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Innovation processes in times of a crisis: a research during the COVID-19 pandemic

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Abstract

The COVID-19 pandemic is causing global disruption with impact on economic, social and political systems. Many organisations are already looking at the post-pandemic era and how their innovation processes are changed or will change in the future. However, organisations found difficulties to identify the impact of the crisis due to the COVID-19 pandemic on their business.

The aim of this research is to identify the impact of the current crisis on innovation processes within a Dutch ICT organisation. Based on a literature review the Eight Essentials are used as a basis to design a framework that enables ICT organisations to analyse their innovation processes. The Eight Essentials is a set of factors which are essential for organisations to innovate. It consists of practices and processes to organise and construct innovation in your organisation.

The research consists of two parts: quantitative and qualitative research. The quantitative survey analysis consists of 188 respondents. These results show a significant impact of the crisis on nineteen out of thirty-five innovation items. It was interesting to see that the impact of the crisis was only negative on providing time for employee to share ideas, to set objectives to drive innovation and to transfer effectively ideas across departments. The crisis shows a positive impact on for instance the awareness of the business continuity plan, the response to working remotely and digitisation of customer channels. The qualitative results of the interview with directors of the ICT organisation support these results. These interviews contribute to the interpretation of the results with underlying factors and perspectives from the directors on the impact of the crisis. The results of the survey find out that there was not a statistical difference on the relationship of the impact of the crisis with the job tenure and business units.

Innovation is mostly affected in the idea generation and idea evaluation phase of the process. The organisation experienced difficulties to provide sufficient time to generate and share new innovative ideas or solutions with each other. However, the innovation process is not harmed by the migration of technology trends which is one of the biggest changes of the crisis. The organisation can learn from the changes as a result from the crisis to design as early as possible a hybrid innovation process to stay ahead of the competition.

The field of innovation management benefit from this research, because evidence for future research is given. The designed framework can be reused after the current crisis or be used in a different research context. Moreover, a look into specific components of the framework or innovation process steps can give valuable insights.

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1 Introduction

This section provides a short introduction to the objective of this research. A problem analysis is executed to get insight into the core problem and the problem statement of this research is formulated. This statement is used to define the research questions and how these questions as a whole lead to achieving the research objective. Finally, the scientific and practical relevance of this research are mentioned.

1.1 Background

The current COVID-19 pandemic has a lot of major consequences in terms of direct impact on the health and mortality, and with indirect impacts on economic, social and political systems (Shen et al., 2020). According to Shen et al. (2020) the COVID-19 pandemic is caused as the worst global recession since 1930. The international travel is decreased to its lowest level in 75 years, and nearly all of the world's economies are in recession. Confronted with these unprecedented consequences of this pandemic the world is experiencing a profound change in nearly all aspects of the global society (The Economist Intelligence Unit, 2020).

Although the world is focussing on limiting the spread of COVID-19, many organisations are already looking at the post-pandemic era and how their products, services and way of work will change. It seems that technology and digital transformation are playing a starring role to respond to the major consequences of this pandemic and the post-pandemic era (The Economist Intelligence Unit, 2020). Am et al. (2020) showed that businesses can gain long-term advantages by investing in innovation through a crisis such as the COVID-19 pandemic. Organisations that maintained their focus on innovation during the financial crisis in 2009, outperforms the market average by 30 percent and deliver accelerated growth in the upcoming years (Am et al., 2020).

As the current situation due to the COVID-19 pandemic is still causing global disruption, there is a need to analyse how current challenges are addressed and what can be learned for post-COVID-19 innovation management. Guderian et al. (2020) mentioned that the pandemic has both downsides and upsides according to the innovation management of organisations.

1.2 Exploration of the topic

In the past 30 years innovation management is an often-researched topic in the literature, because innovation is important for survival of an organisation (Eveleens, 2010). In the information and communication technology (ICT) industry to be innovative is similar to be successful and profitable (Feshchuk, 2017). The importance of innovation is reflected in the competitive position of

an organisation, in particular in the ICT sector (Huizinga, 2001). Digital convergence of content, communications, consumer electronics and computing have a huge influence on the ICT industry (Shahid & Shoulian, 2007). The digital convergence of these new technologies results in blurring the boundaries between industries and the ICT industry is less identifiable as a discrete sector (Shahid & Shoulian, 2007). For the next few years new innovation trends will arrive and will continuously change the market and hence business models. Some examples of new innovation trends in the ICT sector are virtual reality, hybrid clouds, blockchain and artificial intelligence.

ICT consists of a permanent process of innovation since the first appearance (Laudon, 1985). The process of innovation in ICT organisations can be characterized into different phases such as: invention, innovation and spreading (Mansfield, 1988). It starts with a new idea or product that become usable further in the process. At the end, spreading is the ability to produce the innovation and use it (Kunz & Hogreve, 2011). Licht and Moch (1999) noted that a large part of the ICT organisations aims to improve their productivity for their customers and strengthening their innovation capacity to achieve this productivity.

A characteristic of innovation in the ICT sector could be the generation of new services (Mainardes et al., 2016). This type of innovation is identified as radical innovation and doing something completely different and which has not been done before (Norman & Verganti, 2012). It can result in a continuous growth within such an unstable business environment as a crisis (Milic, 2013).

1.3 Problem statement

The case organisation of this research is one of the biggest listed ICT organisations of the Netherlands. This organisation connects technology, platforms and data for healthcare, finance, education and the social domain. The management is constantly conscious of the strategic plan and are willing to be flexible to the changing world and creating new business opportunities. The organisation strives to be an innovation leader and thereby occupy a distinctive position compared to its competitors. To achieve this ambition the organisation invests in a broad portfolio of software business initiatives that provide their customers with impactful services and products. The organisation develops specific software systems to address the particular needs of their customers. The differentiated insight of their business, markets, customers and technology enables the organisation to create new business models and to launch innovation in the relevant markets and segments.

However, in the current crisis the management does not have sufficient insight into the changes which affect their innovation processes. In a research of Am et al. (2020) the result of a survey of more than 200 organisations across industries

shows that more than 90 percent of executives expected a fundamentally change in the way they do business over the next five years. Almost 50 percent of the executives expects the crisis will have an impact on their customers' needs. The limited insight of organisations into the current changes is recognized and mentioned in the literature. According to Guderian et al. (2020) it can be stated that organisations are struggling with identifying the impact of the COVID-19 pandemic on their organisation. The ICT organisation recognises the struggle, because they expect that COVID-19 has impact on the innovation processes. Nevertheless, the organisation is not able to identify to what degree the crisis has slowed down or accelerated the innovation processes.

One of the biggest changes in the current pandemic is the rapid migration to digital technologies and remote work (Baig et al., 2020). In the education sector the organisation notices a change in the behaviour of customers, because during crisis it was mainly digital education. For instance, the ICT organisation automates student administration with a student tracking system. During the crisis the organisation noted a significant increase in the need for this platform and invested more to meet the demand. A similar situation was noticeable in the healthcare sector, because due to the pandemic the clients and doctors wanted as few contact moments as possible to minimize the spread of the virus. An online doctor platform makes it possible to get an online treatment to the client's complaints. Due to the COVID-19 pandemic this platform was tested earlier in a pilot and the whole development process had to be accelerated to make this tooling available for the society.

These are just examples of the situation due to COVID-19 pandemic which changes their processes. The management does not have sufficient insight into the factors of these changes and they would like to have better control over these factors. The urgent need for such a clear strategy is supported by Sneader and Sternfels (2020): "organisations should consider how they react to the structural changes a crisis entails". The current circumstances accelerate working remotely and the rise of video and phone call is exponential. Other changes such as an increase demand for e-learning and e-governance are all taking place to avoid crowded areas. All these changes result in a new environment in which ICT business opportunities are created. According to Baig et al. (2020) organisations should refocus on digital efforts on the changes in the expectations of customers.

Sossa et al. (2019) highlight the problem of the case organisation for theoretical analysis and conceptual strength. The state of the art does not show good practices, patterns, or theories to analyse processes for innovation management (Sossa et al., 2019). The lack of insight in the relationship between the factors of the changing world and innovation is another theoretical gap which is earlier mentioned by Cortimiglia et al. (2015).

So, the core problem of the ICT organisation is to identify the impact of the current crisis. The organisation is not able to point out the factors that influence innovation processes in the COVID-19 pandemic and what measures they should take to remain innovative. For this reason, an urgent need has emerged to address the challenges related to innovation and the underlying processes. The current circumstances offer a great opportunity to address these challenges and to observe the impact of the crisis on those processes (The Economist Intelligence Unit, 2020).

1.4 Research questions

The research question to solve the core problem is defined below:

RQ: How are innovation processes affected by the situation due to the COVID-19 pandemic in ICT organisations?

Given the lack of insight in existing theories and literature about the impact of the crisis on innovation it is hard to hypothesize how innovation processes are affected by the situation due to the COVID-19 pandemic. So, the research question remains as such and is divided into sub-questions to derive a comprehensive answer. The first two sub-questions will be answered by executing a literature research to investigate the relationships between innovation processes and the factors that influences such processes during a crisis.

As mentioned in the problem statement there is a lack of conceptual models to analyse innovation processes. The first sub-question fills this gap by proposing an analysis framework for innovation processes and is formulated as:

SQ1: What is a suitable theoretical framework that enables ICT organisations to analyse their innovation processes during the COVID-19 pandemic?

The answer on SQ1 makes it possible to identify the most relevant drivers and barriers of innovation processes during a crisis. The second sub question is aimed at investigating the relationship between those factors and the framework as result of SQ1. So, therefore the second sub question is:

SQ2: What are the drivers and barriers of innovation processes in times of a crisis?

The drivers and barriers, as a result of SQ2, will be operationalized and used in empirical research to analyse the impact of the situation due to the COVID-19 pandemic on innovation processes. The third sub question is:

SQ3: What is the impact of the situation due to the COVID-19 pandemic on the innovation processes within the ICT organisation?

The final sub question is related to what the organisation can learn from the measures taken to exploit the drivers and bypass the barriers in times of a crisis such as the COVID-19 pandemic. Many organisations are already looking to the post-pandemic era and how their operations will change. The organisation should learn from measures which can contribute to emerge as an innovation leader after the crisis. The final sub question is formulated as:

SQ4: What is learned from the measures taken to exploit the drivers and bypass the barriers in the circumstances of the COVID-19 pandemic?

Answering the four sub questions of this research enables to derive a comprehensive answer on how innovation processes are affected in times of a crisis.

1.5 Relevance

Innovation management is an often-researched topic in the literature but according to Sossa et al. (2019) there is, although innovation management models are grown, a lack of conceptual models to analyse innovation processes. This research fills this gap by proposing an analysis framework which is based on the factors that influence such processes during a crisis.

This research addresses the drivers and barriers of the current crisis on innovation processes. This was previously discovered by Falaster et al. (2020) in their paper about how management scholars can contribute with research in the COVID-19 pandemic. In their paper the authors call to action for future research on the effects of crises on innovation processes, because it is crucial for researchers to acknowledge and understand these effects. This research contributes to this by providing knowledge about what extent the situation due to the pandemic influences organisations. Furthermore, how they can learn from the measures to emerge as an innovation leader after the crisis.

The practical contribution is related to finding out what are the most affected components of innovation management during a crisis such as the COVID-19 pandemic. During global crises the world is changing and each industry expects fundamentally changes in the way they do business (Am et al., 2020). Baig et al. (2020) mentioned that the current pandemic will change and accelerate migration to digital technologies and remote working. The findings of this research help to understand how such changes affect innovation processes. The theoretical gap as mentioned by Cortimiglia et al. (2015) will be filled by an empirical investigation to highlight the relationship between the drivers and innovation process steps. This research finds out what can be learned from the

measures taken to improve the innovation activities. The first step is to understand the earlier mentioned drivers and barriers. These findings are used to analyse the impact within the ICT organisation as an empirical investigation. Furthermore, the results are useful to learn from the crisis and which measures an organisation can take during and after a crisis.

1.6 Main lines of approach

The remainder of this paper is organised in several chapters and adheres the following structure:

- Chapter 2 provides the state of the art of the literature in the field of innovation processes and sets out the theoretical framework which is developed. The conclusions and implications of this framework are mentioned.
- Chapter 3 introduces a substantiation for the empirical research which is conducted.
- Chapter 4 contains the results which have been obtained through the case study at a Dutch ICT organisation.
- Chapter 5 discusses the outcomes and interpreting the research results in relation to the literature. In the final section the recommendations for future research and an answer on the research questions are given.

2 Theoretical framework

A literature research is executed to find a suitable framework that enables the ICT organisation to analyse their innovation processes during the COVID-19 pandemic. Based on this framework the drivers and barriers of innovation process in times of a crisis are identified. To the end, the conclusions of the theoretical framework and the implications of these conclusions for the remainder of this research are listed.

2.1 Research approach

The aim of this research is to find an answer for SQ1 and SQ2 by conducting a literature review. To develop a theoretical framework, this review starts with defining innovation as a basis for this theoretical framework. Based on this definition, a literature review on innovation management frameworks is conducted. The review resulted in a suitable framework that enables ICT organisations to analyse their innovation processes. The framework includes the drivers and barriers of innovation in times of a crisis.

2.2 Implementation

The literature review is executed based on the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) Statement (Liberati et al., 2009). Articles from 2015 to 2021 are collected and extracted from the Scopus database. The review resulted in 900 records through database searching based on inclusion and exclusion criteria. After full-text reading the review resulted in six frameworks to analyse innovation processes. For more detailed information see Appendix A.

2.3 Results and conclusions

Innovation management is an often-researched topic in the literature in the past 30 years (see Figure 1). According to Eveleens (2010) this is because innovation is important for survival of an organisation. Innovation is imperative; however, it is difficult and it often happens those organisations are unable to manage innovation.

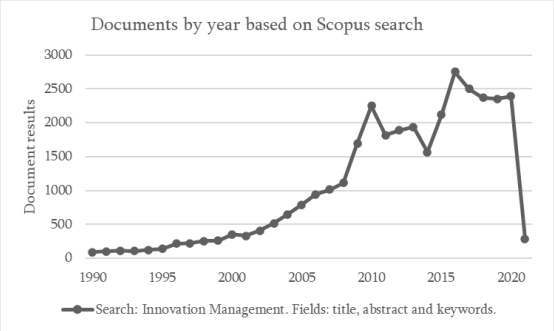

Figure 1: Documents by year based on Scopus search on February 12, 2021

An example of an iconic failure of innovation: Blockbuster Video. As mentioned by Arbulu et al. (2018), the home movie and video game rental services company which was founded 1985. This company was one of the leading giants in the movie-theatre sector and they built their business around the new technology of home videotape players at home. However, new advanced digital technologies were developed and just a decade later Netflix became one of the biggest streaming service in the world. In 2010 Blockbuster declared their bankruptcy. However, it seems that the failure to innovate was unnecessary if they accepted offers to acquire Netflix for $50 million in the early 2000s (Cole, 2019). This example reflects how a wrong innovation strategy influences the survival of the company.

When looking for definitions of innovation it varies across sub-fields of innovation research (Baregheh et al., 2009; Eveleens, 2010; Kogabayev & Maziliauskas, 2017). Baregheh et al. (2009) undertook a content analysis to propose an integrative definition of organisational innovation. They collected 60 definitions from various papers and concluded their work with: "Innovation is the multi-stage process whereby organisations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplaces.". The fact that the definition starts with "the multi-stage process" highlights that innovation is a process and not a discrete act (Williams, 1991). Jacobs and Snijders (2008) also indicate this in their definition of innovation management "the management of the innovation process".

Based on a systematic literature review of Cortimiglia et al. (2015) a lot of firm-level innovation management models or systems are proposed throughout the years. The main outcome of this review is a framework in which the most common elements and aspects are shown: the innovation processes and the elements which drive or support innovation. The review resulted in papers from 1992 to 2012 which converge to a generic innovation process which consists of four steps:

i. Idea generation: the collection of information and knowledge which is related to innovation.
ii. Idea evaluation: the evaluation of the alignment of these ideas on technical, economic and strategic level.
iii. Innovation development: promising the evaluated ideas to become projects which are prioritized and which receive resources and support from the organisation.
iv. Innovation implementation: the project is implemented in the market of the organisation.

It can be argued that this four-step process is too generic and should be considered as a basis for analysing innovation processes (Cortimiglia et al., 2015). They suggest future research to associate particular techniques or tools with the different process steps. The same applies to the gap on the relationship between innovation drivers and the innovation process steps.

For this reason, it is decided to execute an additional systematic literature review to show the wide range of frameworks on innovation processes after 2015. This review resulted in six frameworks to analyse innovation processes which are summarized in Table 1.

These six frameworks are reviewed to investigate whether these frameworks can be applied to the ICT organisation. First of all, the Leannovation Framework of Solaimani, Veen, et al. (2019) is especially related to five overarching dimensions of Lean innovation. Although software development is a natural application of Lean methodology, it is not generally implemented in each ICT organisation. To makes this research more generalizable it is chosen to take a more generic model as a starting point of this research. Secondly, the Capabilities-driven innovation management framework is too much emphasized on the capabilities and does not reflect how ICT companies can analyse their innovation process. The integrative framework by Song et al. (2015) does reflect how organisations can analyse innovation and which elements are essential on tactic level. This also applies to the innovation management system of Badrinas and Vilà (2015). Both systems confirm that the 'The Eight Essentials of Innovation' by De Jong et al. (2015) are relevant for innovation and therefore this framework will be taken as a starting point for the remainder of this theoretical foundation. This set of essentials fits the situation and complication of the Dutch ICT organisation the most. The Eight Essentials enables the organisation to identify the drivers and barriers of the innovation process in times of a crisis, and to relate them to the innovation process steps.

Table 1: Summary of selected papers on innovation frameworks

Title	Summary
An integrative view on Lean innovation management (Solaimani, Haghighi Talab, et al., 2019)	This study proposes the Lean philosophy to enhance firm innovativeness. This study is based on a survey which results that the Lean philosophy is considered as an inter-related socio-technical system.
On the application of Lean principles and practices to innovation management - A systematic review (Solaimani, Veen, et al., 2019)	In this article an integrated view is generated on Lean innovation management. The Leannovation framework and the various connections between the dimensions are discussed.
An Innovation Management System to Create Growth in Mature Industrial Technology Firms (Badrinas & Vilà, 2015)	The authors of this paper introduced a framework that links key components of the innovation system to growth performance.
Capabilities-driven innovation management™: Conceptual framework to manage the innovation ecosystem (Bouwer, 2015)	Bouwer introduces a Capabilities-Driven Innovation Management conceptual framework to introduce a flexible map to simplify the understanding of innovation management capabilities and to manage a corporate innovation system.
An integrative framework for innovation management of product–service system (Song et al., 2015)	The proposed product-service system innovation management framework in this paper consists of three levels: strategy, tactic and innovation support.
The Eight Essentials of Innovation (De Jong et al., 2015)	This paper proposes a set of eight essential attributes which are required to structure, organize, encourage innovation practices and processes.

2.3.1 The Eight Essentials of Innovation

De Jong et al. (2015) found in their research a set of factors which are essential at every big organisation to perform high on innovation. By conducting in-depth interviews and a survey over 300 organisations and 2.500 executives in a broad set of sectors and countries. They propose that innovation requires a set of practices and processes to organize and construct innovation. The 'Eight Essentials of Innovation' are: *Aspire*, *Choose*, *Discover*, *Evolve*, *Accelerate*, *Scale*, *Extend* and *Mobilize* as visualised in Figure 2.

Aspire - The first essential of innovation is focused on accepting the fact that innovation led growth as absolutely critical, and if an organisation have cascaded targets that reflect this. An organisation should paint a picture of the

potential of innovation and make explicit what innovation contributes to the future strategic plans and why innovation accountability is necessary. The targets of innovation should make teams aware of the added value of innovation and force them to include innovation investments in their business plans. So, teams should understand the magnitude of what they need to achieve and how they can translate their work against goals.

Choose - De Jong et al. (2015) mentioned that innovation initiatives are more related to managing risk instead of eliminating risk. It is important that the innovation portfolio is big enough to make it possible to kill an idea if it is not valuable anymore. From their research it is concluded that most established companies are too much focused on the short-term innovations which are relatively safe and between their risk parameters. This type of innovation is earlier discussed in this paper as 'Incremental innovation' by Dahlin & Behrens (2005). It is classified as innovation that is focused on existing products, processed or service and has low uncertainty.

Discover - To create insights for new ideas of innovation an organisation can look into three different areas as suggested by De Jong et al. (2015): innovation to solve a valuable problem, enabling a solution by (new) technology and generating money from a business model. The chairman of Alcoa ones summarizes this essential as: "If you get the sweet spot of what the customer is struggling with, and at the same time get a deeper knowledge of the new technologies coming along and find a mechanism for how these two things can come together, then you are going to get good returns.". To go beyond the company's boundaries and to gain new insights, the insight-discovery process is relevant and is required for successful innovation (De Jong et al., 2015).

Evolve - A vital part of innovation systems is related to business-model innovations. In the current age where ICT, internet and industry 4.0 are threatening the old industries it becomes more important to reinvent business if necessary. This type of innovation is earlier defined in this theoretical framework as "a change of frame and is typically defined as doing something completely different and which has not been done before" by Norman and Verganti (2012). Nevertheless, big companies are reluctant to risk tempering with their existing core business model (De Jong et al., 2015).

Accelerate - The speed of launching innovations quickly is the fifth essential to deliver and organize innovation. A common conflict in organisations is bureaucracy which is halting approvals of innovation. Organisations should place managers with the right knowledge on the right place to make crucial decisions for approving innovations on time. Innovation should be a continually process to create and maintain competitive advantage.

Scale - The next essential is related to scaling innovation in the relevant markets and segments. When prioritizing the resources and capabilities within the organisation the managers should take into account whether the new product or service can meet the volume and quality requirements.

Extend - External networks are relevant for innovation in almost every sector. By using the skills and talent of other innovators companies can speed up their innovation and create new ways to add customer value. An organisation can collaborate with external partner to share costs and find faster ways to bring their product or service to the customer. In general, de Jong et al. (2015) indicate that most organisations cast a relatively wide network in the ideation phase and are more specific and narrowing their sourcing when the company comes closer to commercializing their innovation.

Mobilize - The final essential is related to the employees within the company. It is about motivating, rewarding, and organizing people to innovate. Big innovative companies find ways to embed innovation within the culture of the company. When individual innovation projects come to life across the company, innovation managers should reward the individuals and clarifying their responsibilities. In the end, it may take a long period to establish internal communication and experimentation but it contributes to sharing ideas and knowledge for establish new innovations.

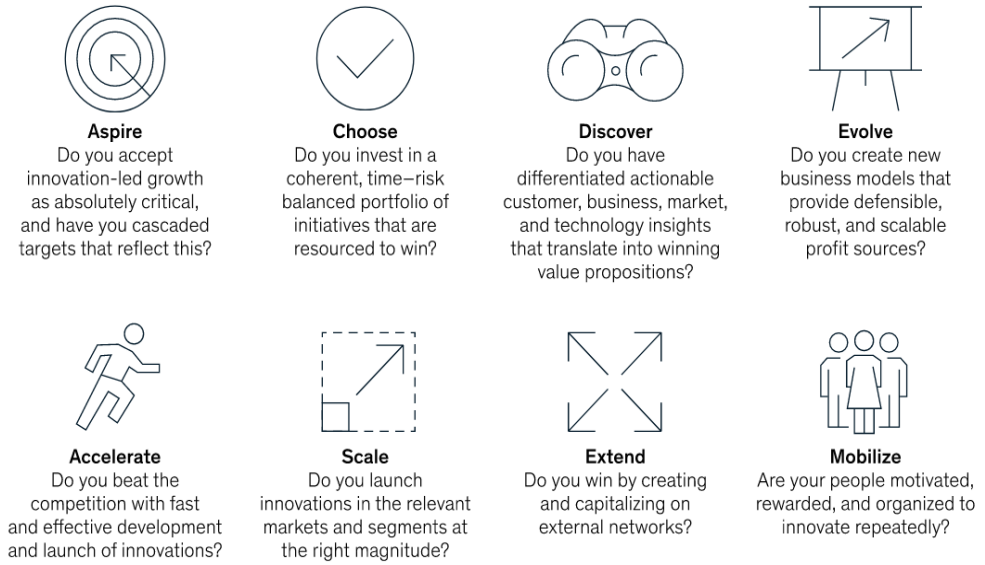

Figure 2: The Eight Essentials of Innovation

Note. Reprinted from "The Eight Essentials of Innovation.", by De Jong et al. (2015), McKinsey Quarterly.

