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Investigating firms' innovation behavior during the COVID-19 crisis

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Abstract

This thesis examines the COVID-19 crisis through the lens of innovation. A particular emphasis is placed on how innovation differs between firms based on firm size, age, and level of digitalization. The COVID-19 pandemic provides a unique opportunity to investigate firms' innovation behavior during a crisis since it has had a significant impact on economic activity across the globe. Therefore, it is highly intriguing to explore which organizations are innovating due to the crisis. The notion of using innovation as a strategic tool to respond to a crisis is particularly relevant in this thesis since the innovation literature has been sparse on this topic.

The findings of the thesis show that small and young firms are not more likely to conduct innovations as a response to the crisis than larger and more established firms. However, digitalization appears to be essential for innovating during the crisis. The thesis points out that there is an imbalance in innovation investments between digital frontrunners and digital latecomers. Firms with higher degrees of digitalization are not only more likely to innovate but also to a larger extent and with better prospects, which is argued to stand for opportunity-driven innovations.

As a result, the thesis sheds some light on the importance of digitalization when it comes to innovating jauntily and adapting quickly to a crisis, such as the COVID-19 crisis. It is argued that these features will almost certainly become even more crucial to be highly innovative in a future digital era. Moreover, the thesis provides findings for future research to further delve deeper into digitalization as an indispensable capability for innovation, as well as some insights to explain possible differences in firm performances after the crisis.

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1 Introduction

In the past, crises have revealed differences in innovation behavior across firms. Many firms' innovation behavior is procyclical, thereby reducing innovation investments during a crisis. Some firms' innovation behavior, on the other hand, is persistent or even countercyclical, as these firms are increasing their innovation investments throughout a crisis.

Although the innovation literature gives a wide range of explanations for increasing, maintaining, or even decreasing existing innovation projects, the innovation literature lacks on how innovations can be strategically employed as a tool during a crisis. The intriguing question is what firms and which characteristics of these firms drive innovations to respond to a crisis and utilize innovation as a tool.

The COVID-19 pandemic provides a unique opportunity to test firms' innovation behavior during this crisis. It has significantly strained many healthcare systems worldwide, and infection-control efforts have generated an economic catastrophe by severely impacting economic activity. Therefore, it is interesting to investigate which firms are innovating due to the crisis and use innovation as a tool to respond.

Since Schumpeter's creative destruction argument, which describes a new upcoming wave of small and young firms during the crisis that innovatively disrupt the market, has earned attention and support in previous findings by Archibugi et al. (2013a), this thesis aims to test if it can be upheld for the COVID-19 crisis. It will be explored if small and young enterprises are more likely to innovate than larger and more established firms during the crisis to acquire momentum. Moreover, by investigating the creative destruction hypothesis, it can be tested if the COVID-19 crisis depicts an innovative environment of creative accumulation and creative destruction simultaneously. As Lien and Timmermans (2021) recently showed, the COVID-19 crisis depicts an innovation environment of creative accumulation, which means that already experienced firms in innovation invest in innovation during a crisis. However, a possible coexistence of creative destruction has still to be tested.

Furthermore, since the pandemic forced society to reduce physical contact to a bare minimum, many firms were forced to think about digital solutions to stay afloat and serve their customer needs. Since the COVID-19 crisis occurs in an emerging digital era, and digitalization is becoming drastically more important in the future, it cannot be brushed aside. Therefore, the element of digitalization is another aspect that is of particular interest when conducting innovation behavior of firms during the COVID-19 crisis. It is especially interesting to examine

if firms that were digitally better equipped before the crisis differ from other firms in their innovation behavior during the COVID-19 crisis.

In a nutshell, the main goal of this thesis is to investigate differences in innovation behavior across firms regarding firm size, firm age, and the level of digitalization.

Thereupon, the research question for this study is the following:

How does innovation differ across firms during the COVID-19 crisis?

The remainder of this thesis is structured as follows: The following section provides the theory of innovation and business cycles/recessions. After that, theory and literature of innovation persistence, crisis-related innovation, and digitalization and innovation are presented. This is the foundation for the formulated hypothesis at the end of this section 2. The following section outlines the methodology of this thesis, where the empirical setting, the data and sample, and the measurement of variables are described. The findings of this thesis are reported in section 4, followed by a discussion, implications, and limitations of this thesis in section 5. In section 6, the conclusion of this thesis is made. Chapter 7 lists the appendices.

2 Theory and literature review

2.1 Theory of innovation

In today's economic world of global competition, rapid technological advancement, and scarcity of resources, innovation is a critical tool for thriving, being successful, and even surviving. (Damanpour & Wischnevsky, 2006).

Schumpeter defined innovation as "the commercial or industrial use of anything new—a new product, process, or technique of production; a new market or source of supply; a new form of commercial, business, or financial organization" (Schumpeter, 1934). Further, innovation is described as a crucial factor for economic growth and a potential element to provide firms with a long-term competitive advantage (Schumpeter, 1934). Managers have seen the primary purpose of innovation as promoting change within the organization in order to create new opportunities or capitalize on existing ones (Drucker, 1985). Most successful innovations can be described as the result of the meticulous application of an unspectacular but methodical managerial discipline rather than the fortunate occurrence of a brilliant flash of insight (Drucker, 1985). At the foundation of that discipline is where to seek and how to find innovation opportunities (Drucker, 1985).

Even though the importance of innovation should be well understood, the managerial implications presented by the innovation literature have been inconsistent in the past. As a result, academics addressed these obstacles by delving deeper into identifying various sorts of innovations and their associated characteristics.

Differentiations have been made between product and process innovations (Berchicci et al., 2014; Damanpour & Gopalakrishnan, 2001). Product innovation refers to creating a new product that is introduced and used in the market. In contrast, process innovation refers to implementing new factors such as systems, equipment, and human resources to improve product quality, optimize manufacturing procedures, or lower production costs (Berchicci et al., 2014). Furthermore, innovations can also be differentiated between radical and incremental innovation (Germain, 1996). Boer and During (2001), however, stress that innovation can highly differ by ranging from incremental, small-step innovation to synthetic innovation (creative recombination of existing methods) to discontinuous, radical, and even quantum-leap innovation. Further, it has to be mentioned that innovation is quite subjective since the generation of something new can be perceived differently. The question is whether the innovation is new to the world, new to a country, new to an industry, or new to an individual

firm (Boer & During, 2001). Damanpour and Wischnevsky (2006) distinguish between two sorts of innovation. They categorize innovation into innovation-generating organizations and innovation-adopting organizations. The latter are firms that are primarily users of innovations developed by innovation-generating firms.

The literature describes innovation as an outcome of either positive or negative driving forces. Researchers present 'positive' driving forces for innovation, such as private returns to innovation and market demand (Taalbi, 2017). Furthermore, innovation is also described as an outcome of advancements in knowledge stocks (Aghion & Howitt, 1992), practical knowledge (Mokyr, 2011), new technological opportunities (Klevorick et al., 1995), and the further development of technology that serves the general-purpose (Lipsey et al., 2005). On the other hand, a set of 'negative' forces, such as the notion "necessity is the mother of innovation," are also mentioned (Taalbi, 2017). Innovation is often seen as a result that occurs due to problem-solving activity, such as in an economic crisis (Berchicci et al., 2014) or the overcoming of technological impediments (Dahmén, 1988).

Taalbi (2017) proposed a framework that combines these factors and comes up with four grouped types of innovation incentives based on positive and negative aspects: problems, technological opportunities, market opportunities, and institutionalized search for enhanced performance. Even though research presents several factors for innovation, it is most likely that various factors influence innovation simultaneously (Taalbi, 2017).

Investments in innovation are distinct from other investments (Paunov, 2012). According to Hall and Lerner (2010), three distinctions to other types of investments can be made. To begin with, the outcomes of innovation investments are highly unclear. Therefore, access to external credit is comparatively difficult due to asymmetric information. Second, initial set-up expenses might be high, necessitating extensive financial resources on firms. Since these expenses are difficult to recover (sunk costs), corporations may have an incentive to postpone investments in innovation if financial resources are scarce. Third, skilled workers account for a sizable amount of the investment. Knowledge capital would be lost if innovation projects were abandoned and workers were laid off. It takes a significant amount of time and money to train new employees to the previous level of expertise to relaunch an innovative project. These aspects of innovation highlight the considerable consequences for firms of discontinuing such investments.

2.2 Business cycles and recessions

2.2.1 Business Cycles

Business cycles are fluctuations in an economy's income relative to its long-term trend (Burns & Mitchell, 1946; Hamilton, 1989). Clément Juglar (1862) was the first economist to distinguish business cycles into two separate phases: expansion, when income increases the average, and recession, when income falls below it (Legrand & Hagemann, 2007). Later, Joseph Schumpeter (1939) expanded Juglar's work and distinguished between four phases of an economy: expansion, recession, depression, and recovery. The business cycle stages, expansion, and depression represent movements away from the equilibrium, and recovery and recession represent movements towards equilibrium. The four different stages are depicted in the figure below. The next chapter goes into further detail on the recession phase of a business cycle.

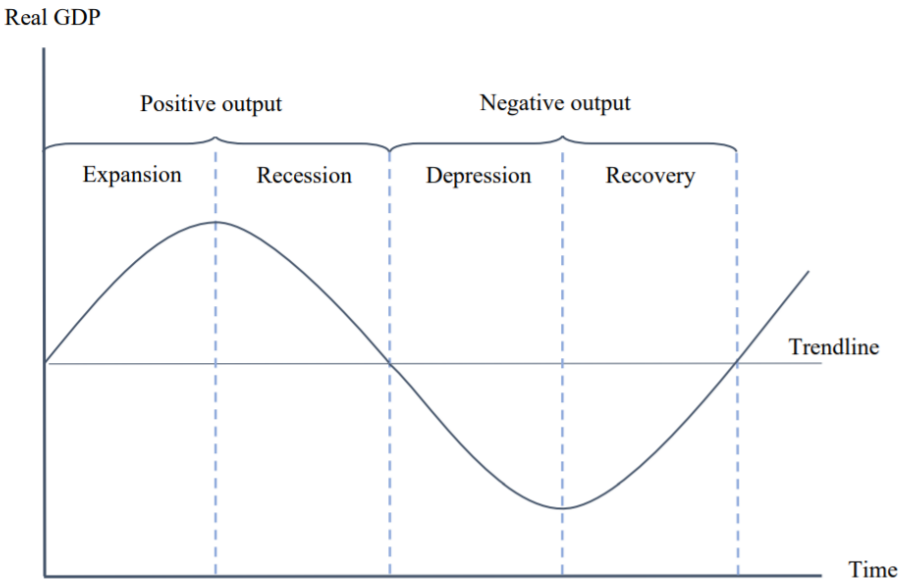

Figure 1: Simplified illustration of phases within a business cycle

There are two approaches to measuring and identifying fluctuations within a business cycle. The National Bureau of Economic Research (NBER) identifies business cycles based on various economic identifies (American standard). The second approach compares an economy's GDP to its GDP trend-line (European standard). Therefore, according to the European standard, expansions occur when the economy grows faster than potential GDP, whereas downturns happen when the economy grows slower than potential GDP. However, the GDP trend-line can also be influenced, thereby leading to the discussion of which sorts of events

should be regarded as part of the business cycle and which should be regarded as other fluctuations (Škare & Stjepanović, 2016). Since other economic activity can co-occur, some macroeconomic variables may originate before and after some cycles. Therefore it is crucial to distinguish between business cycles and seasonal variations, random fluctuations, and other trends (Škare & Stjepanović, 2016). This is often more challenging than anticipated since business cycles are rarely as smooth as illustrated. According to Burns and Mitchell (1946), the duration and intensity of the four phases of a business cycle might vary significantly. Business cycles can range in length from more than a year to even ten or twelve years (Burns & Mitchell, 1946).

2.2.2 Recessions

According to the definition of NBER, a recession is defined as a considerable drop in economic activity that is widespread and lasts longer than a few months (NBER, 2022). Scholars have shown that recessions drastically alter industrial landscapes and "cleanse" industries since not all firms can adapt and survive an economic slowdown (Latham & Braun, 2011; Schumpeter, 1939). In contrast to other environmental changes, on the other hand, they tend to occur more gradually (Agarwal et al., 2009). A recession is depicted by its sudden and unexpected occurrence and the power to drastically change the future of entire industries (Meyer et al., 1990).

When studying recessions, it has to be mentioned that they mostly share common key characteristics while each recession is unique in its origin, intensity, and length (Knudsen & Lien, 2014). Recessions have in common that they entail significant drops in demand and a tightening of credit supply (Agarwal et al., 2009; Aghion et al., 2010). The demand reductions impact firms' by lowering cash flow, investment opportunities as well as financing availability (Bernanke, 1983; Bhagat & Obreja, 2011; Ghemawat, 2009; Ivashina & Scharfstein, 2010), thereby resulting in severe declines in real GDP, industrial production, employment, real income and wholesale-retail sales (NBER, 2022). The concrete implications for firms' innovation investments are further described in the next chapter.

However, recessions are different in the sense that the balance of these two characteristics differs among recessions, across industries during the same recession, and across firms within a particular industry (Knudsen & Lien, 2014; Ramalho et al., 2009; Tong & Wei, 2008).

2.3 Hypotheses development

2.3.1 Innovation persistence

Procyclicality

There is a substantial amount of densified evidence in the literature that shows that investments in innovation tend to be procyclical, which means companies significantly reduce innovation during recessions (e.g., Archibugi et al., 2013a; Barlevy, 2007; Filippetti & Archibugi, 2011; Ouyang, 2011; Paunov, 2012). The reasoning behind the evidence of procyclical investment behavior is that companies have to deal with two major implications of recessions, a demand shock and an increase in financing constraints which leads to fewer investments in innovation (Barlevy, 2007; Paunov, 2012).

An abrupt reduction in demand is forcing companies to protect their core activities to guarantee their survival. Cutting costs is a prevalent strategic response for companies to mitigate the demand shock during a recession. One part of the cost-cutting of firms is innovation projects, especially the ones that are not part of the company's core business. Furthermore, companies are more inclined to deprioritize innovation projects due to declining demand since the uncertainty of a successful realization of these projects increases even more, while expected payoffs decline (Paunov, 2012). Therefore, companies tend to postpone investments in innovation and wait for better times until uncertainty decreases again (Bloom, 2007). The innovation behavior of firms, therefore, tends to be procyclical.

The second main repercussion of recessions on firms is increased financing constraints. Negative demand shocks lower internal revenues, and higher uncertainty in a recession makes it more challenging for firms to access external credit (Paunov, 2012). Aghion et al. (2012) provide evidence for the negative relationship between credit constraints and R&D expenditures of companies across the economic cycle by focusing on French firms from 1993 to 2004. They show empirical evidence that, during economic downturns, companies' investments in innovation become increasingly procyclical when tighter financial constraints occur. Given the role of banks in the global financial crisis of 2008-2009, it was not simply that corporate revenues plummeted, as they do in every recession, but that access to external credit became increasingly difficult (Aghion et al., 2012).

Countercyclicality

Even though there are many indications for a procyclical innovation behavior of firms, this study aims to shed light on firms that swim against the stream by innovating during a crisis.

Here we talk about firms' countercyclical behavior. Despite evidence for procyclicality, there is a range of opposing arguments and different findings presented by the literature that show evidence for a countercyclical innovation behavior of firms during economic downturns.

Aghion et al. (2012) provide evidence for countercyclical investment behavior in R&D and innovation for firms without credit constraints, but as mentioned earlier, a procyclical behavior as credit constraints increase. The findings are consistent with Bovha Padilla et al. (2009) and López-García et al. (2013), who show that investments in R&D and innovation are for Slovenian and Spanish firms procyclical for credit-constrained firms but countercyclical for firms with no credit restrictions. Furthermore, Paunov (2012) showed for Latin American firms during the financial crisis in 2008 that young firms are more likely to experience significant funding limitations, thereby being more prone to stop innovation investments during a crisis. Young firms are at a severe disadvantage in obtaining external funding since they have a shorter credit history (Paunov, 2012). The countercyclicality of R&D investments, which may change by the presence of credit limitations, conforms with the opportunity-cost approach.

Opportunity and adjustment costs

The opportunity-cost approach, also known as the pit-stop effect, describes a scenario where idle labor resources are being used in R&D in times of economic downturns since firms' capacity is underutilized, and excess capacity arises (Bovha Padilla et al., 2009). The opportunity costs of using production personnel in R&D in an economic downturn are dropping sharply, which leads companies to undertake an internal shift, meaning a reallocation of labor within the firm (Knudsen & Lien, 2014). Since returns of investments in R&D and innovation appear in the future, firms tend to shift focus and make substitutions between production and R&D in times of recessions (Bovha Padilla et al., 2009). Furthermore, laying off employees in a research and development department and then rehiring employees when the crisis is over has long-term effects since workers must go through a lengthy training process to achieve full productivity again (Lien & Timmermans, 2021). This is especially the case for firms' cutting-edge innovation operations. As a result, the more engaged organizations are in innovation, the less likely they will give up productivity by scaling down their innovation efforts (Ganter & Hecker, 2013). Therefore, adjustment cost can be the reason for no reductions in innovations or even a slight increase in firms' innovative activity during a recession (Knudsen & Lien, 2014).

Moreover, it is essential to mention that R&D investments fundamentally differ from physical investments. Physical investments can be easily scaled up and down over the business cycles

in response to changes in demand. R&D investments, however, are typically long-term investments that are not easy and also costly to scale up and down quickly (Antonioli et al., 2011; Knudsen & Lien, 2014). Once R&D investments are scaled-down, it is very intricate to scale them up again (Li, 2011). The adjustment costs of R&D are relatively high, implying that managers are cautious about too quick changes in R&D in response to environmental shocks. R&D stocks cannot simply be changed since they must be modified by investments in activities that contribute to the creation of the R&D stock (Dierickx & Cool, 1989). Because of the high cost of R&D adjustment, firms are less likely to substantially reduce R&D investment in response to temporary demand decreases (Knudsen & Lien, 2019).

2.3.2 Crisis-related innovations

After the presented insights on innovation investments over the business cycle of already existing innovation projects, this section concentrates on innovations that arise as a response to the crisis. Firms can either use innovation to mitigate the impact of a recession or even capitalize on new opportunities presented by a shift in the competitive landscape. In other words, a recession or crisis necessitates adaptation, and one method of adaptation is innovation (Lien & Timmermans, 2021).

