

# The Covid 19 Pandemic and its Effects on Agile Software Development

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Companies worldwide have enabled their employees to work remotely as a consequence of the Covid 19 pandemic. Software development is a human-centered discipline and thrives on teamwork. Agile methods are focusing on several social aspects of software development. Software development teams in Germany were mainly co-located before the pandemic. This paper aims to validate the findings of existing studies by expanding on an existing multiple-case study. Therefore, we collected data by conducting semi-structured interviews, observing agile practices, and viewing project documents in three cases. Based on the results, we can confirm the following findings: 1) The teams rapidly adapted the agile practices and roles, 2) communication is more objective within the teams, 3) decreased social exchange between team members, 4) the expectation of a combined approach of remote and onsite work after the pandemic, 5) stable or increased (perceived) performance and 6) stable or increased well-being of team members.

CCS Concepts: • **Software and its engineering** → **Agile software development**.

Additional Key Words and Phrases: Agile Software Development, agile methods, remote work, covid 19

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## 1 INTRODUCTION

Agile methods, such as Scrum, Kanban, and Extreme Programming (XP), have been established in software development for several years and are widely used in the industry [32]. Recurring practices such as daily stand-up, planning and review meetings, as well as retrospectives are usually part of agile methods. Additionally, roles and artifacts are described in the guidelines of agile methods, like the Scrum Guide [31]. It is well-known that social aspects like collaboration and communication are essential in agile software development (ASD) [34].

The Covid 19 pandemic has led to various changes in everyday working life since the virus swept over the world in 2020. The governmental institutions in many countries defined measures, like contact restrictions and lockdowns, to reduce the spread of the virus and handle the challenges of the several effects concerning the pandemic (e.g., [11]). Also, many companies took containment actions, like sending their employees to remote work from home (e.g., [20]). Before the pandemic arrived, it was common in many countries, e.g., Germany, to work in on-site and rather the exception to work remotely. Due to their extensive and long-lasting scope, any containment measures represent significant changes for professionals, which become particularly evident in the daily working methods for ASD team members. Thus, the change from co-located work to distributed remote work poses challenges for many ASD teams.

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Since the beginning of the Covid 19 pandemic, the effects on ASD have been examined in various studies (e.g., [7, 30]). Several authors focused on switching to remote work and the resulting impacts on ASD [5, 29]. The importance of successfully virtualizing agile practices and digitizing agile artifacts is one aspect [12, 26, 30]. Studies also determined that the perceived performance of ASD teams has not decreased through remote work (e.g., [21, 23]). Various authors address and operationalize the reasons for this development through performance metrics. For example, it can be observed that team members' well-being directly correlates with productivity [30] or that the transparency of the agile approach used increases [23], thus enabling better adaptation to the new types of situations. Other aspects, such as the impact on communication and social interaction in teams or the challenge of virtualizing team collaboration, are also described [21, 23].

As shown, several authors have dealt with the topic in various studies and described partially different results. In particular, the results are partly contrary to each other (e.g., the well-being of ASD team members). It should also be noted that the data collection of many studies was carried out in the first months of the pandemic (e.g., [30]), and it seems, therefore, questionable whether the findings can be confirmed after a certain period. Heeding the call of [24], we address the need for validation of the effects of remote work due to the Covid 19 pandemic on ASD. From our point of view, it is suitable to gain an in-depth understanding for selected companies and teams of how and why existing results are confirmed or not. Therefore, we decided to use our multiple case study [23] and expand it by adding three more cases to it to get a broader view of German ASD teams' work during the pandemic. Thus, we address the following research question: **Which results of existing research on the effects of the Covid-19 pandemic for agile software development teams can be validated?**

The paper at hand is structured as follows: In Section 2, we present a brief theoretical background and describe the related work. We explain the selected research design in Section 3. In the subsections, we describe the case selection process, the data collection, and analysis. We present the results of the paper at hand in Section 4. In the results section, we answer the research question and present the practical implications of our findings. Finally, we describe the Threads to Validity in Section 5 before the paper closes with a summary and our plans for future work in Section 6.

## 2 THEORETICAL BACKGROUND AND RELATED WORK

### 2.1 Agile Software Development

Agile methods in software development originated in the United States in the mid-1990s in order to provide an alternative to plan-based approaches. The motivation of creating those agile approaches was mainly to be able to react to upcoming challenges on software development projects, e.g., requirement changes in more and more dynamic environments as well as increasing complexity in the projects [13]. Thus, more iterative and incremental approaches were used in software development, and, in the following, several agile approaches were presented during the 1990s.

For a consistent understanding of the values and principles of agile approaches, the agile manifesto was created 20 years ago [2]. The agile manifesto defines four pairs of values and 12 principles. It was created by several authors of well-known agile methods like Scrum and XP. Agile methods are usually described in guidelines like the Scrum Guide [31]. The guidelines define a set of agile practices, roles, artifacts, and specific values in some cases (e.g., Scrum and XP).

In the literature, agile methods are described as incremental, adaptable, cooperative, and simple [1]. The iterative structure of agile methods allows ad-hoc and fast reactions to changes during software development projects [10]. ASD teams coordinate daily, reflect iteratively on their work results and their approach, and strive for improvement. The

value-based focus on collaboration and communication in the ASD and with the customer is of great importance for the successful use of agile methods [6].

