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THE EFFECT OF PANDEMIC RELATED RESTRICTIONS ON AGILE TEAM PRODUCTIVITY IN SOFTWARE INDUSTRY

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ABSTRACT

The world is currently facing a crisis in the form of COVID-19 pandemic to which there is no parallel in the immemdiate past. To safeguard the health and safety of its citizens, government across the world has issued restrictive measures, social distancing and lockdown. This has considerably affected both normal population lives and organizational operations. Many studies have been already conducted on impact of COVID-19 at employee level and on different sectors. In this study, the researcher will take into account the group level effect of COVID-19. For this agile teams in software industry will be analysed.

The aim of the study is to understand the effect of mandatory work from home during COVID-19 lockdown on organizational teams. For this, the study will analyse team level variables such as virtual teamwork quality, team productivty and team member success during lockdown. This research aims is to contribute to the emerging era of virtual work environment by investigating the case of agile teams of software industry. For this, the study has used Hoegl's model of teamwork quality and project succes to devise a modified conceptual framework. An understanding of how pandemic related changes will impact team and its productivity is important from management perspective so as to devise solutions to address previously unheard-of issues related to pandemic crisis.

The study considers agile teams from software industry as its population and has used mono-approach with quantitative data. The study found that virtual teamwork quality has positive relationship between team productivity and team member success during COVID-19 lockdown. Moreover according to the perception of agile team members, psychological well-being and team environment is critical in improving team productivity.

Keywords: Agile teams, COVID-19, team productivity, virtual teamwork quality

INTRODUCTION

The world is currently facing a crisis in the form of COVID-19 pandemic which is caused by coronavirus-2. The pandemic has caused global disruption to common working practices and has led to a major shift in regular working conditions. One of the most prominent changes is the increase in working from home for non-essential workers (Bick *et al.* 2020). A recent CEO panel survey (PwC 2020) conducted among CEOs found that the remote working culture is expected to be much more prevalent even after the pandemic ends. When working from home the employees are expected to complete their work and related activities remotely using limited home resources.

Looking from an organizational level perspective, any global crisis is likey to accelerate the trends that were already underway in the peer companies (Sine *et al.* 2003). In pre-covid times, most companies were relunctant to give work from home to their employees due to monitoring and management difficulties (Dalal *et al.* 2020). But, COVID-19 lockdown has mandated this situation to be changed and called for the migration of work to virtual environment. Previous studies have shown that employees who perform complex task or if their work do not need interaction with their colleagues are more productive when thay are working remotely (Meier *et al.* 2014). But a large scale shift of working environment to home has raised challenges such as not enough space in home and no boundary between work and home life. The present research will be concentrated on organizations from software industry. According to Miller (2021), the information technology sector comprises of three major industry groups namely- software; hardware technology and internet related services and each IT firm align with a group that overall describes their core business.

Employee wellbeing is crucial in working of any organization. Earlier studies has shown that crisis affect individuals and their psycological well being (Bakker *et al.* 2018; Sahni, 2016). According to Conservation of resource theory by Hobfall (1989), employees feels imbalanced when existing resources are under threat and new resources are not reachable. There has been many cases of mental breakdown due to stress caused by increased concern on job security and work-life imbalance (Smith *et al.* 2018; Sahni, 2016). These individual level impacts have far

reaching consequence when looking at a group level perspective of an organizational team. This could be better understood by taking the case of agile teams which ideally consist of 5 to 9 members (Mersino 2017). In an agile team, each individual member is expected to contribute to the team's overall productivity. Thus, pandemic related stress at an individual level can negatively impact overall team productivity.

A software firm consist of multiple agile teams with each team member having a designated role. Usually each team member has a back up in case of an personal emergency situation. But, during COVID-19 pandemic the entire team was forced to work from home and had restricted access to regular office space. This has influenced inter and intra team level work. Previous research has shown that virtual work among the team will lead to miscommunication and lack the collaboration that is not observed during face to face meetings (Martins *et al.* 2004). The traditional problems that are usually existing in teams such as conflict and lack of coordination can accelerate quickly in virtual environment (Mortensen *et al.* 2001). There is a need to align the team goals, formalize team processes and foster a psycologically safe environment for smooth working of virtual teams (Gibson *et al.* 2006). Hence from research perspective, understanding the effect of pandemic on the software industry is important as its employees are resorting to remote work during lockdown (Dingel *et al* 2020).

According to Chung *et al.* (2020), one of the social and economic consequence of COVID-19 has been nation-wide move towards working from home, including sectors that had not previously embraced home working. The latest studies have investigated impact of COVID-19 on food supply chain, education, space industry, medical industry and tourism (OECD 2020; Rashid *et al.* 2020; Deshmuck *et al.* 2020; Chowdhury *et al.* 2020; Gössling *et al.* 2020). Several authors (Shahid *et al*. 2020; Al-Marzooqi *et al.* 2020) have made their contribution on individual workers experience and their perception about working from home during COVID-19 pandemic. Morikawa (2020) have already made some valuable insight on individual workers productivity when remote working during pandemic. Also, there are existing studies on employee performance during general crisis (Sahni, 2016) and on business disruption management (Heikkilä *et al.* 2018). The virtual work environment culture can now also be extensively seen in education sector through online classes, virtual labs etc.

However to the best of this author's knowledge, no research has explored the effect of COVID-19 at a group level. There is a gap in literature on this sudden work from home culture at a group

level and its effect on different sectors are not well understood (Deshmukh *et al*. 2020). Hence, it is high time to do an in-depth research on team and its productivity during working from home imposed due to COVID-19 lockdown. To fill the above gap in the literature, this paper will explore the effect of virtual teamwork quality on productivity of agile teams by studying the case of software development firms. Team productivity is the capacity of the team to produce quality output using available input resources at its full magnitude (Tangen 2005). The metrics for measuring team productivity depends on the industry and management. The study will be targeted primarily on software companies located at India, Estonia, United States of America, Canada and Ireland.

Research aim

This research will study the effect of working from home on agile teams of software industry during COVID-19 lockdown. By doing this, the research aims to understand the relationship between the quality of virtual teamwork and the productivity of agile teams, and the extent to which the pandemic related lockdown has affected the productivity of agile teams. Thus, the current master thesis plans to contribute to the emerging era of virtual work environment.

An understanding of how pandemic related changes will impact team and its productivity is important from management perspective so as to devise solutions to address previously unheard-of issues. This paper will contribute to the growing trend of efficacy of virtual teamwork in organizations. The results from this research will benefit organizations that are using agile project management to design organizational specific policies during extended work from home.

Research questions

Given aforementioned lack in current literature, following research questions are raised to which this author aims to find answer to.

1. What is the effect of virtual teamwork quality on productivity of agile teams during COVID-19 lockdown?
2. What is the effect of virtual teamwork quality on agile team members success during COVID-19 lockdown?
3. According to the perception of agile team members, which of the identified factor/factors derived from empirical study are mainly affecting their team productivity during working from home?

The first chapter of this master thesis presents the theoretical foundations and review of relevant literature covering agile project management, importance of productivity, metrics to measure productivity, effect of pandemic on software industry and a conceptual model derived from Hoegl's teamwork quality model. Through this chapter this author hopes to provide the necessary background to this study and point out the gaps in literature.

In the second chapter, the methodology of the research itself is presented and necessary argument for selecting quantitative approach put forth. This chapter will also summarise the constructs used to study the selected variables. In this study the author has used online surveys as data collection techniques to find out answers to the research questions. All methodology related analysis such as demographic profile of the participants will be presented in this chapter.

The third chapter will contain the data analysis along with the most important findings made during present study. The chapter will also present a discussion on the research results and will try to find answer to all research questions of this study.

The final conclusion chapter will include theoretical and practical implications, limitation and future research avenues on this platform.

The author would like to thank her supervisor Susanne Durst for the continuous support and meaningful guidance throughout this thesis. Also, the author wants to express her sincere gratitude to her family members for providing the inspiration in reaching this proud milestone of her academic journey.

1. THEORITICAL BACKGROUND & LITERATURE REVIEW

In this chapter, the author discusses the literature for the framework of the current work. Giving an overview of the research that is carried out so far in the current field of study will give a better understanding of the context as well the gap in literature. To make this happen this author has taken the help of exiting journals, publications and magazine reports to identify the impact of pandemic on team productivity.

1.1 Agile project management

The ongoing fourth industrial revolution (Industry 4.0) created new possibilities in industry for using modern smart technologies such as internet of things, big data, block chain etc. This has created new possibilities and demands on the industry as a whole. To meet these needs process-oriented industry (e.g., manufacturing industry) as well as project-oriented industry (e.g., software industry), nowadays are shifting to flexible management process such as 'Agile' (Jovanovic *et al.* 2015).

The traditional project management approaches focused on delivering a planned scope with in a planned timeline and budget. Agile project management was first introduced in 2001 by a group of IT professionals as a method to manage software development projects (Beck *et al.* 2001). Agile is an iterative approach for project management using which product is delivered to end customer in an incremental and iterative manner (Atlassian 2021). Although, agile practises were first introduced in software industry, this method can be applied to any project that faces uncertain environment (Eschenbach *et al.* 2015) or needs constant feedbacks (Stare, 2014).

Review of past research has shown that agile project management was used in manufacturing industry (El-Khalil *et al*. 2020) and in e-learning sector (Doherty, 2010). But still, agile style of management is not widely popular apart from software industry because partially developed

product may not be marketable and frequent changes may be expensive (Stare, 2013). As this research work is focused on software industry, a basic overview of the industry as well as project management approaches for product development in this industry will be discussed in upcoming sections.

1.1.1 A brief overview of software industry

Software has become an essential part of our everyday life, may it be communication, business or entertainment. Software is an electronically stored computer program to perform various tasks. The software industry started developing in early 1960s when mass production of computers first started. The industry further extended when personal computers (PC) was introduced in market. Currently, the industry is rapidly developing with the advent of cloud computing, software-as-a-service (SaaS), machine learning etc. The industry offers programming services as well as software product development. Hence, software industry consists of creation of software products or services which can be traded to corporate or individual consumers. Microsoft, IBM, Oracle, Apple etc are some of the biggest software companies that have contributed significantly to the technological growth.

1.1.2 Traditional project management approaches to software development

With the increasing complexity of software development process there raised a need to have a standard project management procedure or methodology in the software industry. Software development lifecycle (SDLC) models were thus introduced so as to have a structural practise for building robust software products (Taya *et al.* 2011). These models define a set of activities that need to be followed so as get the desired output; which in this discussed case is a high-quality software. According to Krishna *et al.* (2012), there exists many SDLC models of which Waterfall, V-Model etc. are traditional models and Agile is a newer approach. Software development companies choose suitable model based on their project needs.

Traditional waterfall approach follows a sequential path such that one step cannot commence without finishing the previous step (Gurang *et al.* 2020) which is illustrated in Figure 1. Waterfall approach goes through following sequential steps:

1. Identify the project requirements and analyse the scope of work.
2. Design the product based on above determined requirements.
3. Actual building of product.

4. Test the product and fix any defect if found.
5. Implement the finished product in client environment.
6. Maintain the product to rectify any residual errors in the product.

In this method, a problem cannot be fixed until maintenance stage is reached. Waterfall approach could not accommodate any requirement changes in the project once its underway, thus creating a rigid and inflexible project management model (Hneif 2009).

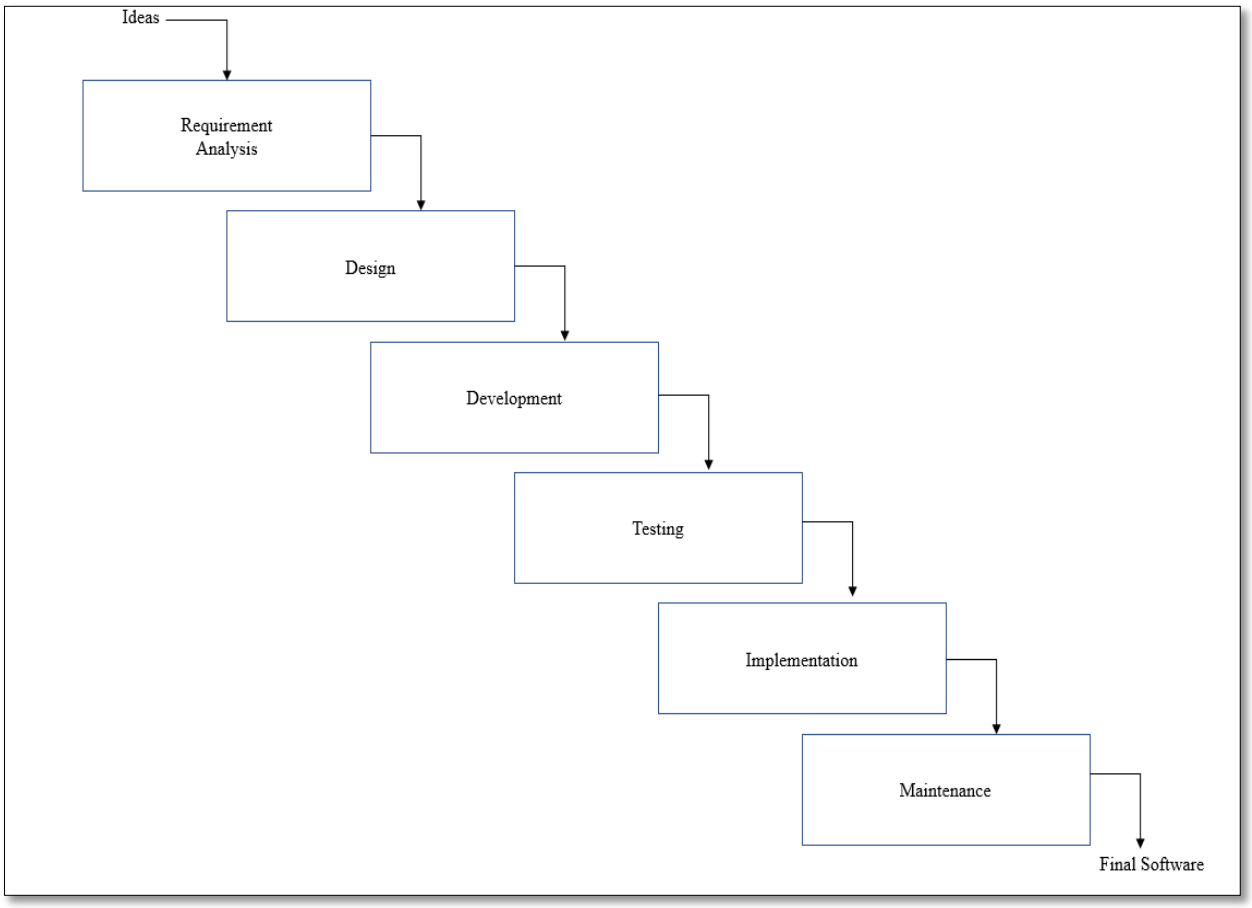

Figure 1. Waterfall process

Source: Gurang *et al.* 2020, 31

Another commonly used traditional methodology is, V-Model which is depicted in Figure 2 in which each phase of development has a corresponding testing phase (Balaji *et al.* 2012). Increased testing in each stage of product development result in a high-level risk analysis which is suitable for critical projects. Like in waterfall approach, in V-model also it is difficult to go back and make changes once product development has started. Moreover, this is a costly approach due to high level of testing involved.Thus, the traditional methodologies were set in their own ways and too full of inertia that they cannot respond quickly to changing environment (Erikson *et al.* 2005).