Crisis impact and innovation behavior

Gopalakrishnan and Kovoor-Misra (2021) argue that, especially if a crisis causes threatening repercussions (Staw et al., 1981), organizations will be likely to innovate during crises. Firms have the intention to counteract and lessen the effect of a crisis, trying to keep the business afloat and maintain the company's customer base. One solution that appears to be a key strategy in a crisis is to develop innovation to counteract the ongoing situation. These innovations are described as threat-driven ones since they are usually reactive, urgent, and aimed at limiting damage to the organization and stakeholders (Gopalakrishnan & Kovoor-Misra, 2021). Several publications support the threat-driven innovation approach during economic downturns: Chen and Miller (2007) observed for US manufacturing companies between 1980 and 2001 that as a firm's performance drops below aspirations, R&D intensity increases. The reasoning behind this appearance is called the problemistic search argument and explains that companies that fall short of their performance targets, e.g. because a crisis impacts them, look for ways to enhance their prospects (Argote & Greve, 2007; Chen & Miller, 2007; Greve, 2003; O'Brien & David, 2014). Greve (2003) shows evidence for the Japanese shipbuilding industry that R&D search rises as performance falls short of expectations and derives it from managerial risk tolerance that is increasing. According to Greve (2003), poor performance not only causes decision-

makers to look for answers but also makes them more willing to adopt riskier alternative solutions, such as innovations in a crisis. However, there are also opposing arguments that R&D decreases a company's risk by allowing it to launch innovations (Grenadier & Weiss, 1997). Either way, a countercyclical innovation behavior is described. O'Brien and David (2014) analyzed Japanese companies and their R&D intensity from 1992 to 2004. They also discovered that problemistic search is used by companies who operate below their aspirational level to solve their challenges. Chen and Miller (2007) show for publicly traded US manufacturing companies from the period 1980 to 2001 that as performance falls below aspirations, R&D search intensity grows, which is consistent with the problemistic search argument.

Opportunity vs. threat driven innovations in a crisis

Not all organizations face the same level of threat and chances during a multi-level crisis. Many previous studies separated threats and opportunities as drivers of innovation, neglecting the existence of innovation drivers of both at the same time throughout a crisis (Gopalakrishnan & Kovoor-Misra, 2021). Therefore, during the same crisis, specific organizations that have not been impacted that severely may also be proactive and take advantage of opportunities arising. New opportunities and customer demands lead companies to *opportunity-driven innovations* (Gopalakrishnan & Kovoor-Misra, 2021; Kitching et al., 2009).

Since crises do not affect every company equally, no uniform behavior by companies can be expected. Researchers break innovation behavior even more down to better understand subsamples that do not fit the overall picture. Filippetti and Archibugi (2011) show that the final effect on innovation investment might vary between countries. They argue that the differences in economic and institutional structure between nations will substantially impact the direction of learning and innovation in those countries.

Innovation capabilities: Creative accumulation

Archibugi et al. (2013a) discovered that even though there was a drastic reduction in short-term investments in innovation for most firms, the financial crisis in 2008 concentrated innovative activity among a small number of firms. These firms were rapidly growing new businesses and firms that were already highly innovative before the crisis, which are described as ‘great innovators’. They further showed that the characteristics of ‘great innovators,’ the cumulative and ongoing nature of the innovative effort, are more noticeable in times of crisis than in times of ordinary (Archibugi et al., 2013a). Further, Archibugi et al. (2013b) showed that before the crisis, incumbent firms were more inclined to increase their investment in innovation, but

following the crisis, a few small businesses and new entrants were willing to “swim against the stream” by increasing their innovative-related expenditures.

The definition of creative accumulation can be used to illustrate continuous investments in innovation. Creative accumulation, which is tracing back to Schumpeter (1942), describes large, established companies that have gained experience and capabilities in launching innovations. These are the most dynamic companies that cannot thrive without modifying their products and services. Firms that practice creative accumulation are innovating continuously by using their pre-existing competence, regardless of the phase of the business cycle (Archibugi et al., 2013a, 2013b; Schumpeter, 1942). These firms developed organizational routines that integrated cumulative learning processes and path-dependent innovation patterns, leading to persistence in innovative activity even over the business cycle (Archibugi et al., 2013a). Research on the persistence of innovation has found substantial evidence that there are considerable relationships between previous innovative activities and the ability to respond to the problems posed by a crisis through innovative actions (e.g., Amore, 2015; Antonelli et al., 2012; Antonioli et al., 2011; Archibugi et al., 2013a, 2013b; Geroski & Walters, 1995; Peters, 2009). This evidence is supported by recent findings by Lien and Timmermans (2021), who show that it also applies to the COVID-19 crisis. According to Lien and Timmermans (2021), firms with more innovation experience prior to the crisis are also more likely to conduct innovations during the crisis.

Furthermore, organizational agility appears to be critical for innovation capabilities in a crisis. Organizations that cling too tightly to old modes of operation will struggle to flourish. Those that concentrate on new product and process development and business model innovation will benefit from their dynamic capabilities (Schoemaker et al., 2018). According to Schoemaker et al. (2018), dynamic capabilities are one key component to enable firms to survive in fast-changing environments by rapidly adjusting direction if they are off track. Organizations have to be flexible and agile in the face of crises because they reflect a rapidly and unexpectedly changing environment. As a result, organizations that have built an agile organization prior to a crisis are more likely to cope with it better by employing their agility to adjust swiftly to changing conditions, and hence using innovation as one way to do so. It appears that what matters in a crisis are not enormous size and internal R&D but flexibility, collaborative arrangements, and market exploration (Archibugi et al., 2013b). Lien and Timmermans (2021) showed that agility is of particular relevance for the COVID-19 crisis. Firms that had established an agile organization prior to the crisis were more likely than other firms to implement crisis-induced innovation (Lien & Timmermans, 2021).

Creative destruction: The role of firm size and age

Although researchers have found substantial path dependencies of firms in innovative activities, the notion of creative destruction is gaining traction. The term creative destruction, which can be traced back to Schumpeter (1939), refers to a dynamic environment in which new businesses emerge as the most prominent innovators due to a significant discontinuity, such as an economic downturn. By using the financial crisis of 2008 as an example, Archibugi et al. (2013a) discovered an innovation environment that is defined by the existence of both creative destruction and creative accumulation at the same time. Their findings showed that the crisis resulted in a concentration of innovation within a limited number of new firms gaining momentum and firms that were already highly innovative before the crisis.

Further research strengthened the creative destruction hypothesis by showing that economic turbulence makes it possible for new and small firms to emerge in a competitive market through innovation to capture market share from established businesses or to open up new markets (Archibugi et al., 2013b; Freeman et al., 2001; Louçã & Mendonça, 2002; Simonetti, 1996). According to Archibugi et al. (2013b), a company's overall resistance to change and inertia might be higher the larger it is. Smaller firms are possibly more flexible for change and therefore more connected with patterns relating to creative destruction. During a recession, incumbent firms might suffer from organizational inertia due to organizational routines and capabilities, which stops them from adjusting properly to environmental shocks (Kitching et al., 2009; Leonard-Barton, 1992).

However, despite the argument of creative destruction, there are contradictory findings of the innovation behavior of young and small firms. Audretsch et al. (2014) showed for Spanish firms between 2004- 2010 that larger and older firms are generally more likely to invest in R&D activities. They further showed that small and young Spanish firms are even less likely to become innovative when impacted by market uncertainty, constraints in human resources, and R&D knowledge. In high-uncertainty markets, firms tend to become less innovative; however, when small and young firms are based in scientific parks and collaborate in R&D activities with external partners, their likelihood of innovating increases (Audretsch et al., 2014). As a result, initial innovation capability and engagement in R&D projects are suggested to increase the likelihood of becoming an innovating small and young firm. This is consistent with the findings of Hottenrott and Peters (2012), who emphasize the necessity of firms to have highly trained employees to reach a high level of inventive capabilities.

Since it would be reasonable to assume that already developed and functioning R&D departments and human knowledge are more related to larger and older firms, this could argue against the fact that young and small firms are innovating more.

Whether or not creative destruction, and also the simultaneous presence of creative accumulation and destruction, is a typical phenomenon that occurs in a crisis scenario makes it appealing to examine and delve deeper into this topic by testing these assumptions in the event of a crisis.

Even though there is mixed evidence, the following hypothesis for this study is formulated as follows:

Hypothesis 1: *Firms of smaller size and younger age are more likely to innovate during the crisis*

2.3.3 Digitalization and innovation

In today's corporate world, there is a lot of uncertainty and continual change. Unlike previous eras, the emerging digital era is characterized by its enormous speed of development and size (Brosseau et al., 2019; Lee & Trimi, 2021). Digital technologies are progressing at a rapid pace, such as the Internet of Things (IoT), artificial intelligence, machine learning, automation, technology-based processes, remote monitoring, predictive maintenance, smart contracts, big data, cloud, analytics, and smart connected products/services (Grubic & Jennions, 2018; Lee & Trimi, 2021; Porter & Heppelmann, 2015). By capitalizing on digitalization, firms of all kinds of industries embrace the fourth industrial revolution (Industry 4.0), which is transforming business models and thereby the way firms are doing business in the 21st century (Crittenden et al., 2019). Organizations strive to become agile entities to survive and thrive in the digital era. This is a challenging endeavor for many businesses, but they have little option but to go on this long path toward digital transformation (Lee & Trimi, 2021). Since the rate of development is unusual, organizations must therefore be not only agile, adaptive, and resilient in the digital era but also highly innovative (Lee & Trimi, 2021). Firms are operating in a new era in which they are becoming smarter by using digital technologies (Porter & Heppelmann, 2015). This significant digital disruption is not a recent phenomenon, but it is immensely accelerating and will affect all industries. To compete in today’s on-demand society and capitalize on customers' digital expectations, firms need to become more digital in their processes, communications, and buyer interactions (Crittenden et al., 2019). The altering global market force in the 4th industrial

revolution and the digital era has made long-term innovation critical for organizational success (Lee & Trimi, 2021). Furthermore, in today's on-demand society, firms use digitalization as a critical tool for market competition and disruption (Crittenden et al., 2019). Consequently, digital technologies create a vast amount of new opportunities, especially for business development and innovation (Lee & Trimi, 2021; Parida et al., 2019; Porter & Heppelmann, 2015; Yoo, 2010) such as such the launch of new products/services, new processes, more efficient solutions, or the entry of new markets (OECD, 2020a).

Researchers highlight that firms that emphasize a digital strategy have a better chance of outperforming their competition, meaning firms that have a comparably lower degree of digitalization in terms of revenue growth, operational efficiency, and innovation (e.g., Cenamor et al., 2017; Gartner, 2021; Parida et al., 2019). Crittenden et al. (2019) emphasize that with artificial intelligence ready to revolutionize machines, robots, and other types of computing, every incumbent in every industry should prepare for the next digital wave of disruption.

According to literature, digital technology-enabled process automation and optimization may boost productivity and profitability by improving cost efficiency, speeding up processes, and significantly decreasing errors (Grubic & Jennions, 2018; Hasselblatt et al., 2018), depicting opportunities that are overlooked for organizations that do not prioritize digitalization.

The use of digital technology has a great potential for business model innovation as well as new income and value-creation opportunities such as new products and services (Gartner, 2021; OECD, 2020a; Yoo, 2010). These functionalities generate multiple chances for value creation (Lenka et al., 2017). They provide a transition from monitoring to control and optimization, culminating in autonomous products facilitated by digitalization (Porter & Heppelmann, 2015). There are several ways in which digitalization may add more value to the customer's experience by introducing new, and often more advanced, service offerings (Parida et al., 2019). Companies with a digital infrastructure can agilely modify or expand their product and service portfolios by including IoT components or even merging diverse offers with unique potential as a result of digitalization (Cenamor et al., 2017). Configuring new solutions based on digital platforms has tremendous prospects (Cenamor et al., 2017; Parida et al., 2019), especially in a crisis when agility and quick adjustment are required. Therefore, numerous firms are encouraged to experiment with novel business models based on digital technology due to the mentioned opportunities and benefits (Parida et al., 2019).

Digitalization was shown to be closely related to agility since digitalization activities help firms in their dynamic-capability stages of 'sensing, 'seizing,' and 'reconfiguring (Rachinger et al.,

2019; Soluk et al., 2021). Aghina et al. (2018) point out that technology and digitalization are frequently components of the route toward completing an agile transformation and stress that in order to adapt to changing consumer and competitive demands, products and services will almost have to be digitized or digitally enabled. Operating procedures will also need to adapt continuously and quickly, necessitating growing technological architecture, systems, and tools (Aghina et al., 2018). Digital technologies, therefore, enable companies to become more agile and to respond faster and more efficiently to the environment. Furthermore, researchers who have prioritized dynamic capabilities in their studies are increasingly supporting and advocating for an environment-strategy-structure fit, therefore promoting the modernity of digital business models and the transition of firms to digitalization (Parida et al., 2019).

Building on digital competencies opens up new avenues for not just customizing services but also promoting continuous innovation (Cenamor et al., 2017). Firms that focus on a digital strategy are seen as promising innovators. Furthermore, the new requirement arising from digital technology and business model innovation is to enable continuous improvement in order to compete and deliver long-term value to customers (Story et al., 2017). This is in line with Lee and Trimi (2021), who claim that innovation should be the top strategic objective to become an agile firm. As a result, organizations that focus on a digital strategy are forced to constantly innovate, making them the corporations that conduct creative accumulation by accumulating ongoing innovation experience. According to Crittenden et al. (2019), in today's digital world, many incumbents have the technical capabilities to detect opportunities for exploitation. Because of their digital expertise as a strategic evolutionary advantage, incumbents may embrace disruption positively, regardless of its origin, following the concept of creative accumulation. If this holds in times of a crisis will be tested.

On the other hand, Crittenden et al. (2017) provide several examples of smaller companies and startups that have utilized technology to disrupt sectors by taking advantage of customer dissatisfaction and incumbent inertia. Incumbents failed to detect critical turning moments and were unable or unwilling to adapt in the face of consumer dissatisfaction. These examples can be seen as examples of Schumpeter’s concept of creative destruction. In both scenarios, it can be assumed companies were already familiar with and experienced in digital technology.

However, to reap the benefits of digitalization, researchers argue that businesses need to innovate their business models by revolving them around digital technologies such as artificial intelligence, digital platforms, and big data analytics (Parida et al., 2019; Yoo, 2010). Taking advantage of digitalization requires unique offers and procedures that define how value is

produced, delivered, and captured amongst suppliers, consumers, and other value chain participants (Parida et al., 2019). Therefore, digital product and service offerings also require a cultural shift within a firm. (Parida et al., 2019). Consequently, firms that have already built this infrastructure and changed their business model and their firm's culture towards digital innovation could be the ones that can innovate more jauntily. Since digitalization requires business model innovation and not every company has built a proper business model/infrastructure to develop digital innovations, companies will possibly face more enormous challenges compared to the experienced companies where these business models for digital innovation are already built. A shift from physical services/products to digital services/products could pose a major problem for firms that do not have the necessary infrastructure and experience in creating digital products.

Degree of Digitalization and innovation behavior in a crisis

Since the digital era is still relatively new, digitalization has not played a significant role in earlier crises, but it is now indispensable. Despite the increased emphasis on the significance of digital technology and how businesses reinvent and innovate their business models, this literature is largely unrelated to recessions and crises, as this current crisis is the first time we can properly investigate the relationship between digital technology and innovation (DIG & FAIR, 2020). However, the obtained data in this study will make it possible to shed some light on this topic. The effect of digitalization in a crisis situation is, therefore, new and unexplored. We still know little about how highly digitalized firms behave differently from less digitalized firms and how important aspects of digitalization influence firm responses (DIG & FAIR, 2020). Understanding how different levels influence how firms respond will provide a useful insight into how firm responses to recessions may evolve in the future as digitalization indubitably continues (DIG & FAIR, 2020). As we can see, the role of digitalization in a crisis is not extensively investigated, leaving many questions unanswered.

Although researchers indicate that digitalization, as pointed out before, enables agility, swiftness, innovative skills, and quick adjustments under ordinary conditions, there is little evidence that these attributes also help firms in a crisis. However, digital technologies have become a vital part of today's world, so they are fascinating to study and should also be examined for extraordinary circumstances, such as in a crisis. Innovation might be a crucial weapon in controlling global crises (Lee & Trimi, 2021)

Based on the foregoing, it can be assumed that businesses with a higher degree of digitalization will likewise innovate more in a crisis. Firms that use a digital strategy have often gained

expertise and knowledge, which may contribute to continuous innovation even during a crisis. Furthermore, because of their optimized systems, these firms may have the organizational agility and greater efficiency required to quickly respond to a changing environment and come up with innovations either as required modifications or as opportunities that arise due to the crisis (Bello et al., 2020). Firms with a higher degree of digitalization can respond to crises and implement new solutions more rapidly due to a greater emphasis on digitalized processes and less human-dependent operations.

Furthermore, organizations with dynamic capabilities based on agility, flexibility, resilience, and speed tend to be better prepared to function in a highly competitive and unstable environment (Aghina et al., 2018; Schoemaker et al., 2018) such as a crisis. Digitalization seems to favor all these factors due to the aforementioned reasons. The same conclusion is found by Parida et al. (2019), who emphasize that digitalization gives businesses plenty more chances to be flexible in the face of changing conditions such as a crisis. Furthermore, Soluk et al. (2021) conducted interviews with several family firms and found that digital artifacts and digital platforms enabled the case firms to become more flexible and respond quickly to changing market demands, resulting in greater adaptive capacity. In a nutshell, the key question appears to be whether organizations with a higher degree of digitalization benefit from the capabilities of knowledge advantage, agility, human independence, and swiftness also in a crisis and if these capabilities can help them to come up with innovations.

The role of digitalization in the COVID-19 crisis

Given the prevalence of digitalization in this crisis, we have a unique opportunity to explore the role of digitalization in a crisis. Digitalization has emerged as a critical company attribute, influencing how organizations react, deploy, invest, and manage their innovations (DIG & FAIR, 2020).