Today, agile methods are established approaches in many fields, also beyond Software Engineering and, are particularly common when it comes to software development. The most widely used agile methods, Scrum, Kanban, and XP, are often combined, e.g., Scrumban [33] or adapted to individually fit the specific application context [18]. An agile method can be adapted by enriching it with other agile practices or roles. It is also conceivable that practices, artifacts, or roles are adapted to the project, team, or company situation. It is also known that plan-based and agile approaches are used in combination in practice. This combination is usually named the hybrid approach [18].

## 2.2 Differences in Co-located and Remote Work

In this study and our understanding, the type of work depends on how an ASD team is located. A co-located ASD team works at one location, maybe even in one room. One can assume that this type of work seems to fit agile methods, focusing on communication and collaboration [2]. However, agile methods are also used by teams that are not working co-located [14]. This "not co-located" type of work is mainly described as distributed work in the context of global software development (e.g., [3, 4, 16]).

For the paper at hand, we cover challenges concerning remote work and switch from a co-located team to a non-co-located team. Even if the team members work in the same region, time zone and speak the same language, some challenges may be similar to the characteristic obstacles associated with distributed teams and require a thorough and comprehensive elaboration [23].

## 2.3 Related Work

The effects of the ad hoc and continuous switch to remote or hybrid remote work on ASD have not yet been extensively investigated in IS research. Although this work is not designed as a systematic literature review (SLR), we tried to ensure to find the relevant studies for the paper at hand by using the guidelines according to Kitchenham and Charters [17]. Following these guidelines, we decided to document several measurements in a literature review protocol: First, we selected Google Scholar for our literature search and argued this choice as it provides us to search for studies in the interdisciplinary topic of ASD without a limitation of a dedicated field (e.g., software engineering). Also, several publishers are listed in Google Scholar.

Second, our used search string is based on keywords combined with boolean operators extracted from the two main topics (agile software development and Covid 19 pandemic) of this paper: (("agile software development" OR "agile method") AND (("covid 19" OR "sars cov 2") AND ("pandemic")))

Third, we used the activated publication period (since 2020) and the inclusion of quotations filter settings to enclose relevant results. The search was performed in an iterative manner to optimize the search string, filter settings, and update the result set with new publications. Fourth, we verified the result set based on a systematic selection process. Therefore, we defined several inclusion and exclusion criteria for selecting the identified studies (see Table 1). Finally, we extracted the data from the final result set methodically.

The search run provides a result set contains 454 studies, which we used as our result set for the study selection process. The process contains two main steps: First, applying the inclusion and exclusion criteria, and second, content-related verification of the primary studies. The content-related verification contains the check of a) title and keywords, b) abstract, c) introduction and conclusion, as well as d), the read of the whole study. Applying the first step of the selection process, we excluded 421 studies. The updated result set of 33 primary studies were used for the content-related

Table 1. Overview of inclusion and exclusion criteria

Category	Criteria
Inclusion	<b>IC1:</b> Studies published between January 2020 and April 2021 <b>IC2:</b> Studies published in the field of ASD <b>IC3:</b> Studies in English or German <b>IC4:</b> Studies dealing with the impact of remote work due to Covid 19 pandemic on ASD
Exclusion	<b>EC1:</b> Gray literature (Technical/experience reports, workshop papers, specialist books) <b>EC2:</b> Contributions with less than three pages <b>EC3:</b> Studies dealing with Covid 19 related topic(s) outside ASD

verification. We included eight primary studies [5, 7, 21, 23, 24, 27, 29, 30] to our result set. Finally, we performed a backward-oriented search and thus, verified the references of the included studies where we identified one more study [26], which we added to our result set. Thus, the final result set contained nine primary studies and was used for our data extraction procedure. The data extraction was mainly done by the first author and verified by the second author. The first author extracted the basic information of the study (author name(s), publication year and type, research field, used research design) as well as the dedicated findings of the study, clustered into the six topics of interest: 1) Adaption of agile approach in use, 2) communication and collaboration, 3) effects on future work in ASD, 4) performance (perceived), 5) productivity and 6) well-being of ASD team members. We present an overview of existing research on the implications of remote work, including the individual research designs and key findings in Table 2. The key findings categorized per topic of interest are presented in Table 5.

At the beginning of the pandemic in 2020, the possible influences on ASD were discussed during conference workshops, panel discussions, and communities of practice (e.g., [19]). Mancl and Fraser assumed that replacing co-located meetings and collaboration in the office would be a core aspect to conduct remote work [19], which various studies have confirmed successfully (e.g., [21, 23, 24]). Furthermore, these studies show that ASD teams made the transition to remote work related to their agile methods without ongoing challenges or problems. This is an interesting aspect, as it affects teams, which are used to distribute remote work before the pandemic, as well as ASD teams without any experience in remote work.

The key to a successful transition to remote work lies within several aspects. We found in our study that almost all ASD teams switched to digital tools very quickly [23]. Examples of digitization are the use of virtual boards (Kanban boards, visualized sprint backlogs) with Jira or Trello, communication tools such as Microsoft Teams, Zoom, and Slack, and the application of digital whiteboard applications such as Miro and Mural to enable digital collaboration. Several studies have identified a significant increase in the transparency of ASD teams' work, for example, concerning artifacts and agile practices during the pandemic [21, 23].