2.3.2 Linkage between the Eight Essentials and the innovation process

Despite the fact that the Eight Essentials are essential factors to be an innovative framework, no link has yet been made with the process steps introduced by Cortimiglia et al. (2015). However, there is a relationship between the Eight Essentials and the generic innovation model proposed by Cortimiglia et al. (2015) (see Table 2).

The idea generation step is the first innovation step and relates to *Aspire*, *Discover* and *Extend*. This is because those essentials are focused on collecting information and knowledge for new innovations. *Aspire* relates to new ideas which should be aligned with the organisation's target of innovation and their future strategic plans. *Discover* is more focussed on insights for new innovation projects and to look in different areas which is essential for idea generation. *Extend* is about extending organisation's network to collaborate with other organisations which involves sharing new ideas and insights which reduces costs.

Idea evaluation is about evaluating if the generated ideas are aligned with the technical, economic and strategic requirements. The organisation should consider whether their current business model still adds value or they have to choose for radical innovation and doing something completely different in comparison with their current business. Leaders should consider during the idea evaluation whether they can meet the volume and quality requirements. So, during the evaluation the management should choose the ideas which add value for organisations and are not only focused on short-term. The extended network can help in identifying the new ways to create customer value and finding fast routes to the market.

The development and implementation of innovation are crucial parts of innovation and therefore included in the Eight essentials of De Jong et al. (2015) to beat the competition. It requires rigor planning and great launch management to implement innovation at the rights scale and relevant markets. By prioritizing the resources and knowledge and placing them on the right place it is possible to beat the competition and launch new innovation by effective innovation development.

Mobilize is a more overarching essential which is related to the organisational culture. In the whole innovation process, it is necessary that employees are motivated, rewarded and organized to innovate. New ideas should be generated and come to life across the organisation and the appropriate talent and incentives should be put on the right place within all process steps.

Table 2: Relationship between the Eight Essentials and the innovation process

	Idea generation	Idea evaluation	Innovation development	Innovation implementation
Aspire	X			
Choose		X		
Discover	X			
Evolve		X		
Accelerate			X	X
Scale			X	X
Extend	X	X		
Mobilize	X	X	X	X

2.3.3 Innovation during global crises

The previous section described innovation as a generic term under normal circumstances and elaborates on the generic framework of Cortimiglia et al. (2015). However, in times of crisis innovation management suffers in most cases and becomes a neglected field of management (Milic, 2013). In 2009 the annual report of the Organisation for Economic Co-operation and Development (OECD) the authors recommended business behaviour and innovation management as a key to permanent recovery (OECD, 2009).

In 2003, the SARS outbreak accelerated the behavioural change of e-commerce in China (Nathan et al., 2020). For example, the crisis kickstarted Alibaba's e-commerce success in Asia because many Chinese were in quarantine and not able to go outside. A similar example is the Chinese JD Multimedia, the organisation migrated their online and offline business in response to the SARS outbreak. So, despite all the negative demand shocks, China became the epicentre of innovation and e-commerce. The Chinese were able to reduce the negative impact of the crisis (Am et al., 2020; Forster & Tang, 2005). Due to the beneficial impact of the SARS pandemic on the Chinese internet sector the internet became a mass medium. Duncan Clark, the author of "Alibaba: The House That Jack Ma Built", points out that this outbreak was the genesis of e-commerce: "This is just when people began to be offered broadband connections, and people began to experience what they could do when they were stuck at home. The full force of China's e-commerce boom would not be felt for a few years yet, but this was the genesis.".

The financial crisis in 2008 is another example of a crisis which had a major impact on innovation. The crisis causes companies to spend less and therefore could invest less in innovation investments. However, it questionable if it is a good choice to invest less in innovation to return to long-term growth after the crisis (Milic, 2013). This consideration is reflected in the European Survey by Archibugi et al. in (2013). They conclude that the economic crisis reduced the willingness to decrease innovation investment from 38 percent to 9 percent.

Companies that are still innovating and according to Archibugi et al. (2013) "swimming against the stream" are more smaller companies which are exploring new market opportunities with technological appropriation methods. The historical data shows these firms outperformed the market during the recovery of this crisis (De Jong et al., 2015).

To recover from a crisis such as the SARS pandemic and the economic crisis of 2008 different innovation essentials become more important (De Jong et al., 2015). So, mastering the essentials of innovation is even more important in the current COVID-19 pandemic, the first global crisis since the economic crisis. The crisis is unique because it does not have an economic origin, but it became also an economic crisis (Borio, 2020). To emerge as an innovation leader after this crisis the Eight Essentials can be used as a road map for success (De Jong et al., 2015).

2.3.4 Drivers and barriers of innovation in times of a crisis

Crises do have an impact on the Eight Essentials which are critical to emerge stronger from a crisis. The current COVID-19 pandemic is a great opportunity to execute an empirical research to analyse the impact of this crisis on the Eight Essentials. To investigate what drives innovation and to identify the barriers of innovation during a global crisis. The previous section already discusses the relationship between the Eight Essentials and the innovation process steps. This section discusses are more detailed view of the drivers and barriers which are summarized in Table 3.

Aspire – To become an innovative leader it is important to look if it is required to reframe the business that shaped the aspiration of an organisation as before a crisis. In a normal environment, leaders sometimes have years to anticipate on inflections in the market, but after a crisis, these inflections can occur in a couple of weeks or months. So, the vision of a company during a crisis is urgent and necessary to prepare for after a crisis and to anticipate on inflections in the market (M. Johnson & Suskewicz, 2020). The business environment can come to an end in one or two years after a crisis and can completely change.

Choose – After the crisis it is likely that customer rethink their needs and an organisation should anticipate and reallocate their resources towards new opportunities (De Jong et al., 2015). However, to exploit those opportunities it requires leaders to avoid getting fully consumed on the short-term of the impact and they should take some risk in their innovation investment in the challenging business environment of crisis (Watkins & Yaziji, 2020). The assumptions of an initiative should be challenged to look whether the assumptions still apply after the crisis.

Discover – It is necessary for companies to understand how the market context is changing and the impact of the crisis on their business. A crisis can reshape the market and an organisation should be activated to collect market insights and to monitor the impact of those changes. Idea generation involves an 'observatory' stage in which new potential direction are explored (Bessant et al., 2015). However, professor de Dreu from the University of Leiden stated that a crisis counteract a creative process (Olsthoorn, 2021). Milic (2013) calls for a balance to maintain a constant flow of innovation during a crisis: revolutionary products and services with incremental improvements of the existing ones. This corresponds to the idea of Dahlin and Behrens (2005): "Radical innovation brings new domains and new paradigms, and it creates a potential for major changes. Incremental innovation is how the value of that potential is captured. Without radical innovation, incremental innovation reaches a limit. Without incremental innovation, the potential enabled by radical change is not captured.".

Evolve – In times of a crisis a number of organisations are seeing a dramatic shift of their profit or the economic that support their business. Crises are therefore great opportunities to evolve. Organisations can consider which elements of their business model still add value and which elements are unlikely to return after the crisis. The current COVID-19 pandemic drives a rapid migration to digital technologies and remote work (Baig et al., 2020). The current crisis will be remembered as a historic deployment of remote work and digital access to services across every domain (Baig et al., 2020). Businesses should consider after a crisis how they can return and how to react such structural changes a crisis entails (Sneader & Sternfels, 2020).

Accelerate and scale – A characteristic of crisis-driven innovation is the extreme conditions to radical rethink solutions in opening up new domains and paradigms for innovation (Bessant et al., 2015). The example of China in 2003 which kickstarted Alibaba's e-commerce shows how a company accelerated the pace of bringing new ideas to the market. Joseph Schumpeter, an Austrian political economist, showed that economic crises give rise to new entrepreneurs to seize opportunities for new models and revolutionize the economy (Śledzik, 2013). So, organisations can beat the competition with fast and effective development if they are able to launch innovations in the relevant markets and segments at the right magnitude.

Extend and mobilize – Gardner and Ivan's research (2020) on the financial crisis of 2008 shows that collaborative partners of a firm outperformed their colleagues during and after the crisis. This reason for collaboration and extending their external partnerships is due to the uncertainty in times of a crisis. Organisations can mitigate their risk by working on multiple initiatives and spreading their

bets across different opportunities. To enable these partnerships it is important create a culture in which people are motivated to innovate and to communicate the strategic objectives and organisational changes (Boehm, 2012). Milic (2013) stated that the human capacity to innovation is the key for recovery and sustainable growth.

Table 3: Drivers and barriers of innovation in times of a crisis

	Drivers [D] and barriers [B]
Aspire	**[D]** A crisis accelerates inflections in the market and potentially disrupt innovation whereby a clear vision during a crisis helps to follow these changes (Johnson & Suskewicz, 2020). **[B]** A crisis causes that an organisation should anticipate on inflections that completely changes the business environment in a couple of weeks or months. In a normal environment the organisations might have had five years to anticipate (Johnson & Suskewicz, 2020).
Choose	**[D]** A crisis stimulates customers to rethink their needs, so organisations should anticipate and reallocate their resources to exploit new business opportunities (De Jong et al., 2015). **[B]** A crisis results in a failure to exploit new business opportunities if there is too much focus on the short-term impact of innovations due to the challenging business environment of a crisis (Watkins & Yaziji, 2020).
Discover	**[D]** A crisis reshapes the market and an organisation should be activated to analyse the market and to monitor the impact of the business changes. Otherwise, it causes the organisation to no longer connect to the market (Bessant et al., 2015). **[B]** A crisis harms the innovative capacity of an organisation and results in fewer radical innovation for revolutionary products (Milic, 2013).
Evolve	**[D]** A crisis stimulates organisations to consider the value adding elements of their model and abandon the elements which are unlikely to return after a crisis (Am et al., 2020). **[B]** A crisis requires organisations to create new business models due to the structural changes a crisis entails, otherwise the organisations fail to find their way after the crisis (Sneader & Sternfels, 2020).
Accelerate and Scale	**[D]** A crisis accelerates radical rethinking for solutions in new domains and paradigms due to the extreme conditions (Bessant et al., 2015). **[B]** A crisis gives rise to seize opportunities for new models, so fast and effective development is necessary to launch innovations and beat the competition in times of a crisis (Śledzik, 2013).
Extend and Mobilize	**[D]** A crisis stimulates collaboration with external partners to mitigate risk due to the uncertainty in times of a crisis (Gardner & Ivan, 2020). **[B]** A crisis requires employees who are motivated, rewarded and organized to innovate otherwise it can hinder external relationships for innovation after the crisis (Boehm, 2012).

As stated by the ICT organisation the core problem is to identify to what degree the crisis slowed down or accelerated the innovation processes in each sector. The crisis either drives innovation by exploitation of the drivers or blocks innovation processes due to the identified barriers. The drivers and barriers of Table 3 confirm that the literature is ambiguous about the impact of a crisis. This makes it hard to define a hypothesis as a starting point for further investigation given the lack of evidence to formulate how innovation processes are affected by the situation due to the COVID-19 pandemic in ICT organisations.

2.4 Objective of the follow-up research

After conducting this literature review the follow-up research at the Dutch ICT organisation is aimed at answering SQ3 and SQ4. Based on the literature the drivers and barriers of innovation in times of a crisis are identified and operationalised. These operationalised variables are used to analyse the impact of the situation due to the COVID-19 pandemic on the innovation processes within the ICT organisation. Based on quantitative and qualitative research, this impact is assessed and it is identified what can be learned from the measures taken in response to the crisis.

3 Method

The main approach used for this research is based on an in-depth analysis of the impact of the current situation due to the COVID-19 pandemic in the case organisation. In this research it is chosen to gain quantitative data by conducting a survey in combination with qualitative interviews to collect data from a predefined group of respondents in the organisation.

3.1 Quantitative research

To analyse the impact on the innovation processes, the empirical research starts with a quantitative research approach. This type of research deals with statistical data which can be analysed with techniques such as the Statistical Package for the Social Sciences (Sheard, 2018).

3.1.1 Setting and data collection

To collect the statistical data from the respondents it is chosen to do a survey research. This type of research is an useful approach to describe the research concepts and explore the operationalised variables (Ponto, 2015). The data is collected by a survey in which the respondents are asked to assess the impact of the situation due to the pandemic. Five directors are asked to provide additional qualitative information in semi-structured interviews. This improves the interpretation of the results by providing additional qualitative in-depth perspectives about the research concepts.

The survey starts with asking how long the respondent works at the organisation, the role of the respondent and in which business unit the respondent works. The control variables are limited to ensure anonymity of the respondents. If more variables were included the anonymity could no longer be guaranteed. The second part of the survey is about twenty-four statements and twelve questions which are operationalised based on research concepts.

By using a Likert-scale for each statement or question the participants are asked to choose the response option that reflects their position on the dimension (Johns, 2020). The advantage of using the Likert format is for simplicity, versatility and responses are comparable. An odd number of scale points is preferable because the participants can choose for a neutral middle point (Colman et al., 1997). Based on earlier research, five or seven number of scale points are the most significant (Colman et al., 1997; Johns, 2020; Neumann & Neumann, 1981). However, because the survey is electronically-distributed due to the pandemic a 7-points scale is the most appropriate and results in more accurate answers (Finstad, 2010). The Likert scale for the statements is defined as: strongly disagree, agree, somewhat disagree, neutral, somewhat agree, agree and strongly agree. For the questions the following 7-points Likert scale is used: very poor, poor, below average, average, above average, good and very good.

To determine whether the respondents give inaccurate or untruthful answers the response bias is important. First of all, to minimize the response bias the survey is reviewed by employees with different job tenures and roles within the ICT organisation. Secondly, the respondents are not allowed to fill out the survey multiple times, because this can result in repetition of answers. Finally, an appropriate sample size is necessary to draw a conclusion and should be five time as many respondents as there are variables within the model. The 1141 employees of the ICT organisation were able to complete the online survey in Google Forms from 11 May 2021 until 17 June 2021. A total of 188 surveys were completed and returned, corresponding with a response rate of 16.5 percent.

3.1.2 Item generation

In Table 4 the Eight Essentials and the related drivers and barriers are operationalised. The concepts are operationalised to turn those Eight Essential concepts into measurable observation. These concepts are first of all represented by variables and the indicators are chosen based on a literature study. The number of indicators is limited to prevent fatigued participants.

Aspire – This essential is related to cascaded innovation targets and if an organisation accepts that innovation is critical. Johnson and Suskewicz (2020) mentioned that a clear vision is necessary to anticipate on inflections in the market after a crisis. The scale of Kozioł-Nadolna (2020) is used to measure if the case organisation have anticipated on a potential reframe of the business. A two-item scale from Kozioł-Nadolna (2020) is used to measure the commitment of employees to the vision, mission and strategic objectives which is crucial for innovative ideas. A business continuity plan enables an organisation to implement coordinated procedures to face unexpected issues causing business disruption so this scale is added from ACCA (2020).

Choose – In times of a crisis it is necessary to invest in a balanced portfolio of initiatives that are resourced to win. Customers are rethinking their needs and therefore the exploration and exploitation scale of Jansen et al. (2006) is used. Exploration is the extent to which the organisation depart from existing knowledge, skills or existing customer, markets, and products (Benner & Tushman, 2003). Exploitation is the opposite and relates to build on these elements (Benner & Tushman, 2003). In this concept a nine-item scale is used to measure this concept with six exploration items and three exploitation items.

Discover – The driver of a crisis of reshaping the market and monitoring the impact of the business changes is measured by a three-item scale from the exploitation concept of Jansen et al. (2006). Furthermore, the barrier of harmed innovation capacity due to the crisis is measured by using a three-item scale which is constructed based on the paper of Loewe and Dominiquini (2006) and

a research of Prajogo and Ahmed (2006). These statements are related to what extend the organisation provides training, time, tools and technologies for innovative ideas or solutions.

Evolve – To evaluate whether the organisation evaluates their business model and abandon the elements which are unlikely to return after a crisis, an item from ACCA (2020) is included. In addition, a four-item scale is included to measure if the organisation creates new business models and how the organisation reacts to current technology trends (Loewe & Dominiquini, 2006; McKinsey, 2020).

Accelerate and scale – A six-item scale from Prajogo and Ahmed (2006) related to process innovation is used to measure this concept. Process innovation is the production of end-products or services through the diffusion or adaption of innovation which is developed earlier (Zhuang et al., 1999). This corresponds to the scope of this concept which is mainly focussed on delivering and organizing innovation over time. It should be a continuous process to create and maintain competitive advantage.

Extend and mobilize – One part of the survey from CIS in 2012 was related to organisational innovation which includes collaboration with external partners and the implementation of new methods and practices. To measure this research concept a three-item scale from CIS about organisational innovation is included in this survey. To determine whether employees are motivated, rewarded and organized to innovate, the set of items related to creativity and idea generation from Prajogo and Ahmed (2006) are included. A scale from Loewe and Dominiquini (2006) is included to measure the effectiveness of knowledge sharing.

Since the pre-specified relationships between the research concepts and survey items are derived from theory, a confirmatory factor analysis is useful. A confirmatory factor analysis examines whether the items really determines the variances of the observed variables and if the model fits (Shek & Yu, 2014). To conduct a confirmatory factor analysis, it is determined whether the survey data meets the required assumptions for executing a factor analysis.

Table 4: Operationalization of research concepts

Concept	Variable	Indicator	Survey Question (item ID)
Aspire	Awareness of strategy	Employee strategy awareness degree	I am aware of the mission, vision and strategic objectives of the organisation. (ASP01)
	Awareness of strategy	Employee vision awareness degree	I have a clear vision of what the company will look like in a few years' time. (ASP02)
	Business environment change	Employee awareness of the business continuity plan	I am aware of the business continuity plan to respond effectively to the inflections of crises. (ASP03)
Choose	New business opportunities	Frequency of demands beyond existing products/services	My business line accepts demands that go beyond existing products or services. (CHO01)
	New business opportunities	Frequency of new product and service development	My business line invents new products or services. (CHO02)
	New business opportunities	Frequency of new product experiments in the current market	My business line experiments with new products or services in the local market. (CHO03)
	New business opportunities	Frequency of commercialization of products/services	We commercialize products and services that are completely new to our business line. (CHO04)
	New business opportunities	Frequency of new opportunities in new markets	My business line frequently utilizes opportunities in new markets. (CHO05)
	New business opportunities	Frequency of new distribution channels	My business line regularly uses new distribution channels. (CHO06)
	Innovation builds on existing knowledge	Frequency of provision's efficiency improvement	My business line improves the provision's efficiency of products or services. (CHO07)
	Innovation builds on existing knowledge	Frequency of economies of scales increase for products/services	My business line increases economies of scales in existing products and services. (CHO08)
	Innovation builds on existing knowledge	Frequency of services expansion for existing clients	My business line expands services for existing clients. (CHO09)

Concept	Variable	Indicator	Survey Question (item ID)
Discover	Monitoring and reshaping	Frequency of product provision refinement	My business line frequently refines the provision of existing products and services. (DIS01)
	Monitoring and reshaping	Number of small adaptions to existing products/services	My business line regularly implements small adaptations to existing products and services. (DIS02)
	Monitoring and reshaping	Number of existing products/services improvements	My business line introduces improved but existing products and services for our local market. (DIS03)
	Innovative capacity	Amount of creativity training	The organisation provides training in creativity, innovation and/or other problem-solving techniques. (DIS04)
	Innovative capacity	Amount of time available for innovation	The organisation provides time for employees to generate, share or experiment innovative ideas/solutions. (DIS05)
	Innovative capacity	Availability of tools and technologies	The organisation provides tools and technologies for employees to generate, share or experiment innovative ideas/solutions. (DIS06)
Evolve	Business model evaluation	The degree of insight into the business disruption caused by the COVID-19 situation	The organisation puts measures in place in response to business disruption. (EVO01)
	Business model creation	Innovation objectives awareness	The organisation has set objectives or measures to drive innovation. (EVO02)
	Business model creation	Amount of new technology trends implemented	How does the organisation react to digitization of employee interaction and collaboration? (EVO03)
	Business model creation	Amount of new technology trends implemented	How does the organisation react to the digitization of customer channels? (EVO04)
	Business model creation	Amount of new technology trends implemented	How does the organisation react to remote working? (EVO05)

Concept	Variable	Indicator	Survey Question (item ID)
Accelerate and Scale	Radical rethinking acceleration	Changes in processes	How would you rate the organisation speed of change in their processes? (ACC01)
	Radical rethinking acceleration	Changes in processes	How would you rate the organisation speed of change in their techniques? (ACC02)
	Radical rethinking acceleration	Changes in processes	How would you rate the organisation speed of change in their technology? (ACC03)
	Development speed	Currency of technology	How would you rate the technological competitiveness of the organisation? (ACC04)
	Development speed	Speed of adoption	How would you rate the updatedness (novelty) of the technology used in the processes? (ACC05)
	Development speed	Adoption of innovations	How would you rate the speed with which the organisation adopts the latest technological innovations in the processes? (ACC06)
Extend and Mobilize	External partner collaboration	Number of business practices implemented	How would you rate the organisation performance to implement new business practices for organising procedures? (EXT01)
	External partner collaboration	Number of methods work responsibilities and decision making	How would you rate the organisation performance to implement new methods of organising work responsibilities and decision making? (EXT02)
	External partner collaboration	Number of new methods implemented	How would you rate the organisation performance to implement new methods of organising external relations with other firms or public institutions? (EXT03)
	Organisational innovation culture	Effectiveness of knowledge sharing	The organisation effectively transfers knowledge, skills or ideas across business units. (EXT04)
	Organisational innovation culture	Degree of open communication	I am working in diversely skilled teams where there is free and open communication among the team members. (EXT05)
	Organisational innovation culture	The amount of nonroutine and challenging work	I frequently encounter nonroutine and challenging work that stimulates creativity. (EXT06)
	Organisational innovation culture	Reward frequency of great project ideas	I am recognised and rewarded for my creativity and innovative ideas. (EXT07)

3.2 Model assessment – Confirmatory factor analysis

Before conducting the confirmatory factor analysis (CFA) it is checked whether the assumptions of conducting a structural equation model are met. All the variables before the crisis are normally distributed based on the criteria that the univariate skewness and kurtosis value are between -2 and +2 with a N < 200 in order to prove normal univariate distribution (Field, 2006). The Mahalanobis distance is calculated to determine potential outliers in the original data set. This measure indicates the distance between an observation and a distribution. Both p-values should be below .05 (Bollen, 1987). The dataset includes 32 possible outliers, however after individually examining these observations it became clear that those data points are valid. Therefore, the complete data set is retained and analysed.