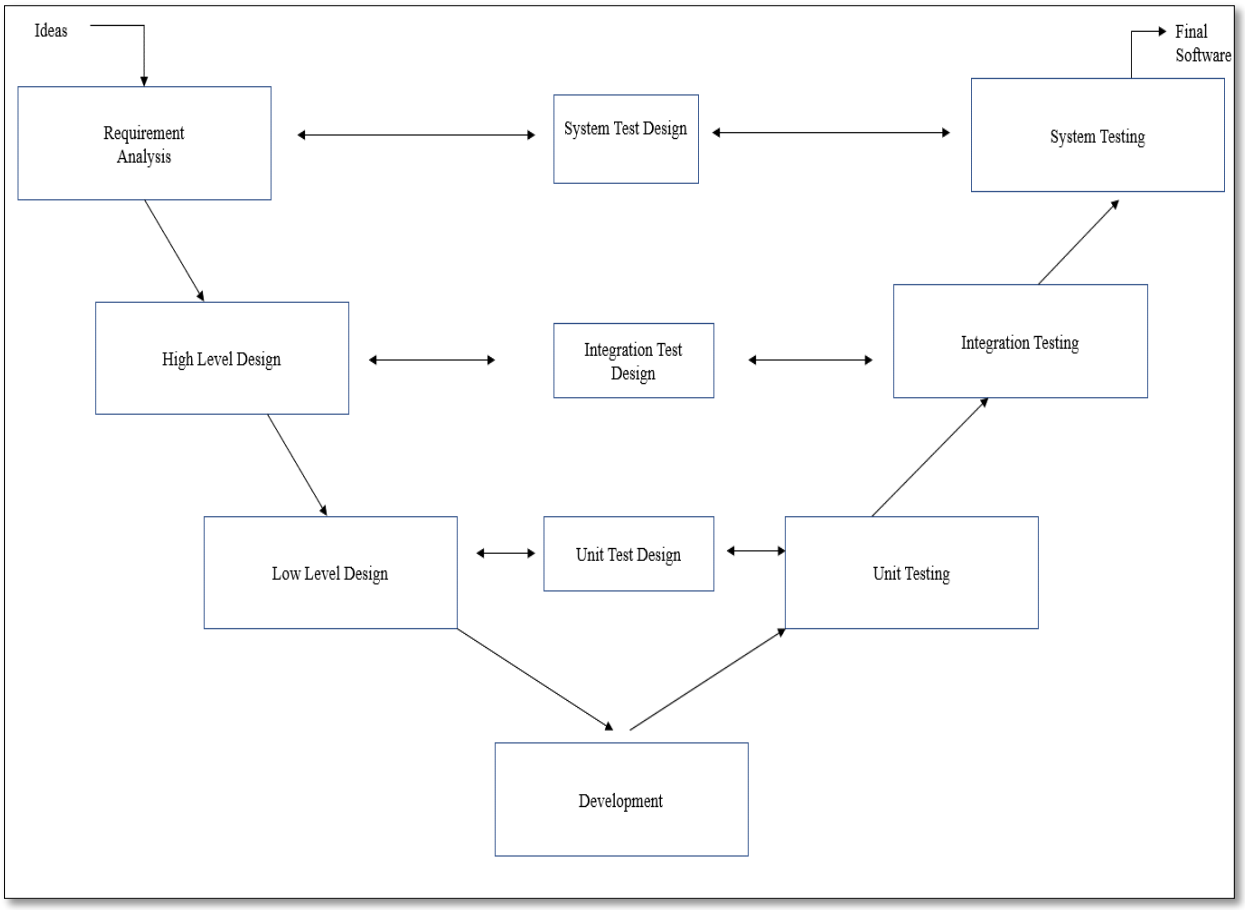

Figure 2. V-Model approach

Source: Balaji *et al.* 2012, 28

1.1.3 Agile: A modern approach to software project management

History of Agile Project Management : In 1990s, many software projects were taking too much time to finish due to the bottleneck in traditional approaches and this prompted the industry leaders to look for a new innovative method. Iterative approach was introduced to overcome the pitfalls in traditional approaches (Cohen *et al.* 2004). In early 2000s, a group of 17 software development enthusiast came together to discuss on methods to speed up the existing development process and reduce market entry time of finished product. Two key points were recognized to make this goal realistic (Lynn 2020).

1. Improve the product-market fit by decreasing the delay in delivery.
2. Receiving continuous feedback from clients to confirm whether the product meets their requirements and improve based on the feedback.

Core Values of Agile : According to Eschenbach *et al.* (2015), Agile methodology was introduced to software industry, as an improved way to manage software development projects. This methodology originated when the same 17 software development pioneers reconvened in early 2001 in Utah to create the 'Manifesto for Agile Development' or as commonly known as 'Agile Manifesto' (Beck *et al*. 2001).

Agile Manifesto laid out following key values (Beck *et al*. 2001):
"Individuals and interactions over processes and tools.
Working software over comprehensive documentation.
Customer collaboration over contract negotiation.
Responding to change over following a plan."

As software business environment is dynamic in nature, when there is a requirements change then the product needs to be adapted accordingly to meet this new environment. The agile methodologies promote quick response to changing requirement and project deadline which is inherent in software development process (Fowler *et al.* 2001),.

Definition and Features: Agile is an iterative approach for project management using which the development team can deliver value to end customer in an incremental manner and get feedback with every iteration (Atlassian 2021). According to Kumar (2019) each iteration will be a self-contained small scale Software Development Life Cycle (SDLC). As seen from Figure 3, although idea is conceived and planning is done in initial stage of this process; changes are made through constant feedback throughout the project (Saeeda *et al*. 2015). Due to its adaptive nature, project scope management is also much easier (Dora 2013).

Conboy (2009, 338) defined agility as " *the continual readiness… to rapidly or inherently create change, proactively or reactively embrace change, and learn from change, through its collective components and relationships with its environment*." Agility at its core removes heaviness that is most commonly seen in traditional methodologies and generates a quick response to changing requirements and environment; thus accelerating project deadline (Erikson *et al.* 2005). Meanwhile Qumer Gill *et al.* (2008, 505) characterises agility as a *"persistent behaviour or ability of a sensitive entity that exhibits flexibility to accommodate expected or unexpected changes rapidly, follows the shortest time span, uses economical, simple and quality instruments in a*

dynamic environment and applies updated prior knowledge and experience to learn from the internal and external environment."

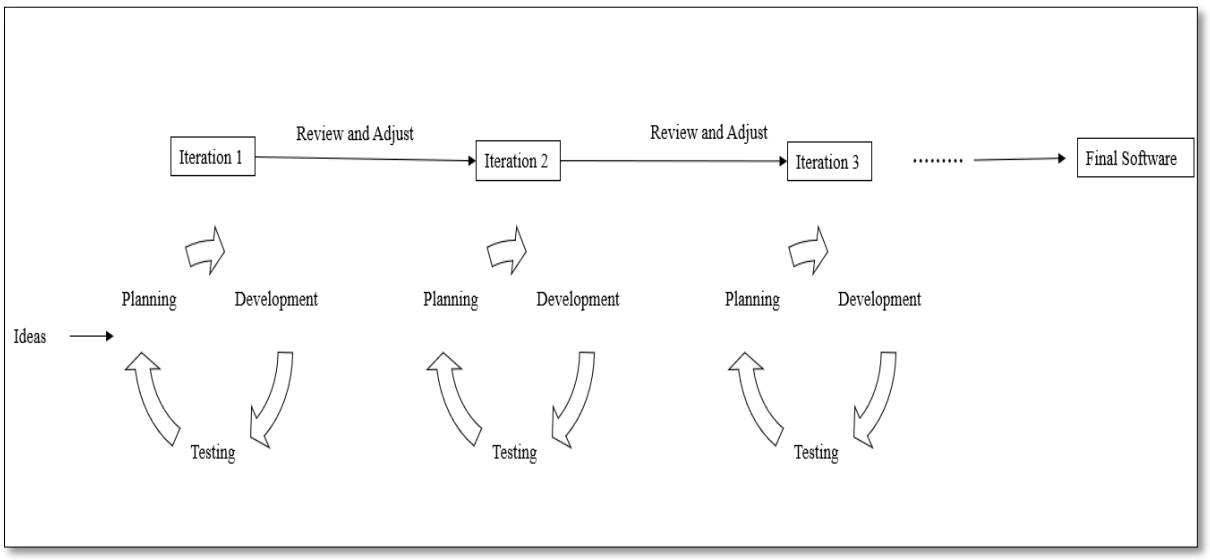

Figure 3. Agile Process
Source: Gurang *et al*. 2020, 34

Agile approach is to break down the large project into smaller chunks so as get them completed within the given time frame (Sarker *et al*. 2015). This has resulted in improved customer satisfaction and people relations, quality deliverables and considerable cost benefits including increase in the flexibility (Kumar *et al*. 2019). These benefits usually result in motivation to the development team (Moniruzzaman *et al*. 2013) leading to overall project success. According to Erikson *et al*. (2005), due to these advantages agile process created large waves with in the software industry.

Another major feature of agile methodology is its short implementation cycle, which falls usually between two to four weeks at the end of which a review of the work done so far is conducted by the customer (Beck *et al.* 2001). Thus, active inclusion of the end-user throughout the development cycle is ensured. It is easier to make modification to the product in between rather than when the entire product is completed. Hence, any change requests from customer that is received after review process are given the highest priority in the next cycle (Sharma *et al.* 2017). This methodology focuses on bringing value driven deliverables to the end-user facilitating more satisfying outcomes. In essence, agility conveys a 'light' methodology as it tends towards minimal formal process and embraces dexterity (Erickson *et al.* 2005).

1.1.4 Role of agile team in software industry

According to Dingsøyra *et al.* (2012), the core of agility lies with the self-organized and self-empowered software development team to create business value by delivering working software to users at regular short intervals. This self-motivated team which practises agile principles is known as an Agile Team. Agile team members are collaborative and their working pace should sustain their creativity and productivity (Dingsøyra *et al.* 2012). Agile Manifesto stresses that agile team should have an on-going communication and cooperation between its team members for alignment of project goals and common awareness of project status. Moreover, the agile team is guided by the agile principles to be flexible and rapidly respond to business changes (Serour *et al.* 2005). Agile team is responsible for delivering shippable product after every iteration and is usually made up of 3 to 9 cross-functional skilled people (Kataria *et al.* 2017*).*

Frameworks in agile methodology as described by Kumar *et al.* 2019 are AM (Agile Modeling), XP (Extreme Programming), SD (Scrum Development), DSDM (Dynamic Systems Development Method), ASD (Adaptive Software Development), Kanban, LSD (Lean Software Development), RAD (Rapid Application Development), AUP (Agile Unified Process) etc. One of the commonly practised method is Scrum Development and it is described as a versatile, holistic project management strategy (Habib 2013). The main activities of scrum team is depicted in Figure 4.

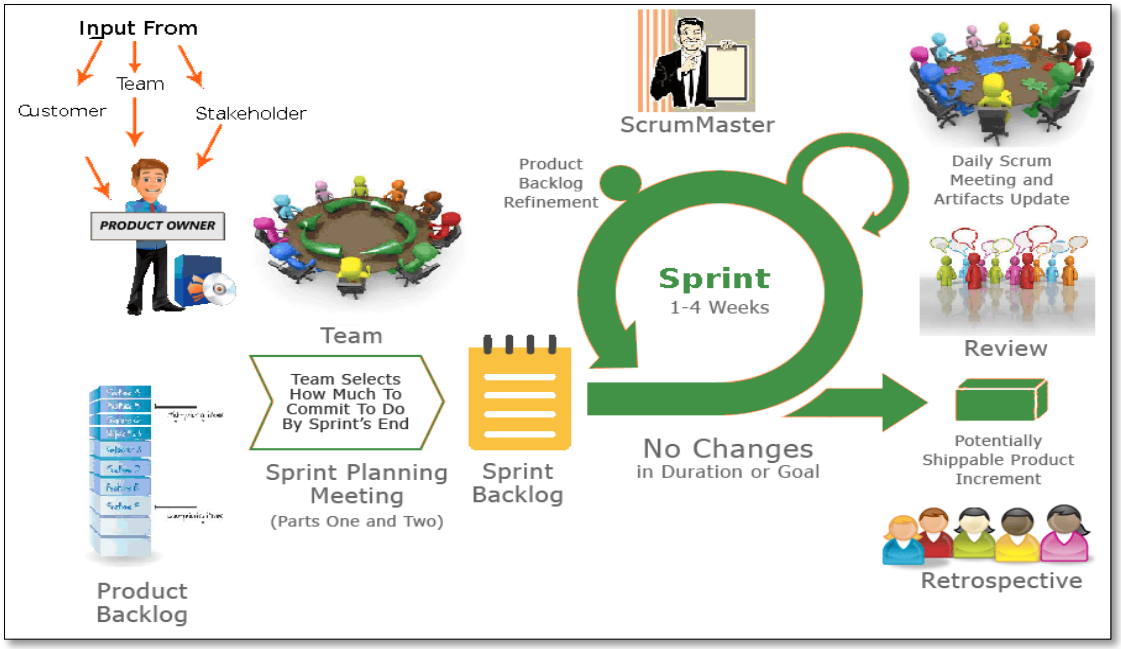

Figure 4. Agile Team and activities
Source: Kataria *et al*. 2017, 90

In a scrum, the agile team works as an unit to achieve team goals. The team consist of product owner, scrum master and development team. Product owner represent stakeholders and is accountable to ensure value to business; scrum master ensures the process is followed and is accountable to remove any blockage for the team's ability to deliver goal; development includes designers, developers and testers (Kataria *et al.* 2017). The team does its work in iterations (known as Sprint). Each sprint starts with a planning meeting to select the work needs to be done from a 'backlog list'; daily stand-up meetings are conducted among the team for status update. At the end of each sprint a potentially shippable product is given for review to product owner. Also, retrospective meeting is conducted at the end of each sprint to discuss on what went well, what did not go well and what could be improved.

By implementing in agile project management, the software industry has adopted a flexible method of product development. But higher management is always interested in keeping track of productivity as it is a mechanism to enhance organizational success (Hanaysha 2016). Hence, next section explores the importance of productivity and factors affecting productivity in software industry.

1.2 Importance of productivity

There are many existing studies on productivity but its definition still remains a controversial topic (Trendowicz *et al.* 2009; Symons *et al.* 2010). Performance, profitability, efficiency and effectiveness are few overlapping concepts and is often considered interchangeable with productivity. According to Melo *et al.* (2011), productivity is traditionally defined as the ratio of output (e.g., delivered product, implemented features) divided by input (e.g., time, effort).

The triple-P model by Tangen (2005) in Figure 5 depicts different levels with performance as the most outer level and productivity at its core. Productivity definition derived from Triple-P model says it is the capacity to produce quality output (i.e.; effectiveness) using the input resources at its full magnitude (efficiency). Another aspect of productivity is that its meaning may change based on perspective (Petersen 2011).