Russo et al. show that the well-being of software engineers increased on average during the pandemic [31]. The authors further point to a connection between the well-being of the ASD team members and their performance.

Table 2. Overview of the existing literature

Reference	Findings
Butt et al. [5]	The authors found decreased productivity of ASD teams due to less coordination between team members. Also, the well-being and motivation of team members are negatively affected.
Da Camara et al. [7]	The paper presents the experimental execution and validation of measures dealing with the challenges of remote work. The measures include both social aspects and the introduction of new tools or agile practices.
Marek et al. [21]	The results show no significant change in the performance of ASD teams due to the switch to remote work.
Neumann et al. [23]	The authors analyzed the perceived performance of German ASD teams in three companies. They found that the perceived performance has not been decreased due to pandemic reasons and argue this with the increased transparency of the process and the used agile artifacts.
O Connor et al. [24]	The study aims to identify the complexity of the ad-hoc switch to remote work due to the Covid 19 pandemic. The authors point to the impact on virtual meetings and, therefore, to communication and collaboration in agile organized ISD teams. They also identified a positive effect on the performance.
Poth et al. [26]	The paper presents a generic approach called self-service kit (SSK) in order to provide methods for distance learning, knowledge sharing, and team coaching.
Ralph et al. [27]	The authors found a correlation between the well-being of the ASD team members and productivity. Also, they identified a decreased productivity of ASD during the pandemic.
Russo et al. [29]	The study deals with the connection of productivity and well-being factors during the COVID 19 pandemic. The authors found that the well-being (e.g., affected by stress and pandemic containment measures) correlates to the productivity of ASD teams. They identified that the well-being of team members on average increased during the pandemic.
Schmidtner et al. [30]	The presented results show a moderate decrease in productivity. However, the authors highlight the increase of digitalization of agile practices and adapt quickly to the new situation among remote work. Finally, they present how future work will be affected by the pandemic and remote work experiences.

The authors also examined the everyday work of software developers during the pandemic and found that software developers generally invest the same amount of time in remote work [29].

Nevertheless, other authors emphasize negative aspects associated with remote work at ASD during the Covid 19 pandemic. In this context, Butt et al. point out that ASD team members perceive increased mental and physical health stress [5]. The authors also note that there are fewer meetings with clients. Griffin describes the challenge of distractions for ASD team members during remote agile practices [12].

Several studies address the challenges of the switch to remote work and describe how employees can overcome these challenges [7, 26, 27]. Da Camara et al. present 23 specific organizational (supplying Hard- and Software) and procedural (tools supporting the agile practices) measures for ASD teams using the example of a Brazilian start-up [7]. The authors describe the positive effects of these measures and argue this with software development metrics (quality of the source code) and knowledge exchange within the ASD team. Poth et al. present the Self-Service Kit (SSK), which activates teams to share existing and new knowledge [26]. They emphasize the increased relevance of knowledge sharing due to the effects of the Covid 19 pandemic. The influences of the Covid 19 pandemic, and therefore especially the switch to remote work, have also been investigated in other disciplines (e.g., [8, 15]).

The presented results show partly different results on similar aspects, like the well-being of ASD team members (e.g., [5] vs. [29]). Also, the data was mainly collected during the first months of the Covid 19 pandemic in 2020. Several authors argue limitations based on the time frame (e.g., [30]) or the research scope (e.g., [24]). From our perspective, it is also interesting that mainly quantitative methods are used to fill a research gap, which is not analyzed in-depth. Thus, we argue the need to validate the described findings.

### 3 RESEARCH DESIGN

#### 3.1 Research Approach

We decided to extend our existing multiple case study [23]. The qualitative research design according to the guidelines by Runeson and Hoest [28]. We follow this design and the mentioned guidelines, as it has already shown to be particularly viable and useful in similar research contexts (e.g., [9, 22]). Thus, we created a case study protocol according to the guidelines by Runeson and Hoest [28]. In order to be able to validate the findings from existing literature, we added three cases to our original multiple case study [23] to generate a broader view concerning the phenomena under study, e.g., in terms of industries or company sizes and cultures (see Figure 1). We argue this decision with the possibility to conduct in-depth data, which is necessary to understand in detail how the ASD teams deal with the challenges of switching to remote work during the Covid 19 pandemic.

Various authors point out the importance of triangulation in empirical studies and argue this with the richness and the associated low precision of the data obtained (e.g., [25, 28, 35]). Accordingly, we have considered the following types of triangulation for our case study: Data source triangulation (three different cases with different characteristics; see Subsection Case Selection), Observer triangulation (various researchers were involved in the data collection, extraction, and analysis), and Methodological triangulation (various Types of qualitative data collection; see Subsection Data Collection).