The hypothesized model will be tested with the survey data. To improve the goodness of fit, the model is revised and fit to the obtained data. In this section each research concept is further improvement with two different approaches. The first approach is to delete the paths in the model which are not significant (p-value > 0.05). These paths often indicate a wrong factor loading (Shek & Yu, 2014). So, with theoretical interpretation the model fit is improved by deleting these paths. This approach is called model trimming and the advantage of this approach is a simplified model with a larger degree of freedom (df) and a better model fit. The second approach is known as model building. This approach uses two statistics to add parameters to the model. The first statistic is "Modifications Indices (MIs)" and represents the expected drop of chi-square when the parameter is freely estimated. The second parameter is the expected parameter change (EPC) value (Saris et al., 1987). The EPC represents the predicted change for each fixed parameter (Shek & Yu, 2014). The higher the MI and EPC values, the better the model fit if the associated relation is added to the model. To justify the model modification the adjustments are based on the data 'before the crisis'. Subsequently, the data 'during the crisis' is used to evaluated the re-specified model.

3.2.1 Aspire

The *Aspire* model is an exception, because the model has zero degrees of freedom. A single latent variable is measured by three observed variables. So, three variances and three covariances. Given these (co)variances the degree of freedom is zero: six elements in the matrix of covariances minus six parameter to be estimated. This type of model is defined as a saturated model and the measures of model fit cannot be applied. This results in a perfect fit, because misfit is impossible.

Table 5 and Table 6 support this observation, because all goodness of fit criteria are met before using an improvement approach to fit the data.

Table 5: Regression weights of the hypothesized Aspire model

Covariances	Estimate	S.E.	C.R.	P-values
ASP01 ↔ Aspire	1			
ASP02 ↔ Aspire	1.801	.391	4.605	***
ASP03 ↔ Aspire	1.079	.187	5.783	***

*Notes: *p < 0.05, **p < 0.01, ***p < 0.001.*

Table 6: Goodness-of-fit statistics of the CFA Aspire model (before the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	.000	0	N.A.	1.000		1.000	1.000	0.472	12.000
Goodness of fit criteria		-	-	≥0.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

So, the hypothesized model is the same as the final model which is visualised in Figure 3.

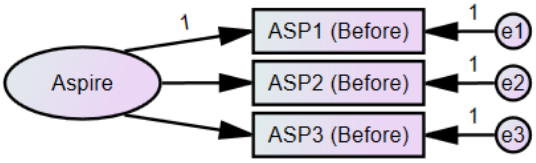

Figure 3: The final Aspire model (M0)

3.2.2 Choose

The model has only significant paths (see Table 7). Therefore, there is no reason to indicate that there exist a wrong factor loading (Shek & Yu, 2014).

Table 7: Regression weights of the hypothesized Choose model

Covariances	Estimate	S.E.	C.R.	P-values
CHO01 ↔ Choose	1			
CHO02 ↔ Choose	4.297	1.569	2.739	.006**
CHO03 ↔ Choose	4.575	1.664	2.749	.006**
CHO04 ↔ Choose	4.229	1.555	2.719	.007**
CHO05 ↔ Choose	3.278	1.232	2.661	.008**
CHO06 ↔ Choose	2.356	0.915	2.574	.011*
CHO07 ↔ Choose	2.639	1.007	2.621	.009**
CHO08 ↔ Choose	2.121	0.835	2.541	.011**

*Notes: *p < 0.05, **p < 0.01, ***p < 0.001.*

To test the Goodness-of-fit for *Choose*, the modification indices of covariances for the hypothesized model are mentioned in Table 8. This suggests that items CHO7 and CHO09 are both related to the improvement or expansion of products and services; CHO07 and CHO08 are associated; and items CHO06 and CHO07 are related. Obviously, from a theoretically perspective there may be some overlap in the meaning of these items. This is due to the item generation from the paper of Jansen et al. (2006) where CHO07, CHO08 and CHO09 are related to exploitation and therefore the highest MI. So, it makes sense to include these suggested correlations in the re-specified model to create a better model fit.

Table 8: Modification indices of covariances of the hypothesized Choose model

Covariances	MI	EPCV	Covariances	MI	EPCV
e7 ↔ e9	**12.473**	**.271**	e3 ↔ e8	6.331	-.174
e7 ↔ e8	**29.565**	**.445**	e2 ↔ e3	6.612	.147
e6 ↔ e7	**9.061**	**.255**	e1 ↔ e9	7.591	.228
e4 ↔ e7	5.620	-.203	e1 ↔ e4	6.606	.237

The next step in the model modification is to re-specify the original model (M0) based on the suggested correlations. The goodness-of-fit statistics for each of the three modified models and the initial model are summarized in Table 9. Model M3 shows a good fit, based on the above analysis and is supported by the different criteria for a goodness of fit. The differences of $\chi 2$ are all non-significant ($P<0.01$) which can indicate a misfit, however $\chi 2$ statistics is sensitive for sample size (N=188). For this reason, this statistic is no longer relied upon a single basis for rejecting the model (Lance, 2011; Schermelleh-Engel et al., 2003). In addition, the AIC values are much smaller for M3 compared with the original model M0. The same analyse is executed to check whether this also applies to the data during the crisis and is summarized in Appendix E. This data shows a good fit based on the same criteria for goodness of fit. So, based on these findings it can be concluded that M3 has the best model fit and shown in Figure 4.

Table 9: Goodness-of-fit statistics of the Choose CFA model (Before the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	101.383	27	.000	.855	.807	.816	.858	.121	137.383
M1	M0 + correlated errors of CHO07 and CHO08	69.297	26	.000	.916	.883	.874	.917	.094	107.297
M2	M1 + correlated errors of CHO07 and CHO09	58.529	25	.000	.935	.906	.894	.936	.085	98.529
M3	M2 + correlated errors of CHO06 and CHO07	46.697	24	.000	.956	.934	.915	.957	.071	88.697
Goodness of fit criteria		-	-	≥0.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

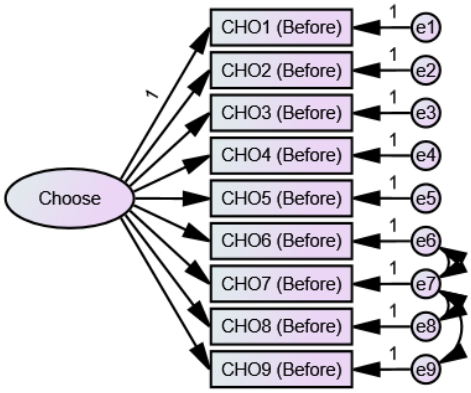

Figure 4: The final Choose model (M3)

3.2.3 Discover

The model does not have any non-significant paths in the model (see Table 10). So, there is no reason to indicate that there exist a wrong factor loading (Shek & Yu, 2014).

Table 10: Regression weights of the hypothesized Discover model

Covariances	Estimate	S.E.	C.R.	P-values
DIS01 ↔ Discover	1			
DIS02 ↔ Discover	0.789	0.116	6.784	***
DIS03 ↔ Discover	1.096	0.149	7.363	***
DIS04 ↔ Discover	0.449	0.142	3.174	0.002**
DIS05 ↔ Discover	0.606	0.146	4.141	***
DIS06 ↔ Discover	0.521	0.145	3.597	***

Notes: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

To test the Goodness-of-fit for *Discover*, the modification indices of covariances for the hypothesized model are mentioned in Table 11. This suggests that items DIS04, DIS05 and DIS06 are related to each other. This is in line with the theory, because these three items are related to the barrier 'A crisis requires organisations to create new business models due to the structural changes a crisis entails, otherwise the organisations fail to find their way after the crisis' (Sneader & Sternfels, 2020). It makes sense to include these suggested correlations in the re-specified model to create a better model fit.

Table 11: Modification indices of covariances of the hypothesized Discover model

Covariances	MI	EPCV
e5 ↔ e6	**68.573**	**1.090**
e4 ↔ e6	**66.423**	**1.071**
e4 ↔ e5	**41.135**	**0.835**
e3 ↔ e6	4.255	-.193
e3 ↔ e4	4.882	-.204

Covariances	MI	EPCV
e2 ↔ e6	12.999	-.317
e2 ↔ e5	8.550	-.255
e2 ↔ e4	5.147	-.197
e1 ↔ e5	4.414	-.181

The next step in the model modification is to re-specify the original model (M0) based on the suggested correlations as mentioned before. The goodness-of-fit statistics for each of the three modified models and the initial model are summarized in Table 12.

Table 12: Goodness-of-fit statistics of the Discover CFA model (Before the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	186.208	9	.000	.476	.127	.473	.485	.324	210.208
M1	M0 + correlated errors of DIS05 and DIS06	102.010	8	.000	.458	.479	.711	.728	.251	128.010
M2	M1 + correlated errors of DIS04 and DIS06	61.140	7	.000	.840	.657	.827	.844	.203	89.140
M3	M2 + correlated errors of DIS04 and DIS05	10.589	6	.102	.986	.966	.970	.987	.064	40.589
Goodness of fit criteria		-	-	≥0.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

At the end, M3 shows a good fit based on the analysis and the different criteria for goodness of fit. However, the difference of χ^2 has only a non-significant value for M3 (P = 0.102) and the other models are significant. As mentioned earlier, this is not a reason for rejecting the model (Lance, 2011; Schermelleh-Engel et al., 2003). The AIC value of M3 is much smaller compared with the original model M0. To check whether this also applies to the data during the crisis conclusion, the same analysis is executed and summarized in Appendix E. This data also shows a good fit based on the same criteria for goodness of fit. So, it can be concluded that M3 fits better to both datasets compared to the other tested models. The final model is shown in Figure 5.

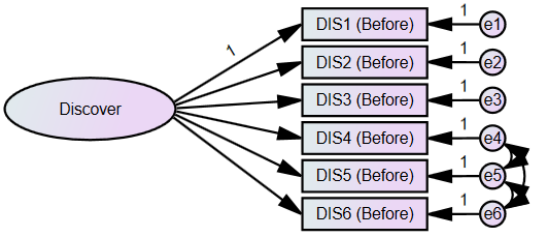

Figure 5: The final Discover model (M3)

3.2.4 Evolve

The model does not have any non-significant paths in the model (see Table 13). So, there is no reason to indicate that there exist a wrong factor loading (Shek & Yu, 2014).

Table 13: Regression weights of the hypothesized Evolve model

Covariances	Estimate	S.E.	C.R.	P-values
EVO01 ↔ Evolve	1			
EVO02 ↔ Evolve	0,878	0,266	3,307	***
EVO03 ↔ Evolve	1,875	0,421	4,455	***
EVO04 ↔ Evolve	1,565	0,353	4,439	***
EVO05 ↔ Evolve	1,931	0,456	4,24	***

*Notes: *p < 0.05, **p < 0.01, ***p < 0.001.*

The modification indices of covariances for the hypothesized model are mentioned in Table 14 to test the Goodness-of-fit for *Evolve*. This suggests that EVO01 and EVO02 are related to each other. Both items respectively correspond to the statements 'Measures put in place or actively being considered in response to the business disruption caused by COVID-19' and 'The organisation has set objectives or measures to drive innovation'. So, there may be some overlap in the meaning of these items because and therefore the suggested correlation will be applied to the original model.

Table 14: Modification indices of covariances of the hypothesized Evolve model

Covariances	MI	EPCV
e1 ↔ e2	**10.442**	**0.347**

The next step in the model modification is to re-specify the original model (M0) based on the suggested correlations as mentioned before. The goodness-of-fit statistics are summarized in Table 15.

Table 15: Goodness-of-fit statistics of the Evolve CFA model (Before the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	16.809	5	.005	0.942	0.885	0.922	0.944	0.112	36.809
M1	M0 + correlated errors of EVO01 and EVO02	6.016	4	.198	0.990	0.975	0.972	0.990	0.052	28.016
Goodness of fit criteria		-	-	≥0.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Based on the above analyses model M1 shows a good fit, supported by the goodness-of-fit indexes. However, the difference of χ^2 has only a non-significant for M2 (P = 0.198) and the original model shows a significant chi-square test. M1 shows a good fit for both datasets (see Appendix E) based on the indexes and is shown in Figure 6.

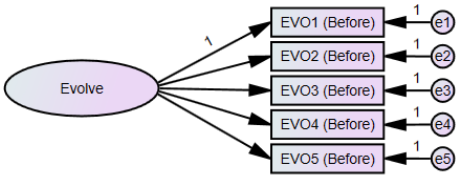

Figure 6: The final Evolve model (M1)

3.2.5 Accelerate and Scale

The model does not have any non-significant paths in the model (see Table 16). So, there is no reason to indicate that there exist a wrong factor loading (Shek & Yu, 2014).

Table 16: Regression weights of the hypothesized Accelerate and Scale model

Covariances	Estimate	S.E.	C.R.	P-values
ACC01 ↔ Accelerate and scale	1			
ACC02 ↔ Accelerate and scale	1.341	0.145	9.281	***
ACC03 ↔ Accelerate and scale	1.528	0.156	9.774	***
ACC04 ↔ Accelerate and scale	1.321	0.146	9.046	***
ACC05 ↔ Accelerate and scale	1.465	0.152	9.658	***
ACC06 ↔ Accelerate and scale	1.427	0.147	9.713	***

*Notes: *p < 0.05, **p < 0.01, ***p < 0.001.*

The modification indices of covariances for the hypothesized model of *Accelerate and Scale* are mentioned in Table 17. This suggests that items ACC05 and ACC06 are correlated; and ACC01 and ACC06 are correlated. From a theoretical perspective this makes sense, because these three items are related to the speed of change, updatedness and the adoption of technological innovations in the innovation processes. So, the suggested correlations are added to create a better model fit.

Table 17: Modification indices of covariances of the hypothesized Accelerate and Scale model

Covariances	MI	EPCV
e5 ↔ e6	**27.301**	**.150**
e3 ↔ e5	14.718	-.114
e2 ↔ e6	4.473	-.066
e2 ↔ e4	8.416	-.110
e2 ↔ e3	15.795	.128
e1 ↔ e6	**20.018**	**-.177**
e1 ↔ e2	14.781	.172

The next step in the model modification is to re-specify the original model (M0) based on the suggested correlations. The goodness-of-fit statistics for each modified model and the original model are summarized in Table 18.

Table 18: Goodness-of-fit statistics of the Accelerate and Scale CFA model (Before the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	81.621	9	.000	0.915	0.859	0.907	0.916	0.208	105.631
M1	M0 + correlated errors of ACC05 and ACC06	42.516	8	.000	0.960	0.925	0.951	0.960	0.152	68.516
M2	M1 + correlated errors of ACC01 and ACC06	27.847	7	.000	0.976	0.948	0.968	0.976	0.126	55.847
Goodness of fit criteria		-	-	≥0.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Based on the above analyses, model M2 shows a good fit. The difference of χ^2 is significant for each model, but the model will not be rejected due to the relative low sample size (Lance, 2011; Schermelleh-Engel et al., 2003). The AIC value of M2 is almost halved compared with the initial model (M0). The goodness-of-fit is validated with the dataset 'during the crisis' and summarized in Appendix E.

Given these points, the re-specified model M2 has a better model fit and is visualised in Figure 7.

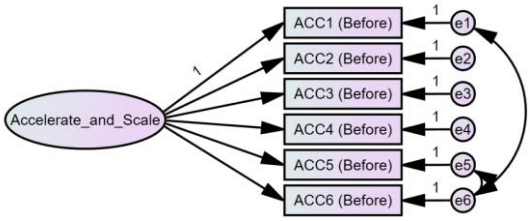

Figure 7: The final Accelerate and Scale model (M2)

3.2.6 Extend and Mobilize

The standardizes regression weights showed that the value EXT01 was extremely low (0.060), so therefore it is decided to assign the pre-defined regression weight to EXT02. This original model shows that EXT01, read as "I am working in diversely skilled work groups where there is free and open communication among the group members." has a non-significant paths in the model (see Table 19). So, this item will be deleted from the model (Shek & Yu, 2014).

Table 19: Regression weights of the hypothesized Extend and Mobilize model

Covariances	Estimate	S.E.	C.R.	P-values
EXT01 ↔ Extend and mobilize	0.15	0.199	0.753	0.451
EXT02 ↔ Extend and mobilize	1.000			
EXT03 ↔ Extend and mobilize	1.686	0.514	3.279	0.001**
EXT04 ↔ Extend and mobilize	1.553	0.501	3.097	0.002**
EXT05 ↔ Extend and mobilize	2.409	0.668	3.605	***
EXT06 ↔ Extend and mobilize	2.296	0.639	3.595	***
EXT07 ↔ Extend and mobilize	1.546	0.441	3.505	***

Notes: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

The goodness-of-fit indexes are analysed. However, all indexes support a good fit after deleting EXT07 (M1) to the data before the crisis (see Table 21). So, it was not necessary to use model building and the modification indices of Table 20 as modification method.

Table 20: Modification indices of covariances for the hypothesized

Covariances	MI	EPCV
e2 ↔ e3	5.734	.347
e1 ↔ e3	21.814	.354
e1 ↔ e2	4.209	.182

Table 21: Goodness-of-fit statistics of the Extend and Mobilize CFA model (Before the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	41.992	14	.000	0.921	0.882	0.888	0.923	0.103	69.992
M1	EXT01 deleted due to non-significant regression weights (P=0.451)	18.686	9	0.152	0.987	0.979	0.962	0.987	0.050	37.235
Goodness of fit criteria		-	-	≥0.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Based on the above analyses model M1 shows a good fit, supported by the different criteria for goodness of fit. Additionally, although the sample size χ^2 shows a non-significant for M1 (P = 0.152). The AIC value of M2 is smaller compared with the original model M0. The data during the crisis also shows a good fit based on the same criteria for goodness of fit (see Appendix E). So, based on these findings it can be concluded that the model without EXT01 fits better to the data. This final model is shown in Figure 8.

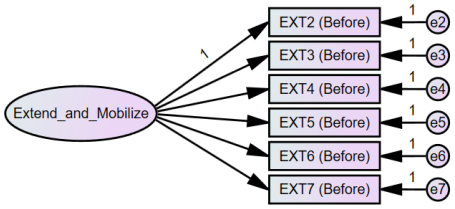

Figure 8: The final Extend and Mobilize model (M1)

3.3 Qualitative research

Five semi-structured interviews are conducted to obtain qualitative data. Each interview is conducted with the director of each business unit within the case organisation. Each interviewee is asked to give answers on questions which are related to the research concepts as shown in Table 4. These concepts are consecutively discussed and for each concept there are some introduction questions, more specific questions related to the drivers or barriers and finally there is some time for a discussion about previous open-ended questions. The interview protocol is shown in Appendix D.

The earlier conducted quantitative analysis gave the opportunity to ask the directors to explain any remarkable results or questions which are ambiguous based on the survey. The survey results were not shared before the interview, because this can influence the interview. However, the directors are informed in advance with the interview protocol about the purpose of the interview and which questions they can expect. At the start of the interview the interviewee was asked if it is allowed to record the interview to make the analysis more reliable. To confirm this, the research participants were asked to sign an informed consent form for research with human participants (see Appendix C).

After conducting these interviews, the interviews transcripts are coded with a code manual. The transcripts are coded by the different research concepts as code manual and ends up with corroborating and legitimating of the earlier coded themes (Fereday & Muir-Cochrane, 2006). A methodology which was earlier used by Hülscher (2020) and resulted in additional perspectives on the research concepts.

Due to the COVID-19 pandemic the Dutch government took measures to restrict the spreading of the coronavirus. The case organisation decided to protect employees from risk to health and safety, and decided to work as much as possible from home. For this reason, it was not possible to physically meet all the directors and therefore three interviews became virtual.

4 Results

The results of the follow-up research at the ICT organisation are mentioned in this chapter. First of all, the survey results are described by using different data analysis techniques. Secondly, the results of the semi structured interviews are explained.

4.1 Results of quantitative research

The dataset as part of the survey research exists of 188 respondents and is analysed in this section. First of all, some descriptive statistics are given to explain the population and distribution across the business units. Thereafter the paired-sample t-test is conducted for each survey statement or question. On the basis of these results a classification schema of Cohen (1988) and Sawilowsky (2009) is used to classify the impact of the crisis.

4.1.1 Descriptive statistics

In Table 22 the population statistics of the respondents are shown. The population is distributed over five business units. The directors of each business were interviewed to gain additional perspectives about the impact of the crisis and underlying factors. In Appendix F the descriptive statistics of each survey statement are given.

Table 22: Respondents statistics

Characteristic	N sample group (%)	N respondents (%)	Response rate (%)
Business unit A	92 (8.1%)	18 (9.6)	19.6
Business unit B	220 (19.3%)	26 (13.8)	11.8
Business unit C	369 (32.3%)	86 (45.7)	23.3
Business unit D	417 (36.5%)	49 (26.1)	11.8
Business unit E	43 (3.8%)	9 (4.8)	20.9
All	**1141 (100%)**	**188 (100.0)**	**16.5**

4.1.2 Impact of the crisis

To analyse the impact of the COVID-19 pandemic on innovation processes a paired-sample t-test is conducted for each statement. The impact is described as the difference between the data before and during the crisis.

A mean difference of +1 indicates that the employees give exactly one point higher on the 7-points scale. For instance, if the average position of the employees is 'neutral' before the crisis and 'somewhat agree' during the crisis it will result in a mean of +1 as a result of the paired-sample t-test. The standard deviation shows the variation of the values for each item. If the statements are related to a validated scale from earlier research this is included in the table as 'related scale'. For instance, the exploration and exploitation scale from Jansen et al. (2006) is a validated scale which is used in *Choose* and *Discover*. In the case that there is not a related scale it is defined as not applicable (N/A).

4.1.2.1 Aspire

The results of the first two statements "I am aware of the mission, vision and strategic objectives of the organisation." and "I have a clear vision of what the company will look like in a few years' time." showed a minimal difference 'before the crisis' compared to 'during the crisis' (see Table 23). The repeated-measures t-test made clear that these differences are not significant: t(187)= -0.990, $p>0.05$ and t(187)=.984, $p>0.05$. The results of the third statement "I am aware of the business continuity plan to respond effectively to the inflections of crises." showed a difference between 'before the crisis' (M= 3.28, SD=1.635) and 'during the crisis' (M= 4.12, SD= 1.700). From the repeated-measures t-test it can be concluded that there is a significant difference, t(187)= -7.380, p<0.001.

Together this suggests that the situation due to the COVID-19 pandemic has only a significant positive impact on the employee awareness of the Business Continuity Plan.

Table 23: Impact of the crisis - Aspire

Related scale	Statement	Mean	SD	t	df	Sig.
N/A	I am aware of the mission, vision and strategic objectives of the organisation.	0.056	.753	-.990	187	.323
N/A	I have a clear vision of what the company will look like in a few years' time.	-0.061	.833	.984	187	.327
N/A	I am aware of the business continuity plan to respond effectively to the inflections of crises.	0.839	1.525	-7.380	187	**.000*** **

*Notes: *p < 0.1, **p < 0.05, ***p < 0.01*

4.1.2.2 Choose

The t-test showed that six statements related to the *Choose* concept are significant different based on different p-values (see Table 24). The ICT organisation accepts that demands go beyond existing product or services (t(187)= -1.706, $p<0.1$), commercializes products and services that are completely new (t(187)= -1.927, $p<0.1$), and finally the organisation uses new distribution channels (t(187)= -2.569, $p<0.05$). These statements are related to the exploration scale from Jansen et al. (2006) and therefore show that the respondents experienced a little impact on the ability to depart from existing knowledge, skills or products. However, the results showed that the situation due to the COVID-19 pandemic does not have a significant impact on the other statements. This implies that the repeated-measures t-test does not found a significant difference for the invention of new products or services (t(187)= -0.816, $p>0.1$), experiments with new products or services in the local market (t(187)= -1.513, $p>0.1$) and the utilisation of opportunities in new markets (t(187)= -1.345, $p>0.1$).