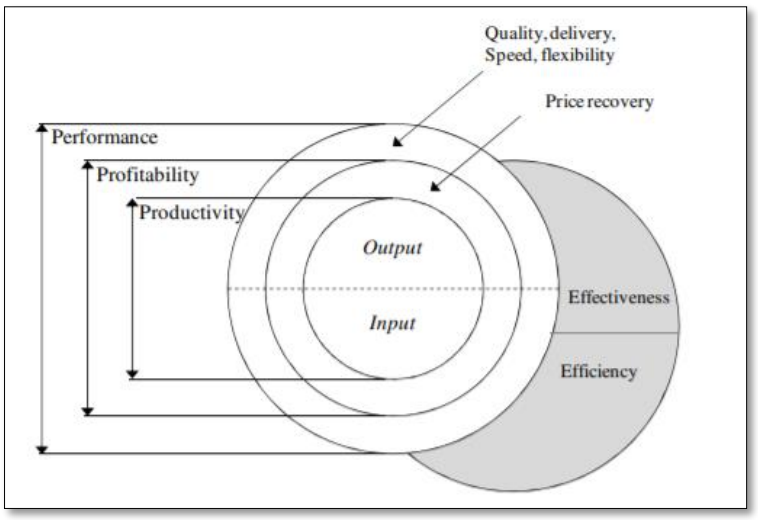

Figure 5. The triple P-model
Source: Tangen 2005, 43

1.2.1 Productivity of agile teams

Organizations use teams to carry out complex tasks as it is better to share the work load and the teamwork results in better chance of success. Software industry predominantly relies on teams to create quality product. As discussed in previous section one most commonly seen team structure in software industry is agile. The agile team consist of knowledge workers (Lindsjørn *et al.* 2016), but measuring individual worker productivity in this context is not so important as studying team productivity. According to studies done by Bosch-Sijtsema *et al.* (2009), individual productivity may not impact productivity of other individuals in the team. Hence, evaluating productivity of team is important to this study for understanding the team level success.

In his work, Iqbal *et al.* (2019) emphasises the importance of studying team productivity as it determines the overall project performance in an agile process. As high team productivity is a measure of project success; the industry is always on lookout for ways to improve it. Research has been done on how to improve productivity by analysing team practices and processes, tools being used etc. (Sudhakar *et al.* 2011). Since agile team is self-organized team, social dynamics also plays an important role in team productivity (Dingsøyr *et al.* 2012). Team members personality and their interactions were studied by Omar *et al.* (2015) for developing strategies to improve team productivity.

Traditional methods involved management expertise to improve team productivity. But, agile teams are self-managed teams and Lindsjørn *et al.* (2016) demonstrated that teamwork is very important in this context. Knowledge sharing through cooperative learning which in turn results in project success is the crux of agile team (Sharp *et al.* 2010). According to conclusion from Melo *et al*. (2011) agile team definition on productivity is based on timeliness, quantity, quality and customer satisfaction. On the same line, relationship between quality of work and team productivity was studied by Salas *et al.* (2005).

Moe *et al.* (2010) created team performance model to analyse teamwork in self-managing teams. Meanwhile, system dynamic model such as casual loop diagram was developed to analyse factors influencing productivity (Israt *et al.* 2018). Team perception was studied (Melo *et al.* 2011) to create the Input-Process-Output (IPO) to understand overall team productivity. Fatema *et al.* (2017) used factors influencing productivity to measure agile teamwork. Constructive Cost Model was used in his study by Boehm (2009) as a productivity measurement model and concluded that a software project is driven by teamwork.

1.2.2 Factors affecting agile team productivity

Existing research has identified that various controllable and uncontrollable factors affect agile team productivity (Melo *et al.* 2011). Petersen (2011) emphasised the need to study team productivity so that the agile teams can focus on these factors to improve their productivity. The below mentioned factors are identified based on existing literature survey.

Team effectiveness, team management, motivation and customer satisfaction were perceived as the main factors impacting agile team productivity (Fatema *et al.* 2017). Meanwhile, the same research concluded that lack of higher management support leads failure in agile team. Sakib *et al.* (2018) demonstrated that main influencing factors are motivation, team effectiveness (communication, coordination, mutual trust, leadership) and team management (team composition, staffing). Some of these factors are a function of time as requirement changes during the development cycle. The empirical study done on Trendowicz *et al.* (2009); Wagne (2008); Sampaio et al. (2010) and Melo *et al.* (2011) shows that product, process, project and personnel factors influence team productivity.

Product factors: The factors involved here are related to character of the software product the team is working on. Software can be characterised by platform, design, requirements, code, size, etc.

Reuse of software product code and artifacts positively impacts the productivity of team as this reduces entry time to market. Product characteristics such as well-planned architectural design will result in quality software and tends to increase productivity (Tan *et al.* 2009).

Personnel factors: This involves experience and capability of human resources within the agile team. Motivation is one of the pivotal factors in productivity as described by Sharp *et al.* (2009). Without motivation to be dedicated to the team, the productivity will be decreased. Experience and skills are another personnel characteristic that impact productivity. A knowledge worker experienced in their respective domain is an irreplaceable asset of agile team.

Project factors: This includes informal aspects such as team communication, coordination, schedule, team composition, size etc. It is proven that high informal communication among team members and stakeholders improves productivity(Trendowicz *et al.* 2009);. Earlier studies have shown that face to face communication is more effective than remote work in complex long-term projects (Carey *et al.* 1997). Resource constraints decreases productivity as this put more work load on existing team members. Team size is another critical factor as studies has shown that in very large teams proper communication network is critical for productivity.

Process factors: This includes methodologies, practices, tools, customer participation, adaption of proper programming language, documentation etc. By following proper practises and methodologies, waste and rework can be avoided in product development. This can in turn positively impact productivity. Customer involvement in project development can improve team productivity due to feedbacks. Another key factors is to frequently integrate of component to build a software system. Also, documenting the knowledge bythe team for future reference is important (MacCormack *et al.* 2003).

1.2.3 Measurement of agile team productivity

The productivity measurement approaches as identified by Petersen (2011) are weighted productivity factors, simple input/output ratios, data envelopment analysis, Bayesian belief networks, earned value analysis, statistical process control, balanced scorecard and metric space. Some other popular basic productivity metrics are Lines of Codes (LOC) per hour and Function points per hour (Tangen 2005). But these metrics are unstable in face of different coding languages and various projects. Moreover, the prior mentioned metric fit the traditional methodologies.

For measuring agile team productivity there is no universally accepted methods, but it has been studied using various productivity dimensions. According to Shankarmani *et al.* (2012), agility is a value-based approach as it make use of lightweight process to increase the the business value. Thus it can be argued that value produced by the product is a way to measure productivity of teams. Another metric for team productivity measurement as pointed by Fowler (2003) is Return of Investment (ROI) for the delivered product.

Most recent study done by Melo (2015) summarized agile productivity metrics and classified them based on agile dimensions namely- quality, value, leanness, efficiency and speed. Quality of software product can be measured through defect count and fault-slip-through. Customer satisfaction and business value delivered are indicator of value dimension. Shorter and stable lead time can improve workflow and can result in leanness. Lead time is *"the amount of time that passed from a request to fulfilling the request"* Budacu (2018, 71). Eliminating waste can increase efficiency which directly result in increase of productivity. Velocity is the metric that is used to measure speed of delivery and is defined as the amount of working product delivered in an iteration Budacu (2018).

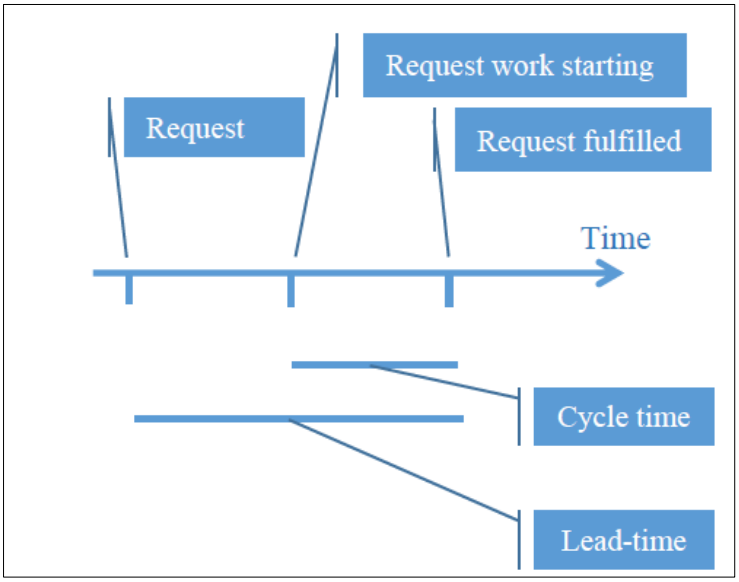

Figure 6. Lead-time and cycle-time
Source: Budacu 2018, 71

Miranda *et al.* (2010) stated the need to analyse the work progress using an indicator called Line of Balance (LOB) which will shed light into what is going inside the project team work. Fatema (2018) used 38 factors chosen from existing literature to analyse the agile team work productivity

by using dynamic strategical model. Study by Budacu (2018) used three key metrics – velocity, lead time and cycle time for measuring team performance.

The existing studies on productivity presented in above sections were done in face-to-face team working in office environment. Currently, world is facing pandemic which throws new factors into the mix. Hence, there is a need to study agile team and its productivity during corona crisis.

1.3 Outbreak of COVID-19 pandemic

The COVID-19 pandemic started at the end of 2019 and the world was thrown into crisis to the like of which there are no parallel in the immediate past. The COVID-19 was first reported in a in the city of Wuhan located in Chin and the disease spread to global level in the first 3 months of 2020 at a rapid speed. The disease caused by the presence of coronavirus (SARS-CoV-2) within the human body. People get infected when coming in unprotected contact with an infector as the disease is spread through human respiratory droplets and fomites (WHO 2020). The symptoms of this disease range from being asymptomatic to severe pneumonia leading to death (Filho *et al.* 2020).

To safeguard the health and safety of its citizens, government across the world has issued restrictive measures, social distancing and lockdown. This has considerably affected both normal population lives and industrial operations (Zuniawan *et al.* 2020). Although, vaccine is now available (Forni *et al.* 2021), the pandemic has already claimed more than 2 million lives (Worldometers 2021). In this situation, various sectors are facing economic crisis and a result of business disruption many companies were forced to terminate a percentage of their workforce (Zuniawan *et al.* 2020). The pandemic has impacted the operations of manufacturing and supply chain industry (Sodhi 2020; Chowdary *et al*. 2020), schools, universities and research (Mekonnen *et al.* 2020), stock market (He *et al.* 2020). Travel restrictions and lockdown has diminished the direct interactions with clients which has negatively impacted business development opportunities.

1.3.1 Effect of pandemic on software industry

There is no parallel to draw on COVID-19 pandemic in near history. But, if one look at a broader picture, then Global Financial Crisis (GFC) of 2008 was the last world-wide crisis that IT industry faced. After GFC, growth rate in software industry has been slow compared to pre-crisis years

(Lakshmi Thanka *et al.* 2013). Neverthless, the software industry has seen some growth in the recent years resulting in economic development (OECD 2004) as well as new start-up activities (Sapprasert 2007). COVID-19 pandemic unexpectedly changed the existing predictions on this industry as it introduced various fast-moving unknown variables into the mix (Statista 2020). While many established IT firms seem to be able to cope (Braithwaite 2020), some of the start-ups seems to be struggling (Chandna 2020). Moreover, this sector has impact on other sectors as a provider of product and services (Kenneth, I.S. 1996; Pagès *et al.* 2009).

In face of COVID-19 pandemic, the software industry is challenged with some new issues. There has been a slowdown in IT recruitment and future workforce has take a hit. Meanwhile, the increase in remote working culture has accelerated the cybersecurity risks (Kazilbash 2020). Another aspect for rising concern is the psychological wellbeing of employees and team communication due to isolation (Whiting 2020). Advancement in digital transformation technologies in the past decade, such as cloud computing, improved 5G connectivity, collaboration softwares such as zoom, Microsoft teams has kept this organizational level changes in software industry very cost effective (Newman 2020). According to IDC data during pre-pandemic situation the software industry was estimated to be at $8 billion. IDC data analytics has predicted a decrease in consumer markets but an increase in corporate customers due to pandemic. A breakdown of challenges and concerns in software industry is illustrated in Figure 7.

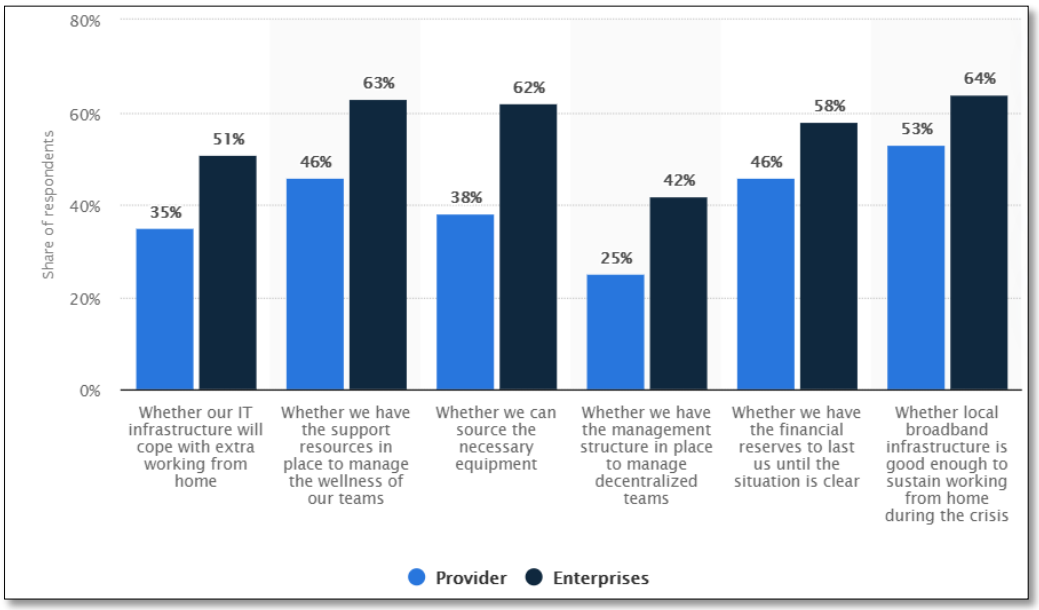

Figure 7. COVID-19 challenges/concerns of software industry worldwide
Source: Statista, 2020

1.3.2 Growing work from home culture

There have been many disruptions caused by COVID-19 pandemic and one of the forerunners among these are increased work from home (WFH) culture. This change is clearly evident in U.S economy as the share of work force working from home reached a staggering 42 percentage (Bloom 2020) during lockdown. As 2020 redefined the working culture, many organizations had to evolve to meet their employee needs such as mental wellbeing, psycho-social support and community support (Sahni 2020). Studies showed that about 37 percent of jobs in the United States can be carried out entirely from home and has a pay scale more than jobs that cannot be done at home (Dingel *et al.* 2020). Workers who could do high share of task from home are less likely to lose their job due to the economic crisis resulted due to pandemic (Adams-Prassl *et al.* 2020). Work from home helps employee to have better work-life balance with less stress as it saves commuting time leading to more personal time. Survey conducted by Al-Marzooqi *et al.* (2020) highlighted that productivity was lower for employees who started work from home practises only after spread of pandemic. Meanwhile, the survey also found that for highly educated, high wage employees and long distance commutates productivity remained the same or increased during work from home. The pandemic has also affected academic activities of educational institutions as teachers resorted to online classes and webinars (Mekonnen *et al.* 2020).