#### 3.2 Case Selection

We selected three companies for this multiple case study (see Table ??). The cases were selected based on several requirements. Two criteria were decisive for this. First, the companies needed to develop software using agile or hybrid

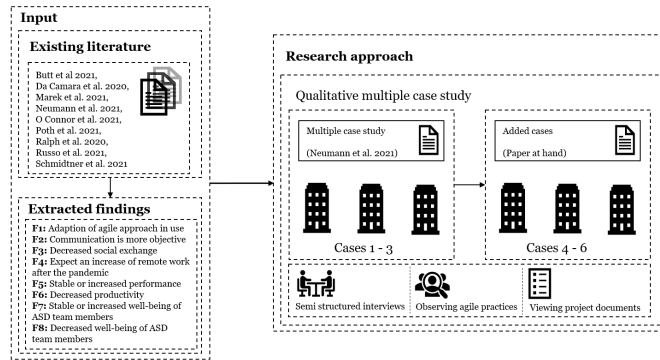


Fig. 1. Research Model

methods. Second, we selected ASD teams that worked co-located before the Covid 19 pandemic and that a switch to remote work was carried out as one of its consequences. In addition to these contextual similarities, the companies needed to show significant differences from one another. This includes not only the industry but also the size of the company and the organizational culture. We want to ensure a broad understanding of the peculiarities of industries, company sizes, or types.

In Table ??, we show an overview of the interviewee's profiles<sup>1</sup> and observed agile practices. To reference a specific interviewee or agile practice, the ID will be used in the following sections.

It can be seen that 7 out of the 19 interviewees occupy multiple roles in the same team. Further, C6I2 distinguishes between multiple roles that typically are part of the role of the developer. With the exception of C4I3, all interviewees have multiple years of experience in ASD with an average of over four years. When looking at the total amount of experience in software development, everyone has at least two years of experience, with an average of nearly 11 years.

We considered the agile maturity in the respective ASD teams as a selection criterion but discarded it. We argue this in particular because, from our point of view, the assessment of agile maturity does not represent a criterion that assesses how an ASD team reacts to the change to remote work. Moreover, the determination of agile maturity is a complex and extensive project on its own, and the period in which the data was collected was critical. Therefore, we decided to prioritize the data collection after switching to remote work instead of delaying data collection by determining the maturity of agile teams and thus endangering the timeliness of the data.

The establishment of contact with the companies and presentation of the study came about through our personal networks in particular. We shortlisted five companies for the study. However, there was no possibility of including two of those companies in the study, mainly due to their increased workload in projects and day-to-day business. Thus, we finally included three companies in the study.

### 3.3 Data Collection

We performed the data collection of this study in the period from September 2020 to December 2020. The selected qualitative method included conducting semi-structured interviews, observing agile practices, and viewing project documentation, such as artifacts or metrics for agile practices.

<sup>1</sup>Note: In brackets years of experience in sd projects; with agile methods. SM = scrum master, PO = product owner, D = developer, SA = solution architect, PL = project lead, BA = business analyst, TL = team lead

Case	Case 4	Case 5	Case 6
<b>Founded</b>	1864	1923	1970
<b>No. of employees</b>	Approx. 1,100	Approx. 50,000	Approx. 6,000
<b>Industry</b>	Insurance	Tourism	Banking
<b>Agile methods in use</b>	Scrum Scrum hybrid	Scrum Scrum hybrid  Scrum/Kanban hybrid	Scrum Scrum/Kanban hybrid
<b>Interview profiles</b>	C4I1: PL, SM, D (4;2) C4I2: SM, D (4;2) C4I3: D, SA (25;1) C4I4: PO, PL (11;2)	C5I1: SM (8;8) C5I2: PO (10;7) C5I3: BA, SA (2,5;2,5) C5I4: PO (21;5)  C5I5: D (21;5) C5I6: BA (4;4) C5I7: D (20;6)	C6I1: PO (5;3,5) C6I2: D, SA, TL (23;10) C6I3: D (12;7) C6I4: D (15;2)  C6I5: SM (4;3) C6I6: D (10;2) C6I7: D, SM, PO (7;7) C6I8: PO (2;2)
<b>Observed agile practices</b>	C4E1: Sprint review C4E2: Sprint retrospective C4E3: Sprint planning C4E4: Sprint review C4E5: Sprint retrospective C4E6: Sprint planning	C5E1: Sprint review C5E2: Sprint retrospective C5E3: Sprint planning C5E4: Daily stand up C5E5: Daily stand up	CEI1: Daily stand up C6E2: Sprint planning C6E3: Daily stand up C6E4: Sprint review C6E5: Refinement

Table 3. Case descriptions

We conducted a total of 19 interviews. On average, the interviews took between 35 and 40 minutes. The Covid 19 pandemic also had an impact on data collection. All interviews were conducted digitally using Microsoft (MS) Teams. The interviews were moderated by one researcher, with a second one documenting the interviewee's answers. At the beginning of each interview, we presented the study and our research group. Firstly, we explained the motivation and goals of the study and then described the interview process. We also went into the specific procedure for data anonymization. The interview partners then asked us questions about the study and the specific procedure for collecting the data. The interviews were performed based on our the interview guideline from the first study [23], which contains open and closed questions. The interview guideline is provided in Appendix A.1. The researcher conducting the interview went through these guidelines question by question. The guideline is divided into three parts: The first part comprises questions to collect general information from the interviewee, the agile approach of the team, and the

company. The second part deals with how work has been carried out before and since the pandemic. With the third part of the guide, we collected data on the influences of remote work, such as communication, (perceived) performance, and the agile approach's adaptation. We made sure that the common ASD roles were interviewed at least once per case.