When the COVID-19 pandemic broke out, much of the globe moved online, hastening a decades-long digital change (OECD, 2020a). The COVID-19 crisis appears to be a stunning glimpse into a future world in which digitalization has become the fundamental component and foundation of nearly every interaction between businesses as well as between companies and customers in response to the increasing demand for online interactions and changing customer needs (Blackburn et al., 2020; LaBerge et al., 2020). In addition to the multi-year acceleration of digitalization, the crisis has resulted in a radical shift in CEO perspectives on the role of technology in business (LaBerge et al., 2020). In line with this perception is the digital economy outlook of OECD that emphasizes the rising significance of digital technology and

communications infrastructures in our everyday lives, as well as that governments are increasingly putting digital initiatives at the center of their policy agendas (OECD, 2020b). Customer expectations have shifted considerably to online interaction and channels during the pandemic, and businesses and industries have followed suit. (LaBerge et al., 2020). For most companies, the necessity to operate and engage with customers remotely necessitated investments in data security and rapid migration to the cloud (LaBerge et al., 2020). A future in which digital channels are the primary mode and automated processes are the primary engine of productivity—and the base for flexible, transparent, and efficient supply chains. In the future, agile working methods will be necessary to adapt to daily changes in customer behavior (Blackburn et al., 2020; Soluk et al., 2021). Companies are three times more likely now than before the crisis to state that at least 80 percent of their customer interactions are digital (LaBerge et al., 2020). While an overarching strategy and outstanding leadership have traditionally been indicators of the success of firms during disruptions, the magnitude of technology's decisive role in this crisis is especially evident (LaBerge et al., 2020).

According to a McKinsey Global Survey of executives from 2020, the proportion of digital or digitally-enabled items in firms' portfolios has increased by a startling seven years due to the COVID-19 crisis (LaBerge et al., 2020). Almost all executives believe that their organizations have put at least interim solutions to fulfill many of the new demands arising from the COVID-19 crisis (LaBerge et al., 2020). According to LaBerge et al. (2020), the majority of the polled CEOs perceive technology as a critical component of the organization, not only as a source of cost savings but especially as a means of remaining competitive in this changing economic environment towards digitalization, necessitating the development of new strategies and approaches.

The crisis impacts all types of businesses and necessitates digital change. Digital improvements and adjustments are essential since the digital era is moving even faster due to the pandemic, propelling every organization several development stages forward. It is evident that the so-called digital latecomers are now being compelled to transition to becoming more digital, implementing first or further developing not-so-well-embedded digital systems.

However, even though the crisis indicates an immense opportunity for digital change for companies, the pandemic has also highlighted existing inequalities and gaps among firms (OECD, 2020a). Although some digital barriers have closed rapidly in recent years, others have not, putting other firms behind in the COVID-induced digital acceleration (OECD, 2020a). The digital economy outlook 2020 of OECD gives crucial insights about significant variances in

digital dispersion and adoption among industries and firms. For example, before the pandemic, e-commerce amounted to 19 percent of companies turnover (OECD countries), with considerable differences between large (24%) and small enterprises (9 %) (OECD, 2020a). Furthermore, the economic crisis caused by the pandemic is posing a threat to the development and survival of startups. Startups are significant actors in innovation and are frequently early digital adopters. The COVID-19 crisis has intensified concerns about market concentration, as startups and SMEs firms struggle to stay afloat, whereas huge technology giants exercise more dominance in the digital sector (OECD, 2020a). LaBerge et al. (2020) found first indications that companies that have successfully responded to the crisis with innovations possess a range of technology capabilities that others do not, most notably bridging shortages for technology personnel during the crisis, the usage of more modern technologies, and the speed with which they experiment and innovate.

Furthermore, LaBerge et al. (2020) emphasize that one of the most significant differences between successful innovators and other firms is the extent to which a corporation exploited cutting-edge technology already prior to the crisis and a variety of other characteristics and capabilities such as talent and the willingness to experiment as a firm. The digital economy outlook 2020 of OECD thus stresses such unequal spread may have severe consequences for organizations' productivity performance as the pandemic accelerates digitalization, potentially expanding the productivity gap between digital innovators and digital latecomers (Criscuolo, 2021; OECD, 2020a). This prediction is in line with LaBerge et al. (2020), who provide the first indications for the COVID-19 crisis that the more advanced firms using digital technology before the crisis are also much more likely to be successful innovators during the crisis.

The methods they learn from and respond to today's crises will have a significant impact on their success in tomorrow's changing world, providing the potential to retain greater agility as well as deeper connections with customers, employees, and suppliers. Those who are effective in making achievements will likely be more successful during recovery and beyond (Blackburn et al., 2020). According to LaBerge et al. (2020), the most significant changes during the crisis are also the most likely to persist after the recovery. However, firms with a lower level of digitalization may be the ones to make the basic necessities of modifications, the so-called low-hanging fruits that may be seized to mitigate the effects of the crisis. However, these short-term fixes could not significantly change the firm, thereby not necessarily displaying long-term value.

Therefore, regardless of how far enterprises have progressed in their digital strategy, it is the ideal time to accelerate digital strategy development at this time of crisis. The quick transition to digital can uncover significant vulnerabilities of firms' present digital architecture, thereby indicating how well firms' foundations of digital technology are and how firms will perform in the future digital era (Blackburn et al., 2020).

The crisis addresses the importance of digital development not just for less digitalized organizations but also for firms already digitalized to a greater extent. It may be essential for a firm that already follows a digital strategy to continuously develop and adjust to remain competitive in the digital sector. Therefore, the COVID-19 crisis is valuable feedback about a company's status quo and an incentive or even an urge for further development as an organization. Companies that have already invested in AI capabilities will be far ahead of the competition. Making additional investments now will continue to pay off post-crisis (Blackburn et al., 2020). Firms with a digital strategy might see the crisis as a chance to grow and position themselves for the future by making needed adjustments during the crisis that will have long-term value even after the crisis, which can be named opportunity-driven innovation.

There are many possibilities for organizations to capitalize on during the pandemic (Lee & Trimi, 2021). Digital technologies come into play, for example, in the health sector for testing, contact tracing, and treatment for coronaviruses or are used in a state of urgency when it comes to innovation, e.g., for re-shaping businesses, products, and services to quickly deploy innovative solutions due to changing customer needs which are caused by the pandemic (Bello et al., 2020; Lee & Trimi, 2021).

In a very unpredictable and rapidly changing world, as the COVID-19 pandemic demonstrates, innovation is essential. Stubbornness and clinging to old structures are lethal in the current crisis. Instead, flexibility and coping with changes, whether on a small scale or in the case of large events like the Corona crisis, is a critical success component (Soluk et al., 2021). As a result, this is still another argument favoring significant investments in innovations, even during a crisis. Businesses have to respond to the digital era's needs by being adaptive, resilient, and innovative (Lee & Trimi, 2021). As a result of the COVID-19 pandemic, the globe has been rocked to its foundations, and most organizations, especially SMEs, are in complete disarray. Organizations have a growing desire for the once-feared digital transformation era (Blackburn et al., 2020). A large number of organizations, especially small and medium-sized businesses (SMEs), no longer have the time to establish long-term strategies. Instead, they have to find short-term strategies to survive the COVID-19 crisis (Blackburn et al., 2020). An increase of

many firms with a lesser degree towards digital transformation could be assumed due to the force to innovate to survive the crisis and respond to changing customer needs.

However, researchers argue that companies need to change their systems and architecture to launch digital innovations (e.g., Parida et al., 2019; Yoo, 2010). As products become more digital, new layered product architecture will develop, which means that organizations will need to embrace a new organizational concept due to the new product architecture (Yoo, 2010). Profiting from digitalization necessitates business model innovation, such as shifting to advanced service business models (Parida et al., 2019). Furthermore, value creation, value delivery, and value capture will significantly change in digital business models as well as the alignment of these components has to be adjusted (Parida et al., 2019).

It has to be mentioned that the COVID-19 crisis enormously forces enterprises firms, regardless of the degree of digitalization, to change. However, firms with a lower degree of digitalization could be the ones that conduct more short-term solutions and choose rather low-hanging fruits (Blackburn et al., 2020; LaBerge et al., 2020). Since COVID-19 is rising demand for digital solutions and changing customer needs, firms with a higher level of digitalization prior to the crisis could see this as an opportunity to make use of their experience and improve by (creative accumulation) innovating new products/services or targeting new customer segments (OECD, 2020a) as a result of increased demand, as opposed to less digitalized firms. In addition, innovations, particularly those that can provide long-term value to businesses, may necessitate the development of an appropriate business model, infrastructure, and digital experience. Therefore, organizations focusing on digital strategy may be predicted to be more likely to innovate during the crisis than firms that do not display these characteristics.

However, on the other hand, firms with a higher degree of digitalization could be less likely to change their already developed distribution channels and logistics. Instead, innovations could be expected in products/services, new processes, or the entering of new markets. Because the term "innovation" is quite broad, the more specific kinds of innovation will be of particular relevance in this study.

Based on the previous reasoning and findings, the following hypotheses for this study are presented:

Hypothesis 2: *Higher levels of digitalization before the crisis leads to more innovation during the crisis*

Hypothesis 3*: Firms with a higher degree of digitalization before the crisis are more likely to conduct opportunity-driven innovation during the crisis*

3 Methodology

3.1 Research design

The research design serves to answer the formulated research question in a study (Saunders et al., 2015). It involves making several decisions regarding the research purpose, the choice of the data, the research strategy, and the time horizon (Saunders et al., 2015).

When conducting research, different research methods can be used depending on its purpose. According to Saunders et al. (2015), research can be either exploratory, descriptive, explanatory, or a combination of these methods. In this thesis, a combination of all three methods is used. Since the research question of this thesis is about the link between firms' pre-crisis characteristics and their innovative response in a crisis, this study has its main focus on an explanatory approach that allows for precise analysis and assessment of these relationships. However, because the link between the degree of digitalization and innovation in a recession has not been widely studied, the study also has its exploratory element. In addition, this research will be descriptive in the sense that it will describe differences in firm responses in a crisis as well as further findings of the data set. As the primary purpose of this thesis is to find causal links between pre-crisis characteristics and innovation, the thesis has a descripto-explanatory research design.

According to Saunders et al. (2015), research of business and economic studies is often either deductive or inductive. In deductive research, the existing literature is used to generate hypotheses and expectations that are then quantitatively evaluated. This study uses current literature to develop hypotheses regarding how firms' innovation response differs during recessions. As a result, our research strategy is deductive, which corresponds to our descripto-explanatory study objective. To test a hypothesis, thereby following a deductive approach, quantitative data is needed. This thesis follows a survey strategy to find out possible relationships between variables. By choosing a survey strategy, a large amount of data from many participants can be gathered (Saunders et al., 2015). In addition, this thesis has a cross-sectional time horizon since this research is conducted at a particular time. A 'snapshot' is taken of the current situation of how firms' innovation responses differ in a crisis.

3.2 Empirical context

3.2.1 COVID-19 crisis

The outbreak of the COVID-19 virus in Norway serves as the context for testing the proposed hypotheses in this study. On the 26th of February 2020, the first case of COVID-19 in Norway was verified (Statista, 2021a). As a result of steadily increasing numbers of infections, the Norwegian government announced the first national lockdown on the 12th of March. Due to the crisis, many Norwegian firms have reported decreasing demand and cancellations due to the coronavirus pandemic in 2020 (Statista, 2021a). In December 2020, 25 percent of the Norwegian production firms that had a drop in revenue due to the impact of the coronavirus (COVID-19) had a decrease of up to 25 percent (Statista, 2020).

Although the health crisis was not as severe as in most other developed countries, the economic consequences of the pandemic were. Many people have lost their employment in Norway since the coronavirus (COVID-19) outbreak began. This was especially true for workers in the tourist and transportation industries. Before the coronavirus pandemic, the sector's unemployment rate was 3.4 percent. However, throughout the COVID-19 pandemic, the incidence jumped to 13.6 percent (Statista, 2021b). In comparison to other heavily impacted businesses, such as manufacturing, the unemployment rate in the tourist and transportation industry was more than twice as high (Statista, 2021b). In sum, according to Statistics Norway's calculations, the COVID-19 pandemic resulted in a 4.7 percent lower GDP than pre-pandemic estimates (Frederiksen, 2021).

Consequently, the Norwegian government implemented several countermeasures such as providing loan and guarantee schemes and direct financial support for firms that experienced a significant decrease in revenues. According to a survey of the Confederation of Norwegian Enterprise (NHO) member firms, In March 2020, 68 percent reported decreasing demand or cancellations, a figure that had dropped to 49 percent in January 2021 (Statista, 2021a). Furthermore, the situation improved throughout the summer of 2021, with fewer enterprises at risk of bankruptcy, fewer having financial issues, and fewer experiencing reduced turnover than typical. However, these figures surged again in December 2021, as COVID-19 instances began to rise again throughout the winter (Statista, 2021a).

3.2.2 Difference of COVID-19 crisis to other crises

The Covid-19 crisis is unique and, therefore, different from previous economic downturns. It results from a pandemic health catastrophe, forcing society and companies to restrict physical contact to a minimum, a situation that has not occurred since the Spanish flu in 1918 (Gopalakrishnan & Kovoor-Misra, 2021).

The COVID-19 virus caused a two-pronged crisis: The COVID-19 pandemic has put enormous pressure on many healthcare systems throughout the world, and infection-control measures have caused an economic crisis by disrupting a significant amount of economic activity. (Kuckertz et al., 2020). Besides this, unlike many previous crises that struck humanity at a single point in time or slowly grew with global effects (e.g., the 2008 financial crisis), the COVID-19 pandemic appears to be both by emerging globally and affecting firms suddenly with no preparation time due to countermeasures that have been implemented by governments around the globe (Kuckertz et al., 2020).

Because of the unique nature of the current crisis, the consequences and the impact on businesses occur in various ways. Based on limitations on travel, lockdowns, border closures, disruptions in value chains, and delays in logistics, the activities of companies have been curtailed (Marques Santos et al., 2021).

The COVID-19 crisis showed serious weaknesses in firms and supply chains regarding working conditions and preparedness for exogenous shocks. Enterprises were forced to find new strategies to survive due to the COVID-19 crisis (Gorzelany-Dziadkowiec, 2021). Due to, of necessity, less physical contact between businesses and customers and major changes in consumer preferences during the pandemic, a substantial number of companies were forced to think about shifting towards digital solutions (products and services) as a strategic response to the COVID-19 pandemic in order to avoid losing a considerable amount of their customer base to keep the business afloat. Although the rise of digital has increased such pressures for more than a decade, the current crisis has amplified its disruptive effect (Am et al., 2020). As a result of the crisis, many businesses must make quick adjustments. A shift to digital solutions is a viable approach for firms to continue reaching out to and satisfying customers. As a result, the COVID-19 situation may provide an opportunity for many firms to accelerate their digital transformation.

Moreover, since the COVID-19 crisis is unique in its emergence by depicting a health crisis, the degree and the mix of demand shocks and credit constraints are likely to differ from previous

crises. First studies indicate that demand shocks play a significant role and have a major impact on companies in the COVID-19 crisis, whereas credit constraints pose a relatively less pressing problem for companies than in previous crises such as the financial crisis (Marques Santos et al., 2021).

3.3 Data and Sample

To study the proposed assumptions, survey data and registry data are being used. The primary data source for this thesis is the results of an online survey of Norwegian CEOs conducted between the 16th of November and the 13th of December 2020. The survey was distributed in the middle of the second wave of the COVID-19 crisis. The survey consists of five sections covering strategy and competition, digitalization, furloughing and layoffs, human capital, and government support. The full survey can be found in the appendix.

The survey was distributed via e-mail by a professional survey company to a total of 10.964 Norwegian CEOs across industries and firm sizes. The same survey was distributed to CEOs of 5.511 members of the Norwegian employer federation using the same size and industry criteria. The survey was limited to companies that operate in the private sector with at least five employees.

In total, 2153 CEOs participated in the survey, which provides a response rate of 13% percent. Due to the missing data of firms in the survey and the relevance of specific questions for this thesis, the effective sample decreases to 1246 responses. This attrition raises concerns about a possible response bias in the data collection. Furthermore, survivor bias may affect the survey since firms that have been adversely affected by the COVID-19 situation may be underrepresented because they did not participate in the survey. Both issues are further described and evaluated in the section on data concerns, reliability, and validity.

The registry data delineate a source of secondary data for this thesis since it is already existing data that has been acquired for a different purpose. The registry data provides financial data as well as other information such as firm size, firm age, geographic location, and industry codes. It is publicly available through Bisnode's Smartcheck database. Brønnøysundregisteret provides the data shown on this page on a yearly basis.

The combination of survey and registry data enables the assessment of pre-crisis characteristics and the investigation of the innovative changes that these firms underwent. For the analysis of these datasets, the statistical software Stata and Microsoft Office Excel are being used.

3.4 Variables

3.4.1 Dependent variables

To address the above-mentioned hypotheses, several dependent variables that provide information about firms' innovation responses during the crisis are developed. The analysis is based on CEOs who shared their subjective perspectives on how the crisis affected firm innovation.

First, a measure of expected changes in innovation investments due to the crisis is created. This measure is based on the survey questions asking firms how their investments in innovation will change compared to the period before the COVID-19 crisis. The question is based on a 5-point Likert- scale, encompassing answers indicating a large decrease, small decrease, no change, small increase, and large increase. Based on this, three innovation investment measures are created. First, a dummy variable is created that indicates whether the firms expect an increase in innovation investments due to the crisis. A second dummy variable is constructed to show whether firms expect a decrease in innovation investments due to the crisis. The third measure is a more detailed look at the different expected changes using the ordinal scale, where the category “unchanged” is the benchmark.

In order to measure the innovation output of firms in the crisis, a measure is created that is based on a survey question which contains four sub-questions about different innovation categories that are asking firms whether/to what extent they had: (i) developed new products and or services; (ii) developed new or improved processes; (iii) targeted new customer groups; and/or (iv) developed new logistical solutions due to the crisis. The questions are based on a 4-point Likert scale (0=no innovation; 1=innovation to a small extent; 2= innovation to some extent; 3=innovation to a large extent).

Given the set of questions, several innovation output variables are created. First, a dummy variable is constructed that indicates whether the firm had implemented any kind of COVID-innovations in response to the COVID-19 crisis. If firms answered "to some extent" to any of the four innovation categories, the firm received a value of 1 and is thereby classified as a firm that has been innovative as a response to the COVID-19 crisis.