It became clear that the three-item scale of exploitation is significant different before the crisis and during the crisis. This implies that the organisation improved their provision's efficiency of products or services (t(187)= -1.654, *p<0.1*), the economies of scales in existing products and services are improved (t(187)= -4.087, *p<0.01*) and the organisation succeeded to expand their services for existing clients (t(187)= -1.673, *p<0.01*).

In summary, the repeated-measures t-test showed that there is a significant impact of the crisis on six *Choose* statements which are related to the idea evaluation step. This step is about evaluating whether the generated ideas are aligned with the requirements.

Table 24: Impact of the crisis - Choose

Related scale	Statement	Mean	SD	t	df	Sig.
Exploration	My business line accepts demands that go beyond existing products or services.	0.067	0.524	-1.706	187	**0.090***
Exploration	My business line invents new products or services.	0.044	0.731	-0.816	187	0.416
Exploration	My business line experiments with new products or services in the local market?	0.083	0.739	-1.513	187	0.132
Exploration	We commercialize products and services that are completely new to our business line.	0.089	0.619	-1.927	187	**0.056***
Exploration	My business line frequently utilizes opportunities in new markets?	0.067	0.665	-1.345	187	0.180
Exploration	My business line regularly uses new distribution channels.	0.089	0.464	-2.569	187	**0.011****
Exploitation	My business line improves the provision's efficiency of products or services.	0.083	0.676	-1.654	187	**0.098***
Exploitation	My business line increases economies of scales in existing products and services.	0.144	0.474	-4.087	187	**0.000*****
Exploitation	My business line expands services for existing clients.	0.072	0.579	-1.673	187	**0.096*****

*Notes: *p < 0.1, **p < 0.05, ***p < 0.01*

4.1.2.3 Discover

The repeated-measures t-test indicated a difference on two items of the six-item *Discover* scale (see Table 25). The results showed a minimal positive impact on the implementation of small adaptions to existing products and services (t(187)= -2.261, *p<0.05*) and a negative impact on providing time for employees to generate, share or experiment innovative ideas (t(187)= -3.057, *p<0.01*).

Additionally, there was no evidence to suggest that respondents experienced statistically significantly impact of the COVID-19 pandemic on the remaining four *Discover* items.

Table 25: Impact of the crisis - Discover

Related scale	Statement	Mean	SD	t	df	Sig.
Exploitation	My business line frequently refines the provision of existing products and services.	0.039	0.489	1.068	187	0.287
Exploitation	My business line regularly implements small adaptations to existing products and services.	0.083	0.494	2.261	187	**0.025****
Exploitation	My business line introduces improved but existing products and services for our local market.	0.039	0.511	1.021	187	0.309
N/A	The organisation provides training in creativity. innovation and/or other problem-solving techniques.	-0.106	1.086	-1.304	187	0.194
Creativity and idea generation	The organisation provides time for employees to generate, share or experiment innovative ideas/solutions.	-0.239	1.048	-3.057	187	**0.003*****
N/A	The organisation provides tools and technologies for employees to generate, share or experiment innovative ideas/solutions.	-0.039	0.704	-0.741	187	0.460

*Notes: *p < 0.1, **p < 0.05, ***p < 0.01*

4.1.2.4 Evolve

The results of the t-test showed the most significant difference before the crisis and during the crisis on this five-item scale (see Table 26). The pandemic has a significant positive impact on the current technology trends mentioned by McKinsey (2020): digitization of employee interaction and collaboration (t(187)= 6.185, *p<0.01*), digitization of customer channels (t(187)= 6.221, *p<0.01*) and remote working (t(187)= 11.224, *p<0.01*). The respondents also experienced a statistically difference in the objectives or measures to drive innovation (t(187)= 1.418, *p<0.1*). However, these measures are not significantly different in response to business disruption (t(187)= 1.418, *p>0.1*).

To sum up, the crisis impacted the idea evaluation step in view of the *Evolve* statements. This is in line with the impact on the other part of evaluating ideas as earlier mentioned in the section of *Choose*.

Table 26: Impact of the crisis - Evolve

Related scale	Statement	Mean	SD	t	df	Sig.
Leadership and organisation	The organisation has set objectives or measures to drive innovation	-0.094	0.715	-1.773	187	**0.078***
N/A	The organisation puts measures in place in response to business disruption.	0.078	0.736	1.418	187	0.158
N/A	How does the organisation react to digitization of employee interaction and collaboration	0.450	0.976	6.185	187	**0.000****
N/A	How does the organisation react to the digitization of customer channels?	0.356	0.767	6.221	187	**0.000****
N/A	How does the organisation react to remote working?	1.261	1.507	11.224	187	**0.000****

*Notes: *p < 0.1, **p < 0.05, ***p < 0.01*

4.1.2.5 Accelerate and Scale

With the exception of one statement, the results of the process innovation scale from Prajogo and Ahmed (2006) showed a significant difference before the crisis and during the crisis (see Table 27).

Table 27: Impact of the crisis - Accelerate and Scale

Related scale	Statement	Mean	SD	t	df	Sig.
Process innovation	How would you rate the organisation speed of change in their processes?	0.161	0.678	3.187	187	**0.002****
Process innovation	How would you rate the organisation speed of change in their techniques?	0.089	0.413	2.885	187	**0.004****
Process innovation	How would you rate the organisation speed of change in their technology?	0.078	0.490	2.131	187	**0.034****
Process innovation	How would you rate the technological competitiveness of the organisation?	0.100	0.486	2.763	187	**0.006****
Process innovation	How would you rate the updatedness (novelty) of the technology used in the processes?	0.089	0.510	2.338	187	**0.020****
Process innovation	How would you rate the speed with which the organisation adopts the latest technological innovations in the processes?	0.028	0.478	0.780	187	0.436

*Notes: *p < 0.1, **p < 0.05, ***p < 0.01*

It indicates that the pandemic has a positive impact on the organisation's speed of change during the COVID-19 on: processes ($t(187)= -3.187$, $p<0.01$), techniques ($t(187)= 2.885$, $p<0.01$) and technology ($t(187)= 2.131$, $p<0.05$).

In addition, the respondents indicated that due to the crisis the technological competitiveness (t(187)= 2.763, *p<0.01*) and novelty of the technology used in the processes (t(187)= 2.338, *p<0.05*) are increased. The statements related to the speed with which the organisation adopts the latest technological innovations in the processes (t(187)= 0.780, *p>0.1*) was the only statement which was not a significant.

4.1.2.6 Extend and Mobilize

The statements related to *Extend* and *Mobilize* are the least significant from all concepts. The only significant impact of the crisis was experienced on effectively transferring knowledge, creativity and innovative ideas (t(187)= -3.549, *p<0.01*). The negative mean indicates a negative impact due to the pandemic. The other six statements have experienced varying degrees of positive or negative impact as a result of the pandemic, but these differences were not significant. All in all, the results of these statements showed that the crisis had not impacted the development and implementation process steps (see Table 28).

Table 28: Impact of the crisis - Extend and Mobilize

Related scale	Statement	Mean	SD	t	df	Sig.
Creativity and idea generation	I am working in diversely skilled teams where there is free and open communication among the team members.	0.050	0.854	0.785	187	0.433
Creativity and idea generation	I frequently encounter nonroutine and challenging work that stimulates creativity.	-0.067	1.060	-0.844	187	0.400
Creativity and idea generation	I am recognised and rewarded for my creativity and innovative ideas.	0.000	0.669	0.000	187	1.000
People and skills	The organisation effectively transfers knowledge, skills or ideas across business units.	-0.211	0.798	-3.549	187	**0.000*** **
Organisational Innovation	How would you rate the organisation performance to implement new business practices for organising procedures?	-0.017	0.429	-0.521	187	0.603
Organisational Innovation	How would you rate the organisation performance to implement new methods of organising work responsibilities and decision making?	0.017	0.388	0.576	187	0.565
Organisational Innovation	How would you rate the organisation performance to implement new methods of organising external relations with other firms or public institutions?	-0.006	0.388	-0.192	187	0.848

*Notes: *p < 0.1, **p < 0.05, ***p < 0.01*

4.1.3 Impact classification

To classify the difference, the Cohen's D was used to measure the effect size. The Cohen's D is used to indicate the standardised difference between two means (Cohen, 1988). The statements for which the repeated-measures t-test found significant differences are taken into account and classified below. Combing the rule of thumb from Cohen (1988) and Sawilowsky (2009) the classifications in Table 29 are used.

Table 29: Effect size classification

Range	Classification	Source
0.00 < 0.20	Very Weak	Sawilowsky (2009)
0.20 < 0.50	Weak	Cohen (1988)
0.50 < 0.80	Moderate	Cohen (1988)
0.80 < 1.20	Strong	Cohen (1988)
1.20 < 2.00	Very strong	Sawilowsky (2009)
2.00 > …	Extremely strong	Sawilowsky (2009)

Together the repeated-measure t-test indicated that the respondents experienced a statistically difference in nineteen items. In Table 30 all statements are classified. The situation due to the COVID-19 pandemic had a weak effect size on six items, a moderate effect size on nine items, a strong effect size on two items and finally the respondents experienced a very strong effect size on two items. In the 'positive or negative' column of Table 30 it is indicated whether the impact of the crisis was positive of negative on these statements.

Table 30: Classification of the significant different research items

Research concept	Statement (item ID)	Cohen's D*	Classification	Positive or negative
Aspire	I am aware of the business continuity plan to respond effectively to the inflections of crises. (ASP03)	1.528	Very strong	Positive
Choose	My business line accepts demands that go beyond existing products or services. (CHO01)	0.525	Moderate	Positive
Choose	We commercialize products and services that are completely new to our business line. (CHO04)	0.620	Moderate	Positive
Choose	My business line regularly uses new distribution channels. (CHO06)	0.465	Weak	Positive
Choose	My business line improves the provision's efficiency of products or services. (CHO07)	0.677	Moderate	Positive
Choose	My business line increases economies of scales in existing products and services. (CHO08)	0.475	Weak	Positive

Research concept	Statement (item ID)	Cohen's D*	Classification	Positive or negative
Choose	My business line expands services for existing clients. (CHO09)	0.580	Moderate	Positive
Discover	My business line regularly implements small adaptations to existing products and services. (DIS02)	0.495	Weak	Positive
Discover	The organisation provides time for employees to generate, share or experiment innovative ideas/solutions. (DIS05)	1.051	Strong	Negative
Evolve	The organisation has set objectives or measures to drive innovation. (EVO01)	0.716	Moderate	Negative
Evolve	How does the organisation react to digitization of employee interaction and collaboration?(EVO03)	0.978	Strong	Positive
Evolve	How does the organisation react to the digitization of customer channels? (EVO04)	0.768	Moderate	Positive
Evolve	How does the organisation react to remote working? (EVO05)	1.511	Very strong	Positive
Accelerate & Scale	How would you rate the organisation speed of change in their processes? (ACC01)	0.680	Moderate	Positive
Accelerate & Scale	How would you rate the organisation speed of change in their techniques? (ACC02)	0.414	Weak	Positive
Accelerate & Scale	How would you rate the organisation speed of change in their technology? (ACC03)	0.491	Weak	Positive
Accelerate & Scale	How would you rate the technological competitiveness of the organisation? (ACC04)	0.487	Weak	Positive
Accelerate & Scale	How would you rate the updatedness (novelty) of the technology used in the processes? (ACC05)	0.511	Moderate	Positive
Extend & Mobilize	The organisation effectively transfers knowledge, skills or ideas across business units. (EXT04)	0.799	Moderate	Negative

** Cohen's D is corrected with Hedges correction*

4.1.4 Difference between business units

A mixed analysis of variance (ANOVA) was used to determine whether there exists a statistically significant difference between the business units. In this research the within-subjects factor is time and the between-subjects factor is the different business units of the research sample.

To conduct a mixed ANOVA there are seven assumptions, listed below:

1. The dependent variable is measured at the continuous level.
   Although the dependent variables of this research were measured with a Likert scale, the variable can be referred as an 'ordinal approximation of continuous variable' (Johnson & Creech, 1983).
2. The within-subjects factor should consist of at least two categorical related groups.
   In this research the dependent variable is time and the same subjects are presented in both groups 'before the crisis' and 'during the crisis'.
3. The between-subjects should consist of at least two categorical independent groups.
   The business units of this research are independent groups and includes five categories: A, B, C, D and E.
4. There should be no significant outliers in any group of the within-subjects factor or between-subjects factor.
   The data does not present any outliers.
5. The dependent variables should be normally distributed.
   Data from Likert scales are non-normal and therefore these assumptions should be violated. However, Norman (2010) argued that ANOVA is highly robust to non-normality and a parametric methods can be utilized without concern for the wrong answers.
6. There must be a homogeneity of variances for each combination of the groups of factors.
   The homogeneity of variances can be checked by using the Levene's test. Unfortunately, the homogeneity of variances was not met by eight variables (see Appendix G - Table 43):
   - DIS2 (During): $F(4,183) = 6.410$, $p = 0.000$)
   - DIS2 (Before): $F(4,183) = 5.144$, $p = 0.001$)
   - CHO8 (Before): $F(4,183) = 3.176$, $p = 0.015$)
   - CHO7 (During): $F(4,183) = 3.040$, $p = 0.019$)
   - ACC3 (During): $F(4,183) = 3.005$, $p = 0.020$)
   - CHO9 (During): $F(4,183) = 2.885$, $p = 0.024$)
   - CHO4 (Before): $F(4,183) = 2.766$, $p = 0.029$)
   - CHO7 (Before): $F(4,183) = 2.583$, $p = 0.039$)

Therefore, it was decided to exclude those items in the mixed ANOVA test.

7. The variances of the differences between the related groups of the within-subject factor for all groups of the between-subjects factor (i.e., your within-subjects factor and between-subjects factor) must be equal.
   In this case, the within-subject factor (time) only has two levels: 'before this crisis' and during the crisis' so the sphericity test is met. The estimates are 1 which indicates perfect sphericity and the significance test cannot be computed (Judd et al., 2018) (see Appendix G – Table 44)

In summary, the result from the assumption test made clear that a mixed ANOVA test can be used to analyse the data. After excluding eight variables given their significance of non-homogeneity of variances the mixed ANOVA test determined the significance of thirteen items. This is due to the fact that if the 'before the crisis' or 'during the crisis' data was not significant both items were excluded (ACC03, CHO04, CHO07, CHO08, CHO09 and DIS02).

The test of Between-Subjects Contrasts (see Appendix G - Table 45) showed whether the mean of the items 'before the crisis' and 'during the crisis' items were significant different across business units. To specify which business units were different, the Tukey post hoc test tested the multiple comparisons significance across business units (see Appendix G - Table 46). The interaction effect whether the impact of the crisis was different across business units is tested by the tests of Within-Subjects Contrasts (see Appendix G - Table 47). It is good to note that business unit A is responsible for the core business of the organisation such as facility, governance, recruitment and marketing. This is different from the other business units, because they develop products for customers in their sector.

In the explanation of the ANOVA test for each essential a clustered boxplot is given to visualise the difference between business units. The average ratings before and during the crisis are summarized for each statement and grouped by business unit. A boxplot is used to visualise the distribution of this data on a five number summary: minimum, first quartile (25^{th} percentile), median (50^{th} percentile), third quartile (75^{th} percentile) and maximum. These numbers give an indication how the respondents data is spread out. The outliers of the data are indicated as circles.

Aspire

There was a statistically significant difference between business units as determined by test between-subjects effects ($F(4,183) = 5.908$, $p = .000$) based on the results of ASP03 "the awareness of the business continuity plan to respond effectively to the influences of the crisis" (see Figure 9).

A Tukey post hoc test revealed that the mean score of business unit A was significant higher (M = 5.083, SE=0.335) than business unit B (M = 3.231, SE=0.279, p=.000), business unit C (M = 3.488, SE=0.153, p=0.000) and business unit D (M = 3.847, SE=0.203, p=0.016) (see Figure 9). There was not a statistically significant difference between the other business units (p>0.05).

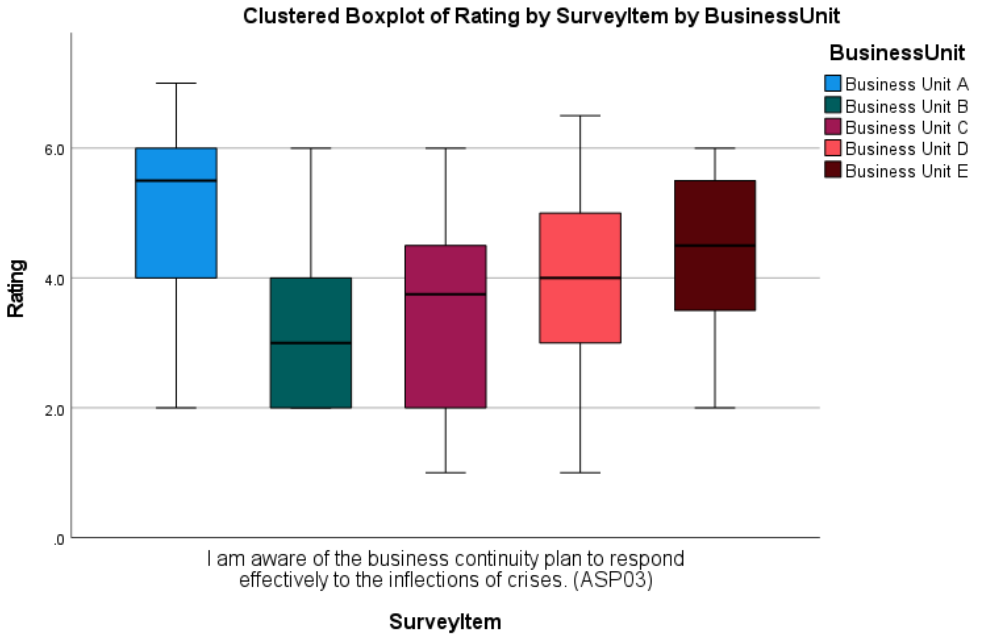

Figure 9: Clustered Bar Mean of Rating by ItemID by Business Unit (Aspire)

In addition, there was not a significant interaction effect between time and business units (F(4,183) = 0.279, p = .891). This means that the impact of the crisis was not statistically different across business units.

Choose

There was a statistically significant difference between business units as determined by test between-subjects effects CHO01 (F(4,183) = 2.909, p = .023) based on the results of CHO01. A Tukey post hoc test revealed that the mean score of the business unit A was significant lower (M = 4.389, SE=0.264) than business unit C (M = 5.279, SE=0.121, p=0.021) and business unit D (M = 5.398, SE=0.160, p=0.011) (see Figure 10). There was no statistically significant difference between the other business units (p>0.05). Additionally, the interaction effect between time and business units was not significant (F(4,183) = 1.622, p = .171). This means that the impact of the crisis was not statistically different across business units.

There was a statistically significant difference between business units as determined by test between-subjects effects based on the results of CHO06 (F(4,183) = 3.724, p = .006). A Tukey post hoc test revealed that the mean score of business unit C (M = 3.628, SE=0.132) was significantly lower than business unit A (M = 4.556, SE=0.288, p=0.031) and business unit B (M = 4.442, SE=0.240, p=0.027). There was not a statistically significant difference between the other business units (p>0.05). No significant interaction effect was found between time and business units (F(4,183) = 0.248, p = .911). This means that the impact of the crisis was not statistically different across the business units.

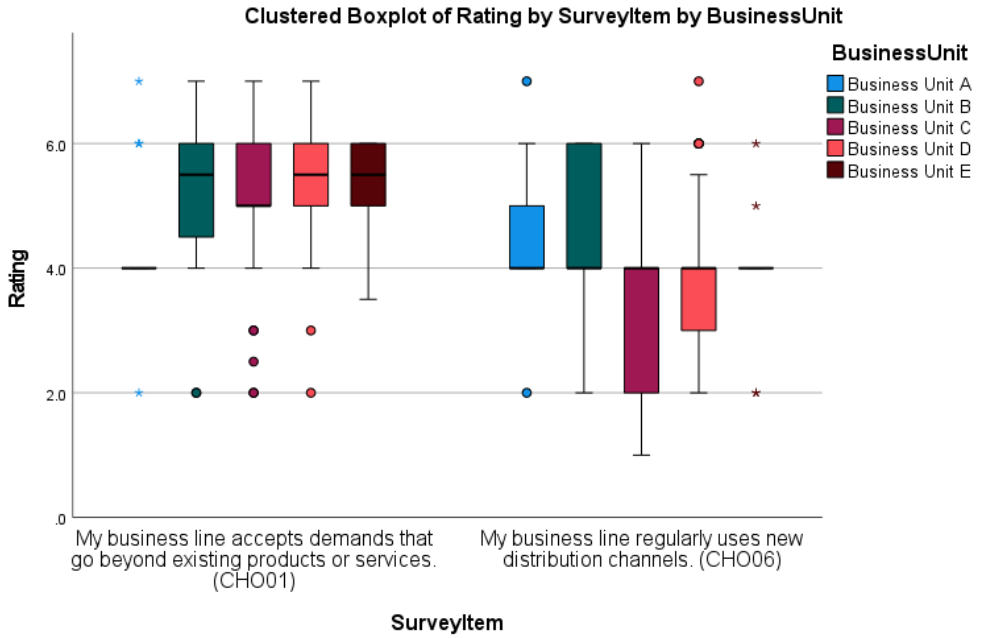

Figure 10: Clustered Bar Mean of Rating by ItemID by Business Unit (Choose)

Discover

There was a statistically significant difference between business units as determined by test between-subjects effects based on the results of DIS05 (F(4,183) = 5.037, p = .001). A Tukey post hoc test revealed that the mean score of business unit C (M = 4.320, SE=0.143) was significantly lower than business unit A (M = 5.346, SE=0.260, p=0.008) and business unit B (M = 5.346, SE=0.260, p=0.006) (see Figure 11). There was no statistically significant difference between the other business units (p>0.05). There existed a non-significant interaction effect between time and business units (F(4,183) = 0.298, p = .879). This means that the impact of the crisis was not statistically different across business units.

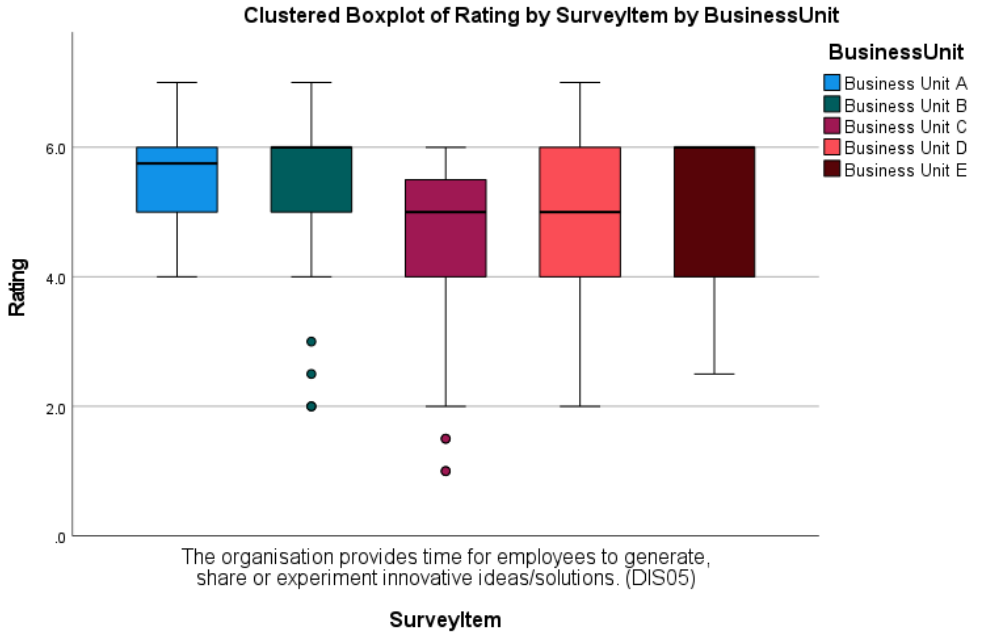

Figure 11: Clustered Bar Mean of Rating by ItemID by Business Unit (Discover)

Evolve

The mixed ANOVA did not result in a significant difference between business unit for EVO03 ($F(4,183) = 1.158$, $p = .331$), EVO04 ($F(4,183) = 0.645$, $p = .631$) and EVO05 ($F(4,183) = 1.078$, $p = .369$). However, the ANOVA test shows a statistically significant difference between business units as determined by test between-subjects effects for EVO01 ($F(4,183) = 3.054$, $p = .018$) (see Figure 12).