In addition to the interviews, we observed 16 agile practices (see Table ??). We carried out these observations with the help of video conference tools. We did not focus on individual practices in the observations but tried to get a sufficiently broad overview of the approach of the respective ASD teams. The first author mainly performed the observation; he documented his observations in our observation protocol from the first study [23], as also referenced in Appendix A.2. The observation protocol consists of two parts: The first part includes general information such as the time or which tools are used. The second part contains specific information on the agile practice, such as the specific process and which methods were used.

Furthermore, we have reviewed several project documents. These include artifacts of the used agile methodology, such as product backlogs or Kanban and sprint boards. We used the project documents as quality assurance and consulted them primarily when confronted with contradictions from the interviews and observations. Ultimately, we also looked at evaluations of agile metrics of individual teams to verify whether the development of the team's outcome correlates with the perceived performance described in the interviews.

### 3.4 Data Extraction and Analysis

The data analysis follows the guidelines according to Runeson and Höst [28]. We used Microsoft Excel for data extraction and Miro (a virtual whiteboard) for data analysis. First, we structured the extraction table based on the findings in existing literature, oriented by the categorized findings from the existing literature (see Table 2): Adaption of agile approach in use, communication and collaboration, effects on future work in ASD, performance, productivity, and well-being of agile team members. Next, we extracted the data from the interviews, observations and screened documentation and clustered them to the mentioned categories. Based on the extracted data in a structured format, we were able to analyze the data in a systematic procedure. We initially looked for similarities in the data. If a researcher identified at least three data points with similar information, the data was marked. A mark contains several information like which data points (e.g., which question in an interview) are identified, which cases are considered, in which data types the similarity was found (interview, protocol, or viewed documentation). In the following, one other researcher reviewed the marked data to ensure the quality of our triangulation approach. Every researcher did the analysis tasks independently but based on the same structured data. We documented our analysis results on our own and discussed the results based on a virtual whiteboard in Miro. These discussions aimed to identify the connection of the marked data to our research question.

## 4 RESULTS

### 4.1 Overview of the Results

First, we deal with the agile methodologies and practices used in the cases. Scrum is the leading agile methodology used in all presented cases (see Table ??). We also asked the interviewees which agile practices and artifacts are used in their teams to get detailed insights into their way of working. We have classified this information as relevant to understand better how the teams proceed and operate. The agile practices and artifacts used per case are shown in Table 4.

The ASD teams of all cases adopted some agile practices and artifacts when they switched to remote work. Some practices or artifacts have also been adapted (e.g., C4E2, C4E5, C5E1, C5E2, C6E1, C6E2). This includes the digitization of artifacts such as the Kanban board and the sprint backlog as stated by C5I2, C5I3, C5I5, C5I7, C6I3, C6I7 and used, e.g.,

Table 4. Overview of the identified agile practices and artifacts per case

Agile practices and artifacts	Case 4	Case 5	Case 6
Code reviews	✓	✓	✓
Continuous integration	✓	✓	✓
Continuous deploy		✓	
Coding standards		✓	✓
Daily stand up		✓	✓
Definition of done	✓	✓	✓
Pair programming	✓	✓	✓
Planning meeting	✓	✓	✓
Product backlog	✓	✓	✓
Refinement meeting	✓	✓	✓
Retrospective meeting	✓	✓	✓
Review meeting	✓	✓	✓
Sprint backlog	✓	✓	✓
Test-driven development		✓	

in C5E4, C6E1, C6E3. Likewise, the procedure for various practices such as retrospectives through virtual whiteboards or tools is different compared to the time before the pandemic (e.g., C5E2, C5E4, C5E5). Another example is how the estimation process is carried out in planning or refinement meetings, which are now performed virtually (C4E3, C5E3, C6E2). Most teams use the chat functionality to do the estimation.

For 14 interviewees, the overall transparency has increased. C4I3 links this to the increased use of digital chat channels. With that, every team member has the opportunity to get all the relevant information. C5I4, C5I6, and C5I7 state that the digitization of the sprint boards led to an increase in transparency. This claim is further supported by the increase in documentation, be it quality or quantity, as stated by C4I1, C4I2, C4I3, C5I5, C5I6, C6I1, C6I5, C6I7. Four interviewees either didn't see a change in transparency or did not give a concrete answer to the question. And only C5I2 sees a decrease in transparency as it is easier and quicker to write post-it notes on a physical board than creating a digital ticket. Additionally, small tasks are finished without any comments in the related tickets. It makes it more difficult to comprehend them.

The perceived performance has increased for interviewees C4I2, C4I3, C4I4, C5I2, C5I3, C6I1, C6I2, C6I4, C4I2, C4I3, C4I4 see the reason for the increase as part of continuous improvement. Further, C4I3 names less distractions and the possibility to work additionally in the evening as possible reasons for the increase in perceived performance. According to C5I2, C6I1, C6I2, and C6I3, a change in the team staffing led to the increase. The decrease of discussions over small details explains the increase of perceived performance for C5I3. For C5I4, C5I7, C6I5, C6I6, and C6I8, the perceived performance did not change. Newly used technical capabilities like screen sharing help keeping the performance stable according to C5I7 and C6I8. For C5I4, the high commitment of the team and socializing is the reason for the stable perceived performance. C5I5, C5I6, C6I3, and C6I7 describe a decrease in perceived performance. The reasons are that problems are not identified quickly enough or the training of new employees. Finally, two interviewees did not provide an answer to this question.