Aside from this more general measure of innovation in a crisis, separate measures for each of the four innovation categories are also created. This enables for a more in-depth analysis and a clearer picture of what innovations, in particular, firms have implemented in response to the crisis. The procedure is the same as before by creating dummy variables and assigning firms

that responded to a question with at least "to some extent" with a value of 1. Another measure is designed to investigate the degree of innovation within each innovation category of firms. Therefore, the ordinal scale (innovation to some extent; innovation to a little extent; and innovation to a large extent) is being used to investigate and distinguish between different levels of innovation intensity.

To test whether digitalized firms are more likely to conduct opportunity-driven innovations in the COVID-19 crisis, a final dummy variable is being created, conditional on having innovated. This measure is based on a survey question and indicates whether the innovations are expected to be valuable for the firm once the epidemic is over. The question is based on a 5-point Likert scale (1=strongly agree; 2=somewhat agree; 3=neither agree nor disagree; 4= somewhat agree; 5=strongly agree) and firms that at least somewhat agree receive the value of 1 and are thereby classified as firms that conducted opportunity-driven innovation during the COVID-19 crisis.

3.4.2 Independent variables

Degree of digitalization of a firm

A set of survey questions is used to create a measure of firms' pre-crisis degree of digitalization. By analyzing questions that are asking firms about what role digitalization played in their firm and how digitalized they were before the COVID-19 crisis started, patterns in digitalization are being identified. Rather than assuming which variables can be summarized to a single measure, a Principal Component Analysis (PCA) is being performed.

The PCA provides a method for reducing a complex data set to a lower dimension to uncover the sometimes hidden, more straightforward structure that often underlies it (Shlens, 2005). By seeking to detect correlations between variables, patterns in the data are uncovered (Jolliffe, 1990). High-dimensional data can be projected onto a less dimensional subspace if correlations exist while maintaining the information (Jolliffe, 1990). A covariance matrix is created based on all variables. Eigenvectors and eigenvalues provide the eigen-decomposition of the covariance matrix, which analyzes its structure (Mishra et al., 2017). The new subspace directions are determined by the eigenvectors (principal components), and their importance in explaining variance in the dataset is represented by the eigenvalue (Jolliffe, 1990). Stata sorts the eigenvalues of the covariance matrix so that the eigenvalue of component 1 is higher than the eigenvalue of component 2, etc. This means that component 1 captures the most variation from the original dataset's variables (Jolliffe, 1990).

There is a general guideline to use all components with an eigenvalue greater than one (Jolliffe, 1990). By doing so, three components are created when performing the PCA in Stata. Thereby, the PCA identifies the strongest components with the highest eigenvalues out of the listed questions and creates a factor for each company based on it. The factors of the strongest component, meaning component 1, are used for the regression analysis for this study.

An overview of the questions and the result of the Principal Component Analysis can be found below.

Table 1: Principal Component Analysis on digitalization (varimax rotation)

Variable	Comp1	Comp2	Comp3	Unexplained
Importance of digital competence (Q3.1.1)	0.5044			0.2187
Digitalization as a key role in a firm's strategy	0.4800			0.2114
Digitalization as a threat to the firm				0.9295
Digitalization as an opportunity for the firm	0.4962			0.3275
Competitive edge in terms of digitalization		0.5672		0.3100
Digital products/services			0.3707	0.4045
Importance of digital sales over physical sales			0.5975	0.3061
Importance of digital distribution over physical distribution			0.6396	0.2215
Digital internal work processes		0.3486		0.3292
Digital collection and processing of customer information		0.4005		0.3683
Competitive edge in terms of exploiting digital technology		0.6059		0.1934
Importance of digital competence (Q3.5.1)	0.4489			0.3335
Type of Strategy	*Digital strategy*			
Classification	*Organization-centric*	*Cost-centric*	*Customer-centric*	

Three different components can be identified after conducting the PCA. In this study, the firms' digital strategies appear to be either organization-centric, cost-centric, or customer-centric.

The first component (comp1) can be regarded as an organization-centric digital strategy. Digitalization appears to play a key role for these organizations. Because firms see digitalization as a huge opportunity, digital competence seems to be a critical skill and driver for the entire organization to thrive.

The second component (comp2) highlights a firm's digital strategy that, in contrast to the organization-centric strategy, focuses on a specific area within the company. These companies are using digitalization to become more cost-efficient by automating their internal work processes and collecting and processing customer information. By modifying their internal processes, they are performing more efficiently. As a result, the firm's costs are being reduced due to digitalization.

The third component (comp3) is a customer-centric strategy. Because of the shift in customer demands and expectations towards digital in today's world, these organizations embrace

digitalization to fulfill their customers' daily needs. Firms with a customer-centric strategy achieve this by offering digital products/services and emphasizing the significance of digital sales and distribution over physical ones.

Because the first component has the greatest Eigenvalues, the factors of the first component are used in this study. This component is now referred to as digitalization.

Firm size and age

To analyze and assess the above-mentioned creative destruction hypothesis, the following independent variables in this study are firm size and age, generated by using the registry data. The firm size variable is constructed by categorizing enterprises into groups following the definition of the Organization for Economic Cooperation and Development (OECD). Firms are classified as follows: Firms with fewer than ten employees are classed as micro firms, firms with 20-49 employees are classified as small firms, firms with 50-249 employees are classified as medium-sized firms, and firms with more than 250 employees are classified as large firms.

A dummy variable is used to create a firm age variable. Firms founded after the year 2000 were assigned a value of one and hence categorized as young firms. The value of 0 was given to all other firms.

An overview of the distribution of firms in terms of size and age can be found below:

Table 2: Frequency table of firms by firm size

Firm size	Frequency	Percent
Micro firm	499	40.05
Small firm	584	46.87
Medium-sized firm	114	9.15
Large firm	49	3.93
Total	1246	100.00

Table 3: Frequency table of firms by firm age

Firm age	Frequency	Percent
Young firm	671	53.85
Established firm	575	46.15
Total	1246	100.00

3.4.3 Control variables

Several factors can influence firms' investments in innovation during a crisis, as outlined in the literature review. Consequently, to strengthen the validity of this study, insights gained from the literature review are used to control for various variables. This includes the impact of the COVID-19 crisis on a firm, its agility, financial measures, and its industry classification.

Impact of the COVID-19 crisis

CEOs were asked if their company was operating at the time of the survey. There are nine different response options available, ranging from operating at full capacity to temporarily closed due to the COVID-19 crisis to permanently closed. A dummy variable is used to distinguish between firms that have been impacted by the COVID-19 crisis and firms that have not been impacted. If a firm agrees to one of the following statements, they receive a value of one and are classified as a COVID-19 impacted firm: (1) Yes - operational, but with reduced capacity (reduced opening hours, service offer, or activity level) due to COVID-19; (2) Yes - has fully reopened after a temporary closure due to COVID-19; (3) Yes - has opened up with reduced capacity after a temporary closure due to COVID-19; (4) o No - temporarily closed due to COVID-19, but we will reopen; (5) No - temporarily closed due to COVID-19, and it is uncertain whether we will reopen.

Agile Organization

In order to control whether a firm is agile, a dummy variable is created. The measure is based on a survey question where participants were asked about their abilities to respond quickly to threats and opportunities compared to their competitors (before the crisis). The question is based on a 5-point Likert scale (much weaker; weaker; same, stronger, much stronger). If respondents answered they perform stronger or much stronger than other firms, they received a value of 1 and are classified as an agile organization.

Liquidity and debt ratio

As pointed out in the literature review, financial measures can influence firms' investment behavior. Liquidity limitations, in particular, have an impact on firms' innovation investments, as shown by Knudsen and Lien (2014). The ability of a firm to meet its short-term obligations can be measured by liquidity, and a lack of sufficient liquidity might lead to missing out on potential investment opportunities (Myers & Majluf, 1984; Wang, 2002). Furthermore, as Geroski and Gregg (1994) demonstrated when studying firms during the British recession between 1991-1992, the degree of debt of firms before a recession matters. Those firms who had greater debt levels prior to the crisis were hit harder in the recession. This could, in turn,

have consequences on the innovation behavior of firms in recessions. Therefore, in this study, firms' pre-crisis liquidity and the debt ratio are used to control for these effects. Pre-pandemic liquidity and the pre-pandemic debt ratio are obtained using publicly available registry data from the year 2019, which can be combined with the survey data.

Industry

The industry variable is used as a control variable to minimize the influence of industry-specific unsystematic variability. Research has shown that the impact of recessions differs by industry (Geroski & Gregg, 1994). Furthermore, industry differences appear to matter when it comes to innovating, as Audretsch et al. (2014) pointed out. High-tech manufacturing businesses, for example, are more likely to invest in R&D than low-tech manufacturers (Audretsch et al., 2014). In order to assure that the study generates accurate findings and that industry differences are taken into account, industry dummies based on two-digit NACE industry codes are used as a control variable. Based on the two-digit NACE industry codes, industry classifications were created by merging these industry codes into seven broader industries. This approach is motivated by the fact that there would be just a few observations of some industries. Distinctions were made between low-tech manufacturing, high-tech manufacturing, construction, wholesale and retail, hotels, restaurants, and tourism; knowledge-intensive and financial services, and other services.

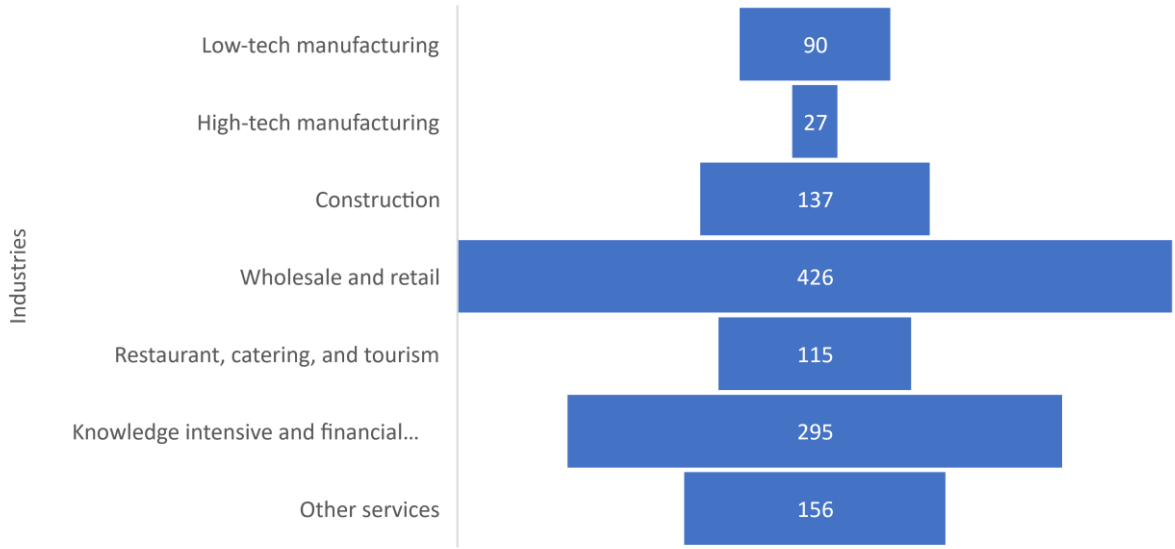

Figure 2: Number of firms per industry

Geographic Location

Finally, 20 country dummies are constructed using the registry data as a metric of geographic location (county classification prior to the 2020 county and municipality merger). The decision

to use larger county controls was influenced by the fact that there was a limitation of data in several of the finer-grained categories, which raised concerns about the subsequent regression analysis.

Table 4: Summary description of dependent, independent, and control variables

Variable	Explanation	Source
Degree of Digitalization	Created by Principal Component Analysis. Based on the questions with their correspondent items: "What role did digitalization play in your company before the COVID-19 crisis started?" and "How digitized was the company before the COVID-19 crisis started?". The Principal Component Analysis identifies the strongest component (with the highest Eigenvalue) and creates a factor for each company	Survey data
Young firm (Dummy variable)	Classified as a young firm if the firm was founded after the year 2000	Accounting data
Large firm	Classified as a large firm if the firm has more than 250 employees	Accounting data
Medium-sized firm	Classified as a medium-sized firm if the firm has 50-249 employees	Accounting data
Small firm	Classified as a small firm if the firm has 10-49 employees	Accounting data
Micro firm	Classified as a micro firm if the firm that has 1-9 employees	Accounting data
Impact COVID-19 (Dummy variable)	If firms consent to one of the following statements, they are classified as an impacted firm by the COVID-19 crisis. (1) Yes - operational, but with reduced capacity (reduced opening hours, service offer, or activity level) due to COVID-19; (2) Yes - has fully reopened after a temporary closure due to COVID-19; (3) Yes - has opened up with reduced capacity after a temporary closure due to COVID-19; (4) o No - temporarily closed due to COVID-19, but we will reopen; (5) No - temporarily closed due to COVID-19, and it is uncertain whether we will reopen	Survey data
Agile Organization (Dummy variable)	Based on the item: "Ability to respond quickly to threats and opportunities compared to our competitors" (before the crisis). If respondents answered they perform stronger or much stronger, they are classified as an agile organization	Survey data
Liquidity	Pre-pandemic liquidity of the firm	Accounting data
Debt ratio	Pre-pandemic debt-ratio of firm	Accounting data
Industry dummies (16)	Industry dummies are based on two-digit NACE codes.	Accounting data
Economic region dummies (5)	County classification prior to the 2020 county and municipality merger	Accounting data
County dummies (19)	County classification prior to the 2020 county and municipality merger	Accounting data

3.5 Data concerns and limitations

When using datasets for research, concerns and limitations regarding those are unavoidable. In this section, concerns that arise from the two datasets used in this thesis will be examined.

Even though it is already the second survey distributed during the COVID-19 pandemic, the release is still relatively new. Since the crisis is almost two years present, data from October to December of 2020 may be too early in the crisis to provide an accurate and complete picture. Because the crisis continues far longer than predicted and hoped for, it would be exciting to analyze innovative activities throughout the crisis rather than based on a single survey that questioned firms about their current situation. It would be useful to have long-term data to compare firms' innovation activity during the crisis. Firms that initially innovate, for example, could later discontinue their activity. In contrast, non-innovators may be the ones who innovate later during a crisis due to the steadily increasing external pressure that is put on them. A single point where this is captured could not be the most effective method to investigate this topic.

Furthermore, missing values reduce the sample size since some firms do not complete the entire survey or do not answer every question. As mentioned earlier, this attrition raises concerns regarding response bias. To address this issue, firms that dropped out of the survey were compared to those that completed it in terms of the impact of COVID-19, firm size, firm age, and industry classification. There are no significant differences between firms that started the survey and abandoned it halfway through and those that completed it regarding the mentioned aspects. The proportion of firms regarding impact by the crisis, firm age, firm size, and industry classification stays the same. There is only a slight reduction in the representation of micro firms in the dataset. Therefore, it can be stated that missing values are thus somewhat more common in micro firms. However, since this is a slight difference and micro firm responses play a major role in this survey data, this concern cannot be upheld.

3.6 Reliability and validity

The notions of reliability and validity are critical in ensuring the quality of research (Saunders et al., 2015). By evaluating a study using four generally used criteria of the credibility of empirical social research, such as reliability, internal validity, external validity, and construct validity, the likelihood of producing inaccurate findings is reduced (Saunders et al., 2015). Therefore, the following chapter will discuss the study's reliability and validity, as well as any potential concerns regarding these aspects.

3.6.1 Reliability

Reliability refers to the replication of the findings, that is, determining whether the chosen data collection techniques and analytical methods can produce consistent results if conducted by a different researcher or on another occasion (Saunders et al., 2015). Saunders et al. (2015) identify four concerns to reliability: participant error, participant bias, researcher error, and research bias.

In terms of survey data, participant error may impact survey responses. A cover letter and information about the survey and its objective were included in the study distributed used for this thesis. This is a smart method of reducing participant error in this study right away. Participant bias can occur when certain factors impact responses, resulting in an inaccurate or even incorrect response from the participant. Memory bias of participants could be one factor that contributes to participant bias. Since the survey was distributed in the middle of the second wave of the COVID-19 crisis, this should not be a problem because the questions concern the firm's current situation.

On the other hand, some survey questions ask about the firm's pre-crisis situation. In this instance, it is possible that the participant incorrectly recalls facts, resulting in a participant bias. These questions, however, are not highly specific, implying that no detailed information is being requested to recall from the participants. As a result, memory inaccuracies should not be regarded as a major concern in this study.

Another aspect that could lead to response bias is that the survey was only completed by one individual, in this case, CEOs, leading to single respondent bias. Because they are the company's head, they may be biased in order to represent their company properly. Because innovation may be regarded as a beneficial option, it may be subject to a slight bias in which organizations respond by claiming to be more innovative than they are. However, the survey questions do not leave much room for depicting individual companies favorably. The survey questions ask about individual investments in a firm's innovation rather than questions that portray firms in a competitive context. Because the survey is well-structured and asks clear, straightforward questions and the fact that responses are given on a Likert scale, inaccurate reporting or interpretation of the results is mitigated. Therefore, this study does not raise concerns about research error or bias.

In terms of the accounting data utilized for this study, participant error and bias may emerge due to modifications in businesses' accounting information. Firms may attempt to portray

themselves favorably by altering the organization's financial condition, and reasons might include making themselves more appealing to investors and saving money on taxes. Firms can be incentivized in both directions to make changes to their accounting data. Nonetheless, because accounting data is regulated and monitored, this study expects researcher error and bias to have a limited impact.

3.6.2 Validity

Internal validity

Internal validity is concerned with the robustness of causal claims and determines if findings are accurate and reasonable (Saunders et al., 2015).

Internal validity may be jeopardized in this study due to its explanatory approach and survey strategy. To ensure the internal validity of this study and, as a result, the robustness of causal claims, a correlation analysis in Stata is performed as a first measure. Thereby, independent variables in this study are examined in terms of correlation, and the reassurance of the absence of multicollinearity between independent variables in this study increases its internal validity. Another problem concerning the validity of this study is whether all relevant independent variables are included in the tested models. The lack of a moderating variable would have major implications for the validity since causality claims would drastically lose their significance. In order to address this issue and strengthen the internal validity in this aspect, a thorough examination of existing research is made to identify and account for all well-known relevant factors. Those relevant factors that could have an impact on firms' innovation behavior in a recession, which have been outlined in the literature review, are therefore used as control variables in this thesis. This minimizes the likelihood that a moderating effect on innovation during recessions is overlooked.