Work from home culture in software industry context means that an employee is not present physically at office but working from a remote location and carrying out all necessary duties through virtual means. Many major software companies such as Microsoft, Facebook, Google, Twitter etc are already planning to continue the remote working trend beyond pandemic (Nickelsburg 2020). According to internal survey conducted by organizations such as Cisco and Chegg, the individual productivity has been just as good or has gone higher during remote working period of pandemic(Gelles 2020).

Despite offering insights into the present field of study, the author could not fail to notice that the existing literature has been associated with gap. While there are many potential impacts of pandemic, there is lack of evidence on organizational teams during this period. As many organizations are supporting work from home culture in the immediate future, it is very critical to analyse its effect on team through teamwork, team productivity and team members success. Team productivity is already discussed in previous section. Following sections will explore teamwork and team member success when teams are working from home.

1.3.3 Quality of virtual teamwork

When employees were forced to work from home during COVID-19 lockdown, the agile teams had to work virtually. According to Robotham (2008, 53), "*Virtual teams are groups of people who work interdependently with shared purpose across space, time and organisation boundaries using technology to communicate and collaborate*". Internet has helped in creating opportunities for collaboration and shrinking the distance barrier between team members. Virtual team work has the potential to surpass traditional face-to-face teams if properly managed (Bhat *et al.* 2017). According to Pangil *et al.* 2014 the advantages of virtual team are many such as to hire the best employees from anywhere in the world, to provides more flexibility in corporate activity and to increase global working hours 8 hours to 24 hours. Next, the author will analyse major characteristics to measure virtual team work quality according to existing literature.

Communication: This is one of the crucial factors affecting virtual team. Informal face-to face communication during meetings or coffee talks that happens in office have direct effect on collaboration with in team (Morrison-Smith *et al.* 2019). But when team members are distributed due to geographic distance, there are high chances of communication turning more formal or through text-based chats. According to Indsjørn *et al.* (2016), frequency of communication that occurs between team members and spontaneity of this communication is essential for information sharing. In an office, agile team members are situated closely to facilitate this open communication. But in virtual team, communication it is difficult to get an awareness of colleagues and their context (Morrison-Smith *et al.* 2019).

Technological Support: Technology is the key enabler for working of virtual team members. Proper technical infrastructure is crucial for work continuity during work from home. Moreover, high quality internet connectivity is needed to keep the communication channel open within the team. Thus, technical competence of team members is essential to overcome challenges in virtual team. Stable technologies and technical support are needed while working from home (Morrison-Smith *et al.* 2019).

Trust: Gambetta (2000, 218) defines trust as a *"particular level of the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action".* Trust that geographically dispersed team members will work towards achieving the team goals is imperative for collaboration and providing team motivation. Trust is a crucial factor when coming

to knowledge sharing or during intra-team conflict management (Pangil *et al*. 2014). Trust within virtual teams is more difficult to establish due to less face-to-face interactions, time and cultural differences (Watson-Manheim *et al.* 2007).

Cohesion: Another critical characteristic for virtual team effectiveness is cohesion. The literature defines team cohesion as a multidimensional construct in which team members stick together and pursue a common goal (Salas *et al.* 2015). Team cohesion is very important in agile methodology, as team members and their interactions are valued over process and tools (Indsjørn *et al.* 2016). Team spirit is a major motivator for team cohesion. This collective team culture wherein each team member is invested in overall team work quality through team activities is a boost to team spirit (Whitworth *et al.* 2007).

The study is not complete if success factors of team members are not analysed when studying a team. Hence, in the next section the author will outline the factors affecting team member sucess.

1.3.4 Factors affecting team member success

Previous studies has shown that there many project success factors. Customer satisfaction, project mission, problem-solving, top management support are few among them (Müller et al. 2012). But recent studies have shown that human resource in a team are imperative for project success (Anantatmula et al. 2013). Software industry has a dynamic and innovative business environment. This has motivated many software firm to adopt agile project management with focus on self-management within the team. Hence, when team members are happy the team is a happy place which can essentially lead to project success. Next, the author will analyse major characteristics for team member success according to existing literature.

Work Satisfaction: Hoegl *et al.* (2001) identified that when there is job satisfaction among team members they will be more interested in contribution to the team. This is essential for any project to succeed. IPO model by Körner *et al.* (2015) considers teamwork as a process factor which will ultimately lead to team member satisfaction. Moreover, higher managment support is necessary for any teamwork to be effective and generate satisfaction among its members (Griffin *et al.* 2001).

Learning: It is important for knowledge workers to aquire work related information for their project success. According Edmondson *et al.* (2006) learning is necessary to develop necessary skills of team members. This will ultimately make the team a better place to work. Moreover,

collaborative learning has been theorized in creating a shared cognition within the team (Bossche *et al.* 2006).

Based on above discussion a modified conceptual model is developed in next section so that higher management can analyse the agile team working in virtual environment.

1.4 Conceptual Framework and Hypothesis

Teamwork quality (TWQ) model by Hoegl *et al.* (2001) is one of the most empirically tested models which investigates the effect of teamwork quality on team productivity and team member success. Hoegl *et al.* concluded that a positive relationship between said variables and predicted these factors are essential for project success. While discussing their results Hoehgl *et al.* (2001) also suggested adding other relevant factors in TWQ model according to the context. Hence for answering RQ1 and RQ2 in current research, the author has used the help of Hoegl's model along with few constructs specific to virtual agile team discussed in sections 1.2.3, 1.3.3 and 1.3.4 to develop a modified conceptual model as shown in Figure 8.

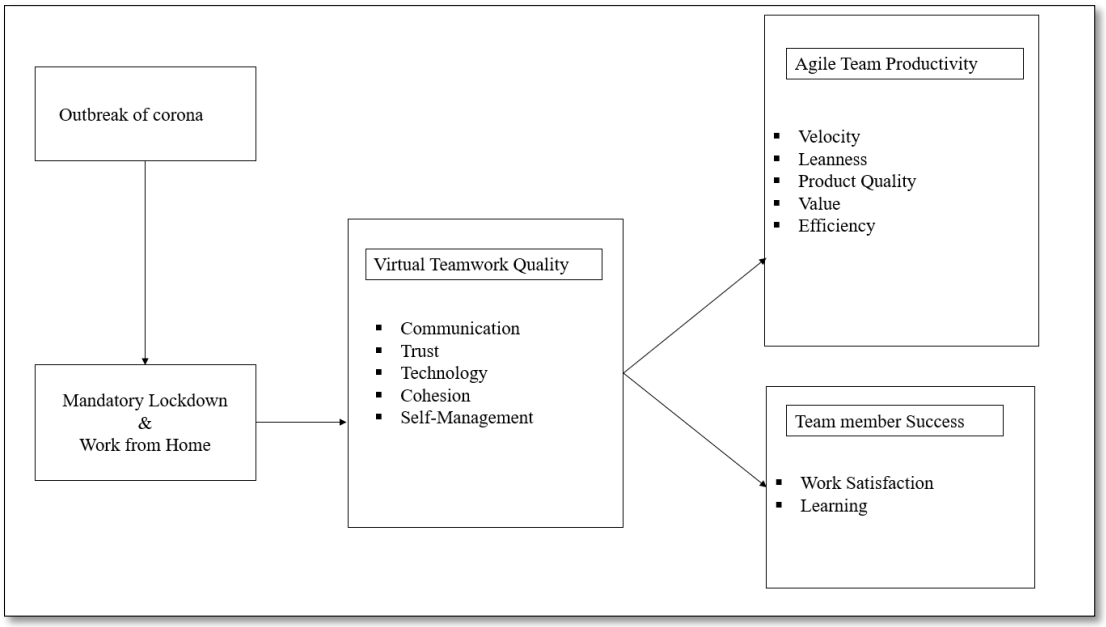

Figure 8. Conceptual Framework

Source: Own creation based on TWQ model by Hoegl *et al.* 2001

Based on above discussion, following hypothesis are framed for analysing RQ1 and RQ2.

1. Virtual teamwork quality has a positive effect on agile team productivity.
2. Virtual teamwork quality has a positive effect on agile team member success.

2. RESEARCH METHODOLOGY

The second chapter gives an overview on the research methodologies used to reach research aim. Research methodology is highly relevant in any research work as it outlines research methods, logic behind choosing a particular technique in the context of study so that research results can be analysed by researcher or by others (Kothari, 2004). To ensure correct outcome of this study, suitable data analysis methods are selected using research onion design.

2.1 Research Design

This study uses research onion approach (Saunders *et al.* 2007) to design the research methodology. This approach consists of six layers and is useful in making holistic decisions about the research. Below section discuss each layer of research onion and the justification on choosing a particular approach.

2.1.1 Research Philosophy

Research philosophy is the outermost layer and is the foundation of any research study as it contains assumptions or beliefs about the way a researcher sees the world (Saunders *et al.* 2007). There are mainly 3 assumptions epistemology, axiology and ontology. This present study uses epistemology and this philosophy is backed by the conclusions derived by Aliyu *et al.* (2015). Epistemology paradigm is based on our assumptions about knowing and nature of this knowledge. Due to its law-like generalizations and casual explanation (Saunders *et al.* 2016) epistemology is most suited in current study. In line with this, this author selects positivism as the philosophical foundation of this study. Positivism provides independent generalization for a situation and period as it is based on data which is devoid of human bias (Saunders *et al.* 2016). Also, this study is based on collecting data through survey process. Hence, positivism is the most appropriate theory.

2.1.2 Research Approach

The next layer of research onion helps the researcher to start their work act as guide for selecting research methods. Deduction, induction and abduction are three different research approaches

(Saunders *et al.* 2016). This study plans to arrive at the conclusion through deductive inference. In deductive approach, a hypothesis or premise is put forward to form a theory. This theory is tested through appropriate data so as to analyse the consistency of the theory (Saunders et al. 2016).

2.1.3 Research Strategy

Research strategy will enable the researcher to find answer to the research questions and be successful in reaching the research aim. The choice of research strategy is usually guided by the formulated research question, time, resources and knowledge (Saunders *et al.* 2007). There are many strategies such as experiment, survey, case study, action research, grounded theory etc. The current research will use survey method in order to gather data through questionnaires.

2.1.4 Choice of Method

The next layer is research method which is concerned with the characteristics of data collected by researcher so as to reach the research objectives (Gratton *et al.* 2010). This are of two types – qualitative and quantitative. This study will use mono-approach with quantitative data. Quantitative methods are effective in determining the association between independent and dependent variables (Saunders *et al.* 2007). According to Gratton *et al.* (2010), quantitative approach involves use of numeric measurement and its analysis. Also, in this method the result is presented in a mathematical manner which is suitable for this survey-based study.

2.1.5 Time Horizon

This study is of cross-sectional nature as the planning and evaluation of this study was done with limited time and resources. According to Saunders *et al.* (2007), cross-sectional study is suitable when using survey strategy. This study is done on software industry at a particular time frame.

2.1.6 Techniques and Procedures

This is the inner most layer which essentially deals with data collection and its analysis. Below section will describe the population, sampling, data source, data collection, data analysis and statistical techniques used in this study.

Population: Population of interest is the target group a research intends to study (Majid 2018). The target population of this study is agile teams of software industry. However, it is not feasible to study whole population due to its large size. Hence sampling is necessary.

Sampling: It is the process of selecting statistically representative data from the whole population of interest (Majid 2018). According to Broeck *et al.* (2013), a research usually conducts study on data samples and then generalize the study findings to the population of interest. There are two sampling techniques namely, probability and non-probability sampling based on whether each member of the population does/does not have a known probability for being selected for study (Bhardwaj 2019). This study is based on non-probability sampling. Quota sampling is a subset of non-probability sampling wherein the members of the sample are selected based on some specific criteria (Bhardwaj 2019). The criteria for participating in the current study was that the respondent should be a part of agile team in a software company. The survey description of this research informs the reader to participate only if they are working in software industry. Also, one of the questions in the survey is to identify whether the participant is a member of agile team. This has enabled the author to remove any alien data.

Data Source: This study used two types of data sources namely primary and secondary. Primary data involves collecting data directly from population of interest so as to answer the research questions meanwhile secondary data are the data which has been already collected by others (Gratton *et al.* 2010). The primary data was used to find answer to RQ1 and RQ2. Both of these questions are about virtual team during COVID-19 situation. There is very less or essentially no empirical evidence available in said context as pandemic condition is fairly new. Hence, collecting data from people facing these phenomena was best possible approach to make valid conclusions. According to Gratton *et al.* (2010), secondary data saves time and effort as it can sometimes provide answer to the research question. To answer RQ3, there was a need for secondary sources as the factors affecting agile team productivity were identified through an empirical study. Subsequently, the survey respondents were required to grade the importance of these factors during COVID-19. In this research, secondary data was collected from various reputed articles, reports and journals accessed through online databases.

Data Collection: This study collected primary data through survey process which was distributed electronically through google forms. The respondents were recruited with the help of this authors past and current colleagues in software industry. Before conducting this survey, the details of this initiative were informed to the said group and their team mates. After getting their approval, the questionnaire was distributed among the team through Facebook, LinkedIn and WhatsApp. Each team was provided with a unique team identification number so that team member response could

be collocated correctly. A total of 30 teams participated from 17 firms geographically spread accross 5 countries – India, Estonia, USA, Canada and Ireland. The name of the organization and respondents are kept confidential due to privacy reasons. The companies participated in this study was from diverse application domain such as finance, cybersecurity, mobile, service providers, travel, education etc. They also varied in size from start-up to large multinational companies.

The structured questionnaire included both open-ended and close-ended questions. The instrument used Likert scale to measure the dimensions of independent and dependent variables. For each statement on these variables, the respondent was request to select their level of agreement from 1(strongly disagree) to 5 (strongly agree). The survey consisted of five sections. The first section was general information regarding the survey and privacy notifications. The second section was to collect demographic data of the participant which included both demographic questions and organizational/ agile project level questions. The next section measured virtual team work quality through 20 questions on communication, trust, technology, cohesion and self-management. The fourth section was to study the team member success through 9 questions on work satisfaction and learning. The last section was on agile team productivity and a total of 5 metrics were used to measure it. To study the agile teams perception on factors affecting their team's productivity 10 factors identified from the literature were given to grade on scale of 1 (least important) to 3 (highly important).

Data Analysis: Data analysis involves systematic use of statistical techniques on the data so as to evaluate its statistical inclination and reach a meaningful conclusion (Rosenthal *et al.* 2008). This study used primary data downloaded from google survey in excel format. The raw primary data then underwent statistical analysis with the help of tools such as Microsoft Excel. This helped the author to get information in valuable form which could be represented in tables, charts and graphs (Rosenthal *et al.* 2008).