Several agile practices were used in a similar way through the investigated ASD teams. This also includes pair programming, which seems easier to carry out in co-located work, i.e., at a physical workplace, than in distributed remote work. Interviewees C5I3 and C5I4 report that pair programming has been used less frequently since the change

to remote work. More than half of the interviewees report the digitization of different items like sprint boards or whole practices like sprint reviews executed in online tools like Miro. Other than that, C4I1 explains that the sprint reviews are shorter, and C6I1 that daily stand-up meetings take place more frequently. C5I3 and C5I4 see an increase in the degree of the documentation. C5I1 and C6I also report new socializing meetings.

Communication is another aspect that changed as a consequence of switching to a remote working model. C6I1, C6I5, C5I7, C4I2, and C5I3 perceive the communication as better or slightly better than before the pandemic. C6I1 and C5I3 explain that it is now easier to reach a colleague as everyone is available via MS Teams, and the communication is now more focused on the topics at hand. For C4I1, C4I3, C6I2, and C6I4, the perceived communication is neither better or worse, although changes are noted. C6I4 explains that, on the one hand, the communication is results-oriented, which makes it more efficient. On the other hand, the social aspect is completely missing now. C5I2, C5I8, C5I1, C5I4, C5I5, C5I6, C6I3, and C6I6 feel that the communication has gotten worse. Several interviewees state the missing social aspect and social interaction as reasons for the perceived worsened communication. C5I1 describes that it is increasingly difficult to read the body language and that people prefer personal communication to digital communication. The missing non-verbal communication is also listed by C6I7. In case 5, C5I1, C5I2, C5I3, and C5I7 perceive that stakeholders from the management are more frequently present in meetings. C5I3 says that the daily stand-up meeting timebox was increased from 15 to 30 minutes so that the management can use the time to report on current topics and events outside of the actual software development. C5I1 explains that due to the digitization it is now easier to join or exit a meeting than it would be the case for face-to-face meetings. C5I5 perceives the stakeholders from the management as less active. Interviewees in cases 4 and 6 don't perceive an increase in stakeholder activity.

The inclusion of the product owner has also changed in some cases. C4I1, C4I3, C4I4, and C6I7 say that it is now easier to reach and interact with their product owner. C5I1, C5I7, C6I1, C6I3, and C6I4 explain that their product owner is more present. C6I3 and C6I4 trace that back because now the product owner has access to technical MS Teams channels and the opportunity to be stronger involved. Additionally, C6I1 and C6I2 mention that their product owner now has more responsibility. Other interviewees either didn't perceive a change in the product owner involvement.

We identified two aspects concerning working time: the extent of working time (e.g., in hours) and the quality of working time (e.g., efficiency). Only a few team members of the investigated teams worked more hours than before the pandemic. In some teams (Case 6), interviewees (C6I1, C6I2, C6I4, C6I5) indicated that they had worked more hours, especially in the weeks after the first lockdown in Germany from March 2020, to cover the effort related to the initial switch to remote work. The other interviewees in Case 6 (C6I3, C6I7, C6I8) stated that they worked the same number of hours. In cases 4 and 5, the distribution of team members who invest the same or more working hours is distributed equally. We can see that the number of working hours has not increased significantly and has mostly remained the same. Building on this, we examined whether something had changed in the perception of the type of work. The majority of the interviewees (14 of 19) in all cases rated the quality of the work as higher (C4I1, C5I1, C5I3, C6I1, C6I2, C6I3, C6I4, C6I5, C6I7, C6I8). The team members argue this primarily because they are less likely to be disturbed and thus interrupted at work than in co-located cooperation. We found out that most ASD team members in the three cases tried to find a solution to problems or challenges more often instead of contacting a colleague in the team and asking for support. The sensitization of the team members to the disruptions in working hours has increased. The individual team members have also noted that they have control over potential disruptions in remote work. While in the co-located work in the office, someone could often be addressed (and thus implicitly interrupted by one's work). It is possible to set the availability status in the communication tool used accordingly and signal that you do not want to be disturbed at the moment. It was also mentioned that working hours were allocated more flexibly. Interviewees have noted that they

sometimes worked in the evenings (e.g. C6I6), and were significantly more effective there, as they were not exposed to any interruptions. From this, the interviewees deduce a higher concentration and efficiency.

#### 4.2 Result Comparison with existing Findings from the Literature

The first study results regarding the Covid 19 pandemic's influence and the resulting switch to remote work have been published in the past months (see Section 2). Relevant for answering the research question are the studies that deal with the influence of the Covid 19 pandemic on the work of ASD teams (see Table 5). We compare the results of these studies with those of our case study to identify possible overlaps in the results of various studies. The verified studies present results across various situations and contexts such as countries, industries, or company-specific procedural and cultural characteristics and are therefore also relevant for practical recommendations.

Our study results confirm that the ASD teams were able to react to the new circumstances in remote work and adapt their approach. Several authors describe this, particularly on the virtualization of the implementation of agile practices (such as retrospectives) [21, 23]. Due to the digitization of agile practices, a change in the methodological implementation can also be observed [7]. We have found that retrospectives in some ASD teams are more playful than before the pandemic, e.g., due to the use of virtual whiteboards combining storytelling. The type of estimation is also different today. Several teams used estimation methods with a playful approach like planning poker before the pandemic. Today, the estimation techniques in use are more straightforward. For example, the ASD teams use chat functionalities in the virtual conference tools.