However, one specific concern in terms of the internal validity of this study could be the already mentioned survival bias. Since the survey was only sent to surviving firms, severely impacted firms that are close or already bankrupt could be the ones that are being underrepresented in the sample. Thereby the most impacted firms of the crisis would be left out, which would lower the internal validity of this study. Since the survey was conducted relatively early in the crisis (in its first year), survival bias is expected not to be a major concern.

Another source of concern is the use of two-digit NACE industry categorization numbers to control for industry classifications in this study. This approach is driven by the fact that several firms within NACE categories are not fairly distributed since certain categories contain few or

nearly no firms, whereas others a lot, which would lower statistical validity. As a consequence, industry categories are therefore broader, and one category might encompass firms that are distinct, resulting in a lowered accuracy. Even though there is a trade-off, the former issue, that more specific NACE codes come along with substantially reduced numbers of firms within each category, tends to have a more significant negative impact on internal validity than the latter, leading to the use of broader industry classifications.

External validity

External validity is ensured when research findings can be generalized to a larger theoretical significance (Saunders et al., 2015). In this study, there are some concerns in regard to external validity that have to be addressed.

Recessions vary in nature, as shown by the literature review, since they arise and impact in different ways. Even though the conclusions reported in this study apply to most firms and countries, it has to be kept in mind that recessions have an unequal impact on firms and countries. Because of this, the recession literature faces a particularly difficult task in terms of generalizability, and this study is not exempt from this either.

Therefore, it is difficult to ensure the generalizability of the findings of this study without limitations. It is controversial, for example, whether the findings of this study are entirely generalizable to future recessions. Furthermore, since this study focuses solely on the Norwegian market, the results may not be generalizable to other countries. Because recessions impact countries differently and government interventions vary by country, there may be context-specific components in this study that are not generalizable to other countries. However, it is not the goal or scope of this study to provide results that can be applied to other countries. Furthermore, the economy itself, as well as the support for innovation and the culture of innovation in a country, have a significant effect. Norway might be a country with reduced, or potentially greater, obstacles to innovation which would also influence firms' innovation behavior in a recession.

Although there are a few concerns about our study's external validity, I believe that the findings can be applied to the majority of firms and market economies.

Construct validity

Construct validity refers to establishing appropriate operational measurements for the concepts under investigation (Saunders et al., 2015).

To avoid a lack of construct validity, a researcher should use indicators based on existing theory or subdivide complex indicators to achieve more accurate results (Saunders et al., 2015). Therefore, in this study, in addition to using the dependent variable innovation itself, a particular focus is placed on its more fine-grained categories. This allows to break down the broad innovation variable into smaller, more concrete ones to obtain a more detailed picture. However, there is some caution about measuring innovation. Although the survey responses give information about the various levels/extents of firm innovation during recessions, there is no accurate data on how incremental or radical these innovations are. Although this distinction cannot be clearly drawn in this thesis, the major purpose of this thesis is to determine whether a firm is generally innovating during a crisis, regardless of whether these innovations are incremental or radical.

Furthermore, it might be argued that the responses in terms of innovation are biased since firms' perceptions of the degree of innovation differ. An implemented innovation might be perceived as having innovated to a large extent by one firm but only to a small extent by another. As a result, firms' perceptions of innovations may be very subjective. However, while this may skew the level of innovation, it cannot ignore the fact that corporations developed innovations as a crisis response.

3.7 Empirical Strategy

3.7.1 Regression model

Two different models, a binominal logit and a multinominal logit model are used to test the proposed hypotheses empirically.

The binominal logit model examines the characteristics of firms for an expected increase as well as an expected decrease in innovation investments during a crisis. Following that, the same model is used to analyze the probability that firms developed any crisis-related innovations and for each of the four major innovation categories separately. Furthermore, it will be tested if these innovations investments are opportunity-driven. The multinominal logit model is being used to identify more nuanced differences in innovation intensity within each innovation category.

Considering the fact, as literature points out, that agility might enable smaller and younger firms to outperform larger and more established firms in terms of innovation during the crisis, agility control variables are excluded while testing the creative destruction hypothesis but included when testing for digitalization. As a result, each logistic regression is performed twice.

3.7.2 Logistic Regression

Logistic regression is often seen as a subset of linear regression but with a categorical response variable rather than a continuous response variable (Abonazel & Ibrahim, 2018). Logistic regressions are best suited when dealing with a binary categorical response variable. This is the case when dependent variables have a binary outcome. The dependent variable can then be either 0 or 1. Unlike an ordinary regression that predicts the outcome with a straight line, logistic regression employs the Logistic Function and will always produce a result between 0 and 1 (Abonazel & Ibrahim, 2018; James et al., 2013)

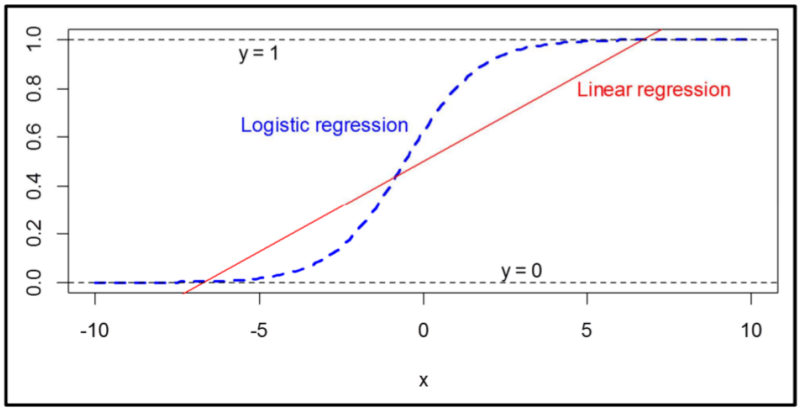

Figure 3: Linear versus logistic regression (Abonazel & Ibrahim, 2018)

By transforming the probabilities, which can only take values between 0 and 1, to odds, the upper limit is removed:

$$Odds = \frac{p}{1-p}$$

By transforming the odds to the log of odds (logit), the lower bounds for the dependent variable are also removed.

$$Logit = log\left(\frac{p}{1-p}\right)$$

The logit model can therefore be described as:

$$Log\left(\frac{\mathrm{p}}{1-\mathrm{p}}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \cdots + \beta_k x_k + \mathrm{e}$$

The log of odds (logit) can accept values ranging from negative infinity to positive infinity (Abonazel & Ibrahim, 2018). Logit is used as the dependent variable in logistic regression

because it is not constrained to a certain interval, whereas probability (p) moves between 0 and 1 (James et al., 2013).

Instead of utilizing least squares as in an ordinary linear regression, the Maximum Likelihood is calculated to identify the best fit (Abonazel & Ibrahim, 2018). The Maximum Likelihood method evaluates the parameters of each observation and predicts values either closer to 1 or 0 (Abonazel & Ibrahim, 2018).

The results from the logistic regression provide a coefficient for each independent variable that shows how the logarithm of the odds of innovation investments in a crisis changes when the independent variables increase by one unit. A t-test, as used in ordinary regression, can be used to determine whether or not a coefficient is significant. A positive coefficient shows that as the value of the independent variable increases, so does the log of odds for innovation investments, thereby increasing the likelihood of innovation investments. If a negative coefficient occurs, the reverse interpretation is applied.

After conducting a logistic regression in Stata, unlike in ordinary regressions, a parameter Pseudo-R^2 is generated based on the log-likelihood function. The values of the Pseudo-R^2 ranges from 0 to 1, with a greater value indicating that the model explains more of the variation in the dependent variable. A score of 0 indicates that the model explains none of the variations in the dependent variable. On the other hand, R^2 measures how much of the variance in the dependent variable can be explained by the regression's projected probability. Unfortunately, there is no such inherent interpretation in the logistic model as there is in OLS. The pseudo R^2 is, however, useful to assess how well different models fit the same dependent variable in the same sample.

4 Analysis/findings

4.1 Descriptive statistics

In this section, descriptive statistics are being presented that add further understanding and give a more concrete picture for the context of this study.

4.1.1 Impact on firms

The COVID-19 pandemic had a significant influence on the Norwegian economy. The crisis affected 30 percent of the sample of Norwegian firms, as shown in figure 4. This means these firms have had to deal with reduced capacity or even severe consequences such as the temporary shutdown of the business due to COVID-19.

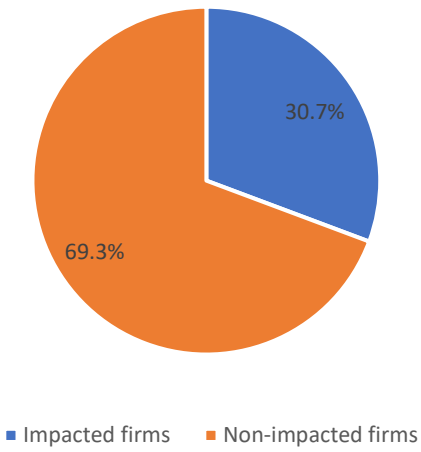

Figure 4: Percentage of impacted vs. non-impacted firms

Table 5 shows an overview of the more fine-grained categories regarding the impact of the COVID-19 pandemic on firms. For most firms, the impact resulted in a reduced capacity (25%). Just a minority of firms that got impacted had to deal with consequences such as a temporary closure of the business. On the other hand, almost 70 percent of the firms in the survey answered that they were not affected by the crisis.

Table 5: Frequency table of the impact of COVID-19 on firms

	Frequency	**Percent**
Operative with normal capacity	863	69.26
Operative with reduced capacity	303	24.32
Fully reopened after temporary closure	23	1.85
Reopened with reduced capacity after temporary closure	24	1.93
Temporarily closed, planning to reopen	28	2.25
Temporarily closed, uncertain about reopening	4	0.32
Temporarily closed for other reasons	1	0.08
Permanently closed due to Covid-19	0	0.00
Permanently closed for other reasons	0	0.00
Total	1246	100.00

When examining the impact of the COVID-19 crisis on firm size, it is crucial to highlight some notable disparities between the impact of the crisis and firm size. Micro, small, and medium-sized firms are all affected to more or less the same extent (~30%). On the other hand, about 14 percent of large firms reported that the crisis influenced their operations. This significant difference sheds light from a different angle by highlighting the apparent victims, those impacted the most by the crisis, namely micro, small, and medium-sized firms.

There are also considerable differences in the impact of younger firms and more mature, established firms. The crisis affected 36.5 percent of young firms (founded after 2000), compared to 23.8 percent of established firms (table 7).

Table 6: Frequency table of impacted firms by firm size

Firm size	Impacted	Population	Percent
Micro firm	163	499	32.7
Small firm	175	584	30.0
Medium-sized firm	37	114	32.5
Large firm	7	49	14.3
Total	382	1246	

Table 7: Frequency table of impacted firms by firm age

Firm age	Impacted	Population	Percent
Young firm	245	671	36.5
Established firm	137	575	23.8
Total	382	1246	

When studying the impact of the COVID-19 pandemic across industries (merged industry categories are being used), further noteworthy findings arise. The least affected industry in this sample, as indicated in figure 5, is high-tech manufacturing, followed by wholesale and retail. The construction and the knowledge-intensive and financial service sectors are affected similarly (25 %). The crisis affects 30 percent of firms in the low-tech manufacturing sector and around 33 percent of firms offering "other services." However, the restaurant, catering, and tourism sector has been the most severely impacted by indicating that the crisis impacted 86.1 percent of firms operating in this sector.

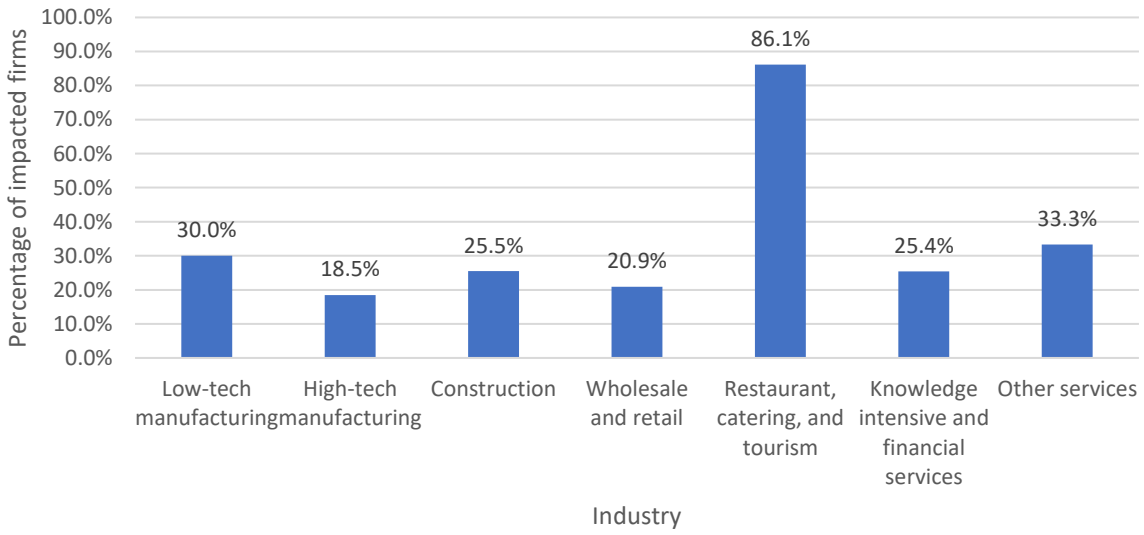

Figure 5: Percentage of impacted firms by industry

4.1.2 Innovation response

Firms are considered to have innovated during the crisis if they replied that they innovated to some extent in at least one of the four innovation areas (new products/services, new processes, new consumers, and new logistics). As a reaction to the COVID-19 crisis, nearly 50 percent of Norwegian firms innovated. Even though the COVID-19 pandemic impacted around 30 percent of the firms in the sample, approximately 49 percent of firms innovated.

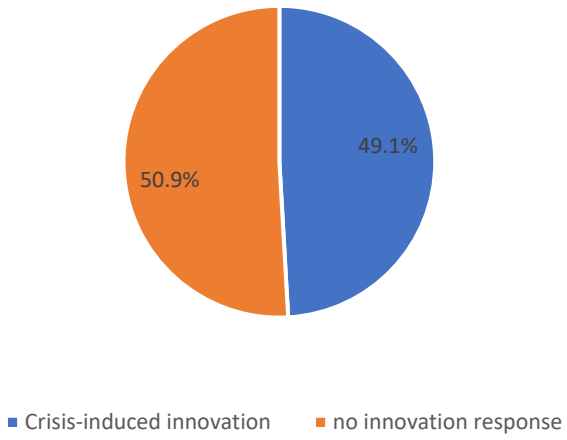

Figure 6: Percentage of innovators vs. non-innovators during the COVID-19 crisis

Furthermore, while examining the different innovation categories, it is worth noting that the number of implementations and the extent of these innovations are pretty similar. According to the total number of innovations, firms have emphasized implementing new processes, followed by new products/services due to the pandemic. The third category of innovation that has been used throughout the crisis is new logistics. According to the total number of observations, targeting new customers has been the least popular innovation choice. However, this measure also includes minor innovations (innovation to a "little extent").

Once the more fine-grained categories are examined, a slightly different picture emerges. New products and services are the kinds of innovations that have occurred the most to some extent. However, among the innovation categories, new logistical solutions appeared to be the type of innovation embraced to the greatest extent the most frequently. Moreover, innovation to a little extent is the most frequent observation for every innovation category. In contrast, innovation to a large extent is the least frequent, as illustrated in the figure below.

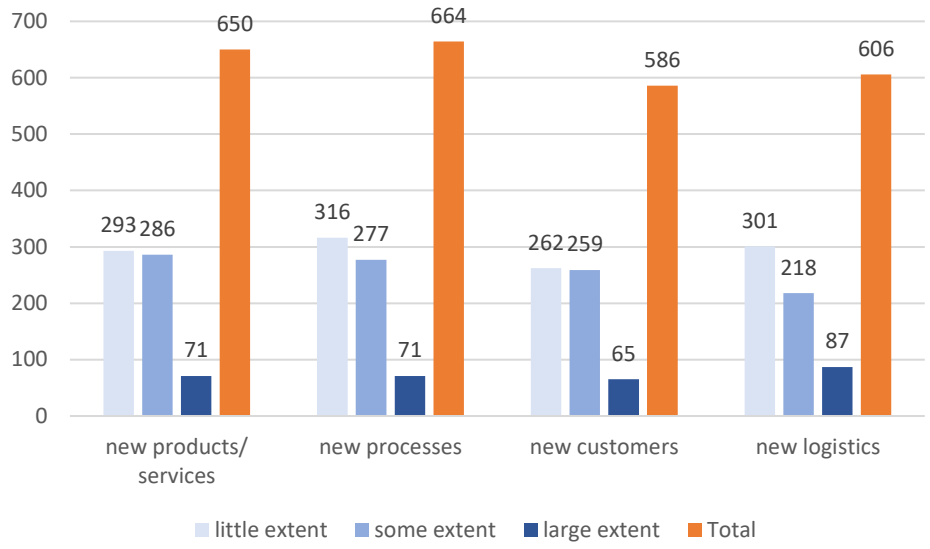

Figure 7: Frequency table of innovations by innovation category

4.1.3 Digitalization

The crisis highlights the rising importance of firms' digital competence and the expected digital transformation needs in the following years. In the table below, respondents to a survey question expressed their perceptions of the value of digital competence before the onset of the crisis for the firm, as well as how the importance is at the time of the survey and how the importance of digital competence will evolve in the coming years. Before the COVID-19 outbreak, roughly 13 percent of firms regarded digital competence as very important for their business. At this point, 35 percent of businesses viewed digital competency as important. However, almost 11 percent of firms regarded it as not very important, and even 5 percent regarded it as unimportant.

At the time of the survey, there was a significant shift in the importance of digital competence for firms. Almost every fourth firm considers digital competence very important for the firm. Furthermore, 44 percent of organizations consider it is important. Nearly 70 percent of firms acknowledged and identified digital competence as important or even very important. The number of businesses that saw it as not very important or unimportant declined. At the time of the survey (second wave of COVID-19 infections), 6 percent considered digital competence to be not very important, while 4 percent considered it to be unimportant.

