3 states "immediate clarification of work tasks is lost, but they are compensated with technological tools such as Skype that allows solving impediments quickly and effectively."

5.3 Challenges

The main challenges highlighted in the case studies are communication, collaboration and coordination issues. It has been recognised that to continue obtaining the benefits of scrum, its practices must be extended and modified, always aiming at improving communication and synchronising the teams' work. Gustavsson et al. (2022) highlight that a crucial issue for scrum's success on a large-scale is good communication among those involved, which in the case of geographically distributed teams can become a problem. In this dimension, CS2's scrum master highlights that the ideal is to provide a rich communication environment between teams through video conferencing, SMS, e-mail, chats, wikis, forums, etc. This technological diversity is also mentioned by Harris (2020) to ensure that those involved in the project feel closer and have a greater facility to hold the necessary meetings. In line with this vision, slow and unreliable means of communication should be avoided, which could hinder coordination, collaboration, and problem-solving. A collateral effect of this approach was emphasised in CS3. According to the product owner in CS3, there has been an increase in the importance of describing user stories that are much richer and more detailed. This is intended to minimise

communication efforts to clarify items whose interpretation or available information suggests additional questions or clarification.

The loss of visibility of the project study and the delay of feedback are other identified issues. One way to combat this situation is through the adoption of management structures in which the division of roles is clearer. This does not mean lower levels of collaboration, but only a greater formalisation of roles, which will also allow the welcoming of new collaborators. The definition of user stories is a work that assumes greater relevance. It has been accepted in all case studies that the role of the product owner in a distributed model has to be re-checked. The client's needs must be clear to the technical team from the beginning of the project, as the necessary clarification and rectification efforts will have a greater effort. CS3 refers to the importance of having a centralised backlog with themes not yet addressed to any of the teams. This backlog should have global access promoted through a backlog management tool that has this functionality. Walimbe (2016) advocates that a centralised backlog is a tool to maintain the overall vision of the project, and should be discussed constantly with the business area, as it can lead to reprioritisation or the creation of new teams. Furthermore, it is important to use tools that counteract the discussion of problems (Talukder et al., 2017). However, CS1 states that this more decisive role of the product owner does not inhibit developers from coming up with solutions to overcome possible challenges, or even more efficient ways of building a solution. Also, the product owner assumes a greater relevance in prioritising the tasks of the backlog. This task should always be aligned with what the company needs within the strategic planning performed. Furthermore, the correct prioritisation of the backlog tasks will allow increasing the visibility of the project development that assumes a greater relevance in distributed environments.

Maintaining the cohesion of the teams is a key element for the success of the projects (Kadenic et al., 2023; Mariam et al., 2022). A good way to foster cohesion is to have small team sizes (i.e., up to six members) even in distributed environments (Strode et al., 2022). Furthermore, in scrum environments, the daily meeting provides a significant contribution for all members to participate and increases the visibility of the project. This approach is a contribution to trust and team spirit (Söderback et al., 2015). However, the alignment of teams according to the same team zone is a factor that helps in building team cohesion. Therefore, CS3 reports difficulties in the teams in which members with significant cultural differences participate. CS3 product owner reports the difficulty of some members in accepting the equal participation of women in their teams when visiting clients or in team-building initiatives. The development of more personal relationships emerges as a challenge. CS3 also reported difficulties in aligning working weekdays between Portugal and Egypt, as the beginning of the week in Portugal is on Monday, while in Egypt is on Sunday. There were also difficulties in aligning workdays related to regional holidays that are often not known by the whole team.

5.4 Benefits

The adoption of distributed scrum teams has contributed to greater support from the top management to the technological infrastructures that proved to be fundamental with the emergence of COVID-19. According to CS2 product owner, the companies that bet on distributed scrum were better prepared for the collaborative efforts of remote work and digitalisation that emerged with COVID-19. Work progress monitoring emerged as a key element for increasing team cohesion (Hidalgo, 2019). Furthermore, it was also

mentioned in all the cases of study of the attributions given by distributed scrum for the promotion of knowledge management in organisations. This observation is in accordance with the results of the study conducted by Andriyani et al. (2017) who consider that the scrum methodology is an appropriate space for knowledge creation and conversion. Moreover, the study conducted by Abdul et al. (2017) and Sjödin et al. (2020) reveals the potential of scrum as a stimulus for innovation in products and services. It was mentioned in CS3: "I believe that the distributed scrum methodology adopted in the company stimulates teamwork, collaboration, and the behavior of knowledge" (Scrum master, CS3). The influence of knowledge management on the use of scrum arises, because during all processes of execution of the framework ceremonies, the interaction between individuals is the most practiced, which stimulates knowledge exchange. CS1 refers to this level: "the migration to the distributed environment has raised some resistance among our younger employees since they felt inhibited to participate in the project's remote activities" (Scrum master, CS1). However, this situation does not invalidate the role of knowledge management in distributed scrum but indicates greater training needs.