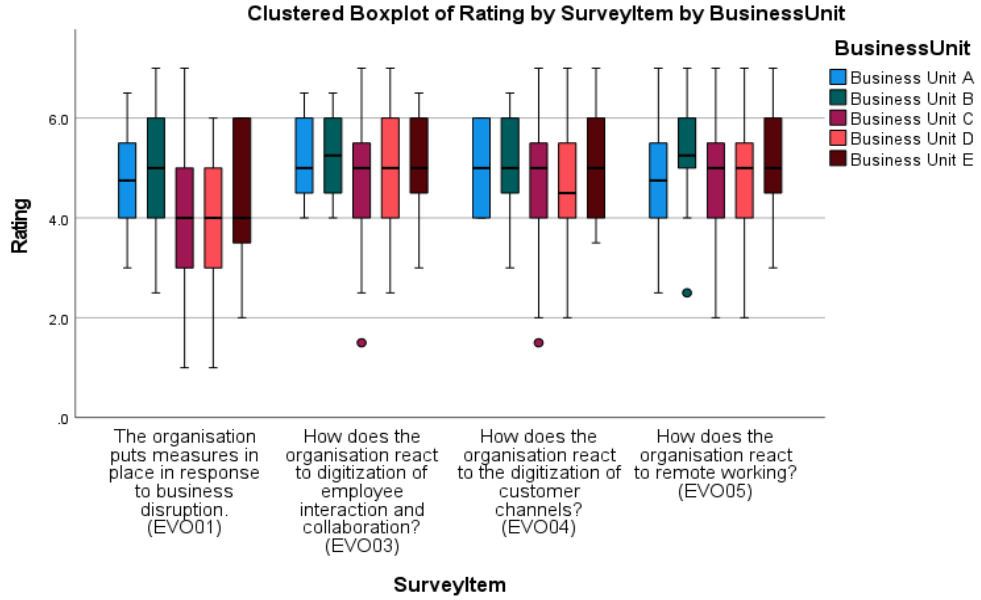

Figure 12: Clustered Bar Mean of Rating by ItemID by Business Unit (Evolve)

However, the multiple comparison test did not show a significant difference between business units. This is possible due to the fact that these tests are pairwise tests of the means of the business units instead of ANOVA which tests if the data from business units have equal means. So, the overall ANOVA can reject the null hypothesis that all group means are the same and simultaneously the post hoc test does not find a significant difference among group means.

The interaction effect of the *Evolve* statements were not significant (p>0.05). This means that the impact of the crisis was not statistically different across business units.

Accelerate and scale

There was a non-significant difference between business units as determined by the test between-subjects effects based on the results of ACC01 (F(4,183) = 2.531, p = .042). This is earlier explained in the *Evolve* section and this can occur due to weakly significant global effect (the p-value is close to the significant level p = 0.05) or a small group size of some business units. Unlike ACC01, the other items showed a significant difference between business units: ACC02 (F(4,183) = 8.259, p = .000), ACC04 (F(4,183) = 5.324, p = .000) and ACC05 (F(4,183) = 8.163, p = .000) (see Figure 13).

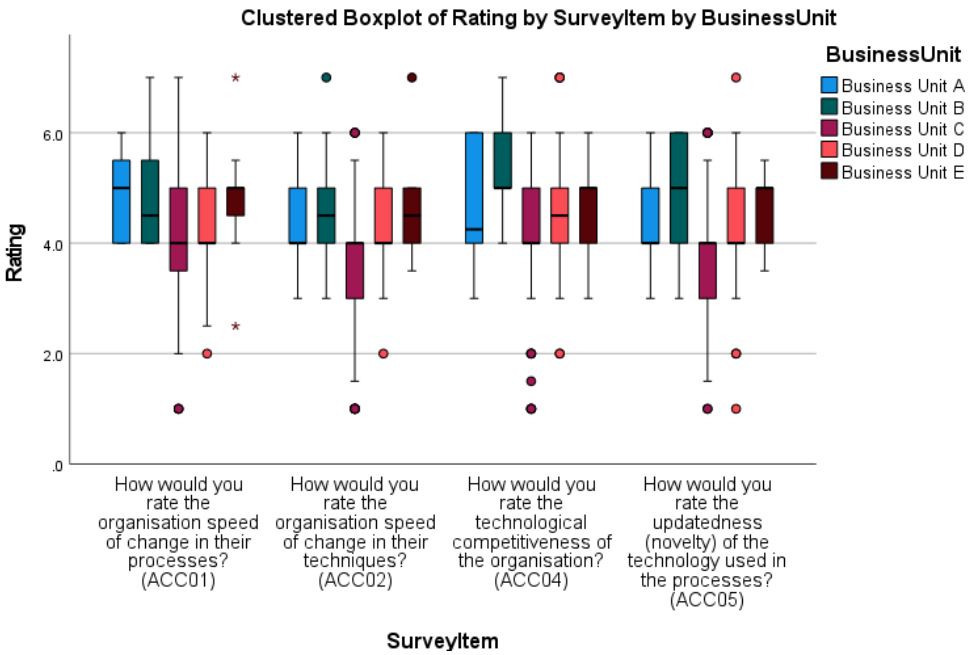

Figure 13: Clustered Bar Mean of Rating by ItemID by Business Unit (Accelerate and Scale)

First of all, the Tukey post hoc tests revealed that business unit C has a significant lower value for ACC02 (M = 3.570, SE=0.117) compared to business unit A (M = 4.417, SE=0.255, p=0.024), business unit B (M = 4.615, SE=0.212, p= .000), business unit D (M = 4.357, SE=0.154, p= .001) and business unit E (M = 4.667, SE=0.360, p=0.034). Second, a significant lower value was revealed for business unit C (M=4.157, SE=0.121) related to ACC04 than business unit D (M = 4.612, SE=0.160, p= .000). Finally, the Tukey post hoc test also revealed a lower value for business unit C (M = 3.744, SE=0.118) on ACC05 compared with business unit B (M = 4.981, SE=0.214, p= .000) and business unit D (M = 4.418, SE=0.156, p=0.006). There was no statistically significant difference between the other business units (p>0.05). Finally, the interaction effects between time and the business units were non-significant for each item. This means that the impact of the crisis was not statistically different across business units related to the *Accelerate and Scale* research concept.

Extend and mobilize

There was a statistically significant difference between business units as determined by test between-subjects effects based on the results of EXT04 (F(4,183) = 5.248, p = .001) (see Figure 14). A Tukey post hoc test revealed that the mean score of business unit A (M = 5.056, SE=0.309) was significantly lower than business unit C (M = 3.541, SE=0.141, p=0.000) and business unit D (M = 3.857, SE=0.187, p=0.010). There was no statistically significant difference between the other business units (p>0.05).

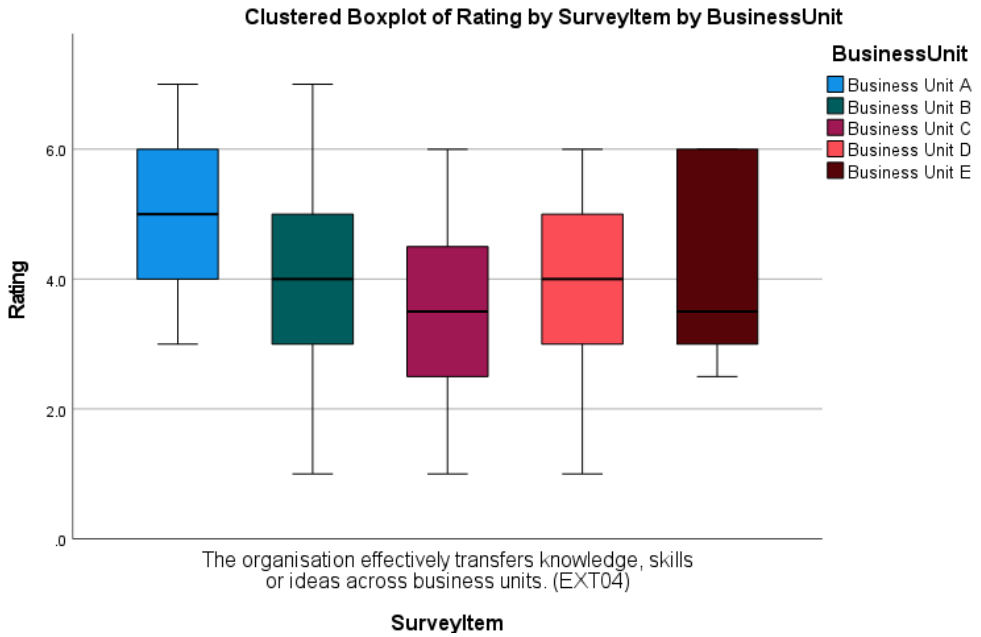

Figure 14: Clustered Bar Mean of Rating by ItemID by Business Unit (Extend)

There was not a significant interaction effect between time and business units ($F(4,183) = 0.366$, $p = .833$). This means that the impact of the crisis was not statistically different across business units.

To sum up, the mixed ANOVA showed a statistically significant difference between business units for ten items which are normally distributed. The Tukey post hoc test revealed fourteen differences in items for business unit C, six differences for business unit B, ten differences for business unit A, five different results for business unit D and only one for business unit E. So, in total eighteen differences between the business units were found based on the post hoc tests. The interaction effects whether the impact of the crisis was different across the business units were non-significant for each item.

4.1.5 Difference between tenure

To calculate if the impact of the crisis was different given how long the employee is employed at the ICT organisation a Mann-Whitney U Test was conducted. In this test two groups are identified: short tenure and long tenure (see Table 31). This type of test is useful given the data which was not approximately normally distributed and the group sizes differ (115 and 45). The groups are based on the means and standard deviation of tenure for all respondents (M=5.505, SD=5.155). The short tenure group consists of all respondents with a tenure ranged from 0.350 (M minus SD) to 5.505 (M) and the long tenure group from 5.505 (M) to 10.659 (M plus SD). For these groups the independent t-test was executed for each statement which was statically significant different 'before the crisis' and 'during the crisis' (see Table 30).

Table 31: Tenure groups

Tenure group	N	Range from	Range through
Short tenure	115	0.350	5.505
Long tenure	48	5.505	10.659

There are four assumptions to conduct a Mann-Whitney U test:

- The independent variable should have two categorical groups.
  The tenure group was the independent variable of this test and has two groups: short tenure and long tenure.
- The dependent variable should be continuous or ordinal
  The absolute difference before the crisis and during the crisis was identified as a continuous dependent variable.
- The independent variable should have unrelated groups
  Unrelated groups are groups with different respondents, so an individual is not a member of two groups. In this research this was not possible, because the individuals could not be classified as short tenure and long tenure.

- The Mann-Whitney U test can be used when the data is not normally distributed.
  The test requires that the impact of the crisis (the absolute difference) is approximately not normally distributed. Therefore, the Shapiro-Wilks test was conducted and none of items were normally distributed ($p<0.005$) as shown in Appendix H - Table 48.

The independent-Samples Mann-Whitney U Test was used because the distributions of the two groups have the same shape. So, medians were compared rather than mean ranks. The test tested for each item if the null hypothesis that the impact similar across the tenure groups could be rejected.

In this research the absolute difference of each item with statistically significant impact of the crisis showed in the Mann-Whitney U test a significance greater than 0.005 (see Appendix H - Table 49). So, given these p-values the impact of the crisis was the same for short and long job tenure.

4.2 Results of qualitative research

The results of the five interviews with the directors from the ICT organisation was aimed at answering SQ4: "What has the ICT organisation learned from the measures taken to exploit the drivers and bypass the barriers in the circumstances of the COVID-19 pandemic?". By gaining qualitative perspectives, information is gathered to analyse how the different business units anticipate to circumstances of the COVID-19 pandemic. This contributed to the understanding of the underlying dimensions of the results from quantitative research. The quantitative survey statements found nineteen significant differences between before the crisis and during the crisis. This means that the analysis of these interviews will be focussed on what were the measures taken by the ICT company related to the drivers and barriers of these statements.

The five directors are members of the board of directors, including the chief executive officer (CEO) who presides over the organisation's day-to-day operations during the COVID-19 pandemic. During the interviews the specific characteristics of each business unit were highlighted to properly explain the differences in terms of the underlying dimensions (see Table 32).

When looking at the more strategic perspective of *Aspire* it can be mentioned that the ICT organisation has positions and platforms in sectors with a huge impact of the crisis. Director A experienced upscaling and an acceleration of the adoption of their products and platforms. In contrast to director D, who experienced that they made choices about which platform he should give the most priority and would bring the most for the organisation. The organisation is structured in such a way that most of their innovations are ambitiously

designed, so it was perfectly in line with the digitalisation during the crisis. Director B explained that their vision is focussed on education projects which most of the time will be adopted after six years. The current crisis was a trigger for the market to adopt their platforms faster and showed that their vision on innovation is organised in such a way that it can handle a crisis. Director A stated that "we should be happy that COVID-19 was not a digital virus. Although it is good to mention that no one at the organisation had a manual for what was going to happen and the unpredictability of the virus was beyond control.". This was also a reason why at the beginning of crisis in march 2021 innovative creative sessions were limited and operations were aimed at running the business and looking for new business opportunities.

These new business opportunities were stimulated by new customer needs due to the changes in the business environment. Due to the pandemic everything was remotely and digitalized, because the world was focussed to minimize the spread of the virus by avoiding physical contact between people. Each of the directors experienced the impact of COVID-19 was not only felt in the ICT organisation, but also at the customer side the impact of working remotely was huge. So, this introduced new opportunities for existing products, existing markets, but also for new products in new markets. For example, in the sector of social services. The civil servants could no longer visit people at home. The municipalities were forced to involve residents in the processes. For example, by giving permission for things and uploading information online. In addition, the ICT organisation designed a platform for registering who has tuberculosis, including contact tracing for a Dutch municipal health service. When COVID-19 was detected in the Netherlands, this health service asked the ICT organisation to build a similar system for COVID-19 as tuberculosis. The consequence of developing of this system was also mentioned as a barrier "A crisis result in a failure to exploit new business opportunities if there is too much focus on the short-term impact of innovations due to the challenging business environment of a crisis." (Watkins & Yaziji, 2020). Director D seems to be aware of this risk. He stated that "the long-term strategy is not changed. We did not start doing a completely different thing or panicked. We only adjusted the short-term strategy, because of the social impact this system can deliver for the Netherlands". As a result, capacity had to be distributed again, because this COVID-19 system had the highest priority and should be developed as soon as possible. Capacity from other innovative projects were minimised and sometimes a project was even stopped for a moment.

In the organisation it was noticeable that during the crisis the innovation capacity was harmed. However, this did not impact the success of the organisation. Director C indicated that this makes sense, because if the operational pressure is high, people are first going to solve that problem instead

of spending time on innovation. At the same time, he is aware of the danger and the organisation should provide more time for creativity, to share innovative ideas and experiment. Director B and director D confirm this statement of director C. They stated that the during the crisis the main focus was to deal with the consequences of the virus. Therefore, the organisation lost some innovation speed, but they did not experience this as a big deal given the slow adoption of the market. During the crisis a lot of production was required and taking the advantage of new opportunities was therefore given more priority. Furthermore, providing training, tools or technologies became more difficult due to the restrictions of working remotely and to minimize physical contact.

To anticipate on the technology trends like remote working, digitization of employee interaction or customer channels it requires flexibility of the organisation. Director E described this impact from one side as negative, because of looking at your screen all day. The biggest challenge at the business unit of director B was related to the digitization of communication in the service desk team: "the effectivity of communication was very difficult because instead of having a service desk team, we had ten separate service desks working from home". Additionally, the service desk had to deal with an increase of customers contacting the service desk given the increase of free licenses. However, it gave the opportunity to organise online customers events in which customers were at the same presentation at the same time. All in all, the quality of the customer channels was perhaps decreased instead of physical meetings, but the quantity of customer contact was quite high. To drive innovation during the crisis was difficult to facilitate. Director A stated that "an innovation process within our ICT organisation requires physical contact and we should think about new methods to organise such events after the crisis". Director C and director E confirm this quote of director A by reporting the social aspect of interacting with each other and standing in front of a whiteboard during a creativity event. All directors agreed that working from home in combination with working at the office gives new opportunities in the current digital era, but requires a new way of work. It brought a new mindset for the development of products and platforms, because from the customer's perspective they are confronted with working from home. So, a more hybrid form of servicing the customer.

All directors agreed that the productivity and development speed was never this high before and therefore the organisation was able to beat the competition: before and during the crisis. Director D mentioned that they are continuously adjusting the proposition and products to stay relevant in the market. The flexibility and rate of changes in the first quartile of the crisis was a great advantage for the ICT organisation to anticipate with this new reality. Director B was very satisfied with the transformation from working at the office to working from home. Their processes were maintained and only modified to an

online environment. When looking at innovation the rate of change was not sufficient. The impact of the COVID situation had such an impact on innovation that the organisation was not able to organise new processes, techniques or technologies for virtual innovation events. Director D indicated that it took too long to learn from the crisis and to facilitate the employees in tools and office equipment.

The crisis made clear that the business unit of director E was not organized to innovate: "The COVID crisis was like a trigger to reorganise the way we organized our employees to innovate". Unfortunately, innovation is not the highest priority of the employees in his business unit and therefore relatively little happened on innovation. Director A and director B contradicted this, because they argued that motivation to innovate is something in your 'DNA'. Leaders can encourage or facilitate this, but they should not motivate employees to innovate. Director D agreed with director A and reported that the organisation should stimulate the employees more to innovate, but indicated that this is not only the cause of the crisis. He explained that during the crisis the management team (MT) met each other to talk about: how can we stimulate innovation? How can we activate people to innovate? To be better organised after the crisis director C indicated that the organisation should have more attention to development teams and whether they are set up in such a way to stimulate creativity.

Looking at the collaboration with external partners to mitigate risk due to the uncertainty of crisis, the directors have different views. Director E and director A had similar view that external partnership is difficult due to divided interest to take advantage of the partnership. In the case of director D and director C, they create external partnerships to develop new platforms and to mitigate risk. However, they did not saw any impact of the crisis on existing or new partnerships.

Given these points, a complete overview of the interviews is given in Table 32.

Table 32: Qualitative results summary

Director	Aspire	Choose	Discover	Evolve	Accelerate and scale	Extend and mobilize
Director A	*Weak* - Accelerated anticipation due to the business changes and crucial propositions in the market.	*Strong* – The COVID-19 pandemic was an incentive to focus on a lot of new business opportunities.	*Strong* - Innovation capacity decreased because more priority was given to operational work.	*Strong* - The business model should be evaluated to facilitate innovation and developing a successful product.	*Strong* - The organisation has great platforms to become successful even in a crisis.	*Moderate* – The crisis triggered a new impulse to stimulate innovation and how the organisation can innovate in a hybrid way of working.
Director B	*Weak* - Our market is very slow to adopt new innovations, so this had only a weak impact on our vision.	*Strong* - The product licences were offered for free, because many customers needed this social valuable product.	*Strong* - Innovation capacity was lost as a result of dealing with the consequences of the virus.	*Strong* - Both customer and the ICT organisation are faced with a new hybrid way of work which had a strong impact on all processes.	*Weak* - The processes were maintained and only modified to an online environment process.	*Weak* – Innovate is something in your 'DNA'. Leaders should not motivate employees to innovate. The crisis stimulated to look at the facilitation of innovation.
Director C	*Moderate* - The vision during the crisis was clear: the well-being of our employees was given the highest priority.	*Moderate* - This crisis stimulated collaboration with customers and to look for new opportunities.	*Moderate* - If the operational pressure is high, it makes sense that people first solve problems instead of innovate.	*Very strong* - Creativity sessions or innovation events are difficult in a digitized world.	*Moderate* - The organisation was flexible to the new situation. However, innovation processes are delayed.	*Moderate* - We need to evaluate whether the teams are set up to stimulate creativity. During the crisis it was difficult to be creative.

Director	Aspire	Choose	Discover	Evolve	Accelerate and scale	Extend and mobilize
Director D	Weak - New business opportunities impacted the short-term strategic goals, but people were aware of this and this was clearly communicated.	*Very Strong - A* lot of our resources were reallocated to redesign a new system as soon as possible. This had impact on other projects due to the distribution of capacity.	*Moderate* - Business innovation had the highest priority, which was at the expense of technical innovation.	*Moderate* - A creative process was difficult remotely, because brainstorm sessions were less effective.	*Moderate* - It took too long to learn from the crisis and to facilitate the employees in tools and office equipment.	*Weak* – the organisation is driven by innovation, but it should be more implemented in our culture. This is not completely the impact of the crisis.
Director E	*Weak* - The continuous collaboration with the employees resulted in an effective response to the inflections of a crisis.	*Moderate* - The crisis offered new opportunities, but these are limited by legislation.	*Moderate* - The productivity was increased, but this had impact on the innovation capacity.	*Strong* - The physical interaction was missing, which made brainstorm-sessions very difficult.	*Weak* - The crisis was a trigger to restructure the innovation processes to come up with more valuable ideas.	Moderate – The crisis was a trigger to reorganise the way how we innovate. Partnerships were difficult due to formalities.

5 Discussion

The core problem of the ICT organisation is to identify the impact of the crisis on the sectors in which they are active. The organisation is not able to point out which factors influences the innovation processes in times of the COVID-19 pandemic. This section focuses on the interpretation and implications of the results and limitations of the research. The section ends with recommendations for future research.

5.1 Interpretation

Regarding the results of this research there are multiple perspectives to interpretate. First of all, the innovation process steps of Cortimiglia et al. (2015) are related to the Eight Essentials. Secondly, the impact of the crisis is divided into two categories: drivers and barriers. As mentioned in the introduction of this paper, the organisation has difficulties to identify whether the crisis slowed down or accelerated innovation. Thirdly, the mixed ANOVA showed whether there was a difference between the business units. Given the wide area of sectors in which the organisation is active, this perspective can give valuable insights to distinguish between business units. Fourth, the respondents have filled in their job tenure and therefore this additional analysis perspective is added. The last interpretation of the results will be focussed on explaining the impact on the validated scales from earlier research.

5.1.1 Innovation process steps

Regarding the innovation process steps, the quantitative research resulted in a significant impact of the crisis on nineteen statements. The impact on the innovation process steps is in line with the (translated) statement from professor de Dreu from the University of Leiden “We may see that fewer inventions have been made during this crisis” (Olsthoorn, 2021). The largest impact was found on the first steps of the innovation process.

In the first two steps ‘idea generation’ and ‘idea evaluation’ the focus is on the collection of information and the evaluation of the alignment of the ideas. The two statements with a ‘very strong’ impact classification are both related to these steps (ASP03 and EVO05). In addition, a strong negative impact was experienced by the respondents on DIS05 “The organisation provides time for employees to generate, share or experiment innovative ideas/solutions.”(see Figure 15). A negative impact also applies to EVO01 “The organisation has set objectives or measures to drive innovation.” a typical example which confirms the suspicion of professor de Dreu (see Figure 16).