Statistical Techniques: Basic statistical measures such as frequency, percentage, proportion are used to analyse the demographic profile of respondents. Descriptive statistics is used to summarise the collected data sample. In this study, the independent variable is virtual teamwork quality; dependent variables are agile team productivity and team member success. As few research questions are related to finding the effect of independent variable on dependent variables, this study will use correlation and regression analysis to reach a conclusion. Correlation analysis is

used to measure the association between independent and dependent variables. Meanwhile, regression analysis is done to determine the strength of the relationship between the variable.

2.2 Ethical considerations

Ethical considerations might come up in any stages of business research may it be planning, data collection or presenting the report (Saunders *et al.* 2007). This study relayed on data collected from software firm employees and has taken following ethical norms into consideration.

Informed Consent is obtained from the participants before conducting the survey. The objectives and the purpose of the study was informed to them before starting the survey to ensure voluntary and informed participation (Bell *et al.* 2007).

Confidentiality was maintained while conducting the study as identity of the participants was not asked to ensure their anonymity. Thus, privacy of the participants was maintained. Moreover, questions were framed such that that no harm will fall on the participant in terms of dignity or future opportunities (Bell *et al.* 2007). Confidential nature of the study also guaranteed to remove any psychological stress on the participant.

Data Protection has been maintained as the collected data is strictly used for the current study and will not shared with any third party (Ducato 2020).

2.3 Developing constructs for evaluation

As discussed in prior chapter, the aim of this dissertation is to study effect of COVID-19 lockdown on agile teams. To reach this aim, the study will analyse work from home scenario during lockdown in agile teams of software companies. For this the relationship between selected variables such as virtual team work quality, team productivty and team member success during mandatory lockdown of COVID-19 is studied. RQ1 and RQ2 are framed to address aforementioned aim. A conceptual model based on Hoehgl *et al.* (2001) teamwork quality (TWQ) model is used in this study to investigates below two research questions.

1. *What is the effect of virtual teamwork quality on productivity of agile teams during COVID-19 lockdown?*
2. *What is the effect of virtual teamwork quality on agile team members success during COVID-19 lockdown?*

Virtual Teamwork Quality: Communication is crucial as collaboration within virtual team happens through seamless information exchange (Indsjørn *et al.* 2016, Hoegl *et al.* 2001). The next factor Trust is important in any geographically dispersed team for motivation, knowledge sharing and conflict management (Pangil *et al.* 2014, Watson-Manheim *et al.* 2007). Another key enabler in a virtual team is technology which is taken as the third construct in the conceptual framework (Morrison-Smith *et al.* 2019). Virtual team effectiveness is realised through a multidimension construct known as cohesion (Salas *et al.* 2015). The last construct self-management is one of the core values of agile teams (Melo *et al*. 2015).

Agile Team Productivity: To measure the agile team productivity the author uses the metrics proposed by Melo *et al*. (2015) and Hoehgl *et al*. (2001) namely velocity, leanness, quality, value and efficiency. These metrics were discussed in detail in chapter 1.

Team member success: For analysing team member success, the same constructs used in Hoegl model are used i.e.; work satisfaction and learning.

For realising the RQ3 - *According to the perception of agile team members, which of the identified factor/factors derived from empirical study are mainly affecting their team productivity during working from home*, major factors were identified from existing literature. Chow *et al.* (2007) proposed that organizational factors such as organizational environment and team environment are critical in agile team success. The study also points out that technical factors such as standard coding practices, availability of proper technical tools and providing appropriate technical training to the team are necessary to improve agile team productivity. Personnel factors such as team capability is needed so that team has the necessary domain experience in reaching the team goals (Melo *et al.* 2011, Trendowicz *et al.* 2009). Psychological well-being was added by the author to the personal factor section as the team is working in a crisis situation. This factor is important because a positive outlook by team members is critical in project success. Project factors involves management aspects such as team composition and project schedule (Melo *et al*. 2011, Chow *et al.* 2007). Meanwhile, Process factors encompass customer involvement (Trendowicz *et al.* 2009)

and following agile oriented project management process (Chow *et al.* 2007). Comprehensive details on these factors are already covered in chapter 1. A summary of factors affecting agile team productivity is given in table 1.

Table 1. Team productivity factors derived from empirical studies

Productivity factors	**Constructs**	**Author**
Organizational factors	Organizational environment, Team environment	Chow *et al.* 2007
Technical factors	Technical tools	Chow *et al.* 2007
Personnel factors	Team capability, Psychological well-being	Melo *et al.* 2011 Trendowicz *et al.* 2009
Project factors	Team composition, Project Schedule	Chow et al. 2007
Process factors	Customer involvement, Project Management process	Chow *et al*. 2007 Trendowicz *et al.* 2009

Source: Own Creation

2.4 Profile of participants

The survey collected data from 30 different teams and there were 127 participants. The study rejected any data from respondents who were not working from home during COVID-19 lockdown (total =1) and who were not a part of an agile team (total =8). The author was able to find this alien data through questions 5 and 6 of survey questionnaire given in Appendix 1. Another criterion for data sampling which is based on traditional survey criterion among teams (Lindsjørn *et al.* 2016, Hoehgl *et al.* 2001) is that at least 3 members from a team must participate in the survey. In present study, two teams did not meet this criterion and hence the data from these teams was rejected for analysis. Taking into consideration above details, data analysis was done on 28 teams with a total of 114 participants.

2.4.1 Demographic profile: Team members

Basic statistical analytical method such as frequency distribution and percentage were used to characterise the profile of respondents. Table 2 shows the summery of this data followed by Figure 9 which depicts frequency distribution.

Age: The majority of the respondents (93%) participated in the survey fall in the 25 to 35 years age group. The rest of the age groups have only less than 5% of representation in the survey.

Gender: The study has used almost equal gender representation. Both male and female group are about 50% and hence no gender-based discrimination was shown in this study.

Table 2. Frequency distribution of demographic profile of team members

Particulars		**Frequency**	**Percentage**
Age	Less than 25 years	2	1.8
	25 to 35 years	106	93.0
	36 to 45 years	5	4.4
	Above 45 years	1	0.9
Gender	Male	59	51.8
	Female	55	48.2
Designation	Team Lead	22	19.3
	Product Owner	8	7.0
	Developer	41	36.0
	Tester	39	34.2
	Business Analyst	1	0.9
	Others	3	2.6
Agile Experience	Less than 6 months	3	2.6
	6 to 12 months	13	11.4
	1 to 3 years	27	23.7
	Above 3 years	71	62.3
Total		114	100.0

Source: Own calculation

Designation: The study used the response from team members who are performing variety of roles. Out of 114 respondents, the majority of the partcicipants either work as developer (36%) or tester (34%). There is also quite good representation for major decision makers such as team lead and

product owners. Business Analyst and other miscellaneous roles have less representation in the study as they are 0.9 percent and 2.6 percent respectively.

Agile experience: Majority of the respondents of the survey had high level of experience in working for agile projects. Only about 3% of respondents have low agile experience of 6 months or less.

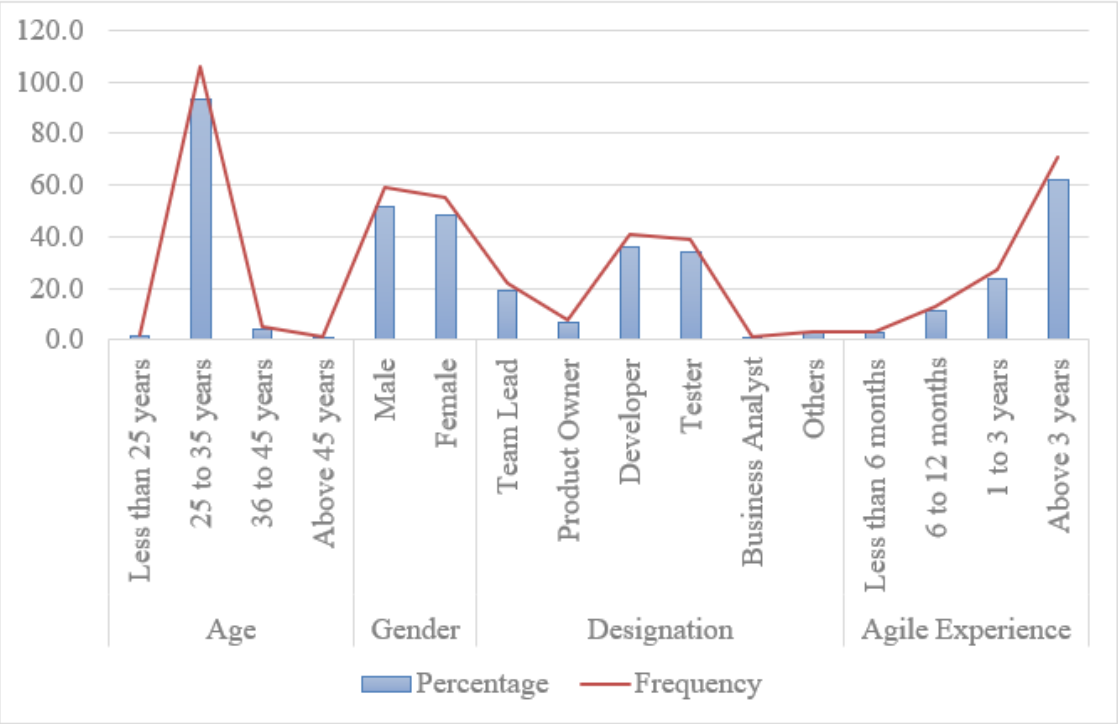

Figure 9. Demographic Profile of team members
Source: Own Creation

2.4.2 Organizational profile: Team and team members

The study used data from 28 teams from 15 different organizations with geographical dispersion of 5 countries – Canada, Estonia, India, Ireland and United States of America. Table 3 shows the summery of organization level data.

Country: India has the highest representation in the survey with about 60% followed by Estonia with about 30%. Meanwhile from Canada, United States of America and Ireland only single team each participated. Hence, it is evident that main data source originated from India and Estonia.

Domain: Majority of the respondents works in financial domain with a strength of 25.4 percentage. Other main domains which participated in the survey are cybersecurity, conculting/services and mobile. Software companies building products for healthcare, travel, education sectors also participated in the survey.

Table 3. Frequency distribution of organizational profile

Particulars		**Frequency (Respondent)**	**Percent**	**Frequency (Team)**	**Percent**
Country	Canada	4	3.5	1	3.6
	Estonia	35	30.7	8	28.6
	India	68	59.6	17	60.7
	Ireland	3	2.6	1	3.6
	United States of America	4	3.5	1	3.6
Domain	Consulting/Services	8	7.0	2	7.1
	Cybersecurity	9	7.9	3	10.7
	Education	4	3.5	1	3.6
	Financial	29	25.4	7	25.0
	Healthcare	6	5.3	2	7.1
	Mobile	11	9.6	3	10.7
	Others	39	34.2	8	28.6
	Travel	8	7.0	2	7.1
Total		114	100.0	28	100.0

Source: Own calculation

3. RESULTS

To address the research questions the study collected data from primary data source through survey. This chapter of this project deals with the analysis of the collected survey data. According to Saunders *et al.* (2007) data analysis is necessary in any research so as to turn raw data into summarized result. This is possible as the researcher finds pattern and themes in collected data through data analysis (LeCompte *et al.* 1999). This pattern will then lead the researcher to further interpretations and give ideas for future research opportunities.

3.1 Analysis of team-level variables

As only agile teams are chosen for this study, when the terminology "team" if used henceforth will implicitly mean agile team. This section will analyse the team level variables used in this research which are Virtual teamwork quality and Team productivity. For each statement on these variables, the respondent was requested to select their level of agreement from 1(strongly disagree) to 5 (strongly agree). The unit of current analysis is team itself not an individual. Thus, an aggregated team member response must be used for analysis. This is necessary to get a reliable team level measurement and to avoid potential bias (Maruping *et al.* 2008). Hence, this study uses arithmetic means of the response of members is considered as the value of the team. This method was implemented based on the traditional team survey procedure followed in Hoehgl *et al.* 2001; Maruping *et al.* 2008.

3.1.1 Descriptive statistics of virtual teamwork quality during COVID-19 lockdown

Virtual teamwork quality in a team is represented by the arithmetic mean of its individual particulars – communication, trust, technology, cohesion and self-management. Table 4 shows the summary of the data obtained.

Communication: This construct used 4 questions on frequency of communication, spontaneity of communication, information sharing and coordination within team during COVID-19. The mean value ranged between 3.43 to 3.78. The graph shows that spontaneity of communication has not increased within team during COVID-19 lockdown. This may be because of geographical dispersion of the team. Meanwhile, team related information is shared in a timely manner with a 3.76 agreement. The opinion of respondent is most spread out for information sharing (SD=0.94) and all the rest have lower dispersion of 0.8.

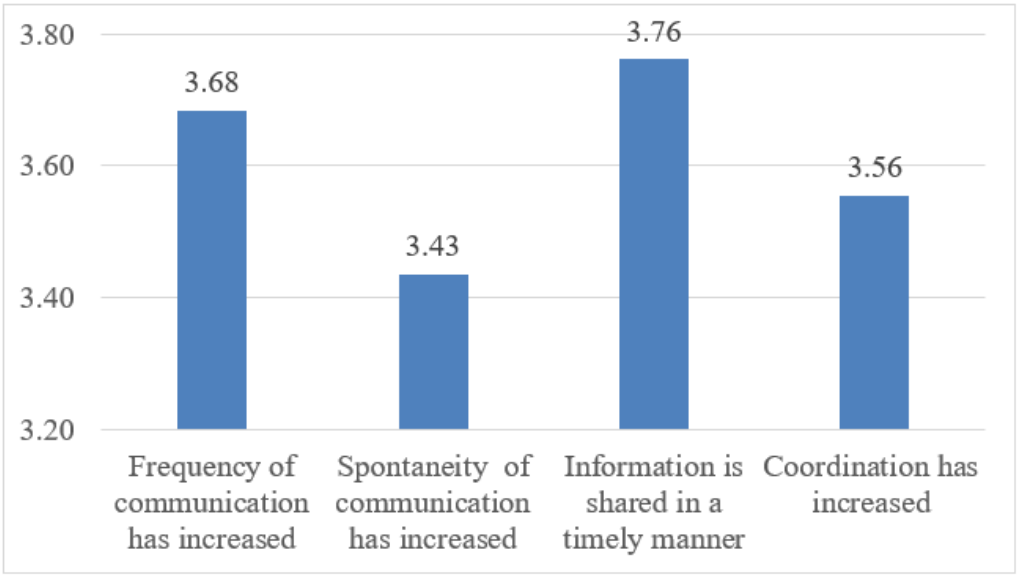

Figure 10. Communication within team COVID-19 lockdown.
Source: Own Creation

Trust: The mean value of trust particulars ranged between 4.33 to 3.86. The analysis showed that a team member cannot depend the team to cheer them up when mentally down during lockdown. But, work-wise the team members trust each other to be honest about the work status or to share work related knowledge even when working remotely.

The graph showed that there is high agreement that team members are ready to share knowledge within the team through virtual means. Also, there is high agreement that team members do their share of work while working from home. The only factor related to work that got less agreement Honesty related to work status.