This trend continues as CEOs of Norwegian firms were asked about the importance of digital competence one year after the survey. Almost one-third of the firms see digital competence as very important, and 41.7 percent consider it important. The number of firms that see digital competence as not very important or not important decreases further compared to the answers of CEOS given at the time of the survey (5.5% and 3.1%).

This trend is consistent, as CEOs of Norwegian firms were surveyed about the relevance of digital competence one year after the survey. Almost one-third of firms consider digital competence very important, and 41.7 percent of firms as important. The number of firms that regard it as not very important or unimportant decreased (5.5 % and 3.1 %).

In three years (after the survey), 41 percent of firms perceive digital competence as very important and 38 percent as important. In sum, almost 80 percent of firms consider digital competence as important in the future, compared to roughly 50 percent of firms before the COVID-19 crisis started. Three years after the survey, 7 percent of firms see digital competence as not very important or even unimportant. Before the COVID-19 pandemic, this was the case for around 15 percent of the firms.

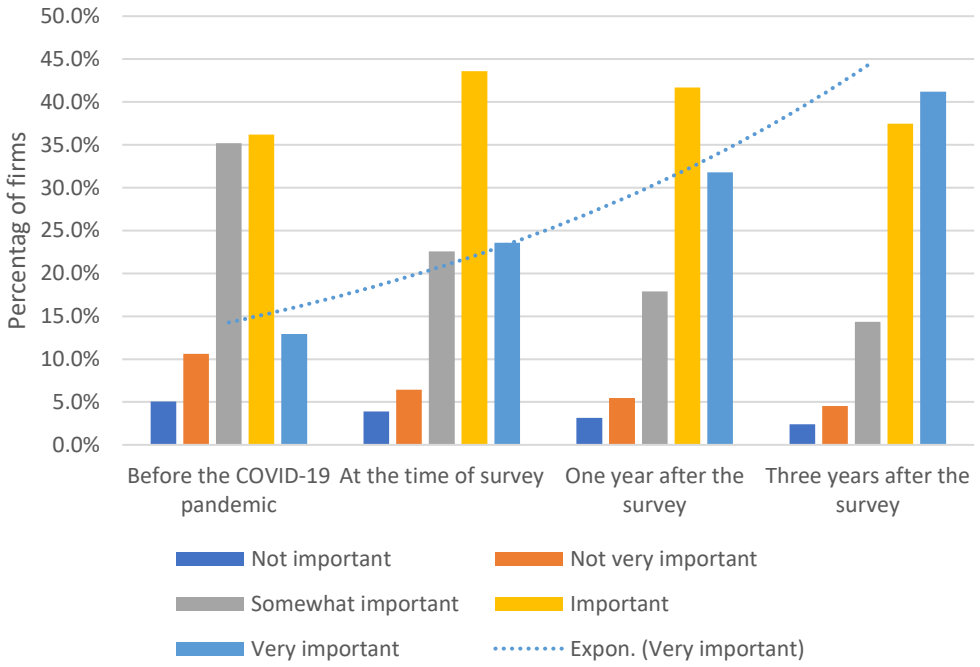

Figure 8: Firms' perceived importance of digital competence over time

Several noteworthy findings occur when assessing the relevance of digital competence for firms prior to the onset of the COVID-19 crisis. It should be noted that a bigger proportion of firms founded before 2001 viewed digital competence as slightly more important prior to the crisis than younger firms (53.4 % vs. 45.5 %). When looking at firm size, it is notable that a large proportion of large firms regarded digital competence as vital before the crisis. Before the crisis, 67.5 percent of major enterprises deemed digital competence as important. Prior to the start of the crisis, around 60% of medium-sized firms saw digital competence as important. It is noticeable that there is a large difference between large/medium-sized and small/micro firms when it comes to the pre-crisis importance of digital competence. Compared to 67.5 percent

large firms and nearly 60 percent medium-sized firms, just roughly 46 percent of small firms and 48 percent of micro firms regarded digital competence as important prior to the crisis.

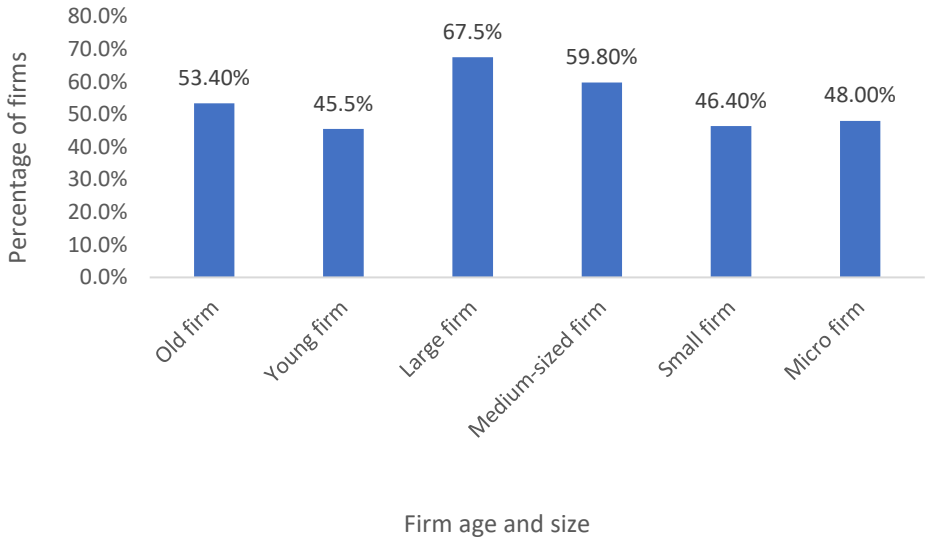

Figure 9: Percentage of firms that considered digital competence as important before the COVID-19 pandemic started (by firm age and size)

Not only is digital competence becoming more important for businesses over time, but the outcome of these competencies is also apparent. The table below shows that digital content in products/services has increased to varying degrees. In total, about 48 percent reported at least a slight increase in digital products/services due to the COVID-19 pandemic. 29.2 percent of firms boosted digital products/services slightly, 15.5 percent increased to a more considerable extent, and 3.9 percent increased digital products/services significantly.

The most notable change is an increase in the use of digital tools for customer interaction, which 67.2 percent of firms reported having accomplished. This trend is followed by 61.8 percent of firms increasing their use of digital technology for internal work processes and 57.1 percent of firms increasing their use of digital technology for supplier interaction.

Table 8: The effect of COVID-19 on firm use of digital technology

%	Decrease	No change	Slight increase	increase	Significant increase	Increase overall
Digital content in products/services	1.1	50.3	29.2	15.5	3.9	48.6
Use of digital tools in customer interaction	0.3	32.6	31.8.	23.7	11.7	67.2
Use of digital tools in supplier interaction	0.4	42.6	31.2	17.8	8.1	57.1
Use of digital tools for internal work processes	0.4	37.8	31.2	20.3	10.3	61.8

4.2 Regression results

4.2.1 Innovation investments

Expected change of innovation investments

In the following, the outcome of the first logit regression models is presented where variables of expected changes in innovation investments due to the crisis are investigated. All independent and control variables are included in all models.

The first hypothesis of this study is evaluated by focusing on micro/small and young enterprises to assess if they expect to increase or decrease their innovation investments due to the crisis. By doing so, it will be tested whether creative destruction is an aspect of this crisis. First, it has to be mentioned that young firms founded after 2000 show no indication of an expected increase in innovation investments due to the crisis compared to older firms. When looking at firm size, even though the odds ratio for micro and small firms shows less likelihood of expected innovation investments than the benchmark of large firms, these coefficients show no significance.

When investigating expected investment decreases, young firms show to be 1.50 times more likely (odds ratio) than older firms to decrease innovation investments during the crisis (10 percent level). There is also no significant result that micro and small firms are either more or less likely to expect a decrease in innovation investments compared to larger firms.

However, when examining the more fine-grained categories of expected changes, young firms indicate that they are 2.37 (odds ratio) times more likely to expect a small decrease in innovation investments (5 percent level). Although neither micro nor small firms show significant results in the more fine-grained categories, one result is interesting to observe: Medium-sized firms are significantly less likely to expect a large increase in innovation investments compared to large firms (odds ratio of 0.05 at the 5 percent significance level).

After determining that the first proposed hypothesis cannot be confirmed, at least not for expected innovation investments, the second hypothesis is tested using the same regression outputs from the previous models.

Several exciting findings can be identified when assessing expected innovation investments in relation to a firm's pre-crisis level of digitalization. Firms focusing on digitalization are 1.25 times more likely to expect an increase in innovation investments during the crisis (0.1 percent significance level). Furthermore, testing for an expected decrease in innovation investments shows that these firms are less likely to decrease innovation investments, though only significant at the 10 percent level. When delving deeper into the different extents of expected innovation investment changes, firms with a digital strategy indicate to be 1.19 times more likely to expect a small increase and 1.40 times more likely to expect a large increase in innovation investments.

Innovation output

When investigating innovation output, there is no evidence that young firms show a higher likelihood of innovation activity compared to older firms during the crisis. Further findings show, contrary to the creative destruction hypothesis, that micro firms are significantly less likely to innovate during the crisis than large firms (0.35 odds ratio). Furthermore, small firms are also less likely to innovate (10 percent level).

These findings violate the first assumption of this study of creative destruction, which describes that young and small firms swim against the stream to capitalize on opportunities as presented by Archibugi et al. (2013b) and hence cannot be supported at first glance.

In addition to the total innovation output, a closer look at the more fine-grained innovation categories is taken. Distinctions between different innovation types are made: new products/services, new processes, entering new markets, and new logistic solutions. However, when investigating these categories, there is no evidence that either young firms or small or micro firms are significantly more likely to innovate than older/larger firms. There are just weaker indications that young firms are 1.37 times more likely to develop new products and services and 1.34 times more likely to develop new processes than older firms (verified at the 10 percent level). Another result, at the 10 percent level, indicates that micro firms are even less likely to develop new processes during the crisis.

The creative destruction hypothesis can thus not be supported.

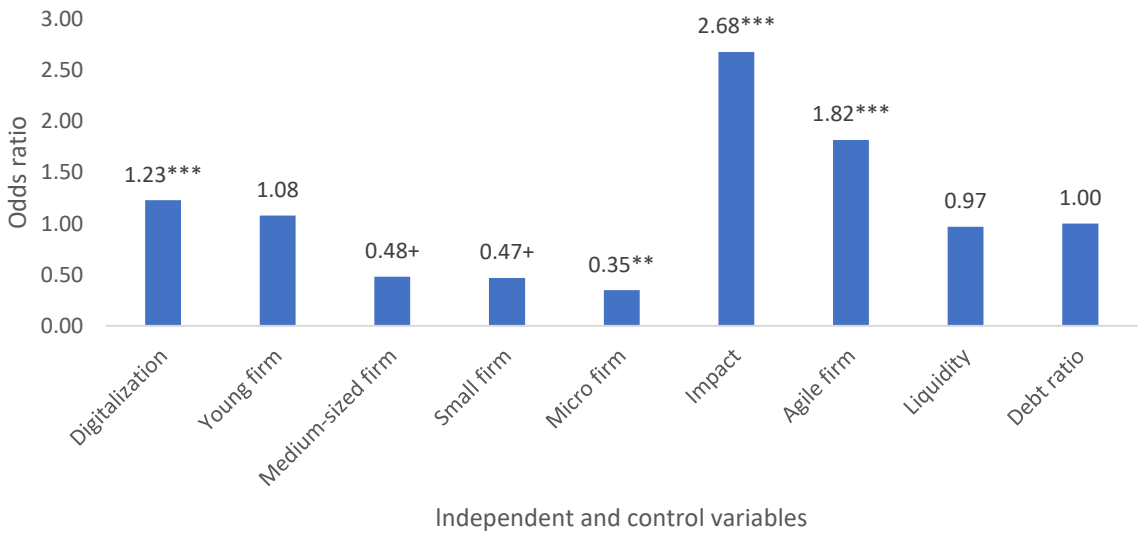

Figure 10: Odds ratios of independent and control variables on innovation during the crisis

The pre-crisis degree of digitalization indicates strong significance (0.1 percent level) to stimulate innovation during the crisis. Firms with a digital focus are 1.23 times more likely to innovate during the COVID-19 crisis than less digitalized firms. For the more fine-grained categories, this is also the case. Firms with a high degree of digitalization indicate to be more likely to develop new products/services and new processes at a high significance level. There is also evidence that this is true for being more likely to enter new markets and develop new logistic solutions. However, the relationship between the pre-crisis degree of digitalization and the likelihood of entering new markets and developing new logistic solitons is weaker than the former presented relationships (5 percent significance level).

The extent to which digitalized enterprises innovate within each innovation category is investigated in addition to the overall innovation output for each innovation category. The findings of the multinominal logit model, which can be found in the appendix, shed light on this.

Firms with a higher pre-crisis level of digitalization are significantly more likely to innovate new products and services to some extent. Furthermore, there is also a strong relationship that they are 1.45 times more likely to innovate to a large extent. There is a strong relationship for innovation in developing new processes to some extent. There is also a solid indication that they are more likely to create new processes to a large extent. When investigating the two other innovation categories, not weaker relationships are noticeable. There is just a weak indication that firms with a high degree of digitalization are entering new markets (10 percent level). These firms indicate that new market entries are happening to some extent. Almost the same findings

are valid for developing new logistic solutions. There is a solid relationship that digitalized firms innovate in this area to some extent. However, there is no indication that these firms are more likely to innovate to a large extent are compared to less digitalized firms. The findings are presented in the table below.

Table 9: Odds ratio for digitalization based on innovation type and innovation extent

Innovation	Little extent	Some extent	Large extent
New products/services	1.10	1.27***	1.45***
New processes	1.10	1.28***	1.24*
Entering new markets	1.00	1.10+	1.15
New logistical solutions	0.97	1.14*	1.03

Based on the findings presented above, the second hypothesis of this study can be confirmed. Firms with a higher degree of digitalization are not only more likely to innovate in general, but they are also more likely to innovate in each of the four innovation categories. However, these relationships vary in their significance. It can be stated that there is especially a strong significance for the development of new products/services as well as new processes. There is a weaker relationship between the likelihood of entering new markets and the development of new logistical solutions. Furthermore, the findings of the multinominal logit model (appendix) give a more detailed picture of the more fine-grained differences within each innovation category. They are significantly more likely to develop new products/services and processes to a large extent than less digitalized firms.

Opportunity-driven innovation

A binominal logit regression model is used to examine the third hypothesis of this study. Firms with a higher pre-crisis level of digitalization were assumed to be the ones that are more likely to conduct opportunity-driven innovation. By doing so, they are not purely passively reacting to the particular crisis. Instead, they exploit opportunities occurring due to the crisis to make changes that have long-term value for the firm even after the crisis.

There is a strong relationship that firms with a high degree of digitalization are more likely to conduct opportunity-driven innovation than less digitalized firms. In particular, they are 1.40 times more likely to use the crisis as an opportunity to innovate that provides value for the firm even after the crisis. This finding is significant at the 0.1 percent level. This finding might be related to the previous results that firms with a digital focus tend to innovate to a greater extent during the crisis. Instead of making the minimal adjustment needed, these firms make more

significant changes through innovation required to set up for the future. These innovations are no short-term solutions; instead, they are beneficial for the firm even after the crisis has ended. As a result, the study's third hypothesis, that firms with a higher degree of digitalization are more likely to engage in opportunity-driven innovation, can be confirmed.

5 Discussion

5.1 Discussion of analysis results

The COVID-19 pandemic appears to stimulate a considerable number of firms to innovate, at least to some extent. Even though the crisis impacted around 30% of the investigated firms, roughly half of them innovated as a response to the crisis. As a reason, it appears that innovation is not only a tool for firms that is mainly reactive by developing innovations as solutions to stay afloat during the crisis, which can be called threat-driven innovations. Non-impacted firms also use innovations as a tool to create new opportunities that arise due to the crisis, which can be called opportunity-driven innovations.

Since the descriptive statistics of this thesis demonstrate that most firms still innovate to a "little" extent, it suggests that firms seek innovations that can be adopted quickly and easily. It can be assumed that these firms are less likely to think about long-term innovation projects that come along with considerable investments in physical and human capital. This implies that these firms are more likely to chase low-hanging fruits that allow them to act quickly. As a result, these innovations are more likely to be innovative to the firms and less likely to disrupt the economy.

As a result of the Covid-19 crisis, there has been an increase in digital goods and services, as well as procedures and interactions with suppliers and consumers. It unquestionably illustrates the growing need for digitalization to function in this crisis. Furthermore, the fact that digital competencies are perceived as increasingly important in the future, accelerated, and forced by the COVID-19 crisis, demonstrates that CEOs of firms recognized the significance of digitalization for the future world.

Creative destruction

One goal of this study was to test the creative destruction hypothesis for the COVID-19 crisis since Archibugi et al. (2013a) showed, using the 2008 financial crisis as an example, that small and young firms can swim against the stream in a crisis. As mentioned in the literature review, other researchers have suggested that small and young firms may have features that allow them to innovate more in a crisis than larger and older firms. Archibugi et al. (2013a) have demonstrated that creative accumulation and creative destruction can simultaneously exist during a crisis.

Lien and Timmermans (2021) have already provided evidence for the COVID-19 crisis showing firms with prior innovation experience are more likely to innovate during the crisis. However, it was attractive to investigate whether there is a scenario of creative destruction occurring simultaneously.

According to the findings of this study, there is no indication of creative destruction unfolding during the COVID-19 crisis. This means that younger and smaller firms are not significantly more likely to innovate during the crisis than older and larger firms. Young and small firms could therefore not leverage the COVID-19 crisis to swim against the stream, demonstrating countercyclical innovation behavior.

A range of explanations might explain why this is the case. Agility might not be the dominant feature in these sorts of businesses. Although the firms' size allows them to make and execute decisions rapidly, capturing opportunities through agility has to be embedded in a firms' strategy. It might also be argued that too many small and young firms in this sample operate in industires which are simply non-agile in nature. Even though industry dummies were utilized in this thesis, they are relatively broad, leaving room for speculation about whether the results might differ with more fine-grained industry classifications.