The respondents also counter Milic's (2013) statement to maintain a constant flow of innovation during a crisis. The qualitative results amplified the survey results from the perspectives of directors of each business unit. They argued that

the organisation should provide more time and resources after the crisis for creativity and to share, generate and experiment with innovation ideas. During the crisis the focus was mostly on dealing with the consequences of the pandemic.

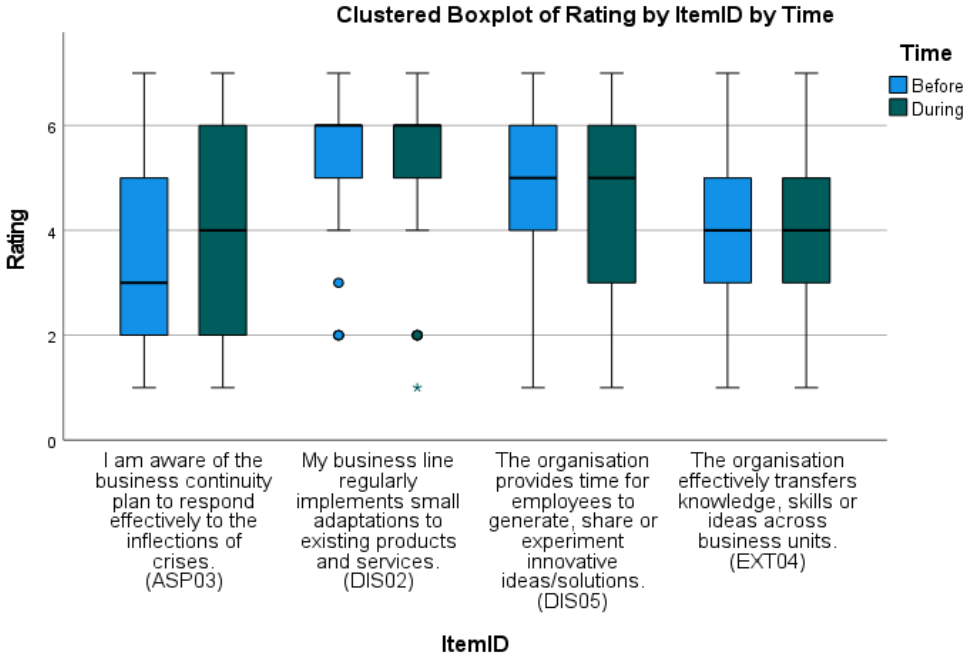

Figure 15: Idea generation - Clustered Boxplot

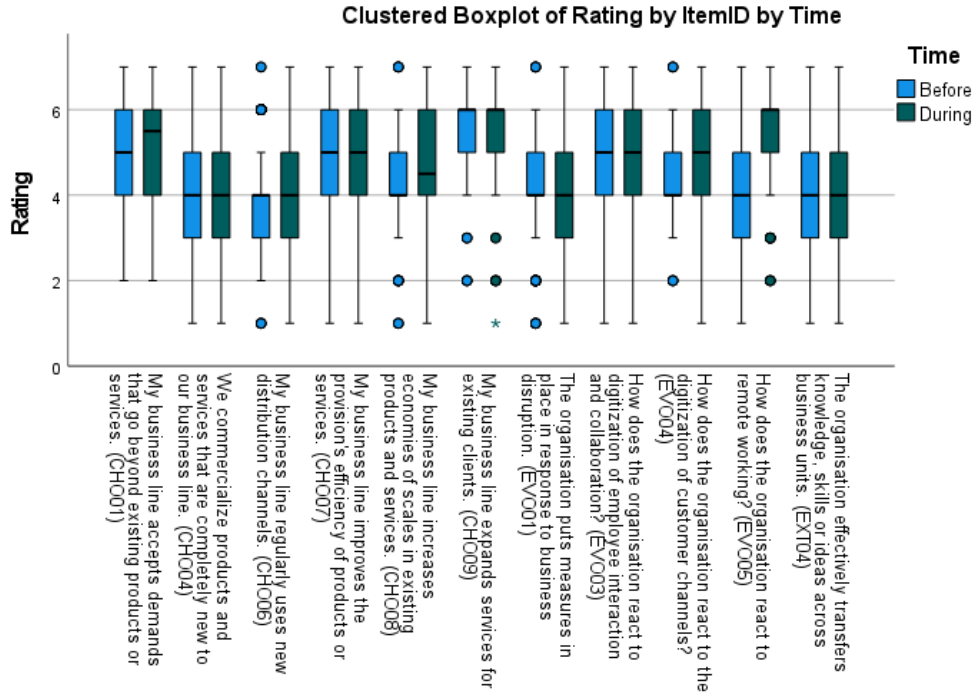

Figure 16: Idea evaluation - Clustered Boxplot

The respondents experienced a small impact in terms of the development and implementation of innovation (see Figure 17). In contrast to the negative impact on the generation and evaluation of ideas, the development and implementation had positively impacted the innovation process. The impact on the speed of change of different component such as techniques, technology and processes were experienced as positive. Director A stated that the flexibility of the employees and processes contributed to anticipate on the new reality due to the crisis. The processes were maintained and suitable for online environments and remote working. However, director A argues that it took too long to consider how to react to structural changes the crisis entails which should be a crucial part as mentioned by Sneader and Sternfels (2020).

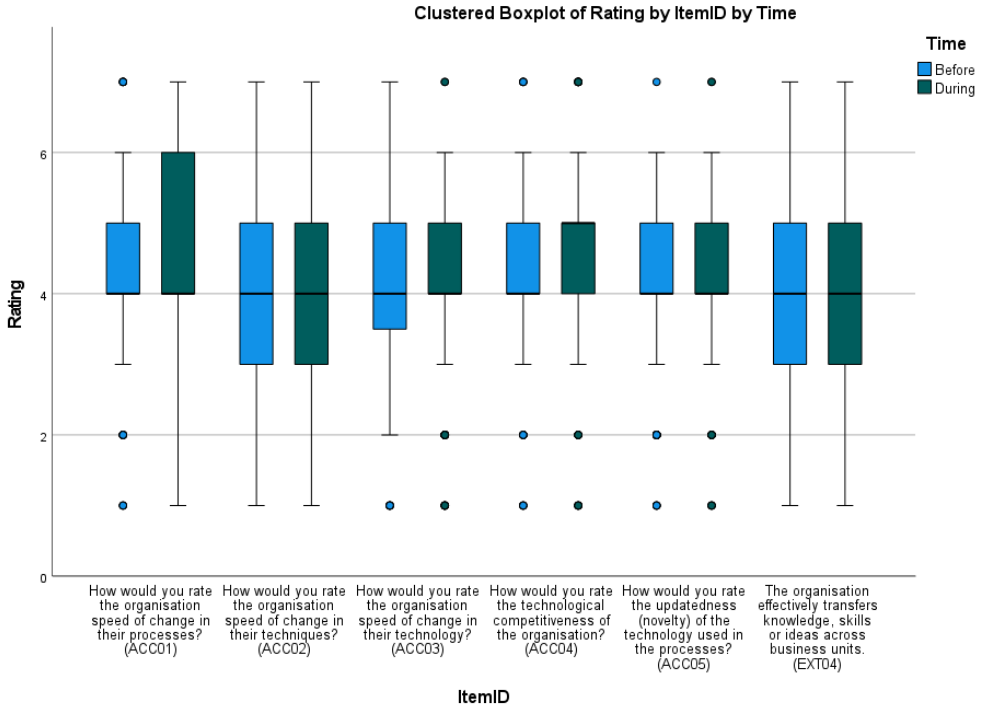

Figure 17: Innovation development and implementation - Clustered Boxplot

In summary, a minimal impact was experienced by the respondents and confirmed by the qualitive research on the development and implementation of innovation. The organisation was able to modify the existing development processes in online environment, but experienced difficulties to generate and share new ideas.

5.1.2 Drivers of innovation

Based on earlier research the drivers and barriers of innovation in times of crisis were identified. The literature suggested that drivers accelerate innovation processes in times of a crisis, but it was not specified for the COVID-19 pandemic. Therefore, an analysis on the impact of these drivers in the current

crisis was necessary to formulate a hypothesis with sufficient evidence to use as a starting point for further research. The follow up research showed that although the crisis impacted the innovation processes on different aspects, it was not always a barrier.

De Jong et al. (2015) mentioned that organisations should anticipate and reallocate the resources for new business opportunities. This driver is recognized by the ICT organisation in both the quantitative and qualitative research. The survey showed a positive impact on the items such as "My business line accepts demands that go beyond existing products or services." and the interviewees recognized this impact. For example, director D mentioned that they had a great business opportunity to use an existing platform for registering tuberculosis as starting point to design such a system for COVID-19. The Dutch municipal health service rethought their needs and decided that a new platform for COVID-19 had the highest priority to prevent the spread of the virus. Given the ambitiously designed innovations before the crisis, these ideas were already generated to respond to the business changes due to the crisis. This makes clear why the difference for the abandon elements which are unlikely to return after a crisis was not statically significant. Bessant et al. stated this in 2015, but does not seem to apply to ICT organisations when digitization is the greatest business change due to a crisis.

As mentioned by Bessant et al. (2015) a crisis also accelerates radical rethinking for solutions in new domains and paradigms due to the extreme conditions. A good example was recognized by respondent E in the way of work for civil servants who were not able to visit people at home. The communication in this sector was mainly focussed on face-to-face contact, but was forced by the crisis to digitise. The ICT organisation should take advantage of such opportunities and develop new systems and platforms to solve such issues.

Overall, it can be stated that the crisis has a positive impact on the introduction of new opportunities for existing products in existing markets and new products in new markets. The ICT organisation was already focussed on innovations with impact using smart technology. For this reason, director A stated that the ICT organisation should be happy that the crisis was not a digital virus, but a crisis that stimulated digitised solutions.

5.1.3 Barriers of innovation

In the theoretical background of this research six barriers of innovation in times of crisis were mentioned. The literature suggested that these barriers should be bypassed in the circumstances of a crisis. However, as earlier mentioned, the impact of these barriers was not specified for the crisis due to the COVID-19 pandemic. So, in this research the impact of the crisis on the items related to the

barriers are analysed. This can be classified as negative or positive, because some items are defined as a solution to bypass a barrier.

Johnson and Suskewicz (2020) argued that organisations should anticipate on inflections that completely changes the business environment in a couple of weeks or months. Therefore, it was asked in the survey whether the employees were more aware of the business continuity plan to respond effectively to the inflections of the COVID-19 crisis. The paired-sample t-test showed a statically significant difference which is classified as 'very strong'. This result means that the ICT organisation was able to create awareness of this plan during the crisis and the employees experienced this as a huge impact of the crisis. Moreover, it made clear that the short-term impact of the crisis should not have all the focus of the organisation.

According to Watkins and Yaziji (2020) the organisation should balance their focus on the short-term and long-term impact of the crisis to exploit new business opportunities. The quantitative results of this research find a significant positive difference on each item which was formulated as a solution to exploit this barrier. For example, a weak impact was found for CHO09: "My business line expands services for existing clients.". This indicates that the organisation was able to not only focus on the short term but also on the long term. Director D is aware of the barrier mentioned by Watkins and Yaziji (2020) and argued that the long-term strategy is not changed, but it was necessary to adjust the short-term strategy.

To anticipate on the short-term impact of the crisis the respondents experienced less time was available to share and exchange innovative ideas or solutions. This result of the survey confirms the statement of Milic (2013) that a crisis harms the innovative capacity of organisations. However, despite the reallocation of resources which harmed the innovative capacity, the qualitative research showed additional causes for fewer radical innovation for revolutionary products. Given the restrictions of working remotely the directors of the business unit experienced that it was difficult to provide training, tools or technologies for employees to stimulate innovation. Director B argued that the organisation was not able to facilitate techniques or technologies for virtual innovation events. The lack of this elements also harmed the invention of radical innovations.

One of the biggest structural changes of the crisis is related to the rapid migration of digital technologies and working from home (Baig et al., 2020). For this reason the respondents were asked how they experienced the impact of the crisis on digitisation of employee interaction and collaboration, customer channels and remote working based on a three-item scale from Am et al. (2020).

The paired-sample t-test found a statically significant difference on each technology trend which indicates that the organisation was able the create new business models. The organisation succeeded to find a way to implement these trends into their business model and therefore bypass the barrier of Sneader and Sternfels (2020). On the other hand, the organisation was not able to transfer knowledge, skills and ideas across business units as they did before the crisis. The employees experienced that the crisis had a negative impact on this item. This confirms the feeling of director C who indicated during the interview that the organisation should had more focus on the teams to stimulate innovation and creativity. Director E had the feeling of reorganising his business unit to stimulate collaboration not only in the teams, but also across teams and business units. Boehm (2012) mentioned in his paper that if organisations are not organised to innovate it can also hinder innovation after the crisis.

5.1.4 Business units

To analyse the impact across the business units an ANOVA test made clear that there was not a statistically significant different impact of the crisis across business units. The paper of Am et al. (2020) about innovation through the crisis showed a decline in focus on innovation and creativity across every industry. The only exception was found in the pharma and medical supplies. This means that executives are responding to the crisis by maintaining business continuity and driving productivity. The respondents of the survey recognized this response to the crisis and especially the productivity was increased in the whole ICT organisation, which supports the results of Am et al. (2020).

An interesting quantitative result was found on the size-innovation performance correlation which did not support earlier research. The results of the meta-analysis of Camisón-Zornoza et al. (2004) found a significant and positive effect on the size-innovation correlation with a magnitude of fifteen percent. The results of the quantitative results differ for each item, but the two biggest units of the organisation underperformed the smallest business units and therefore do not support Camisón-Zornoza et al. (2004). For instance, the finance business unit had fourteen significant differences with other business units due to their underperformance on these survey items. According to Das et al. (2018) the barriers of (radical) innovation in the financial services sector is due to: a lack of research and development, the absence of exploiting new innovative ideas, the organisational structure of financial services which is unsupportive for innovation and too much on risk avoidance.

Business unit B outperformed the other business units with the highest ranking on innovation items related to the *Evolve* and *Accelerate and Scale*. According to Cerna (2014) this contradicts the inherent conservatism in the education sector which is considered as resistant to innovation. Which also fits to the interview

with the director of this business unit he mentioned that the education sector is very slow to adopt new innovation. However, the reason why business unit B outperformed is mentioned in the journal by Schleicher (2020). In this journal the need for remote learning was enormous and it became the lifeline of education. The digital learning systems, which are offered by the ICT organisation, offers new solutions to teachers and students to adapt the learning experiences of students. This opportunity of digital learning systems was recognized six years ago by the ICT organisation and shows that the vision on innovation is perfectly organised to react to the current changes.

The different performance on innovation is also mentioned by the directors. Especially director E experienced that due to different underlying reasons the business unit underperformed on innovation. The first reason was given due to the size of the business unit differs from the other business unit, because they only have 43 employees. For instance, business unit D has almost ten times more employees. This contradicts again the positive size-innovation correlation from Camisón-Zornoza et al. (2004). The business unit is limited by legislation and therefore there are more innovation obstacles. Goldkuhl (2009) recognized this legal barrier for digitalisation in a regulated environment. Although this is a barrier, it does not need to be a strict barrier according to Goldkuhl: "There are definitively constraints for innovation in a regulated institutional environment. But there may be paths ahead and they need to be identified and accomplished consciously.".

The governmental regulations is also one of the reason why innovation is hard in the healthcare sector. Herzlinger (2006) stated that regulations require healthcare organisations to show that new products are cost-effective related to other similar products and it should do what is claimed. This is why director D mentioned that they are continuously adjusting their proposition and products, because this makes sure that they are relevant in the market. Another reason given by Herzlinger (2006) is given the medical and financial information which should be provided to the ICT organisation when adopting new innovative technology platforms. The quantitative results of the survey supported the statements of Herzlinger that innovation in healthcare is hard. The estimated mean of the sector on digitization of customer channels was the lowest compared to the other business units. A high result of the healthcare business unit was found on the exploitation and exploration items which is explainable given the development of COVID-19 infection platform for a Dutch municipal health service.

As earlier mentioned, business unit A is responsible for the core business of the organisation. Therefore, the quantitative results of this business unit are probably biased. Based on the survey the business unit underperformed on expanding services for existing clients and commercialisation of products which are completely new. The business unit outperformed on the business continuity plan to respond to the inflections of the crisis, which is probably given the capability of the business unit to share knowledge across business units. Director A made an interesting statement about this in the interview. The respondent explained that there was not a manual to survive the crisis. However, organising information and synthesizing new insights should not only be siloed to one business unit (Am et al., 2020). It means that although business unit A outperformed the other business units on sharing, generating and experiment ideas and information there should not be a significant difference with other business units on those items according to Am et al. (2020).

5.1.5 Job tenure

Given the tenure of each employee the impact of the crisis was investigated for two groups: short tenure and long tenure. The Mann-Whitney U test did not find a significant result and therefore there was not sufficient evidence to conclude that the impact of the crisis differs for tenure groups. This means that if from each group an employee is randomly selected, the probability that the impact on a short tenure employee being greater than the impact on a long tenure employee is equal to the probability that impact of a long tenure employee being greater than the impact on a short tenure employee (see Figure 18).

Ng and Feldman (2013) refuted the common belief that longer-tenured employees perform poorly on innovation related behaviours. In their article they presented evidence that there was a lack of significant relationships of tenure with innovation related behaviour. In addition, the effect of moderators was modest. This implied that longer-tenured employees are as effectively as shorter-tenured employees when talking about innovation-related activities (Ng & Feldman, 2013). Given these points it can be stated that the results from the quantitative research supported these statements.

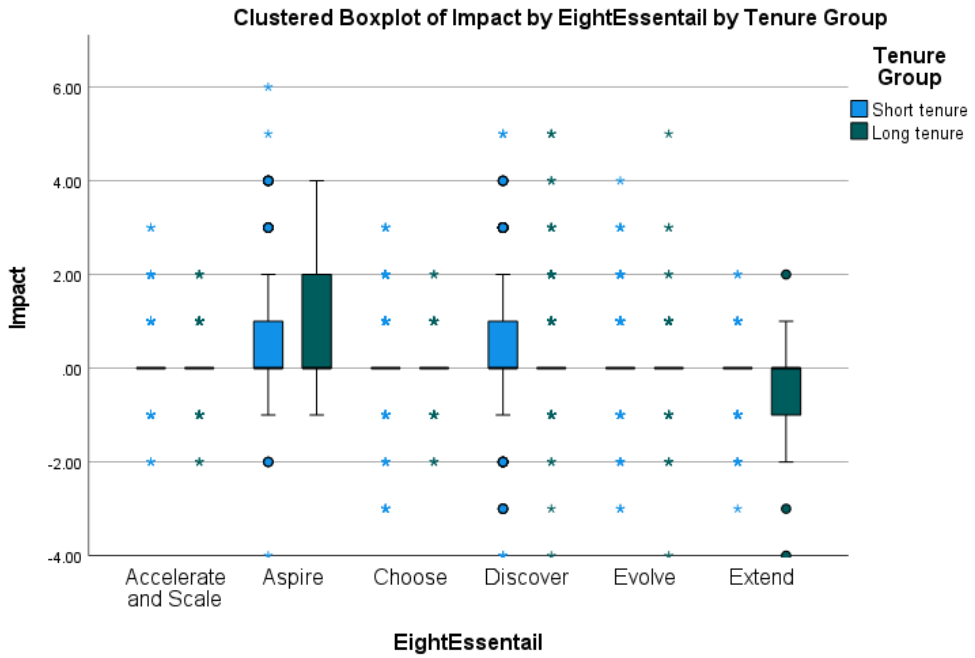

Figure 18: Clustered Boxplot of Impact by Eight Essential and Tenure Group

5.1.6 Validated scales

The exploration and exploitation scale of Jansen et al. (2006) was used in the survey. This scale consists of twelve items which measures the extent to which organisations depart or build on existing knowledge, skills, markets and products (Benner & Tushman, 2003). In the survey these items were related to *Choose* and *Discover*. The process innovation scale from Prajogo and Ahmed (2006) is used to measure the impact of the crisis on radical rethinking acceleration and development speed.

Exploration and exploitation

De Jong et al. (2015) argued that organisations should anticipate and reallocate the resources for new business opportunities to drive innovation in times of a crisis. The quantitative research found a significant result on three out of the six items exploration items which are related to this driver (CHO01, CHO04 and CHO06 in Figure 19). First of all, the research showed that the organisation was able to improve their ability to accept demands that go beyond existing products and services. Secondly, the organisation commercialized more products and services which are new by using new distributions. Thirdly, the organisation used new flows to bring a product or service from production to the final consumer. This improvement of distribution channels is also reported by the directors. Director B stated that digitisation of customer channels contributed to new ways of organising events with customers. According to director B it was necessary to introduce a more hybrid form of servicing customer to deal with the consequences of the pandemic and to seize new opportunities. This indicates

that during the crisis the organisation departs from existing knowledge and products to anticipate on new customer needs.

The exploitation scale was distributed over the barrier of *Choose* and the driver of *Discover*. The first three items should stimulate a balanced focus on both the short-term and long-term impact of the crisis as suggested by Watkins and Yaziji (2020). The respondents experienced that the organisation improved their provision's efficiency of products and increased economies of scales in existing products. Moreover, the organisation was able to expand their service for existing clients. This means that the organisation was able to build on their existing products and customers to exploit new business opportunities. For example, director A experienced that upscaling their services was required to deal with the increased amount of product adoption. Another example was mentioned by director E which expanded his services for civil servants to deal with working from home instead of a visiting people at home. It shows that the organisation was able to anticipate on the impact of business changes and to connect to the market.

In summary, the crisis impacted the exploitation and exploration capability of the organisation in a positive way. Seven out of twelve items were classified as a significant positive effect of the crisis (see Figure 19). The way employees experienced this impact was identical to the way directors experienced this.

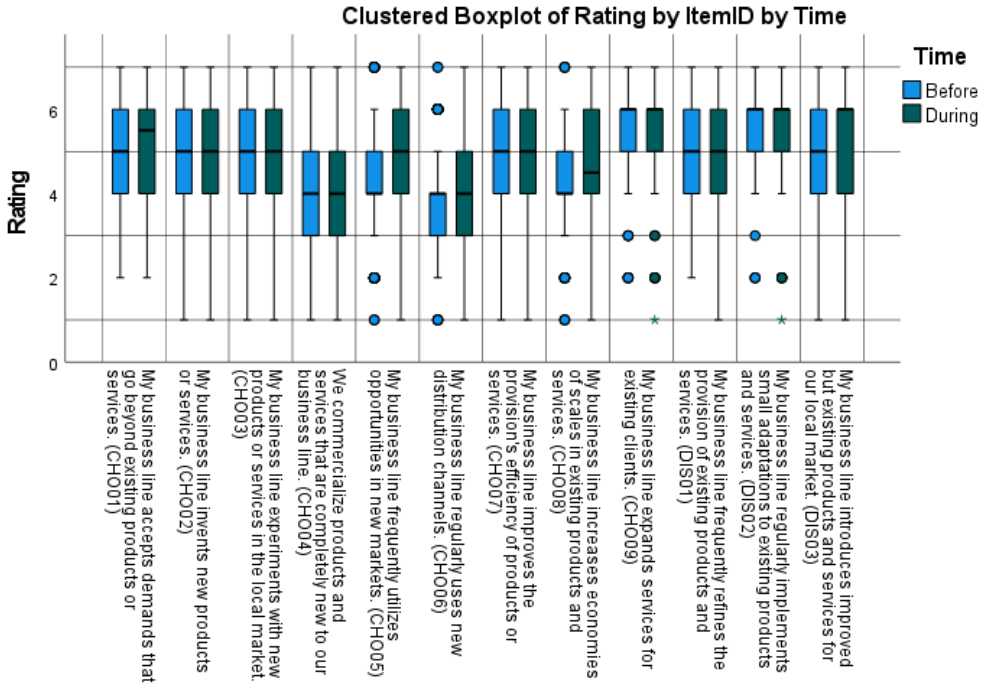

Figure 19: Clustered Boxplot of rating by itemID by Time

Process innovation

Prajogo and Ahmed (2006) analysed the relationships between innovation stimulus, innovation capacity, and innovation performance. Based on this research a six-point scale was defined and used to measure the impact of the crisis on radical rethinking acceleration and development speed (see Figure 20).