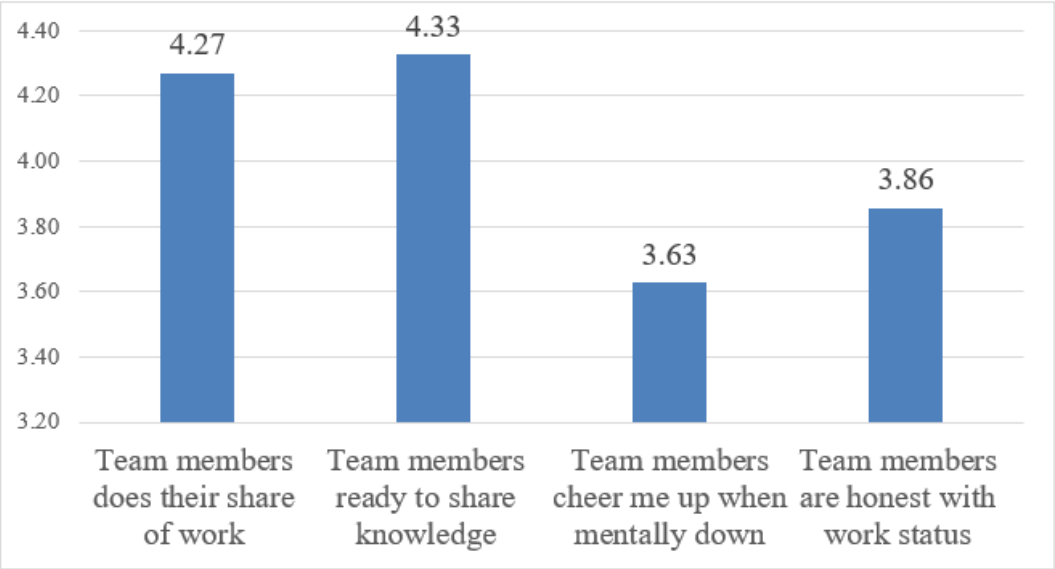

Figure 11. Trust among team members during COVID-19 lockdown

Source: Own Creation

Technology: This construct has the most comparable mean across each statement. As the analysis is done is software industry technological support and competence is utmost important. The survey result show that high level of agreement in technical statements as mean is above 4. The least agreement is for infrastructure support. This might be because providing new infrastructure for home office for team require unplanned budget from organizations.

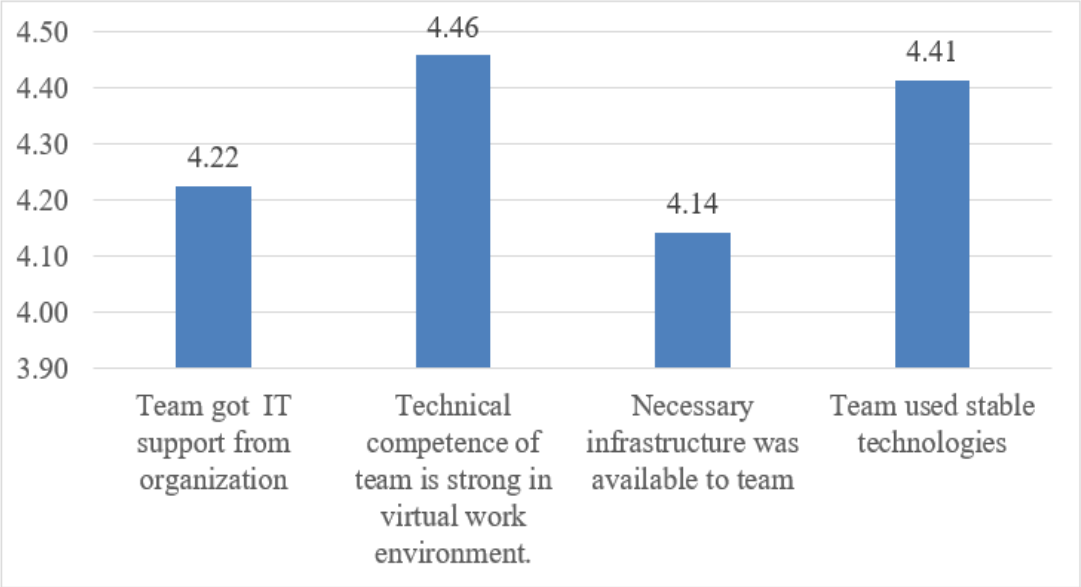

Figure 12. Availably of technology for team during COVID-19 lockdown

Source: Own Creation

Cohesion: The mean ranged between 3.37 and 4.17. From graph it can be inferred that team spirit has not improved during remote working and person conflicts has not gone down. This might be a result of the less spontaneous communication with in team as seen in communication section. When team mates communicate face to face, they can understand each other's body language. This is imperative for good team balance. But when working from home, this is not possible.

The team members still continue to think the team as a single unit and their work responsivities has increased while working from home. This is good for the team as when team members are more responsible it's easy to manage the work within the team.

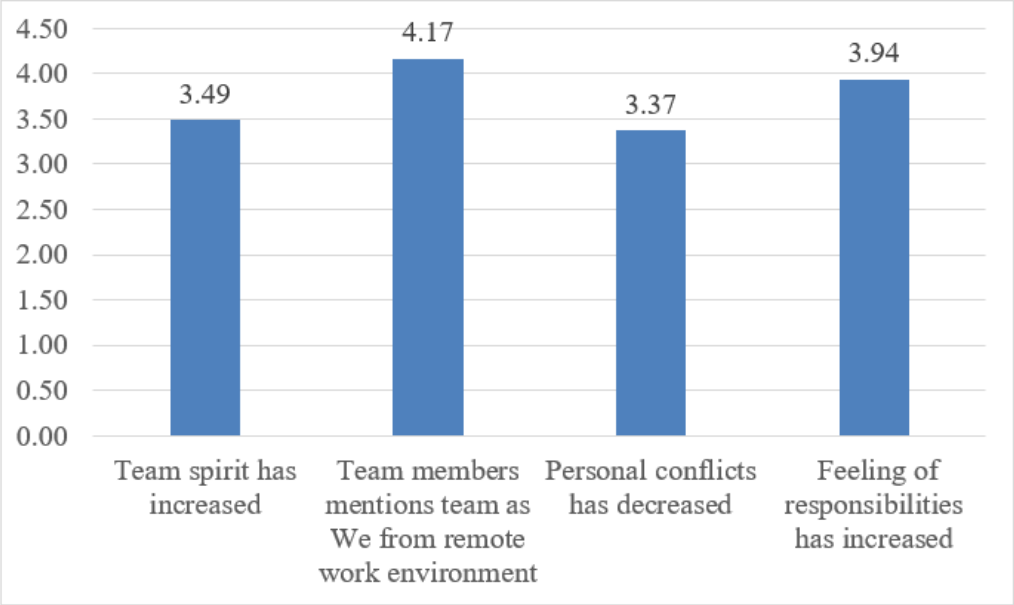

Figure 13. Cohesion within team during COVID-19 lockdown
Source: Own Creation

Self-Management: One of the major characteristics of agile team is that it is a self-managed team. There was considerable self-management within the team during covid-19 lockdown. The team members are still active in self managing their work from remote setting as shown by high values for promptness in taking new tasks and they still have the freedom to choose the procedure to complete their work.

The statement for participation in decision making in COVID-19 lockdown got the least agreement. From this it can be inferred that team members are have more active participation during face-to-face meetings rather than through virtual meetings.

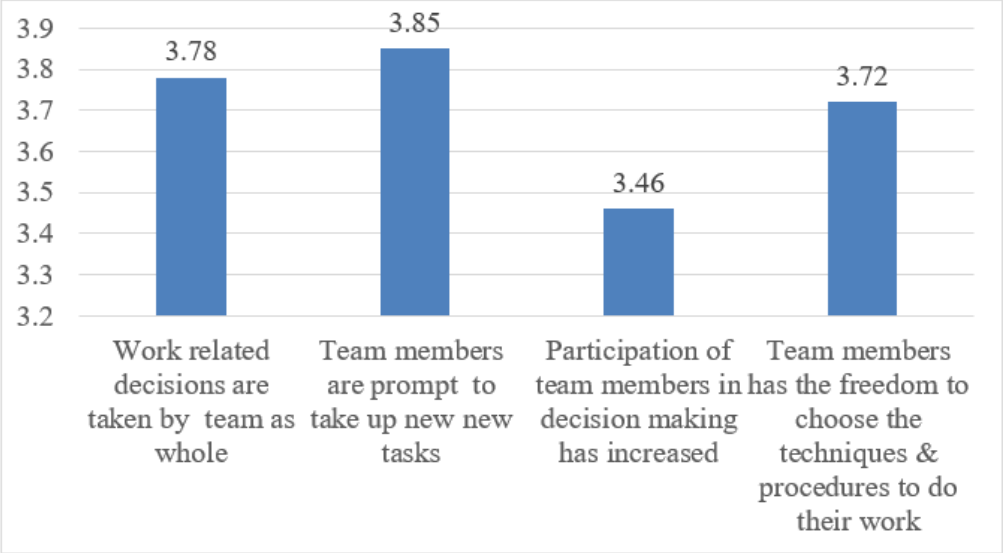

Figure 14. Self-Management of team during COVID-19 lockdown
Source: Own Creation

Virtual Teamwork Quality: Descriptive statistics of all construct used to study this variable shown in table 3. There is high agreement among the survey respondents that trust (mean = 4.02) and technological competence (4.31) within the team has increased during COVID-19 lockdown while working remotely. But overall consent for improvement in communication (mean = 3.71), cohesion (mean =3.74) and self-management (mean =3.70) is less. The opinion of respondents is highly clustered among team for trust (SD= 0.49), technology (SD=0.55) and cohesion (SD=0.56). But, for communication (SD = 0.73) and Self-Management (SD = 0.72) the opinion is more spread out.

Table 4. Descriptive Statistics of Virtual Teamwork quality constructs

Particulars	**Mean**	**Median**	**Mode**	**Std. Deviation**
Communication	3.71	3.88	4.25	0.73
Trust	4.02	4.13	4.25	0.49
Technology	4.31	4.43	4.50	0.55
Cohesion	3.74	3.83	4.00	0.56
Self-Management	3.70	3.83	3.83	0.72

Source: Own Calculation

3.1.2 Descriptive statistics of agile team productivity during COVID-19 lockdown

Agile team productivity is represented by five metrics – velocity, trust, leanness, quality, value and efficiency. Table 5 shows summarised descriptive statistic for these metrics. The team productivity mean varies from (3.11 to 4.10). All particulars have comparable level of standard deviation (=0.7), hence the level of dispersion of data is low.

Table 5. Descriptive Statistics of Agile team productivity metrics

Particulars	Mean	Median	Mode	Std. Deviation
Velocity	3.55	3.71	4.00	0.77
Leanness	3.11	3.00	3.00	0.77
Quality	3.33	3.33	4.00	0.69
Value	3.61	3.90	4.00	0.67
Efficiency	4.10	4.27	4.00	0.71

Source: Own Calculation

The data shows a high level of agreement (mean =4.10) that efficiency of the team has increased during working from home of COVID-19 lockdown. This was measured by the utility of project budget by team during COVID-19 lockdown. Speed of achieving work goals (velocity) and customer satisfaction (value) for the project has improved (mean =3.6) during COVID-19 lockdown. Meanwhile, time taken by team to complete a task (leanness) has not improved during COVID-19 lockdown.

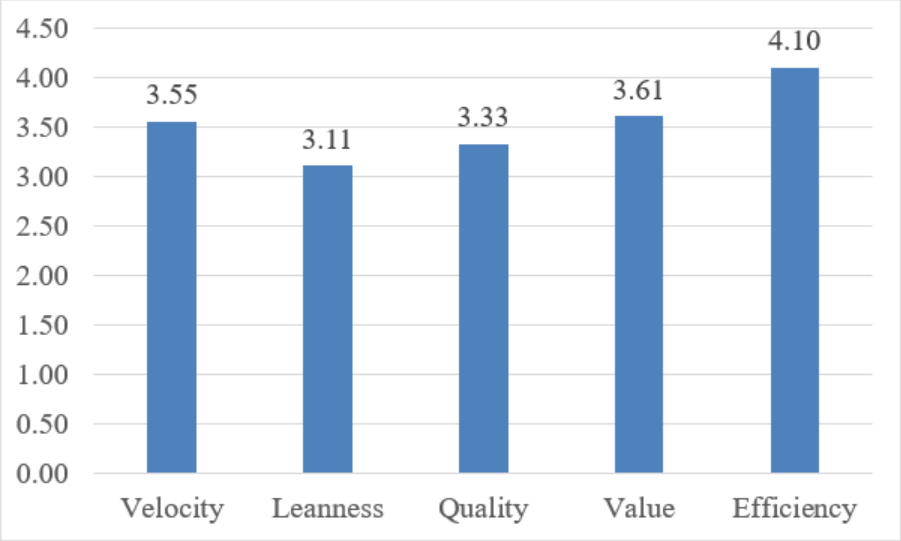

Figure 15. Agile team productivity during COVID-19 lockdown
Source: Own Creation

3.1.3 Test for difference in mean of sample across firms

Overall, 28 teams participated in the survey from 17 firms. This section is to analyse whether mean of the variable is statistically different across different firms. For this test default alpha value is taken, $\alpha = 0.05$. Hence, confidence level of the test is 95%.

Virtual teamwork quality: Conducting Levene's test obtained a mean of 0.0014 (< 0.05). This shows an unequal variance across the variable and assumption for using One factor Anova is not met. Thus, the author used Kruskal-Wallis Test to conduct this study. Kruskal Wallis test is a non-parametric test to check whether the samples originate from same population. Conducting Kruskal Wallis test obtained a p-value of 0.5 (>0.05) which shows that there is no significant difference in the mean of virtual teamwork quality across the firms during COVID-19 lockdown.

Agile team productivity: Conducting Levene's test obtained a mean of 0.00174 (< 0.05). This shows an unequal variance across the variable and assumption for using Anova is not met. Hence, once again Kruskal-Wallis test is used to conduct this study. Conducting Kruskal Wallis test obtained a p-value of 0.29 (>0.05) which shows that there is no significant difference in the mean of team member success based on agile team experience during COVID-19 lockdown.

3.2 Analysis of individual-level variables

This section will analyse the individual level variable used in this research which is 'team member successes. It is represented by particulars – work satisfaction and learning of the team members while working from home during COVID-19. For each statement on these variables, the respondent was requested to select their level of agreement from 1(strongly disagree) to 5 (strongly agree). Table 6 shows the summary of the data obtained.

3.2.1 Descriptive statistics of team member success during COVID-19 lockdown

Work Satisfaction: The study showed that mean for particulars in work satisfaction during COVID-19 lockdown ranged between 3.7 to 4.07. There is a strong agreement in the members that their opinion is respected in the team (mean =4.07) although they are working in a remotely. But there is considerably less agreement in that members got opportunity to use their skills to full extend.