When it comes to the adaption of roles, our interview results indicate that the product owner involvement and/or presence has increased for all cases. Based on this, we argue that the finding **F1** can be confirmed to the extent that in all three cases in our study, the agile approach was adapted, although mainly through tools. Another aspect identified by digitization in several studies is the involvement of all team members and interface roles in communication [7, 21]. By using team chat groups, professional communication in the team is perceived as better in some cases. An example of this is the asynchronous communication with interface roles such as product owners or scrum masters, which leads to an increased awareness of accessibility and integration into the agile approach [23]. Further, the communication seems to be more focused on work-related things, as multiple interviewees across all cases, like C4I4, C5I3 and C6I4 explain. Thus, the finding **F2** can be confirmed

The finding **F3** can also be confirmed, as we notice a significant decrease in social exchange. By this, we understand all types of communication and collaboration that do not primarily have a professional context but promote social interaction. Other authors point out the importance and consequences of these aspects [7, 21]. Some teams (in Cases 5 and 6) try to counter this aspect by introducing socializing events. These can have very different characteristics. Some teams organize virtual game evenings; others plan a weekly virtual team breakfast or coffee talks. Many ASD teams adapted their socializing events regularly due to the decreasing participation of the team members. Even if the teams perceive this as consistently positive, many interviewees point out that these events cannot replace personal, social exchange in the office.

We find that the majority of interviewees in all cases would like to continue to use remote work. It follows that the virtual collaboration will also be maintained in the future. An increase in remote work would not mean 100% of the time, as 17 out of 19 interviewees favor a combined form of work. This means a mixture of remote work and co-located work. The idea is mostly similar and includes the requirement that most teams meet in the office, especially on days where agile practices with a collaborative character (such as refinements, planning, review meetings, or retrospectives) are carried out. Simultaneously, several interviewees point out that they do not consider it realistic that all team members

Table 5. Overview of confirmed findings of existing literature

Topic of interest	Finding(s)	Reference(s)	Conf.?
Adaption of agile approach in use	<b>F1:</b> The ASD teams rapidly adapted the agile practices and roles in use due to the Covid 19 pandemic effects (e.g., switch to remote work)	[7, 21, 23, 24, 30]	✓
Communication and collaboration	<b>F2:</b> Communication is more objective	[21, 23, 24]	✓
	<b>F3:</b> Decreased social exchange	[7, 21, 23, 24]	✓
Effects on future work in ASD	<b>F4:</b> ASD team members and specialists expect an increase in remote work and the use of digital tools after the pandemic	[30]	✓
Performance (Perceived)	<b>F5:</b> Stable or increased performance after the switch to remote work	[21, 23, 24]	✓
Productivity	<b>F6:</b> Decreased productivity due to the Covid 19 pandemic	[5, 27, 30]	
The well-being of agile team members	<b>F7:</b> Stable or increased well-being of ASD team members	[29]	✓
	<b>F8:</b> Decreased well-being (e.g., due to mental health stress) of ASD team members	[5]	

will also be present in the office on these days (e.g., C4I2, C5I2). The interviewees justify this idea with the fact that the social exchange between the team members, in particular, has deteriorated or even comes to a standstill during remote work. This is perceived as negative in all three cases. Nonetheless, with the presented results, we can confirm the finding **F4**.

Some studies have identified the (perceived) performance of ASD teams as not being reduced [21, 23]. There are various reasons for this. In addition to software development professionals' well-being, optimized transparency and the ability to quickly adapt to the new circumstances are named causes. In all three cases of this study, we could not find any permanent decrease in performance (see Results). With some ASD teams, the performance fell briefly at the time of the ad-hoc switch to remote work. This condition lasted a few weeks (less than a month). The performance is at least the same as it was before the pandemic. We thus confirm the finding **F5**.

However, studies also rate ASD teams' productivity as worse due to the pandemic, as seen in finding **F6**. We attribute this to the different circumstances in the respective contexts. Aspects such as the maturity of the agile approach used by the team, the specific project situation, or changes in the team composition can impact the performance. Based on our study, we are not able to neither confirm nor deny this finding.

In the interviews, we asked whether the mood on the personal level or the team level has changed since the pandemic. Interestingly, the interviewee's answers to both questions were very similar. Although several interviewees report a dip in mood at the beginning of the pandemic, nearly all interviewees say that today it has reached at least the same level as before the pandemic. C6I8 concludes that his perceived improvement of the mood within the team is not attributed to the remote work or other consequences of the pandemic. It can be argued the reasons for the changes in mood, be it within a team or personal, are defined by many different factors. Nevertheless, we can confirm the finding **F7**. As for the opposite, finding **F8**, we can deny it. Only the interviewees C5I6 and C6I7 think that the mood within their team has gotten worse.

#### 4.3 Practical Implications

As the pandemic leads to changes of success, some companies benefit greatly, and others are struggling with the effects on their business. We believe that with the presented results and findings, companies can derive valuable information, mainly but not limited to ASD. These aspects also open up new research perspectives (see Section 6).