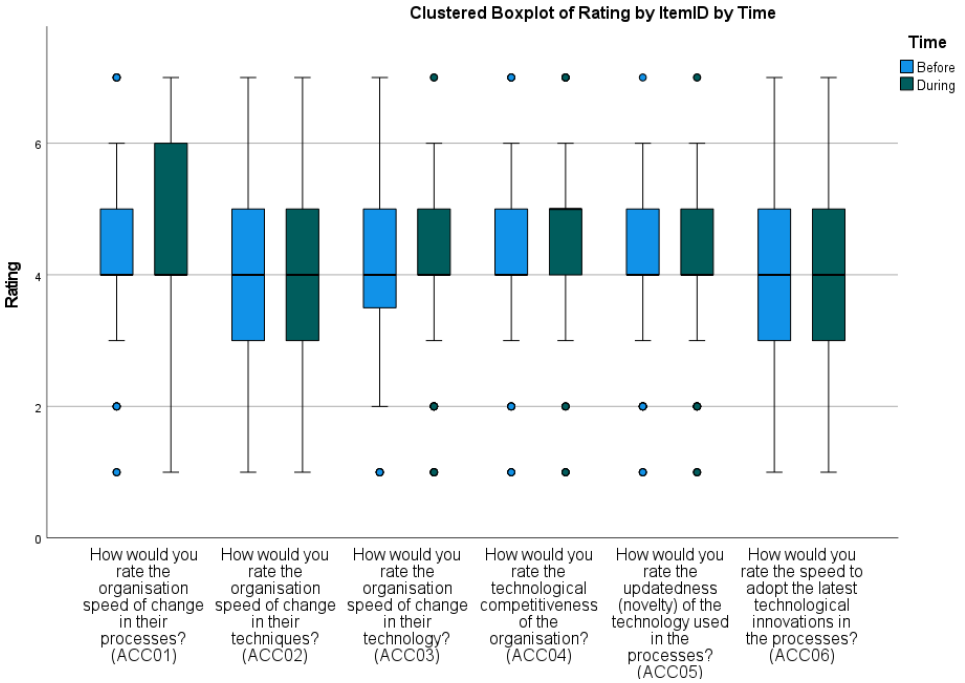

Figure 20: Clustered Boxplot - Process Innovation

A crisis should stimulate organisations to rethink their paradigms and processes given the extreme conditions of a crisis (Bessant et al., 2015). This can be measured with the speed of change in the processes, techniques and technologies of the organisation (Prajogo & Ahmed, 2006). On the basis of the survey results it became clear that the crisis accelerated to rethink about radical solutions. As a result of the crisis there was a moderate impact on the rate of change in the processes of the ICT organisation. The quantitative research found out that the crisis had a statistically significant weak effect on the rate of change in the techniques and technologies. However, director B mentioned that the organisation was unable to introduce new technologies or techniques for virtual innovation events. Earlier literature goes in line with this. For instance, Edson (2012) and Walter et al. (2011) concluded that innovation work behaviour is maintained by social interaction. Unfortunately, this was not possible during the crisis and therefore the ICT organisation experienced these difficulties. Bastian et al. (2018) also concluded in their paper that sharing experiences supports innovation.

So, this research does not support a fast and effective development process which is necessary in times of a crisis according to Śledzik (2013). In the interviews, respondent E underlined that the crisis was only a trigger to reorganise the way how the processes were organised to innovate. After the crisis the organisation should spend more time on process innovation which is in line with the results of Roper and Turner (2020). They reported that process innovation increased more rapidly after the great financial crisis than during recession. An interesting statement was made by director C, because he explained that the organisation should have more attention to stimulate creativity. This shows the intention of the directors to make a major impact on process innovation after the crisis.

5.2 Contributions and implications

In times of crisis organisations are struggling with identifying the impact on their processes (Guderian, 2020). This struggle was recognised by the Dutch ICT organisation and therefore this research is aimed at addressing the challenges related to innovation and the underlying processes. In this section the main contributions of this research are mentioned and based on the limitations of this research recommendations for future research are given.

5.2.1 Theoretical contributions

While earlier researchers contributed to the introduction of innovation management models (Sossa et al., 2019). Therefore Sossa et al. highlighted the problem of the case organisation for theoretical analysis and conceptual strength: the state of the art does not show good practices, patterns, or theories to analyse processes for innovation management. For this reason, this research contributes to existing literature by the introduction of a conceptual model to analyse innovation process in times of crisis. Falaster et al. (2020) called for future research in their paper on how researchers con contribute with research in the COVID-19 crisis. This research fills the gap by analysing the impact of the crisis with the use of the proposed conceptual model which was based on earlier research. This analysis provides practical evidence of this model with quantitative and qualitative research in the Dutch ICT organisation.

This model consists of six drivers and six barriers which are operationalised with thirty-five items to measure the impact of the crisis. The quantitative research showed evidence for a statistically significant impact on nineteen items. These findings contribute to the literature, because this shows on which components the employees of the ICT organisation experienced the most impact due to the crisis. This reason for many positive impacts was due to the fact that the implementation of digital technologies was the greatest business change of this crisis. The ICT organisation took their advantage and was able to provide solutions to the arising problems in the society.

This research also contributes to another theoretical gap about the lack of insight in the relationship of the changing world and innovation as mentioned by Cortimiglia et al. (2015). Therefore, this research analysed the relationship between the generic innovation model proposed by Cortimiglia and the Eight Essentials for innovation. This made clear that the essentials for innovation are related to the innovation process steps. Additionally, the quantitative research clarified a difference between the first part of the innovation process and the last part of the process. These findings contribute to existing literature to show that the impact of a changing world such as the current crisis, is mainly focussed on the idea generation and idea evaluation instead of the development or implementation of innovation.

Finally, the research contributes to the literature by giving evidence on relationship between different variables and the impact of the crisis. At the start of this research there was not sufficient evidence to formulate hypotheses. In this research the results are based on 188 respondents and semi-structured interviews and despite the limitations, there is sufficient evidence to define hypotheses as starting points for further investigation. Further researchers can build on this research by adopting the formulated hypotheses which are mentioned in the 'Recommendation for future research'.

5.2.2 Practical contributions

Based on theoretical framework, this research contributes to the investigation of the drivers and barriers of innovation in times of a crisis. Due to the structural changes a crisis entails the business environment of each sector changed completely (Am et al., 2020). This research makes clear how managers can react to those changes and how employees experienced the impact of these trends.

Although the board of directors took measures to stimulate innovation activities and events in times of the crisis, it also became clear that this was not sufficient. To construct a proposal which additional measures an organisation can take and what can be learned from the current crisis, organisations should understand the different concepts of innovation. This research found out on which components an organisation should focus to improve their innovation capabilities. For instance, the literate research shows that the exploitation and exploration scale of Jansen et al. (2006) is relevant to take into account during the idea generation and idea evaluation innovation process steps.

The quantitative research showed that only three items are classified with a significant negative impact of the crisis. The employees experienced a negative impact on setting objectives to drive innovation, sharing knowledge across business units and providing time for employees to share innovative ideas. For practical contribution it is interesting to know the underlying factors of this

negative impact to respond to this. The directors of the ICT organisation reported that too much resources were allocated to the operational pressure and to deal with the consequences of the crisis.

Further, the organisational culture was focussed on an informal human interaction and therefore impacted the interaction of employees to share, communicate and drive innovation. Knowing these factors can support the organisation to reorganise the way how they set objectives and communicate this across the business units in a hybrid way of working. Also, it is interesting for practical contribution to know the impact of job tenure and business units for innovation. Given the results of the quantitative and qualitative research it became clear that impact does not differ across business unit or job tenure. So, the organisation does not have to investigate actions to anticipate on this, because the differences do not exist. However, the estimated means of the business unit do differ across business units and the ICT organisation should investigate events to share best practices and to learn from each other.

5.2.3 Limitations

Despite the valuable contributions, this research also has some limitations. In this section these limitations are explained and will follow by recommendations for future research.

First of all, the generalizability of the results is limited by the ICT organisation. The survey data was only gathered from a Dutch ICT organisation which connects technology, platforms and data. So, the results are only generalizable by organisations who are similar to this. However, despite this limitation other organisations can learn from this research and can offer insights in the identified relationships. For instance, an organisation can learn from the identified impact of COVID-19 on the innovation processes in the ICT organisation.

Further, the data of the impact of the crisis on each item was gathered simultaneously. This means that the respondents of the survey choose at the same time the response options that best reflect their position 'before the crisis' and 'during the crisis'. However, it was not possible to analyse the situation before the crisis and this was the best possible solution to gather the data from the same respondent. This also applies to the qualitative research, because the directors were asked to outline the situation before the crisis and during the crisis at the same time. In addition, it was not possible to analyse the situation after the crisis because the COVID-19 virus is still active in the world. This limits the conclusions about the how innovation processes are organised after the crisis. Kniffin et al. (2021) stated that notwithstanding the unknows, COVID-19 will be recognized for fundamentally changing the way of work.

Regarding this comparison of the situation before the crisis and during the crisis, this can be affected by the listing of the organisation at the start of 2021. The respondents of the survey and interviews are informed that the listing of the organisation was beyond the scope of this research, but it can still perform as a moderating effect on the results. So, the reliability of this data is impacted by the listing of the organisation and should be taken into account when analysing the results.

Finally, due to the lack of data on the survey it was not possible to specify the results on departments of the business units. The sample was too small to show significant results and therefore it was decided to only focus on the business units of the organisation.

5.2.4 Recommendations for future research

On the basis of the discussion and limitations some avenues for further research arise. This research fills the gap of conceptual models to analyse innovation processes by investigating the relationship between the Eight Essentials and the innovation process steps of Cortimiglia et al. (2015) a framework is designed. This framework enables ICT organisations to get insight in their innovation processes. It is recommended to use this framework before, during and after a crisis. By using this an organisation can learn from how a crisis impacted their innovation processes. It is therefore also a recommendation for the ICT organisation to reuse this framework in the post-COVID period.

This research found out that the impact of the crisis is mostly experienced on the generation and evaluation of ideas. It is interesting to monitor the long-term impact of the crisis on those innovation process steps or the exploitation and exploration scale of Jansen et al. (2006). Later research in the post-COVID period on these scales can contribute to valuable insights in the long-term impact of the crisis on these items. Due to the fast cycles in ICT organisations the short-term and long-term impact of the crisis can differ and probably the innovation pipeline will stagnate after the pandemic. If this will occur, a follow-up measurement will show whether this applies to the ICT organisation. A look into the *Aspire* and *Discover* items can contribute to the understanding how an organisation generates ideas. If an organisation is interested in the idea evaluation step, the *Choose* and *Evolve* essentials are valuable components of the framework to research.

Moreover, as a result of the structural changes of the crisis, a new way of working originated. Organisations took measures to a hybrid way of work and should change the innovation process in a more digitized world. The qualitative research made clear that the directors mainly focus on the way of work before the crisis, but they should have more focus on a hybrid way of work. Lund et al.

(2020) found out that after the pandemic four to five times more remote work will take place. The world is completely changed and the way of work will not return to the situation before the crisis. It is therefore recommended to give more priority to organise new practices and technique for innovation brainstorming in a virtual world. Learning from the measures taken to exploit the drivers and bypass the barriers is a first step to introduce process improvements. Additionally, internal benchmarking can contribute to this new way of working by sharing best practices across business units and departments.

Thompson (2021) stated that virtual collaboration will not be the death of creativity. In his opinion it can improve group creativity and ideation of new innovations. The case organisation should be aware that creativity is driven by factors such as motivation and persistence (O'Connor et al., 2013). Creativity do not need collaboration in person if employees believe that creativity is under their control. So, it is recommended to embrace a proactive mindset about innovation and creativity in an independent way. On the other hand, organisations should prevent production blocking which interferes the employees focus on idea generation. Social scientists showed with meta-analysis that individuals are better in creative-idea generation compared to groups (Thompson, 2021). An organisation should take steps to minimize production blocking and reserve time for individual work away from virtual meetings. Another recommendation from Thompson is to anonymize ideas, because virtual-communication tooling enables people to share ideas without revealing authorship. Moreover, a breakout function in virtual meeting is a great opportunity to share ideas with participants they do not know. According to Hoon-Seok Choi, group diversity stimulates a creative innovation process. The field of innovation management can benefit from further research in the field of hybrid innovation processes. The suggestions mentioned above do not solve the unclarity of organising hybrid innovation processes, so this is valuable to address in future research. For instance, organisations can learn from using this framework in both physical and hybrid innovation processes and analyse the differences.

Further, it is valuable to use this framework in different case studies to assess the reliability of the gathered data and the completeness of the framework. These case studies can also contribute to improve the innovation process in a new way of working by benchmarking between organisations. The case studies are also valuable to add more control variables to analyse the impact of a crisis. This research found out that the impact of crisis is similar across business units and job tenure. However, the impact of a crisis can for example be different for employees with different personality traits.

Finally, it is recommended to execute further research in different organisations and industries. If the framework is applicable in these industries the generalizability and reliability increase. For instance, the ICT organisation does not experienced impact on the process innovation scale of Prajogo and Ahmed (2006). So, it is recommended to use the *Accelerate and Scale* statements in different organisations and on a bigger scale. This future research should point out whether this result is generalizable or only a specific result of the case organisation. Hopefully it will last a while, but if there is a new crisis it is also interesting to see whether this research is generalizable on different crises.

6 Conclusion

This research aimed to find out how innovation processes are affected by the situation due to the COVID-19 pandemic in ICT organisations. The impact of the crisis is measured by assessing the difference between the level of innovation before and during the crisis, the relationship between this impact and the business units, and the relationship between this impact and job tenure. Due to the lack of evidence, there is no hypothesis formulated as a starting point of this research.

The impact of the crisis is assessed based on both quantitative and qualitative research. To make this analysis possible a theoretical framework was designed to enable ICT organisations to analyse their innovation processes. A set of practices and processes which are essential for innovation in big organisations are used as the basis of the theoretical framework and defined as the 'Eight Essentials' concept. However, this is a generic set under normal circumstances and innovation management is a neglected field in times of a crisis. For this reason, a more detailed model was specified on innovation in times of a crisis.

In particular, the drivers and barriers in times of a crisis are examined. Innovation drives on the awareness of strategy and changes in the business environment. Organisation should anticipate on new business opportunities by analysing and monitoring the structural changes due to the crisis. To exploit these opportunities the organisation should reallocate their innovation capacity to maintain their development speed. However, this is only possible when employees are motivated and the organisational culture is organised to innovate.

The quantitative results showed that the impact of the crisis was statistically significant on nineteen out of thirty-five innovation items. These items are operationalised based on the earlier mentioned drivers and barriers. The innovation process is mostly affected in the first two steps: idea generation and idea evaluation. For example, the organisation experienced difficulties with providing time for employees to generate, share or experiment innovative solutions. On the other hand, the organisation succeeded to react to the structural changes of the crisis such as the migration of new digital technologies and working remotely. The interviews with the directors of these business units support these quantitative results and reveal underlying factors on these results. For example, the innovation capacity is decreased due to more operational work and the consequences of the virus.

Further, the relationship of this impact with the job tenure and business unit was investigated. The results found out that there was not a statistically significant difference between this impact and how long someone is employed or in which business unit someone is employed. This means that the impact of the crisis is equal across job tenure groups and business units.

Finally, this research investigated what organisations can learn from the measures taken to exploit the drivers and bypass the barriers during a crisis. It can be learned from the crisis that it was a difficult to continue the innovation process for an organisation known for its innovative products. The processes were geared to physical contact and offering a creative working environment. The crisis exposed that at the time of major structural changes this process stagnated. A redesign of the innovation process was triggered by the crisis, but the organisation proved insufficiently capable of realizing this. It is necessary to design this new hybrid innovation process in the short term in order to stay ahead of the competition in the field of innovation in the long term.

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8 Appendices

A. Innovation Frameworks

The systematic literature review was executed based on the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) Statement (Liberati et al., 2009). The aim of this statement is to support authors in reporting systematic reviews (Moher et al., 2009). In the supported document of the PRISMA Statement, a flow of information is given for researchers which is based on four phases of a systematic review: identification, screening, eligibility and included (see Figure 21).

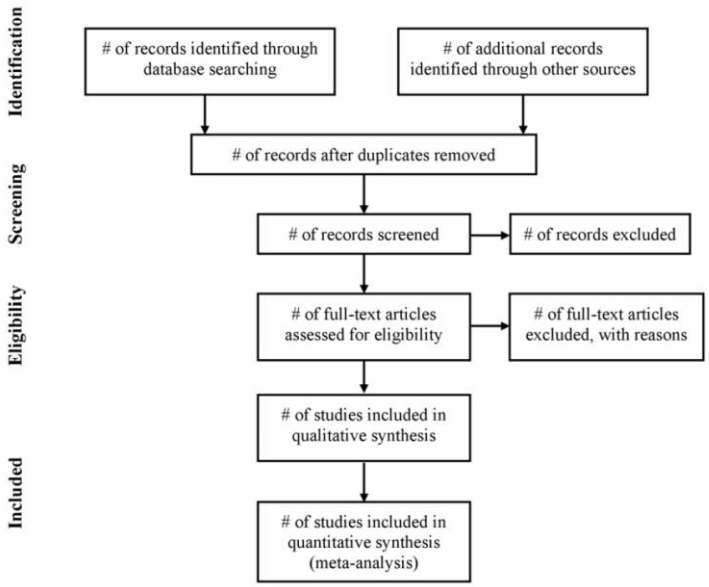

Figure 21: Flow of information through the different phases of a systematic review
Note. Reprinted from "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement.", by Moher et al., 2009, PLoS Medicine.

Literature review on existing innovation management frameworks

This literature review is executed to obtain more context about the current innovation management frameworks. To get the most relevant search results the following search query is used in Scopus: *("Innovation management") AND ("framework" OR "model" OR "system" OR "method")*

In this study, articles from 2015 to 2021 are collected and extracted from the Scopus database. This period is chosen, because several researchers started to publish articles on innovation management in the last decade (Pertuz & Pérez, 2020). Therefore, it is expected to collect appropriate data for identifying future lines of research for innovation management. The other conditions of the literature review are summarized in Table 33.

Table 33: Literature review protocol

Academic databases sources	Scopus
Search fields	Title
	Abstract
	Keywords
Language	English
Publication year	2015-2021

The inclusion and exclusion criteria of this systematic literature review are shown in Table 34.

Table 34: Inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
Literature is written in English	Literature in all other languages
Literature published after 2014	Literature published before 2015
The publication stage of the literature is final	All other publication stages
Literature related to Business, Management and Accounting	Literature not related to Business, Management and Accounting

The first search based on the search query resulted in 900 records. After using the inclusion and exclusion criteria, as mentioned in Table 34, 777 records are excluded from the literature review. After reading the abstract of these records, 29 records were selected for full-text screening. Finally, 6 papers are summarized and used to create an overview of the existing frameworks within the literature. A complete overview of this literate review is shown in Table 35.

Table 35: A systematic literature review on innovation management frameworks
Date: 02-02-2021
Database: Scopus

Search filtering	**Number of papers**
# of records identified through database searching	900
# of records in- or excluded based on inclusion/exclusion criteria	-777
# of records after inclusion/exclusion criteria	**123**
# of records screened on abstract	123
# of records excluded based on abstract	-94
# of records screened after abstract reading	**29**
# of records screened on the full text	29
# of records excluded based on full-text reading	-23
# of records included after full-text reading	0
# of research articles after full-text reading	**6**

B. Opening Statement for an Online Survey/Questionnaire

Hi!

You are being invited to participate in a research study titled "Innovation processes in times of a crisis:
a research during the COVID-19 pandemic". This study is being done by Gijs Sterken from the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

The purpose of this research study is to analyse the impact of the situation due to the COVID-19 pandemic on innovation processes in ICT organisations, and will take you approximately 5 minutes to complete.

The survey consists of 2 parts:
1. Personal information
2. Research statements

Your participation in this study is entirely voluntary and you can withdraw at any time.

I believe that there are no known risks associated with this research study. Your answers in this study will remain confidential and anonymous.

Kind regards,

Gijs Sterken
gijs.sterken@xxx.nl
06 XXX XXX XX

C. Informed consent for research with human participants

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated [DD/MM/YYYY], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves a video-recorded interview, which will be transcribed and destroyed afterwards.	○	○
Use of the information in the study		
I understand that information I provide will be used for writing the thesis about innovation processes in times of a crisis. Which will be anonymously and confidentially published on the University of Twente database.	○	○
I understand that personal information collected about me that can identify me will not be shared beyond the research team.	○	○
I agree that my information can be quoted in research outputs	○	○

Signatures

_____	_____	_____
Name of interviewee	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Name of interviewer	Signature	Date

Contact details for further information:
Gijs Sterken
gijs.sterken@xxx.nl
06 XXX XXX XX

D. Interview protocol

Interviewee: _____ Interviewer: Gijs Sterken Date: ___ - ___ - ___

Introduction – Research purpose

[1] Purpose of the research: to gain qualitative information about the eight essentials and how the different business units anticipate to exploit the drivers and bypass the barriers in the circumstances of the COVID-19 pandemic.

[2] Research Concepts: The Eight Essentials as a result of a literature review

Confidentiality and anonymity

[1] Explain confidentiality of the interview and their anonymity

[2] Sign informed consent form for empirical research with human participants.

Research concepts

[1] **Aspire: Do you accept innovation-led growth as absolutely critical, and have you cascaded targets that reflect this?**
- How have you responded to the changes as a result of the crisis?
- How are the mission, vision and strategic objectives communicated to employees during the crisis?

[2] **Choose: Do you invest in a coherent, time-risk balanced portfolio of initiatives that are resourced to win?**
- How have new opportunities arising from the crisis been seized within the business unit in both the current market and potential new markets?
- To what extent has the crisis shifted the focus of innovation towards the short term rather than the long term?

[3] **Discover: Do you have differentiated actionable customer, business, market, and technology insights that translate into winning value propositions?**
- How do you analyse the changes in the market in order to stay connected?
- How is innovation capacity made available to give the employees possibilities to come up with new innovative ideas?

[4] **Evolve: Do you create new business models that provide defensible, robust, and scalable profit sources?**
- How is innovation stimulated within the business unit?
- Which measures are taken during the crisis to digitize employee and customer communication?

[5] **Accelerate: Do you beat the competition with fast and effective developments and launch of innovations?**
- Do you think the business unit is sufficiently capable of developing quickly and effectively to launch innovations and beat the competition in times of crisis?

[6] **Scale: Do you launch innovations in the relevant markets and segments at the right magnitude?**
- How would you rate the speed of change within the business unit to stay aligned in the relevant markets and segments?

[7] **Extend: Do you win by creating and capitalizing on external networks?**
- What have you done to discover new methods to collaborate with external partners during the crisis?