Furthermore, there is another likely explanation that leaves discussion for future research. When it comes to innovating during a crisis, as demonstrated by Lien and Timmermans (2021), innovation experience matters. Therefore, it is likely that firm age and size characteristics may not be adequate to predict their innovative behavior during a crisis. Other factors, such as the presence of an R&D department and the company's historical innovation performance, tend to be more critical, as Archibugi et al. (2013a) point out. This would also be consistent with the findings of Audretsch et al. (2014), who show that initial innovation capability and early engagement in R&D projects increase the likelihood of becoming an innovating firm. Therefore, it could be reasonable to assume that larger and older firms have an advantage compared to smaller and younger firms since they had simply more time to establish well-functioning R&D departments within their organizations.

The fundamental underlying feature is thus most likely innovation experience. Firms, particularly those that are younger but also likely to be smaller, are less likely to have a proven record of innovation. On the other hand, large, established businesses may possess these features to a greater extent. This is due to the presence of embedded R&D departments within firms. It is likely to be a precondition for committing to innovation and incorporating it into the

firm's strategy through investigating new products/services, processes, logistical solutions, or new markets; a precondition that enables to innovate jauntily even in times of a crisis.

Furthermore, the digital component may play a critical role, particularly in this crisis, where small and young businesses might fall behind. According to the descriptive statistics, the percentage of firms that regarded digital competence as crucial before the COVID-19 is significantly lower for smaller firms. This aspect might contribute to the rejection of the creative destruction hypothesis.

The role of digitalization

Since the COVID-19 pandemic depicts a dramatically more digital-oriented society, the findings of this study give a stunning glimpse of a future world where digitalization will play even more a crucial part in how businesses operate. Due to the amplification of the importance of digitalization, the connection to innovation can be grasped throughout the COVID-19 crisis. In addition, the presented findings can shed some light on how things will develop in a future economy where digitalization is omnipresent.

The digital transformation and acceleration resulting from the COVID-19 crisis, as described, e.g., by LaBerge et al. (2020), is also apparent in this study. The descriptive statistics of this study show that the COVID-19 pandemic has vigorously enforced the importance of digitalization. However, firms were thrown into the COVID-19 pandemic with varying levels of digital infrastructure. There were considerable discrepancies between firms, ranging from less or nearly non-digitalized to firms that already had a high degree of digitalization before the crisis. This gap in digitalization among firms appears to matter in this crisis regarding innovative activity and capabilities.

The findings of this study show that firms with higher levels of digitalization are not only significantly more likely to innovate but also to innovate to a greater extent. Furthermore, these firms are more likely to conduct opportunity-driven innovations that provide long-term value even after the crisis. These findings imply that firms with a higher degree of digitalization are more likely to take advantage of the crisis by innovating to reconfigure and modify their current business models, at least in the case of the COVID-19 crisis.

Other first publications which are focusing on the link between digitalization and innovation during the COVID-19 crisis show similar findings. Criscuolo (2021) shows evidence that not all businesses adjusted to the crisis to the same extent. Firms that were already more digital prior to the crisis embraced more and more advanced technology. The findings of this study are

also congruent with those of LaBerge et al. (2020), who demonstrate that enterprises that effectively responded to the crisis with innovations possessed a variety of technological capabilities that others lacked.

Researchers' described associated characteristics of digitalization such as innovativeness, automatization, swiftness, human independence, efficiency, and agility seem to favor firms to innovate more jauntily during the COVID-19 crisis. Also, the mentioned speed at which these firms experiment appears to play a crucial role in innovation during the crisis. Firms with a higher degree of digitalization are therefore better positioned to recognize crisis-innovation projects even with long-term value and are more inclined to do innovate due to their earlier digitalization achievements and already adapted systems.

Highly digitalized firms were even more likely to turn the crisis into an opportunity by launching more profound innovations and innovations that are long-term in nature. This implies that these businesses can exploit the crisis due to their innovative capabilities and create post-crisis value. While highly digitized firms are taking the next required step to prepare themselves for the further emerging digital era, less-digitalized firms attempt to respond to the crisis by chasing the so-called low-hanging fruits. Less digitalized firms are visibly struggling to keep up, lagging in innovation velocity. These innovations appear to be adjustments that are not solely crisis-related and short-term remedies. However, in today's economic climate, keeping up with the speed of innovation and development is becoming increasingly crucial to remain competitive by providing customers with the latest demands. The findings reveal that the gap between less and more digitalized firms in terms of innovative capabilities did not narrow during the crisis. This raises the possibility that the COVID-19 pandemic has widened the gap between digital frontrunners and laggards.

Therefore, the differences in firms' innovation activity might have implications for the crisis' aftermath, potentially putting highly digitalized firms in a better post-crisis position. Even though this thesis does not focus on the aftermath of the crisis, such as the resulting competitive advantages and market powers of specific firms, the link between firm digitalization and innovation capabilities indicates future scenarios. Long-term market repercussions might arise as a consequence of the notable gap in innovativeness between less and more digitalized firms.

These indications are also stressed by Criscuolo (2021), who sees implications in terms of productivity dispersion and business dynamics of this crisis due to the gap in digitalization. Furthermore, this could have implications for market power and, therefore, economic growth and inequality. (Criscuolo, 2021). Also, OECD's digital economy outlook 2020 stresses that the

gap between digital innovators and digital latecomers may have severe consequences for businesses' productive performance over time (OECD, 2020a).

This thesis emphasizes digitalization as a crucial component for innovation during the COVID-19 crisis. This tool appears especially vital in the future, as society embraces the digital era—an era in which digital innovation is required for growth. The recession pushed firms to embrace digital technology sooner than planned, and it appears to have favored firms that were already digitalized to a larger level before the crisis. Firms of all sizes and sectors sensed the need to take the next step since the COVID-19 pandemic revealed their vulnerabilities, but also the potential that has yet to be realized to become a successful player in a digital world. Since the digital environment is already highly dynamic and fast-paced, innovation is a critical tool, as shown by the findings.

5.2 Limitations

The presented findings of this thesis are coming along with some limitations that have to be considered. Since the investigation is solely based on Norwegian firms, it raises concerns if the findings apply to other countries. As highlighted, governments from all over the world intervened in their countries to lessen the effects of the pandemic. However, it could be that different dynamics might influence firms' innovation behavior in every country differently due to other governmental measurers and financial support schemes.

Moreover, since the thesis is investigating firms' innovation behavior during the COVID-19 crisis, it raises the concern if the tested hypotheses apply to other crises. Especially, the creative construction hypothesis could be influenced by the particular circumstances of the COVID-19 pandemic. The causes and characteristics of the COVID-19 crisis, as pointed out before, were arguably distinct from those of the financial crisis. Still, it appears that any crisis that harms many firms and innovation may be utilized to minimize its impact.

Furthermore, some other limitations arise due to the survey method used in this thesis. It is probable that the survey did not include all of the aspects required to identify and construct a robust estimate of the degree of digitalization. Furthermore, because the survey asks about CEO views on digitalization characteristics and other aspects such as the agility of their firms, there may be a bias. Since this is based solely on CEOs' subjective perceptions, each organization may view digitalization differently, thereby biasing the created measure employed in this study. A similar issue arises when it comes to measuring innovation. Even though this thesis uses more fine-grained categories of innovation to make the definition more explicit, CEOs may

have a different vision of what innovation means to their company. Furthermore, it is difficult to agree on a common concept of what it implies to innovate to some extent, to a large extent, etc.

Since the survey also asks questions about firms' pre-crisis conditions and characteristics, the survey data may be exposed to recall bias. However, because the survey was conducted early in the COVID-19 crisis (second wave), this problem appears to be minor. Nevertheless, because the survey utilized for this testing was conducted early on and is cross-sectional, it has a disadvantage. This study looks into the behavior of innovators at a certain period in time. Therefore, it is not clear what will happen to enterprises' innovation behavior if the COVID-19 crisis lasts much longer. Furthermore, the long-term consequences of innovation during the crisis are unknown.

This study provides evidence of enterprises' innovation behavior during the second wave of the COVID-19 crisis; however, the impact of future innovation behavior, such as possible shifting market dynamics and competitive advantages, cannot be explored using this survey, leaving room for further research.

5.3 Research implications and future research

Firstly, future research should acquire data that enables investigations over longer time periods. Furthermore, replications and expansions to future crises and prior crises in the case of the creative destruction theory should be carried out. It could be the case that the creative destruction hypothesis cannot be confirmed due to the particular circumstances of the COVD-19 crisis.

Secondly, since this study's findings are confined to the Norwegian market, further research should the presented hypothesis on other countries, European countries, and a worldwide scale. In addition, future studies should have access to data that allows for more precise measurements of innovation, intensity, and digitalization. Instead of questioning CEOs about their perception of the degree of digitalization, a metric such as the proportion of digital sales vs. total sales may be employed.

Lastly, since the thesis did not concentrate on post-crisis results, future studies should explore the link between pre-crisis digitalization and post-crisis firm performance, such as their post-crisis market position and competitive standing. Furthermore, future studies should focus on understanding the impact of digitalization in times other than a crisis and how digital innovation can be leveraged to drive firm growth.

6 Conclusion

The thesis focused on differences in innovation behavior across firms during the COVID-19 crisis. Since the field of crisis-related innovation has not been extensively researched, the COVID-19 crisis served as a further occasion and provided an excellent chance to do so. In this thesis, particular emphasis was placed on two aspects. First, the thesis sought to test Schumpeter's creative destruction argument, which has since acquired support, for example, from Archibugi et al. (2013a). Second, this thesis has placed a particular emphasis on digitalization due to its unquestionably gaining speed and importance due to the COVID-19 crisis in an already emerging digital area.

Schumpeter's creative destruction argument cannot be supported for the COVID-19 crisis in the Norwegian market. Small and young enterprises are not more likely to innovate during the crisis, nor are they more likely to use the crisis as an opportunity to outperform larger and older firms in terms of innovation. This means that innovation as a tool is not more likely to be used by these firms. As Lien and Timmermans (2021) showed, the COVID-19 crisis describes more of a situation of creative accumulation. Despite the simultaneous existence of creative accumulation and creative destruction in earlier crises, this does not appear to be the case for the recent COVID-19 crisis.

The thesis highlights the importance of digitalization for innovation capabilities during the COVID-19 crisis. Firms with a higher level of digitalization prior to the crisis are more likely to innovate during the crisis than firms with a lower level of digitalization. Furthermore, firms with a digital focus develop innovations to a greater extent, and these firms see these innovations as an opportunity since they have expected value even after the crisis. This thesis thereby underlined the crucial differences in innovation between digital frontrunners and digital laggards. As a result, the thesis emphasizes that implementing digitalization into firms' strategies, processes, and business models positively affects firms' innovation capabilities and their possibilities to adjust and modify their businesses during the COVID-19 crisis.

In addition, since the COVID-19 crisis appears to be a stunning glimpse into a future world in which digitalization has become the fundamental component, the findings of this thesis give indications about future trends. A future in which digital strategy is highly relevant to be innovative. Furthermore, the COVID-19 crisis is a wake-up call for CEOs and managers of less or even non-digitalized firms to change their business practices toward digitalization. The crisis uncovered the current state of firms, their strengths, and weaknesses in digitalization.

However, the implications of the innovation gap between digital frontrunners and digital laggards were not examined in this thesis. Thus, future research should look at the consequences of the crisis and their connections to digitalization.

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8 Appendices

8.1 Appendix I

Code	Industry group
C	**Manufacturing**
	10 Manufacturing
	11 Beverages
	13 Textiles
	14 Wearing apparel
	15 Leather and leather products
	16 Wood and wood products
	17 Paper and paper products
	18 Printing and reproduction
	20 Chemicals, chemical products
	21 Pharmaceuticals
	22 Rubber and plastic products
	23 Other non-metal mineral products
	24 Basic metals
	25 Fabricated metal prod.
	26 Electronic and optical products
	27 Electrical equipment
	28 Machinery and equipment
	29 Motor vehicles etc.
	30 Other transport equipment
	31 Furniture
	32 Other manufacturing
	33 Repair, installation of machinery
D	**Electricity, gas, steam, and air conditioning supply**
	35 Electricity, gas and steam
E	**Water supply; sewerage, waste management, and remediation activities**
	36 Water supply
	37 Sewerage
	38 Waste act., materials recovery
F	**Consumption**
	41 Construction of buildings
	42 Civil engineering
	43 Specialized construction activities
G	**Wholesale and retail trade; repair of motor vehicles and motorcycles**
	45 Motor vehicles, trade and repair
	46 Wholesale trade
	47 Retail trade
H	**Transportation and storage**
	49 Land transport, pipeline transport
	50 Water transport

	51 Air transport
	52 Support act. for transportation
	53 Postal and courier activities
I	**Accommodation and food service activities**
	55 Accommodation
	56 Food and beverage service act.
J	**Information and communication**
	58 Publishing activities
	59 Motion pict./video/tv-program. act.
	61 Telecommunications
	62 Computer programming, consultancy
	63 Information service activities
K	**Financial and insurance activities**
	64 Financial service activities
	65 Insurance, pension funding
	66 Auxiliary financial activities
L	**Real estate activities**
	68 Real estate activities
M	**Professional, scientific and technical activities**
	69 Legal and accounting activities
	70 Head offices, management consult.
	71 Architecture, engineering act.
	72 Scientific research and development
	73 Advertising and market research
	74 Other prof., scientific, techn. act.
	75 Veterinary activities
N	**Administrative and support service activities**
	77 Rental and leasing activities
	78 Employment activities
	79 Travel agency, tour operators
	80 Security, investigation activities
	81 Buildings, landscape services act.
	82 Business support activities
S	**Other service activities**
	93 Sports activities and amusement and recreation activities
	96 Other personal service activities

(Source: statistics Norway, 2016)

Industry	NACE Rev. 2 codes – 2 digit level
Low-tech manufacturing	10-19
	22-25
	31-32
	33
High-tech manufacturing	20-21
	26-30
Construction	41-43
Wholesale and retail	45-47
Hotels, restaurant, and tourism	55-56
	79
Knowledge intensive and financial services	50-51
	58-66
	69-75
	78
	80
	84-93
Other services	35-38
	49
	52-53
	68
	77
	79
	81-82
	94-99

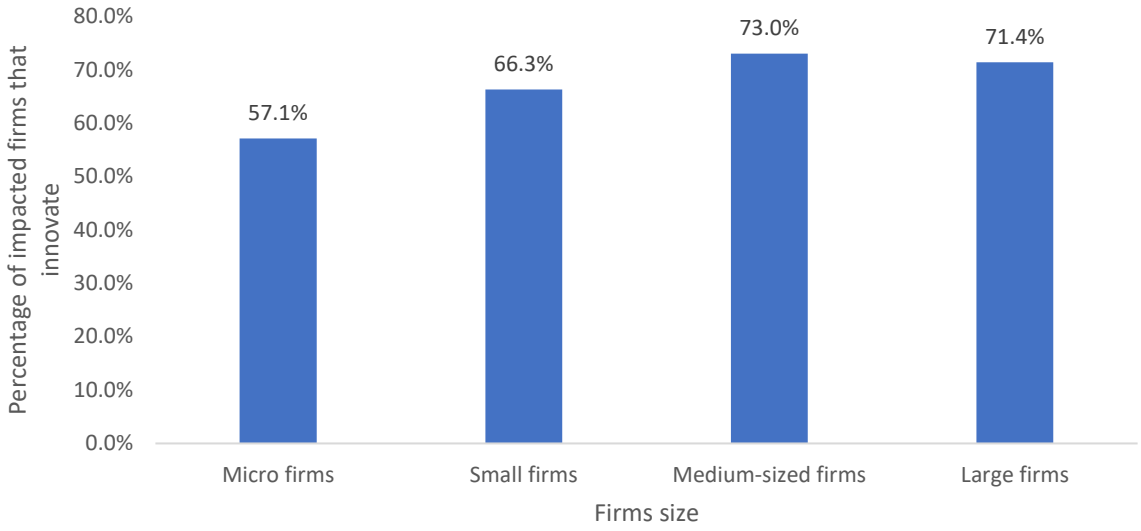

Figure 11: Percentage of impacted firms that innovate

Table 10: Descriptive statistics and correlation table

Variable	Obs	Mean	Std. Dev.	Correlation Table																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 Increase in innovation invest.	1103	0.269	0.444	1.00																	
2 Decrease in innovation invest.	1103	0.121	0.327	**-0.27**	1.00																
3 Changes in innovation invest.	1103	0.144	0.832	**0.78**	**-0.72**	1.00															
4 Innovation	1246	0.491	0.832	**0.16**	-0.03	**0.12**	1.00														
5 New products and services	1246	0.287	0.452	**0.17**	-0.03	**0.13**	**0.58**	1.00													
6 New processes	1246	0.280	0.449	**0.15**	-0.07	**0.14**	**0.56**	**0.37**	1.00												
7 New customers	1246	0.260	0.439	0.05	0.03	0.03	**0.52**	**0.32**	**0.33**	1.00											
8 New logistics	1246	0.245	0.430	**0.10**	-0.06	**0.12**	**0.50**	**0.28**	**0.46**	**0.35**	1.00										
9 Opportunity-driven innovation	917	0.520	0.500	**0.21**	-0.07	**0.17**	**0.78**	**0.53**	**0.48**	**0.43**	**0.39**	1.00									
10 Level of digitalization	961	0.000	1.799	**0.18**	**-0.12**	**0.21**	**0.19**	**0.18**	**0.17**	**0.08**	0.07	**0.28**	1.00								
11 Large firm	1246	0.039	0.194	0.06	-0.05	0.07	**0.07**	0.03	0.05	0.01	0.03	0.04	**0.10**	1.00							
12 Medium-sized firm	1246	0.091	0.288	-0.04	0.06	**-0.08**	0.02	0.03	0.05	-0.02	0.00	0.06	0.04	**-0.08**	1.00						
13Small firm	1246	0.469	0.499	0.03	-0.04	0.04	0.05	0.03	0.03	0.05	0.04	0.04	-0.03	**-0.21**	**-0.32**	1.00					
14Micro firm	1246	0.400	0.490	-0.03	0.03	-0.02	**-0.09**	-0.06	**-0.08**	-0.04	-0.05	**-0.09**	-0.04	**-0.18**	**-0.27**	**-0.73**	1.00				
15 Impact COVID-19	1246	0.307	0.461	0.05	**0.26**	**-0.10**	**0.13**	0.07	0.06	**0.11**	0.06	0.07	**-0.08**	**-0.10**	0.01	0.05	-0.01	1.00			
16 Agile firm	1161	0.468	0.499	**0.10**	-0.06	**0.09**	**0.12**	**0.11**	**0.11**	**0.09**	**0.10**	**0.17**	**0.15**	0.00	**0.10**	-0.02	-0.04	-0.01	1.00		
17 Liquidity	1223	1.906	3.205	-0.01	**-0.09**	0.03	-0.05	-0.01	-0.06	-0.07	-0.04	-0.02	0.01	-0.01	**-0.08**	-0.04	**0.10**	**-0.12**	-0.03	1.00	
18 Debt ratio	1223	5.634	42.94	-0.01	0.04	-0.04	-0.03	-0.00	-0.06	0.01	-0.04	-0.01	**-0.09**	-0.02	-0.00	-0.04	0.05	-0.01	-0.05	0.01	1.00