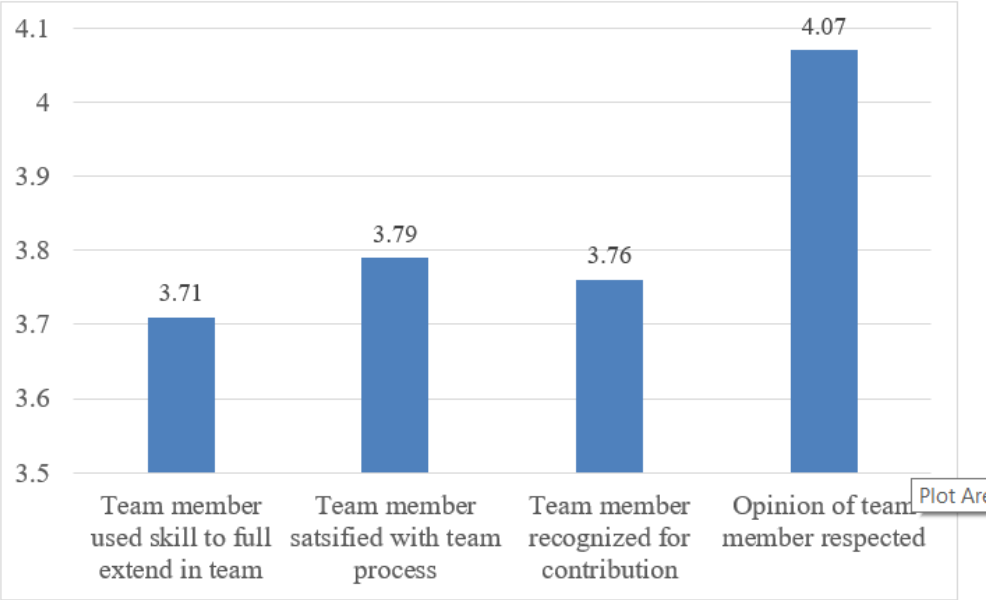

Figure 16 Team member work satisfaction during COVID-19 lockdown
Source: Own Creation

Learning: This construct was used to research whether team members got opportunity to learn and grow during COVID-19 lockdown. The mean ranged between (3.54 to 3.79). There more agreement that team members learned to work and collaborate in virtual environment. Also, agreement is almost high that they were able to grow professionally and learn new work-related knowledge. But there is less agreement for work-life balance from home environment.

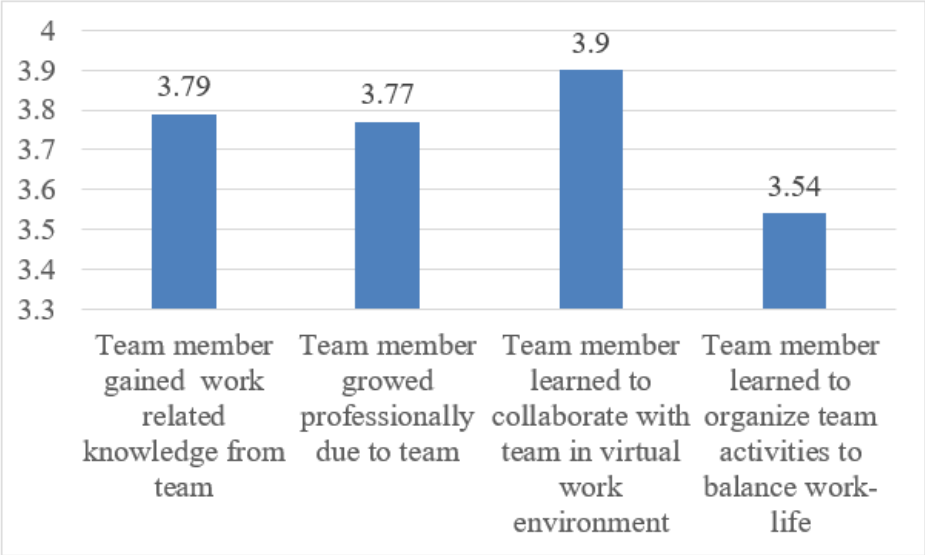

Figure 17. Team member learning during COVID-19 lockdown
Source: Own Creation

Team member success: Descriptive statistics of all constructs used to study this variable shown in table 6. Both work satisfaction and learning has almost same mean (3.7) and standard deviation (SD = 0.92). This shows that over all agreement on team member success is not that dispersed.

Table 6: Descriptive Statistics of Team Member Success constructs

Particulars	**Mean**	**Median**	**Mode**	**Std. Deviation**
Work Satisfaction	3.72	4.00	4.00	0.92
Learning	3.73	4.00	4.00	0.92

Source: Own Calculation

3.2.2 Test for difference in mean of sample across agile experience

Team member success: Overall, 114 individuals participated in the survey from 17 firms. This section is to analyse whether mean of the variable is statistically different based their agile experience. For this test default alpha value is taken, $\alpha = 0.05$. Hence, confidence level of the test is 95%.

Conducting Levene's test obtained a mean of 0.440(> 0.05). This shows an equal variance across the variable and assumption for using One factor Anova is met. Thus, the author used one-factor Anova to conduct this study. Anova test gave a p-value of 0.197 (>0.05) which shows that there is no significant difference in the mean of virtual teamwork quality across the firms.

3.3 Effect of virtual teamwork quality on team productivity

This section analyses the effect of independent variable “virtual team member quality” on the dependent variable “team productivity”.

Correlation: It is used to find the association between the variables. Table 7 shows the relationship between independent and dependent variables using Pearson correlation. The sample data follows normal distribution as verified using Shapiro-Wilk Test. Hence, Pearson correlation method was chosen to study the association between the independent and dependent variable. The correlation coefficient for virtual team work quality and team productivity obtained from calculations is 0.660***. This value lies in the 0.6<r<0.8 range, hence it has a strong positive correlation. The

significance of correlation coefficient is also calculated using p-value = 0.000 (<0.01), which shows high level of significance. From these calculated values it can be concluded that there is an association between the dependent and independent variable. Thus, virtual team work quality has a positive and robust relationship with team productivity during work from home of COVID-19 lockdown.

Regression: Linear regression is used to find the strength of effect that the virtual team work quality has on team productivity. All assumptions for conducting linear regression are verified before conducting the analysis.

a. Assumption on linearity – The linearity between variables virtual teamwork quality and team productivity is verified using scatter plot depicted in Figure 18.

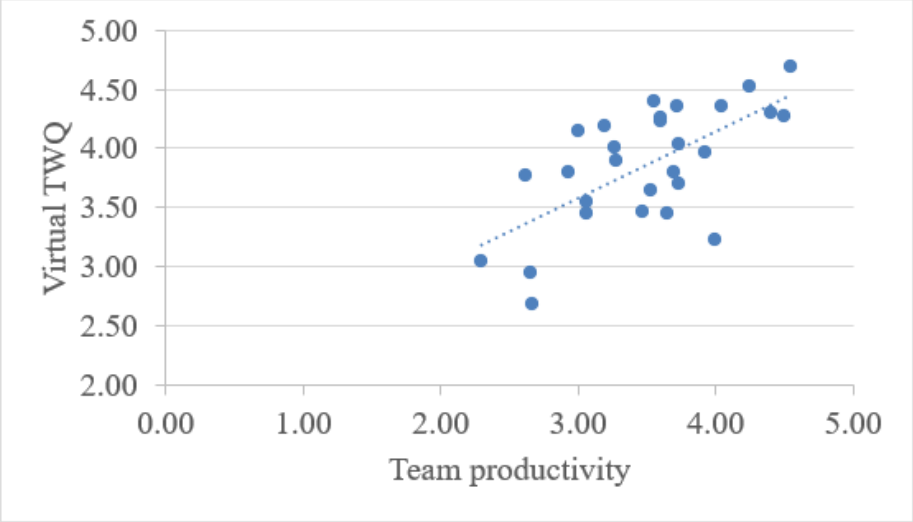

Figure 18. Scatter plot between virtual teamwork quality and team productivity
Source: Own Creation

b. Assumption of homoscedasticity – Data values of the variables have an equal variance as tested using Levene's test: mean = 0.501 (> 0.05).

c. Assumption on absence of multicollinearity – There is only moderate correlation between independent variable = 0.673 (<0.7). The absence of high correlation independent variables, points towards absence of multicollinearity

d. Assumption of normality – The data values have a normal distribution as verified using Shapiro-Wilk Test.

Table 8 shows necessary values from regression analysis. The coefficient of determination, R square is 0.436 which the measure of goodness of fit. This indicates a 43.6% influence of virtual team work quality on team productivity. The significance level 0.000(<0.05) which indicates that the regression model statistically predicts the outcome with high level of significance.
The data is modelled using linear regression equation:

$y = mx + c$ …….[Equation 1]

where m=slope of the line, c= intercept, y = dependent variable and x= independent variable
Applying values from table 8 to equation 1 gives,
Team productivity = 0.768*(Virtual Teamwork Quality) + 0.532
From above equation it can be concluded that 1 unit change in virtual team work quality results in a 0.768 unit change in team productivity. By using this argument, null hypothesis "virtual teamwork quality has no effect on agile team productivity during COVID-19 lockdown." is rejected and alternate hypothesis is accepted. The above-mentioned hypothesis is summarized in table 9.

3.4 Effect of virtual teamwork quality on team member success

This section analyses the effect of independent variable "virtual team member quality" on the dependent variable "team member success".

Correlation: Table 7 shows the association between independent and dependent variables using Pearson correlation. The correlation coefficient for virtual team work quality and team productivity is 0.563***. This value lies in 0.4<r<0.6 range, hence has a moderate positive correlation. The significance of correlation coefficient is also calculated using p-value = 0.000 (<0.01), this shows high level of significance. From these calculated values it can be concluded that there is an association between the dependent and independent variable. Hence, virtual team work quality has a positive and robust relationship with team member success during work from home of COVID-19 lockdown.

Regression: Linear regression is used to find the strength of effect that the virtual team work quality has on team member success. All assumptions for conducting linear regression are verified for this dataset as well before conducting the analysis.

a. Assumption on linearity – The linearity between variables virtual teamwork quality and team member success is verified using scatter plot depicted in Figure 19.

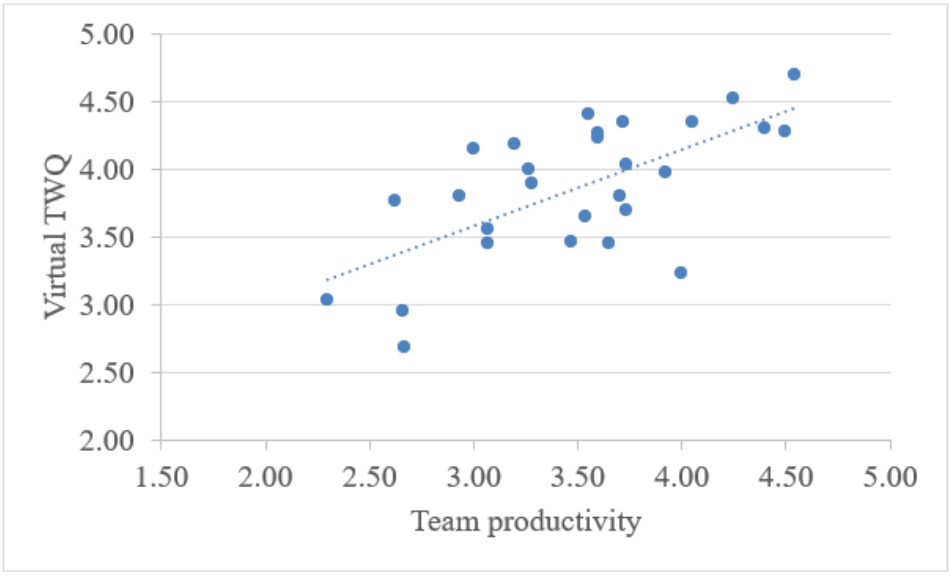

Figure 19. Scatter plot between virtual teamwork quality and team member success
Source: Own Creation

b. Assumption of homoscedasticity – Data values of the variables have as equal variance as tested using Levene's test: mean = 0.071 (> 0.05).

c. Assumption on absence of multicollinearity – There is only moderate correlation between independent variable = 0.673 (<0.7). The absence of high correlation between independent variables points towards absence of multicollinearity

d. Assumption of normality – The data values have a normal distribution as verified using Shapiro-Wilk Test.

The coefficient of determination, R square is 0.317 which indicates a 31.7% influence of virtual team work quality on team productivity. The significance level 0.001(<0.05) which indicates that

the regression model statistically predicts the outcome with high level of significance. The data is modelled using values from table 8 on linear regression equation (i.e.; equation 1) which gives:

Team member success = 0.752*(Virtual Teamwork Quality) + 0.839

From above equation it can be concluded that 1 unit change in virtual team work quality causes in a 0.752 unit change in team member success. By using this argument, null hypothesis "virtual teamwork quality has no effect on agile team member success during COVID-19 lockdown." is rejected and alternate hypothesis is accepted. The above-mentioned hypothesis is summarized in table 9.

Table 7. Bivariate correlation between variables

Particulars	**Team Productivity**	**Team member success**	**Virtual TWQ**
Team Productivity	1		
Team member success	0.673 (.000)	1	
Virtual TWQ	0.660 (.000)	0.563 (.001)	1

Source: Own Calculation

Table 8. Linear regression showing impact of virtual team work quality

Particulars	**R square**	**Beta**	**Intercept**	**F**	**Significance**
Effect of virtual team work quality on team productivity	0.436	0.768	0.533	20.071	0.000
Effect of virtual team work quality on team member success	0.317	0.752	0.839	12.048	0.001

Source: Own Calculation

Table 9. Summary of hypothesis

Hypothesis	**Statement**	**Outcome**
H1	Virtual teamwork quality has a positive effect on agile team productivity during covid-19 lockdown.	Significant
H2	Virtual teamwork quality has a positive effect on agile team member success during covid-19 lockdown.	Significant

Source: Own Creation

3.5 Factors affecting agile team productivity during COVID-19 lockdown

This section is to study which are the most important factors affecting agile team productivity according to the perception of agile team members while working from home during COVID-19 lockdown. To narrow down the study, the author first did a literature survey on previous studies on this field and identified 10 factors. These were asked to grade by the respondents to understand their perception. For each of the factors the respondent was requested to grade its importance during work from home on a scale of 1(Least important) to 3 (Most important). Apart from this, an open question was provided so that respondents could add any comments or other factors they might think relevant.

The result of the survey is given in Appendix 2 in frequency distribution table. According to the perception of agile team their team environment (81.6%) and psychological well-being (82.5%) are the most important factors affecting the team productivity during work from home. This shows that working from virtual environment can become tedious if there are conflict issues in team. Moreover, mental well-being is important during lockdown for good team spirit and interactions. 75.4% respondents had the opinion that technical tools are important while working from home as technical competence on necessary technology is needed to connect with the team. Factors such as project management and team capability got above 50% due to its importance in virtual management of team and requirement of necessary skillset to complete the work.

3.6 Discussions

In this section, the author will undertake a discussion on the findings of this study to determine how well it address the research questions by linking it with existing literature. As stated in previous chapter, the author conducted this research to study the effect of COVID-19 pandemic on agile teams of software industry. For undertaking this task, group level variables such as virtual teamwork quality, team productivity and individual level variable such as team member success was analysed. Furthermore, the study aimed to identify the factors affecting team productivity while working from home during COVID-19 lockdown. The novelty of this research is that so far no study has been done on virtual teams in a crisis situation of this global impact. As more organizations are resorting extended work from home in the foreseeable future, there is a need to understand the team level impact of COVID-19.