[8] **Mobilize: Are your people motivated, rewarded, and organized to innovate repeatedly?**
- What has been done within the business unit to keep employees motivated, rewarded and organized to innovate?

Closure interview

[1] Closure of the interview and a word of thanks to the interviewee. Let them know that the research will be shared afterwards. He or she has the opportunity to listen to the recording again and make any comments.

E. Goodness-of-fit statistics 'during the crisis'

Table 36: Goodness-of-fit statistics for the Aspire CFA model (during the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	.000	0	N.A.	1.000		1.000	1.000	0.433	12.000
Goodness of fit criteria		-	-	≥.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Table 37: Goodness-of-fit statistics for the Choose CFA model (during the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	106.925	27	.000	.854	.805	.817	.856	.126	142.925
M1	M0 + correlated errors of CHO07 and CHO08	69.297	26	.000	.916	.883	.874	.917	.094	107.297
M2	M1 + correlated errors of CHO07 and CHO09	58.529	25	.000	.935	.906	.894	.936	.085	98.529
M3	M2 + correlated errors of CHO06 and CHO07	46.697	24	.004	.956	.934	.915	.957	.071	88.697
Goodness of fit criteria		-	-	≥.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Table 38: Goodness-of-fit statistics for the Discover CFA model (during the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	207.729	9	.000	.444	.074	.442	.453	.344	231.729
M1	M0 + correlated errors of DIS05 and DIS06	98.581	8	.000	.747	.525	.735	.752	.246	124.581
M2	M1 + correlated errors of DIS04 and DIS06	79.548	7	.000	.797	.565	.786	.802	.235	107.548
M3	M2 + correlated errors of DIS04 and DIS05	12.627	6	0.49	.981	.954	.966	.982	.077	42.627
Goodness of fit criteria		-	-	≥.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Table 39: Goodness-of-fit statistics for the Evolve CFA model (during the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	14.790	5	.011	0.958	0.915	0.939	0.959	0.102	34.790
M1	M0 + correlated errors of EVO01 and EVO02	3.254	4	.516	1.000	1.008	0.987	1.003	0.000	25.254
Goodness of fit criteria		-	-	≥.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Table 40: Goodness-of-fit statistics for the Accelerate and Scale CFA model (during the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	74.289	9	.000	0.921	0.869	0.912	0.922	0.197	98.289
M1	M0 + correlated errors of ACC05 and ACC06	36.026	8	.000	.966	0.937	0.957	0.967	0.137	62.026
M2	M1 + correlated errors of ACC01 and ACC06	27.654	7	.000	0.975	0.947	0.967	0.975	0.126	55.654
Goodness of fit criteria		-	-	≥.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

Table 41: Goodness-of-fit statistics for the Extend and Mobilize CFA model (during the crisis)

Model	Modification	χ^2	Df	Sig.	CFI	TLI	NFI	IFI	RMSEA	AIC
M0	Original model	36.021	14	.001	0.935	0.902	0.900	0.936	0.092	64.021
M1	EXT1 deleted due to non-significant regression weights (P=0.451)	19.642	9	.020	0.967	0.945	0.942	0.968	0.080	43.642
Goodness of fit criteria		-	-	≥.05	≥0.90	≥0.90	≥0.90	≥0.90	≤0.10	-

F. Descriptive statistics

Table 42: Descriptive statistics

	Min	Max	Mean	Std. error	Std. deviation	Variance
ASP1 (During)	1	7	5.16	0.090	1.232	1.518
ASP1 (Before)	1	7	5.12	0.091	1.248	1.558
ASP2 (During)	1	7	4.37	0.099	1.352	1.829
ASP2 (Before)	1	7	4.44	0.096	1.317	1.735
ASP3 (During)	1	7	4.15	0.123	1.693	2.865
ASP3 (Before)	1	7	3.32	0.121	1.660	2.755
EXT1 (During)	3	7	6.20	0.060	0.822	0.676
EXT1 (Before)	4	7	6.15	0.068	0.932	0.869
EXT2 (During)	1	7	5.11	0.109	1.489	2.217
EXT2 (Before)	1	7	5.18	0.099	1.356	1.839
EXT3 (During)	1	7	4.97	0.094	1.293	1.673
EXT3 (Before)	1	7	4.98	0.092	1.264	1.599
CHO1 (During)	2	7	5.24	0.086	1.181	1.394
CHO1 (Before)	2	7	5.18	0.085	1.165	1.357
CHO2 (During)	1	7	5.02	0.105	1.433	2.053
CHO2 (Before)	1	7	4.98	0.098	1.348	1.818
CHO3 (During)	1	7	4.77	0.106	1.447	2.095
CHO3 (Before)	1	7	4.69	0.098	1.349	1.821
CHO4 (During)	1	7	4.29	0.114	1.560	2.433
CHO4 (Before)	1	7	4.21	0.107	1.465	2.147
CHO5 (During)	1	7	4.50	0.111	1.529	2.337
CHO5 (Before)	1	7	4.44	0.102	1.392	1.937
CHO6 (During)	1	7	3.99	0.096	1.314	1.727
CHO6 (Before)	1	7	3.90	0.091	1.242	1.542
CHO7 (During)	1	7	5.06	0.099	1.351	1.825
CHO7 (Before)	1	7	4.98	0.092	1.266	1.604
CHO8 (During)	1	7	4.64	0.093	1.269	1.610
CHO8 (Before)	1	7	4.51	0.087	1.195	1.428
CHO9 (During)	1	7	5.54	0.083	1.135	1.287
CHO9 (Before)	2	7	5.47	0.080	1.092	1.191
DIS1 (During)	1	7	5.05	0.085	1.171	1.372
DIS1 (Before)	2	7	5.00	0.082	1.119	1.251
DIS2 (During)	1	7	5.78	0.078	1.071	1.148
DIS2 (Before)	2	7	5.70	0.077	1.054	1.111
DIS3 (During)	1	7	5.24	0.090	1.238	1.533
DIS3 (Before)	1	7	5.19	0.088	1.208	1.460
DIS4 (During)	1	7	4.59	0.108	1.480	2.191

	Min	Max	Mean	Std. error	Std. deviation	Variance
DIS4 (Before)	1	7	4.67	0.100	1.375	1.891
DIS5 (During)	1	7	4.62	0.112	1.534	2.354
DIS5 (Before)	1	7	4.85	0.103	1.408	1.981
DIS6 (During)	1	7	4.40	0.108	1.486	2.209
DIS6 (Before)	1	7	4.43	0.102	1.403	1.968
EVO1 (During)	1	7	4.22	0.103	1.418	2.011
EVO1 (Before)	1	7	4.31	0.099	1.353	1.829
EXT4 (During)	1	7	3.76	0.105	1.442	2.079
EXT4 (Before)	1	7	3.97	0.103	1.406	1.978
EVO2 (During)	1	7	4.93	0.097	1.326	1.759
EVO2 (Before)	1	7	4.85	0.089	1.216	1.479
ACC1 (During)	1	7	4.53	0.093	1.268	1.609
ACC1 (Before)	1	7	4.35	0.081	1.105	1.222
ACC2 (During)	1	7	4.10	0.089	1.222	1.492
ACC2 (Before)	1	7	4.01	0.083	1.140	1.299
ACC3 (During)	1	7	4.19	0.092	1.263	1.596
ACC3 (Before)	1	7	4.10	0.088	1.207	1.456
ACC4 (During)	1	7	4.55	0.090	1.233	1.521
ACC4 (Before)	1	7	4.45	0.085	1.162	1.351
ACC5 (During)	1	7	4.24	0.089	1.217	1.480
ACC5 (Before)	1	7	4.16	0.086	1.177	1.386
ACC6 (During)	1	7	4.07	0.085	1.166	1.359
ACC6 (Before)	1	7	4.04	0.083	1.137	1.292
EXT5 (During)	1	6	4.09	0.076	1.038	1.077
EXT5 (Before)	1	7	4.11	0.074	1.018	1.037
EXT6 (During)	1	6	4.12	0.078	1.063	1.131
EXT6 (Before)	1	6	4.10	0.074	1.019	1.039
EXT7 (During)	1	7	4.29	0.063	0.867	0.751
EXT7 (Before)	2	7	4.28	0.061	0.840	0.706
EVO3 (During)	1	7	5.20	0.080	1.095	1.200
EVO3 (Before)	1	7	4.76	0.083	1.133	1.285
EVO4 (During)	1	7	5.00	0.079	1.090	1.187
EVO4 (Before)	2	7	4.62	0.073	0.998	0.996
EVO5 (During)	2	7	5.58	0.089	1.214	1.475
EVO5 (Before)	1	7	4.28	0.110	1.509	2.278

G. Mixed ANOVA

Table 43: Levene's test, Kolmogorov Smirnov and Shapiro-Wilk

	Levene's test for homogeneity of variances				Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Levene Statistic	**df1**	**df2**	**Sig.**	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
DIS2 (During)	6.410	4	183	0.000	0.311	188	0.000	0.799	188	0.000
DIS2 (Before)	5.144	4	183	0.001	0.289	188	0.000	0.850	188	0.000
CHO8 (Before)	3.176	4	183	0.015	0.206	188	0.000	0.909	188	0.000
CHO7 (During)	3.040	4	183	0.019	0.229	188	0.000	0.858	188	0.000
ACC3 (During)	3.005	4	183	0.020	0.202	188	0.000	0.925	188	0.000
CHO9 (During)	2.885	4	183	0.024	0.302	188	0.000	0.829	188	0.000
CHO4 (Before)	2.766	4	183	0.029	0.160	188	0.000	0.945	188	0.000
CHO7 (Before)	2.583	4	183	0.039	0.204	188	0.000	0.888	188	0.000
ACC1 (During)	2.382	4	183	0.053	0.193	188	0.000	0.922	188	0.000
ACC2 (During)	2.366	4	183	0.055	0.201	188	0.000	0.924	188	0.000
ACC5 (During)	1.998	4	183	0.097	0.191	188	0.000	0.927	188	0.000
DIS5 (Before)	1.947	4	183	0.104	0.209	188	0.000	0.900	188	0.000
CHO8 (During)	1.799	4	183	0.131	0.194	188	0.000	0.902	188	0.000
ACC2 (Before)	1.563	4	183	0.186	0.232	188	0.000	0.915	188	0.000
ACC3 (Before)	1.556	4	183	0.188	0.218	188	0.000	0.925	188	0.000
EVO5 (During)	1.512	4	183	0.200	0.252	188	0.000	0.875	188	0.000
CHO9 (Before)	1.505	4	183	0.202	0.288	188	0.000	0.859	188	0.000
ASP3 (During)	1.356	4	183	0.251	0.171	188	0.000	0.906	188	0.000
EVO4 (During)	1.278	4	183	0.280	0.193	188	0.000	0.895	188	0.000

ACC5 (Before)	1.234	4	183	0.298	0.208	188	0.000	0.920	188	0.000
EVO1 (During)	1.190	4	183	0.317	0.178	188	0.000	0.923	188	0.000
EXT4 (Before)	1.152	4	183	0.334	0.141	188	0.000	0.947	188	0.000
ACC4 (During)	1.135	4	183	0.341	0.173	188	0.000	0.922	188	0.000
DIS5 (During)	1.022	4	183	0.397	0.236	188	0.000	0.890	188	0.000
EXT4 (During)	1.004	4	183	0.407	0.168	188	0.000	0.946	188	0.000
EVO3 (Before)	0.975	4	183	0.422	0.190	188	0.000	0.905	188	0.000
CHO4 (During)	0.827	4	183	0.509	0.144	188	0.000	0.945	188	0.000
CHO6 (Before)	0.764	4	183	0.550	0.275	188	0.000	0.888	188	0.000
EVO1 (Before)	0.725	4	183	0.576	0.176	188	0.000	0.932	188	0.000
ASP3 (Before)	0.631	4	183	0.641	0.224	188	0.000	0.905	188	0.000
CHO1 (During)	0.628	4	183	0.643	0.239	188	0.000	0.880	188	0.000
EVO4 (Before)	0.561	4	183	0.691	0.260	188	0.000	0.879	188	0.000
ACC4 (Before)	0.485	4	183	0.747	0.200	188	0.000	0.914	188	0.000
CHO6 (During)	0.460	4	183	0.765	0.241	188	0.000	0.903	188	0.000
EVO5 (Before)	0.437	4	183	0.782	0.186	188	0.000	0.942	188	0.000
CHO1 (Before)	0.368	4	183	0.831	0.211	188	0.000	0.901	188	0.000
ACC1 (Before)	0.251	4	183	0.909	0.240	188	0.000	0.902	188	0.000
EVO3 (During)	0.137	4	183	0.968	0.214	188	0.000	0.904	188	0.000

a. Lilliefors Significance correction

Table 44: Mauchly's Test of Sphericity[a]

						Epsilon[b]		
Within Subjects Effect	**Measure**	**Mauchly's W**	**Approx. Chi-Square**	**df**	**Sig.**	**Greenhouse-Geisser**	**Huynh-Feldt**	**Lower-bound**
time	ASP03	1	0	0		1	1	1
time	EVO05	1	0	0		1	1	1
time	CHO01	1	0	0		1	1	1
time	CHO06	1	0	0		1	1	1
time	EVO01	1	0	0		1	1	1
time	EVO03	1	0	0		1	1	1
time	EVO04	1	0	0		1	1	1
time	ACC01	1	0	0		1	1	1
time	ACC02	1	0	0		1	1	1
time	ACC05	1	0	0		1	1	1
time	EXT04	1	0	0		1	1	1
time	ACC04	1	0	0		1	1	1
time	DIS05	1	0	0		1	1	1

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + Whichbusiness unitdoyouworkfor
Within Subjects Design: time
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 45: Tests of Between-Subjects Contrasts

Source	Item	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Business unit	ASP03	95.661	4	23.915	5.908	0.000	0.114
Business unit	EVO05	11.281	4	2.820	1.078	0.369	0.023
Business unit	CHO01	29.292	4	7.323	2.909	0.023	0.060
Business unit	CHO06	44.524	4	11.131	3.724	0.006	0.075
Business unit	EVO01	42.084	4	10.521	3.054	0.018	0.063
Business unit	EVO03	9.293	4	2.323	1.158	0.331	0.025
Business unit	EVO04	4.884	4	1.221	0.645	0.631	0.014
Business unit	ACC01	25.449	4	6.362	2.531	0.042	0.052
Business unit	ACC02	77.216	4	19.304	8.259	0.000	0.153
Business unit	ACC05	77.622	4	19.405	8.163	0.000	0.151
Business unit	EXT04	72.113	4	18.028	5.248	0.001	0.103
Business unit	ACC04	53.740	4	13.435	5.324	0.000	0.104
Business unit	DIS05	70.556	4	17.639	5.037	0.001	0.099

Table 46: Multiple Comparisons significance across business units

		ASP03	CHO01	CHO06	DIS05	EVO01	EVO03	EVO04	EVO05	ACC01	ACC02	ACC04	ACC05	EXT04
Unit A	**Unit B**	**0.000**	0.176	0.998	0.998	0.999	0.997	1.000	0.588	1.000	0.975	0.406	0.604	0.062
	Unit C	**0.000**	**0.021**	**0.031**	**0.008**	0.248	0.710	0.903	1.000	0.205	**0.024**	0.406	0.062	**0.000**
	Unit D	**0.016**	**0.011**	0.546	0.378	0.227	0.984	0.887	1.000	0.644	1.000	1.000	0.999	**0.010**
	Unit E	0.637	0.191	0.669	0.906	0.985	0.983	1.000	0.989	1.000	0.980	1.000	1.000	0.527
Unit B	**Unit A**	**0.000**	0.176	0.998	0.998	0.999	0.997	1.000	0.588	1.000	0.975	0.406	0.604	0.062
	Unit C	0.928	0.987	**0.027**	**0.006**	0.053	0.307	0.827	0.276	0.087	**0.000**	**0.000**	**0.000**	0.564
	Unit D	0.385	0.898	0.658	0.467	0.056	0.844	0.814	0.467	0.493	0.862	0.117	0.213	0.995
	Unit E	0.319	0.983	0.768	0.961	0.942	0.918	1.000	0.965	1.000	1.000	0.637	0.851	0.989
Unit C	**Unit A**	**0.000**	**0.021**	**0.031**	**0.008**	0.248	0.710	0.903	1.000	0.205	**0.024**	0.406	0.062	**0.000**
	Unit B	0.928	0.987	**0.027**	**0.006**	0.053	0.307	0.827	0.276	0.087	**0.000**	**0.000**	**0.000**	0.564
	Unit D	0.623	0.976	0.328	0.226	0.999	0.845	1.000	0.999	0.859	**0.001**	0.161	**0.006**	0.661
	Unit E	0.510	0.999	0.973	0.585	0.893	0.998	0.898	0.982	0.598	**0.034**	0.694	0.214	0.574
Unit D	**Unit A**	**0.016**	**0.011**	0.546	0.378	0.227	0.984	0.887	1.000	0.644	1.000	1.000	0.999	**0.010**
	Unit B	0.385	0.898	0.658	0.467	0.056	0.844	0.814	0.467	0.493	0.862	0.117	0.213	0.995
	Unit C	0.623	0.976	0.328	0.226	0.999	0.845	1.000	0.999	0.859	**0.001**	0.161	**0.006**	0.661
	Unit E	0.919	1.000	0.997	0.995	0.852	1.000	0.881	0.994	0.893	0.933	1.000	0.997	0.939
Unit E	**Unit A**	0.637	0.191	0.669	0.906	0.985	0.983	1.000	0.989	1.000	0.980	1.000	1.000	0.527
	Unit B	0.319	0.983	0.768	0.961	0.942	0.918	1.000	0.965	1.000	1.000	0.637	0.851	0.989
	Unit C	0.510	0.999	0.973	0.585	0.893	0.998	0.898	0.982	0.598	**0.034**	0.694	0.214	0.574
	Unit D	0.919	1.000	0.997	0.995	0.852	1.000	0.881	0.994	0.893	0.933	1.000	0.997	0.939

Table 47: Tests of Within-Subjects Contrasts

Source	Item	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time*business unit	ASP03	1.301	4	0.325	0.279	0.891	0.006
Time*business unit	EVO05	1.833	4	0.458	0.400	0.809	0.009
Time*business unit	CHO01	0.843	4	0.211	1.622	0.171	0.034
Time*business unit	CHO06	0.106	4	0.027	0.248	0.911	0.005
Time*business unit	EVO01	0.804	4	0.201	0.819	0.515	0.018
Time*business unit	EVO03	1.873	4	0.468	0.993	0.413	0.021
Time*business unit	EVO04	0.297	4	0.074	0.239	0.916	0.005
Time*business unit	ACC01	0.474	4	0.118	0.499	0.737	0.011
Time*business unit	ACC02	0.151	4	0.038	0.408	0.803	0.009
Time*business unit	ACC05	0.842	4	0.210	1.713	0.149	0.036
Time*business unit	EXT04	0.458	4	0.115	0.366	0.833	0.008
Time*business unit	ACC04	0.251	4	0.063	0.540	0.706	0.012
Time*business unit	DIS05	0.644	4	0.161	0.298	0.879	0.006

H. Mann-Whitney U test

Table 48: Mann-Whitney U test - Test of normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
ItemID	**Tenure group**	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
DiffASP03	Short tenure	0.290	115	0.000	0.836	115	0.000
	Long tenure	0.284	48	0.000	0.850	48	0.000
DiffEXT04	Short tenure	0.351	115	0.000	0.792	115	0.000
	Long tenure	0.385	48	0.000	0.710	48	0.000
DiffCHO1	Short tenure	0.438	115	0.000	0.519	115	0.000
	Long tenure	0.491	48	0.000	0.323	48	0.000
DiffCHO4	Short tenure	0.416	115	0.000	0.557	115	0.000
	Long tenure	0.450	48	0.000	0.484	48	0.000
DiffCHO6	Short tenure	0.473	115	0.000	0.493	115	0.000
	Long tenure	0.540	48	0.000	0.204	48	0.000
DiffCHO7	Short tenure	0.415	115	0.000	0.605	115	0.000
	Long tenure	0.493	48	0.000	0.456	48	0.000
DiffCHO8	Short tenure	0.447	115	0.000	0.617	115	0.000
	Long tenure	0.532	48	0.000	0.260	48	0.000
DiffCHO9	Short tenure	0.440	115	0.000	0.571	115	0.000
	Long tenure	0.538	48	0.000	0.261	48	0.000
DiffDIS02	Short tenure	0.473	115	0.000	0.449	115	0.000
	Long tenure	0.479	48	0.000	0.253	48	0.000
DiffDIS05	Short tenure	0.336	115	0.000	0.811	115	0.000

	Long tenure	0.353	48	0.000	0.740	48	0.000
DiffEVO1	Short tenure	0.421	115	0.000	0.591	115	0.000
	Long tenure	0.415	48	0.000	0.555	48	0.000
DiffEVO3	Short tenure	0.349	115	0.000	0.781	115	0.000
	Long tenure	0.294	48	0.000	0.751	48	0.000
DiffEVO4	Short tenure	0.405	115	0.000	0.686	115	0.000
	Long tenure	0.424	48	0.000	0.675	48	0.000
DIffEVO5	Short tenure	0.265	115	0.000	0.872	115	0.000
	Long tenure	0.199	48	0.000	0.881	48	0.000
DiffACC01	Short tenure	0.411	115	0.000	0.693	115	0.000
	Long tenure	0.335	48	0.000	0.787	48	0.000
DiffACC02	Short tenure	0.475	115	0.000	0.531	115	0.000
	Long tenure	0.463	48	0.000	0.441	48	0.000
DiffACC03	Short tenure	0.444	115	0.000	0.595	115	0.000
	Long tenure	0.458	48	0.000	0.390	48	0.000
DiffACC04	Short tenure	0.467	115	0.000	0.534	115	0.000
	Long tenure	0.478	48	0.000	0.427	48	0.000
DiffACC05	Short tenure	0.470	115	0.000	0.504	115	0.000
	Long tenure	0.469	48	0.000	0.517	48	0.000

a. Lilliefors Significance Correction

Table 49: Independent-Samples Mann-Whitney U Test

ItemID	U	Sig. [ab]	Decision
Absolute difference ASP03	2914.000	0.546	Retain hypothesis.
Absolute difference CHO1	2625.000	0.398	Retain hypothesis.
Absolute difference CHO4	2616.500	0.419	Retain hypothesis.
Absolute difference CHO6	2674.000	0.565	Retain hypothesis.
Absolute difference CHO7	2217.500	0.004	Retain hypothesis.
Absolute difference CHO8	2498.000	0.152	Retain hypothesis.
Absolute difference CHO9	2350.500	0.016	Retain hypothesis.
Absolute difference DIS02	2499.500	0.074	Retain hypothesis.
Absolute difference DIS05	2490.000	0.261	Retain hypothesis.
Absolute difference EVO1	2392.000	0.053	Retain hypothesis.
Absolute difference EVO3	2839.000	0.743	Retain hypothesis.
Absolute difference EVO4	2531.500	0.300	Retain hypothesis.
Absolute difference EVO5	3094.500	0.201	Retain hypothesis.
Absolute difference ACC01	2682.000	0.722	Retain hypothesis.
Absolute difference ACC02	2409.500	0.038	Retain hypothesis.
Absolute difference ACC03	2626.000	0.181	Retain hypothesis.
Absolute difference ACC04	2541.000	0.203	Retain hypothesis.
Absolute difference ACC05	2714.000	0.786	Retain hypothesis.
Absolute difference EXT04	2480.000	0.224	Retain hypothesis.

Note. The Null Hypothesis is defined as: the impact of the crisis is equal across each group

8 Appendices