Based on these results, we expect to see an increase in remote work after the current Covid 19 pandemic. However, this raises various questions regarding infrastructure. An intensified remote work model affects the structure of offices, which should focus more on collaboration and less on workstations. Also, several questions occur concerning the working equipment provided to the employees for remote work. In addition to the infrastructure and equipment of the offices, there are other aspects to consider. When new employees are integrated into a team, the effects are noticeable. This is perceived as more challenging and complex, especially in pure remote working models. The duration of induction, socialization in the team, and the time, until new employees perform are perceived as more extended than in the co-located working model. Many interviewees point out that the stronger the team is, the easier this aspect is. Starting a new team for a new product or project is much more difficult. Team development through collaboration and communication in person is delayed and is not transparent. We also found that the interviewees' work situation, especially in the home office, is heterogeneous. Some participants sat at the kitchen table during the interview, others in the living room or children's room. Other interviewees had a very well-equipped office. Even if this study's data show a high degree of agreement that one can continue to work in remote work in the future, this does not mean that the requirements for the extent of working hours in remote work are just as heterogeneous. One case in this study (Case 5)

and all cases in our first study [23] provide support on this topic and offer docking stations for laptops. In contrast, other companies focus more on the possibility of continuing to come to the office when providing support (Case 6).

Another aspect that could have an impact on the general work model is the working time. Our results show that certain team members chose to work partially during a different time in the day when they felt the most undisturbed. If we expand on the concept, we argue that it might be beneficial to implement a certain core time, where the availability of employees is expected, and a certain amount of time where the employee is flexible. This is highly compatible with the combined work model. Employees could attend appointments which would not be possible when working on-site (e.g., maintenance of the heater system).

We would also like to address the decreased social exchange. Multiple interviewees from all of our cases tell that they miss the social exchange with their colleagues. With that, they especially mean the personal exchange. The fact that several social meetings were discontinued in cases 5 and 6 seems to support that claim. Presumably, this could lead to unstable teams who can no longer collaborate within their team or moreover with other teams. And though the long-term effects remain to be seen, we deduct that this aspect needs to be addressed as soon as possible to mitigate possible negative outcomes. Arguably, the solution for this problem is to work on-site again.

## 5 THREATS TO VALIDITY

Though the presented study follows the guidelines by Runeson and Höst [28], some threats to validity have to be considered.

### 5.1 Construct validity

The time frame in which the interviews were conducted could be considered long (August 2020 to December 2020). Some of the later interviewed ASD teams had more time to adjust to the remote work. Additionally, all ASD teams in November faced different conditions as Germany enacted the second lockdown for its citizens since then. Also, the ASD maturity level was not considered (see Research Design). With interviews lasting between 30 to 40 minutes, the interviewees could have experienced fatigue after a certain time. Consequently, questions towards the end of the interview might have been abbreviated. To counteract this to an extent the interviews were all scheduled during working hours considered normal in Germany (between 09am and 04pm). As described in the chapter Related Work, there is a possibility that not all relevant literature was identified. Reasons for this can be, for example, the used search strings or the search engine.

### 5.2 External validity

The external validity could be higher with more cases considered in the same company, in more industries, or other regions of Germany as all of the cases presented are located in the north of the country. Another limitation is the consideration of only one country, as the switch to a remote working model happened in many countries around the globe. Further, the analysis of non- ASD teams could be interesting as the shift to remote work affected not solely ASD teams. A possible issue is that it cannot be said with certainty that the observed results are a consequence of the shift to a remote working model. Additionally, we heard in the interviews and saw in the observations that the lived agile practices can vary to a certain degree from team to team. More collected data could help to mitigate those risks.

### 5.3 Reliability

The phrasing of questions can differ from interviewer to interviewer as with the existing possibility of changing the meaning slightly. If an interviewee does not understand the question asked, our provided explanation can also differ. Especially when asking open questions, the interviewee's answers can be extended or go in different and unexpected directions. It is up to the individual interviewer to guide the interview.

## 6 CONCLUSION AND FUTURE WORK

The Covid 19 pandemic has led to a paradigm shift in the way many people work. Numerous companies have sent their employees to remote work to contribute to the containment of the infections. Several authors dealt with the effects of the pandemic-caused switch to remote work on ASD teams. We can confirm most of these findings based on our conducted multiple-case-study:

- **F1:** The ASD teams rapidly adapted the agile practices and roles
- **F2:** The communication is more objective
- **F3:** The social exchange has decreased
- **F4:** The ASD team members expect an increase in remote work and the use of digital tools after the pandemic
- **F5:** The (perceived) performance is stable or has increased
- **F7:** The well-being of the agile team members is stable or has increased

As seen in the previous section, we see several arguments that speak in favor of a remote work and show its limits. Thus, we argue that a combined approach would make sense as a possible working model in the future. In ASD, it probably means that the teams will primarily come to the office for collaboration and (personal) social exchange purposes.

The expectation of a combined approach raises the question of what this kind of approach could look like. We are currently preparing an international quantitative study. With this study, we aim to shed some light on a possible combined approach in ASD and also examine whether the findings from Germany are comparable with those in other countries or whether there are significant differences.

## 7 APPENDICES

The guideline for conducting our semi-structured interviews (A.1) is available at the Academic Cloud: <https://sync.academiccloud.de/index.php/s/IdQZgK9YUoew3a2>

The template for our documentation of the observed agile practices (A.2) is available at the Academic Cloud: <https://sync.academiccloud.de/index.php/s/Yi3XnGWRIKf7BT8>

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