Understanding teamwork quality and team productivity is important as it plays a pivotal role success of innovative projects (Hoegl *et al.* 2001). Software companies usually undertake innovative projects for developing new product and technologies. For this, organization spend large amount of time and money. As described in previous chapters software development relay on team effort. Previous studies have shown that increasing teamwork quality accelerate some aspects of team productivity (Lindsjørn *et al.* 2016; Salas *et al.* 2010; Nugroho *et al*. 2017). Hence, teamwork quality has gained lot of attention from management so as to improve the team productivity. Moreover, Hoegl *et al.* (2001) has concluded that team members success is imperative in project success and quality of teamwork has a direct relationship with it. With agreement to above results in literature, this researcher raises below questions with a goal to contribute on virtual work environment culture and to extend Hoegl's TWQ model to encompass remote work culture.

Research Question 1: What is the effect of virtual teamwork quality on productivity of agile teams during COVID-19 lockdown?

Correlation test was used to determine the association between virtual teamwork quality and team productivity. It was found that there is a strong positive correlation between the variables (0.660***). Regression analysis was used to determine the extent of the effect of virtual team work quality on team productivity. It was found that effect is large (R square = 0.436). These present findings are compared with the previously reported findings by Hoegl *et al.* (2001) on relationship between teamwork quality and success of innovative projects. The comparison shows that the result is consistent with previous outcome done in face-to-face teams in software industry(Nugroho *et al.* 2017, Lindsjørn *et al.* 2016). But, the results are contradictory to the finding from Ueno (2012) done in service sector wherein non-significant evidence was found for relationship between the variales. Thus, it can be infered that based on the sector the results may vary.

The study has used an improved conceptual model build upon on Hoegl's teamwork quality model and the results of the study imply that this new model encompass the theory better in virtual environment. This model can be used to evaluate the quality of teamwork in virtual environment for effective team management. Thus, it has the potential to adjust team activities to improve team collaboration ultimately leading better team productivity.

Research Question 2: What is the effect of virtual teamwork quality on agile team members success during lockdown?

Correlation test was used to determine the association between virtual teamwork quality and team member success. It was found that there is a medium positive correlation between the variables (0.563***). Regression analysis was used to determine the extent of the effect of virtual team work quality on team member success. It was found that effect is large (R square = 0.317). A similar result can be found when these present findings are compared with the previously reported findings by Hoegl *et al.* (2001) on relationship between teamwork quality and team member success. Futhermore, other studies done in this regard such as IPO model by Körner *et al.* (2015) and superviror support on teamwork model by Griffin *et al.* (2001) predicted comparable outcome. These studies had found that extend of teamwork in face-to-face teams leads to better work satisfaction.

The present study found that better teamwork from virtual environment results in improvement in team member success. Based on the magnitude of the strength of this relationship, the software project managers cannot avoid the fact that virtual teamwork quality is important in achieving team members' job satisfaction.

Hence, the modified teamwork quality model proposed in this study offers the management a method to assess the quality of team when working from home and be able to identify the problem areas in their team.

Research Question3: According to the perception of agile team members, which of the identified factor/factors derived from empirical study are mainly affecting their team productivity during working from home?

From literature ten factors were identified that affects agile team productivity. These factors were graded by agile team on degree of importance when working from home. According to the perception of agile team, the main factors affecting productivity while working from home during COVID-19 lockdown are team environment (81.6%) and psychological well-being (82.5%). Team environment (Chow *et al*. 2007) is essential in maintaining team dynamics and cooperation especially in virtual work environment. Psychological well-being was added by the author to the personal factor section as the team is working in a crisis situation. The high level of agreement on this factor shows that positive outlook by team members is critical in project success

Another important factor affecting productivity is technical tools (75.4%) which is highly important when working from virtual environment for connecting with team. This is fuelled by the conclusion in Melo *et al.* (2011) where technical competence is considered critical for agile project success. Meanwhile, above half of the respondents graded that project management process and methodology practised (Chow *et al.* 2007; Melo *et al.* 2011) in the team are important when working from home. This is necessary as proper structure of team process is necessary for coordination of its activities especially when geographically dispersed.

CONCLUSION

During COVID-19 lockdown, the team started to work virtually. Study found that team level information is shared in timely manner. Also, the frequency of communication within the team has increased and thus coordination of work tasks is maintained. But, spontaneous informal communication among team members has not improved. The result from communication section has a direct effect on trust construct. As spontaneous chitchat among team members is not there, the team members had the opinion that their team is unable to cheer them up when mentally down. But, work related trust factors such as team members doing their share of work and being honest with each other regarding work status was not affected during work from home.

The study found that the team got amble technical and infrastructural support from organization while shifting their work environment from office to home. But team spirit has taken a hit during remote working and personal conflict within the team has not decreased. Also, it was found that team members are still prompt in taking new task by themselves after the current task is completed but they are not actively participating in decision making with respect to team. Another finding was that time that time taken by team to complete work from remote environment as compared to from office settings has not increased. Also, customer satisfaction and speed of achieving work goals has improved during working from home of COVID-19 lockdown. Team dynamics was also explored in the study. Opinion of team member are respected by others and they are recognized for contribution to teamwork while doing working remotely. But one major concern shown in the study was that team members are not using their skill to full extend while working remotely. Team members learned to collaborate with team virtually during COVID-19 lockdown. But, work-life balance has been affected as it is difficult to find a boundary between work and home life when working from home.

The research questions were answered through hypothesis testing using which the null hypothesis was rejected and the alternate hypothesis was accepted. It was found that virtual teamwork quality has a strong association with team productivity and team member success. The analysis showed

that 1 unit change in virtual team work quality results in a 0.768 unit change in team productivity and 0.752 unit change in team member success. Thus, there is a statistically relevant relationship between independent and dependent variables. From this it can be said that virtual teamwork quality can be used to predict the productivity of team and team member success.

Theoretical implications

The main theoretical contribution of this study is to extend Hoegl's teamwork quality model to encompass virtual environment. This was carried out by including context specific constructs such as trust and technology. The research findings from this study show that proposed theoretical framework can be used to analyse and predict the teamwork during pandemic situation to improve the productivity of agile teams. Moreover, quality of teamwork mechanism in virtual environment plays an important role in team members satisfaction. These findings are in adherence to the Hoegl's research conducted on face-to-face teams in innovative projects during non-pandemic situation. Hence, this study provide evidence that Hoegl's theory stands true in a crisis situation as well.

Practical implications

There are many implications that can be derived from this study. The main implication is that quality of teamwork is very important when team is working from home. This is because the virtual team work quality is directly related to team productivity. Increasing team productivity is beneficial to an organization in both quantity and quality aspects. When team is working efficiently, the quantity of tasks completed will be more and this will result in a reduced cost of business. Improved quality of product is critical for customer satisfaction.

One of the other findings by the survey is that there is less spontaneous communication within the team when remote working as compared to face-to-face teams. This has affected trust between team members and has resulted in conflicts. Moreover, when team is geographically distributed it is difficult to plan and execute a synchronous meeting. Introducing a proper structural process for virtual communication can improve team environment and can in turn result in higher team productivity. Another important factor affecting team productivity during working from home is psychological well-being of team members. The boundary between team activities and home life has become blurry due to continuous work from home. Without proper seating and lighting infrastructure the team is finding it hard to work diligently. Hence, the management should come forward with the best practises and equipment to assist the team.

Already major software companies such as Microsoft, Facebook, Google, Twitter etc are planning to continue the remote working trend beyond pandemic (Nickelsburg 2020). This study found that agile team productivity is not affected by working from home during COVID-19 lockdown. This conclusion might prove as an incentive to concerned organization to accelerate this change.

Limitations

This study has a number of limitations which will be discussed in this section. The first limitation is that data collected from team members for team level analysis might be prone to individual bias or be influenced by external factors. Another limitation is that data for this research was collected mainly from Indian and Estonian firms. Hence, there is geographical limitation for the scope of this study. But, the findings of this study can be generalized to the population as the team level results from different regions are comparable. The next limitation is that generalization of results from this study can be applied only software firms and not to other industries as the focus of this research limited only to software industry. Moreover, the changes related to COVID-19 are fairly new and hence the time period of evaluation is constrained to cross-sectional study.

Future research avenues

As this study was limited only to software industry, the current results could not be generalized to other industries. Thus, a topic for further work is to study the impact of COVID-19 at group level in other industries such as manufacturing industry. This study did not differentiate between the interactions between on-shore and off-shore teams to that in a local team. Thus, studying implication in this regard might shed light into far reaching consequence of teams separated by national boundaries. Another area of research is do a refined study of team level changes due to COVID-19 in start-up vs large organizations.

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APPENDICES

Appendix 1. Questionnaire

Personal profile

1. Please enter your team identification number _____

2. Please select your gender.
   a. Male
   b. Female

3. Please select your age
   a. Less than 25 years
   b. 25 to 35 years
   c. 36 to 45 years
   d. Above 45 years

4. Please select the role which best describes your current position in your organization
   a. Team Lead
   b. Developer
   c. Tester
   d. Scrum Master
   e. UI/UX Designer
   f. Product Owner
   g. Others

5. Were you part of an Agile Team during COVID-19 lockdown?
   a. Yes
   b. No

6. Were you working from home during COVID-19 lockdown?
    a. Yes
    b. No
7. How long have been practising agile methods?
    a. Never
    b. Less than 6 months
    c. 6 to 12 months
    d. 1 to 3 years
    e. >3 years

Organization Profile

8. Where is your current organization located?_____
9. Which is the domain of your software company?
    a. Cybersecurity
    b. Financial
    c. Healthcare
    d. Travel
    e. Consulting/Services
    f. Education
    g. Games/Entertainment
    h. Mobile
    i. Energy
    j. Other

Virtual Teamwork Quality

This section is to analyse the quality of teamwork during working from home in COVID-19 lockdown. For this, study is done in sub-constructs such as communication, trust, technology, cohesion and self-management. Corresponding to each statement in this section, please indicate the extent to which you agree.

1- Strongly Disagree
2 - Disagree
3- Neutral
4- Agree
5- Strongly Agree

I. Communication

1. Frequency of communication within my team has increased during work from home of COVID-19 lockdown.
2. Spontaneity of communication among my team has increased during work from home of COVID-19 lockdown.
3. Information regarding team goals is shared in a timely manner within team during working from home of COVID-19 lockdown.
4. Coordination of work in the team has increased during work from home of COVID-9 lockdown.

II. Trust

1. My team members do their share of work during work from home of COVID-19 lockdown.
2. Team members in my team are ready to share knowledge while working from home of COVID-19 lockdown.
3. I can depend on my team members to cheer me up when I am mentally down during lockdown.
4. Team members in my team are honest with each other regarding work status during work from home of COVID-19 lockdown.

III. Technology

1. My team got IT support from my organization for smooth transition to work from home in COVID-19 lockdown.
2. My organization provided necessary infrastructure for my team to work from home during COVID-19 lockdown.
3. Technical competence of my team is strong in virtual work environment.
4. My team used stable technologies for working from home during COVID-19 lockdown.

IV. Cohesion

1. Team spirit has increased with in my team during work from home of COVID-19 lockdown.
2. When I think of my team during work from home in lockdown, I consider the team as a "We" rather than "They".
3. Personal conflicts have decreased during work from home of COVID-19 lockdown.

4. My feeling of responsibilities in the team has increased during work from home of COVID-19 lockdown.

V. Self-Management

1. Work related decisions are taken by my team as a whole rather than managers during working from home of COVID-19 lockdown.
2. Team members in my team are prompt to take up new tasks once a task is completed during work from home of COVID-19 lockdown.
3. Participation of team members in decision making has increased during work from home of COVID-19 lockdown.
4. Team members in my team has the freedom to choose the techniques and procedures to do their work during work from home of COVID-19 lockdown.

Team member Success

This section is to analyse work satisfaction of team members while during work from home during COVID-19 lockdown. For the questions in this section, please indicate to which extent you agree to each statement.

1- Strongly Disagree
2 - Disagree
3- Neutral
4- Agree
5- Strongly Agree

I. Work Satisfaction

1. I got opportunity to use my skills to full extent during work from home of COVID-19 lockdown.
2. I am satisfied with the process we practice within my team while working remotely in COVID-19 lockdown.
3. I am recognized for my contributions within my team during work from home in COVID-19 lockdown.
4. My opinion is respected by my team mates while working from home during COVID-19 lockdown.
5. I am overall happy with my team and if given a chance for team change during lockdown, I will not take the offer.

II. Learning

1. I have gained important work-related knowledge from my team during work from home of COVID-19 lockdown.
2. I have learned to collaborate with my team in virtual work environment during COVID-19 lockdown.
3. I have learned organize my team activities to effectively balance work-life during work from home of COVID-19 lockdown.
4. I have grown professionally due to my team during work from home of COVID-19 lockdown.

Team Productivity

I. Team Productivity Metrics

This section is to analyze whether overall team productivity has been affected due to work from home during COVID-19 lockdown. For the questions in this section, please indicate to which extent you agree to each statements.

1- Strongly Disagree
2 - Disagree
3- Neutral
4- Agree
5- Strongly Agree

1. Speed of achieving work goals within my team has increased during work from home of COVID-19 lockdown.
2. The time taken by my team to complete tasks has decreased during work from home of COVID-19 lockdown.
3. Customer reported issues has decreased since my team started work from home during COVID-19 lockdown.
4. Customer satisfaction has increased since my team started working from home during COVID-19 lockdown.
5. My team uses less project budget to complete the work during work from home of COVID-19 lockdown.

II. Factors affecting team productivity

This section is to understand agile team members perception on factors affecting team productivity during work from home of COVID-19 lockdown.

On a scale of 1 to 3, please grade the below factors on how important they are in affecting team productivity during working from home.

1- Not Important
2 - Important
3- Most Important

a. Organizational Environment
b. Team Environment
c. Project Management
d. Project Schedule
e. Methodology and practises
f. Team Composition
g. Team Capability
h. Psychological well-being
i. Customer Involvement
j. Technical tool

Appendix 2. Factors affecting team productivity

Particulars	Grade	Frequency	Percentage
Organization Environment	Least Important	13	11.4
	Important	70	61.4
	Most Important	31	27.2
Team Environment	Least Important	1	0.9
	Important	20	17.5
	Most Important	93	81.6
Project Management	Least Important	1	0.9
	Important	43	37.7
	Most Important	70	61.4
Project Schedule	Least Important	4	3.5
	Important	46	40.4
	Most Important	64	56.1
Methodology Practices	Least Important	5	4.4
	Important	39	34.2
	Most Important	70	61.4
Team Composition	Least Important	4	3.5
	Important	70	61.4
	Most Important	40	35.1
Team Capability	Least Important	2	1.8
	Important	48	42.1
	Most Important	64	56.1
Psychological well-being	Least Important	3	2.6
	Important	17	14.9
	Most Important	94	82.5
Customer Involvement	Least Important	20	17.5
	Important	73	64.0
	Most Important	21	18.4
Technical Tools	Least Important	5	4.4
	Important	23	20.2
	Most Important	86	75.4

Source: Own Calculation

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