A pillar of distributed scrum is geography and mobility is a key factor of work management. Employees do not always have to be in the same physical space and as stated in CS3 "the company offers an environment in which employees are mobile and always traveling to accomplish tasks" (Product owner, CS3). These floating workers allow companies to expand their horizons in business. There is an incentive to hire employees in the countries of the company's customers, which allows the operation to become more diversified with specific knowledge of the local context. As Ozimek and Stanton (2022) point out, hiring talent from different backgrounds, generations, and regions also brings the organisation out of the ordinary. Through the implementation of distributed scrum, it is also made possible for each team within the organisation to find the environment that best fits their profile and needs.

Some specific benefits have also been found in CS2 and CS3. With the adoption of distributed scrum, the relevance of cross-functional teams becomes more evident. However, people are not necessarily cross-functional but grow with this profile throughout their maturity process. CS3 at this level launches the following recommendation: "start with a team of several talents and then organically build that team to be individually cross-functional" (Scrum master, CS3). Ideally, all developers should be able to assume all functions. However, this is not always possible, but at least it is intended that each developer should be able to perform some more tasks. Several benefits associated with the adoption of cross-functional teams are greater diversification in the development of solutions, higher quality, and greater learning capacity (De Oliveira et al., 2016; Jeske and Calvard, 2020). The adoption of distributed scrum also contributes to the local empowerment of teams through a more decentralised decision process. As stated in the CS2 scrum master, the resolution of impediments has become a crucial element in achieving the project goals. Finally, benefits were also identified in the documentation of the processes. This outcome appears to be in contradiction with the principles of agile but is in line with the conclusions of the study conducted by Stapel et al. (2011), in which it is highlighted that projects with distributed human resources may require more documentation to avoid any issues related to misunderstandings of scope.

6 Conclusions

The physical separation of software development teams brings a series of challenges that are typically presented as key factors of scrum such as direct interaction with the customer and face-to-face communication between teams. Therefore, to continue obtaining the benefits of scrum, these practices must be extended and modified, always aiming to improve communication and synchronise the teams' work. Several motivational factors emerge in the implementation of scrum in a distributed environment such as the need for global resources, cost reduction, or the advantage of being close to the global market. There is not a single typology for the distributed scrum application. Three approaches were identified in this study:

1 teams are collocated and share the same physical space with some exceptions during the project life cycle

2 distributed with full overlapping hours, in which the employees have a significant number of hours of the day to interact

3 distributed with partial overlapping hours, in which the existence of more than three hours of difference between the teams makes the interaction during working hours difficult.

Several practical challenges emerge in the implementation of distributed scrum. Communication, collaboration, and coordination issues stand out due to the geographical dispersion of the team members. Maintaining cohesion and team spirit is a challenge for all members to have a feeling of presence in the project and organisation. Risks may also arise from an incorrect, incomplete, or outdated view of the project status. Other challenges may also arise from the location of distributed teams, namely cultural and regional differences and holidays which may also pose new challenges to the joint work of the teams. The implementation of distributed scrum brings benefits to organisations and has contributed to the offer of better technological infrastructure and a greater focus on monitoring the work progress so that all team members can have visibility on the development of the project. The distributed environment facilitates the creation of cross-functional teams and the development of knowledge management practices. Finally, the decision process becomes more decentralised, and greater importance is given to documentation to reduce the emergence of possible impediments emerges.

This study offers both theoretical and practical contributions. From the theoretical perspective, this study found three different approaches for implementing distributed scrum and addressing the difficulties of managing collaboration and communication that emerge when implementing distributed scrum, since the traditional scrum model relies on teams sharing the same physical space. From the practical point of view, the results of this study are relevant mainly for software engineering companies that are taking the first steps of migrating from their traditional scrum to a distributed environment. This study has some limitations. First, it is difficult to generalise the obtained results considering that software companies and their teams have their own specificities. Initially, it was considered the involvement of eight enterprises, but it was found to be an excessive number due to the redundancy of information between them and also due to the greater difficulty of participation of the companies in academic studies due to the COVID-19 pandemic. In this sense, it is suggested in the future to complement this study with a quantitative analysis that allows exploring the challenges of migration to distributed

scrum considering the size of each organisation and the degree of maturity of these teams. It would be interesting to explore the benefits of distributed scrum in issues related to time, cost and quality. Furthermore, the specific challenges of team migration to certain countries were not explored. Consequently, the relevance of the cultural issue would need to be better explored considering several specific markets.

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