$p < 0.05$ highlighted in bold
Mean and Std. Dev. are rounded to three digits

Table 11: Binominal logit regression on expected changes in innovation investments

Dependent variable	Model 1 expected Δ innovation investments increase		Model 2 expected Δ innovation investments decrease	
	(1)	(2)	(1)	(2)
Digitalization	0.245***	0.226***	-0.118*	-0.111+
	(0.0498)	(0.0503)	(0.0590)	(0.0603)
Young firm (dummy)	-0.262	-0.304+	0.405+	0.394
	(0.163)	(0.165)	(0.237)	(0.240)
Large firm	benchmark	benchmark	benchmark	benchmark
Medium sized firm	-0.799+	-0.900*	0.667	0.662
	(0.429)	(0.435)	(0.822)	(0.824)
Small firm	-0.452	-0.461	-0.0585	-0.0639
	(0.366)	(0.371)	(0.779)	(0.782)
Micro firm	-0.554	-0.564	0.311	0.319
	(0.371)	(0.376)	(0.778)	(0.781)
Impact COVID-19 (dummy)	0.430*	0.449*	1.553***	1.524***
	(0.181)	(0.185)	(0.236)	(0.239)
Agile Organization (dummy)		0.548***		-0.228
		(0.162)		(0.231)
Liquidity	-0.0262	-0.00261	-0.0441	-0.229+
	(0.0589)	(0.0657)	(0.0807)	(0.120)
Debt ratio	0.000796	0.00103	0.00194	0.00198
	(0.00208)	(0.00210)	(0.00206)	(0.00209)
Constant	0.0718	-0.252	-2.401*	-1.998+
	(0.743)	(0.758)	(1.130)	(1.148)
Industry dummies	yes	yes	yes	yes
County dummies	yes	yes	yes	yes
N	933	928	919	914
Pseudo-R-sq	0.0681	0.0794	0.1382	0.1432

Standard errors in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 12: Multinominal regression on expected changes in innovation investments

	Model 3							
Dependent Variable	expected Δ innovation investments							
	large decrease		small decrease		small increase		large increase	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Digitalization	-0.0970	-0.102	-0.000874	0.000834	0.199***	0.178**	0.359***	0.337**
	(0.0859)	(0.0870)	(0.0783)	(0.0796)	(0.0551)	(0.0555)	(0.105)	(0.105)
Young firm (dummy)	-0.298	-0.328	0.862*	0.851*	-0.196	-0.245	-0.386	-0.434
	(0.340)	(0.342)	(0.338)	(0.345)	(0.179)	(0.182)	(0.334)	(0.335)
Large firm	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark
Medium sized firm	0.0947	0.0431	0.376	0.350	-0.469	-0.573	-2.959*	-3.086*
	(1.157)	(1.157)	(1.146)	(1.148)	(0.464)	(0.470)	(1.214)	(1.223)
Small firm	-0.513	-0.524	-0.172	-0.190	-0.444	-0.457	-1.051	-1.044
	(1.103)	(1.104)	(1.088)	(1.088)	(0.404)	(0.408)	(0.671)	(0.678)
Micro firm	-0.220	-0.230	0.196	0.186	-0.491	-0.504	-1.045	-1.029
	(1.104)	(1.105)	(1.084)	(1.084)	(0.410)	(0.414)	(0.682)	(0.687)
Impact COVID-19 (dummy)	2.464***	2.474***	1.331***	1.287***	0.605**	0.620**	1.561***	1.594***
	(0.378)	(0.378)	(0.310)	(0.315)	(0.208)	(0.213)	(0.357)	(0.361)
Agile Organization (dummy)		0.141		-0.180		0.555**		0.561+
		(0.333)		(0.306)		(0.178)		(0.327)
Liquidity	-0.344+	-0.359+	0.0605	-0.157	-0.0172	-0.00757	-0.160	-0.166
	(0.189)	(0.190)	(0.0850)	(0.150)	(0.0635)	(0.0703)	(0.149)	(0.154)
Debt ratio	0.00462+	0.00462+	0.000671	0.000676	0.00153	0.00175	-0.000480	-0.000324
	(0.00256)	(0.00255)	(0.00346)	(0.00351)	(0.00230)	(0.00231)	(0.00648)	(0.00656)
Constant	-1.542	-1.562	-2.827+	-2.345	0.157	-0.148	-15.68	-15.99
	(1.593)	(1.601)	(1.552)	(1.577)	(0.795)	(0.810)	(2410.6)	(2390.8)
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes
County dummies	yes	yes	yes	yes	yes	yes	yes	yes
N	933	928	933	928	933	928	933	928
Pseudo R-sq	0.1321	0.1388	0.1321	0.1388	0.1321	0.1388	0.1321	0.1388

Standard errors in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 13:Logit regression on innovation investments I

Dependent variable	Model 4		Model 5		Model 6	
	Innovation (total)		New products and services		New processes	
	(1)	(2)	(1)	(2)	(1)	(2)
Digitalization	0.227***	0.207***	0.253***	0.235***	0.226***	0.210***
	(0.0435)	(0.0440)	(0.0494)	(0.0499)	(0.0487)	(0.0493)
Young firm	0.123	0.0747	0.312+	0.276+	0.291+	0.242
(dummy)	(0.149)	(0.151)	(0.163)	(0.164)	(0.162)	(0.164)
Large firm	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark
Medium sized firm	-0.615	-0.739+	0.258	0.160	-0.0810	-0.175
	(0.437)	(0.442)	(0.417)	(0.420)	(0.413)	(0.416)
Small firm	-0.737+	-0.761+	0.0104	-0.00984	-0.337	-0.337
	(0.392)	(0.395)	(0.367)	(0.368)	(0.365)	(0.365)
Micro firm	-1.049**	-1.061**	-0.265	-0.251	-0.688+	-0.675+
	(0.395)	(0.398)	(0.372)	(0.374)	(0.370)	(0.371)
Impact COVID-19	0.991***	0.984***	0.560**	0.562**	0.525**	0.522**
(dummy)	(0.174)	(0.177)	(0.182)	(0.186)	(0.180)	(0.184)
Agile Organization		0.598***		0.525**		0.453**
(dummy)		(0.147)		(0.160)		(0.160)
Liquidity	-0.00425	-0.0305	0.00439	0.0250	0.0105	-0.0548
	(0.0520)	(0.0610)	(0.0571)	(0.0665)	(0.0571)	(0.0703)
Debt ratio	0.000347	0.000586	0.00159	0.00183	-0.00692	-0.00723
	(0.00195)	(0.00197)	(0.00205)	(0.00206)	(0.00478)	(0.00492)
Constant	1.041	0.827	-1.055	-1.353+	-0.339	-0.475
	(0.731)	(0.746)	(0.801)	(0.810)	(0.795)	(0.808)
Industry dummies	yes	yes	yes	yes	yes	yes
County dummies	yes	yes	yes	yes	yes	yes
N	934	929	934	929	934	929
Pseudo R-sq	0.1032	0.1154	0.1054	0.1140	0.0829	0.0907

Standard errors in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 14: Logit regression on innovation investments II

Dependent variable	Model 5		Model 6		Model 7	
	Entering new markets		New logistic solutions		Opportunity-driven innovation[1]	
	(1)	(2)	(1)	(2)	(1)	(2)
Digitalization	0.128**	0.107*	0.129**	0.112*	0.356***	0.338***
	(0.0482)	(0.0488)	(0.0488)	(0.0495)	(0.0527)	(0.0534)
Young firm	0.218	0.186	0.0147	-0.0306	0.0873	0.0553
(dummy)	(0.165)	(0.167)	(0.168)	(0.170)	(0.173)	(0.176)
Large firm	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark
Medium sized firm	-0.160	-0.252	-0.203	-0.302	0.333	0.233
	(0.435)	(0.439)	(0.431)	(0.433)	(0.447)	(0.454)
Small firm	-0.101	-0.101	-0.410	-0.408	0.159	0.162
	(0.377)	(0.380)	(0.374)	(0.375)	(0.394)	(0.400)
Micro firm	-0.338	-0.358	-0.613	-0.597	-0.188	-0.167
	(0.383)	(0.386)	(0.380)	(0.381)	(0.395)	(0.401)
Impact COVID-19	0.745***	0.762***	0.577**	0.564**	0.375+	0.392*
(dummy)	(0.182)	(0.185)	(0.187)	(0.191)	(0.192)	(0.197)
Agile Organization		0.508**		0.533**		0.601***
(dummy)		(0.164)		(0.167)		(0.172)
Liquidity	-0.126+	-0.113	-0.00677	-0.0609	0.0474	0.0256
	(0.0735)	(0.0750)	(0.0594)	(0.0749)	(0.0628)	(0.0733)
Debt ratio	0.00165	0.00189	-0.00471	-0.00477	0.000837	0.00119
	(0.00201)	(0.00203)	(0.00452)	(0.00466)	(0.00189)	(0.00190)
Constant	0.186	-0.0837	0.246	0.0779	0.809	0.444
	(0.731)	(0.742)	(0.725)	(0.737)	(0.959)	(0.978)
Industry dummies	yes	yes	yes	yes	yes	yes
County dummies	yes	yes	yes	yes	yes	yes
N	934	929	934	989	703	699
Pseudo R-sq	0.0708	0.0798	0.0603	0.0707	0.1064	0.1186

Standard errors in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$
[1] Conditional on innovation

Table 15: Multinominal Logit regression on innovation investments I

	Model 10						Model 11					
Dependent variable	New Product and Service						New processes					
	little extent		some extent		large extent		little extent		some extent		large extent	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Digitalization	0.0803	0.0679	0.259***	0.238***	0.403***	0.374***	0.105*	0.0834	0.272***	0.249***	0.260**	0.218*
	(0.0508)	(0.0514)	(0.0561)	(0.0567)	(0.104)	(0.105)	(0.0506)	(0.0513)	(0.0565)	(0.0570)	(0.0962)	(0.101)
Young firm (dummy)	-0.269	-0.331+	0.124	0.0664	0.579+	0.484	-0.330+	-0.376*	0.0569	-0.00660	0.598+	0.505
	(0.180)	(0.182)	(0.186)	(0.189)	(0.336)	(0.340)	(0.176)	(0.178)	(0.186)	(0.188)	(0.350)	(0.360)
Large firm	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark
Medium sized firm	0.644	0.589	0.378	0.270	1.252	1.110	-0.630	-0.756	-0.510	-0.636	-0.102	-0.486
	(0.541)	(0.543)	(0.479)	(0.483)	(0.909)	(0.910)	(0.523)	(0.528)	(0.530)	(0.536)	(0.831)	(0.849)
Small firm	0.291	0.314	0.0657	0.0590	0.493	0.474	-0.886+	-0.927*	-0.707	-0.731	-1.118	-1.186
	(0.485)	(0.487)	(0.411)	(0.413)	(0.834)	(0.832)	(0.463)	(0.467)	(0.471)	(0.474)	(0.756)	(0.768)
Micro firm	0.0860	0.123	-0.281	-0.250	0.0743	0.0788	-0.793+	-0.810+	-1.050*	-1.050*	-1.324+	-1.381+
	(0.488)	(0.490)	(0.416)	(0.418)	(0.853)	(0.852)	(0.465)	(0.470)	(0.477)	(0.479)	(0.771)	(0.786)
Impact COVID-19 (dummy)	0.631**	0.640**	0.751***	0.759***	1.089**	1.123**	0.350+	0.326	0.511*	0.520*	1.296***	1.193**
	(0.206)	(0.209)	(0.213)	(0.218)	(0.360)	(0.366)	(0.203)	(0.208)	(0.212)	(0.215)	(0.364)	(0.380)
Agile Organization (dummy)		0.394*		0.626***		0.914**		0.681***		0.638***		1.091**
		(0.177)		(0.184)		(0.328)		(0.174)		(0.184)		(0.353)
Liquidity	-0.0190	-0.0833	0.0291	0.0243	-0.243	-0.244	-0.00166	0.0109	0.0159	0.00446	-0.0184	-0.625**
	(0.0628)	(0.0745)	(0.0627)	(0.0725)	(0.189)	(0.191)	(0.0601)	(0.0684)	(0.0672)	(0.0761)	(0.114)	(0.238)
Debt ratio	0.000949	0.00108	0.00220	0.00248	-0.00239	-0.00270	0.00268	0.00302	-0.00547	-0.00555	-0.00962	-0.0122
	(0.00226)	(0.00229)	(0.00219)	(0.00219)	(0.00921)	(0.00918)	(0.00196)	(0.00197)	(0.00523)	(0.00532)	(0.0114)	(0.0120)
Constant	-1.475	-1.577	-1.164	-1.483	-2.553+	-3.006*	0.308	0.0165	0.289	0.0193	-1.284	-0.766
	(0.952)	(0.958)	(0.935)	(0.945)	(1.507)	(1.505)	(0.866)	(0.879)	(0.972)	(0.991)	(1.410)	(1.469)
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
County	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	934	929	934	929	934	929	934	929	934	929	934	929
Pseudo-R^2	0.0977	0.1054	0.0977	0.1054	0.0977	0.1054	0.0868	0.1016	0.0868	0.1016	0.0868	0.1016

Standard errors in parentheses

$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 16: Multinominal Logit regression on innovation investments II

	Model 10						Model 11					
Dependent variable	Entering new markets						New logistic solutions					
	little extent		some extent		large extent		little extent		some extent		large extent	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Digitalization	0.0294	0.00406	0.131*	0.100+	0.168+	0.143	-0.0189	-0.0294	0.150*	0.128*	0.0652	0.0306
	(0.0513)	(0.0523)	(0.0550)	(0.0559)	(0.1000)	(0.101)	(0.0497)	(0.0501)	(0.0583)	(0.0587)	(0.0845)	(0.0889)
Young firm (dummy)	0.148	0.0974	0.403*	0.352+	-0.391	-0.439	0.0826	0.0662	-0.0110	-0.0556	0.162	0.110
	(0.182)	(0.185)	(0.190)	(0.192)	(0.340)	(0.341)	(0.176)	(0.178)	(0.198)	(0.199)	(0.303)	(0.310)
Large firm	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark	benchmark
Medium sized firm	-0.246	-0.393	-0.390	-0.532	0.571	0.470	-0.0938	-0.128	-0.290	-0.379	-0.183	-0.436
	(0.488)	(0.491)	(0.499)	(0.506)	(1.175)	(1.177)	(0.487)	(0.488)	(0.518)	(0.522)	(0.789)	(0.797)
Small firm	-0.687	-0.721+	-0.529	-0.535	0.585	0.576	-0.420	-0.410	-0.516	-0.499	-0.756	-0.805
	(0.431)	(0.432)	(0.432)	(0.436)	(1.082)	(1.082)	(0.434)	(0.434)	(0.444)	(0.447)	(0.705)	(0.710)
Micro firm	-0.384	-0.373	-0.614	-0.628	0.308	0.314	-0.471	-0.474	-0.757+	-0.746	-0.946	-0.934
	(0.432)	(0.432)	(0.438)	(0.443)	(1.102)	(1.102)	(0.437)	(0.437)	(0.452)	(0.454)	(0.717)	(0.723)
Impact COVID-19 (dummy)	0.471*	0.408+	0.830***	0.832***	1.244***	1.253***	0.320	0.326	0.580**	0.610**	0.989**	0.885**
	(0.209)	(0.216)	(0.210)	(0.214)	(0.374)	(0.377)	(0.201)	(0.203)	(0.224)	(0.227)	(0.325)	(0.340)
Agile Organization (dummy)		0.691***		0.766***		0.559+		0.287+		0.618**		0.698*
		(0.180)		(0.188)		(0.335)		(0.173)		(0.195)		(0.309)
Liquidity	0.0204	-0.0523	-0.0894	-0.101	-0.271	-0.280	-0.0251	-0.0186	-0.0172	0.00401	0.00524	-0.399*
	(0.0599)	(0.0757)	(0.0791)	(0.0819)	(0.185)	(0.186)	(0.0649)	(0.0711)	(0.0704)	(0.0803)	(0.0983)	(0.192)
Debt ratio	0.00111	0.00138	0.00293	0.00324	-0.0196*	-0.0192*	0.00305	0.00314	0.000394	0.000524	-0.0243**	-0.0234*
	(0.00236)	(0.00237)	(0.00215)	(0.00214)	(0.00924)	(0.00933)	(0.00209)	(0.00207)	(0.00372)	(0.00385)	(0.00908)	(0.00930)
Constant	-14.70	-14.91	0.109	-0.270	-1.924	-2.151	-1.212	-1.360	0.303	-0.0503	-0.742	-0.386
	(662.1)	(668.4)	(0.796)	(0.816)	(1.641)	(1.641)	(1.174)	(1.180)	(0.819)	(0.832)	(1.332)	(1.364)
Industry dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
County	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	934	929	934	929	934	929	934	929	934	929	934	929
Pseudo-R^2	0.0807	0.0921	0.0807	0.0921	0.0807	0.0921	0.0636	0.0721	0.0636	0.0721	0.0636	0.0721

Standard errors in parentheses
$^{+}p<0.10$ $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

8.2 Appendix II

C4 Survey H2020

Q1.1 Is the company operational these days?

- oYes - operating with normal capacity (1)
- oYes - operational, but with reduced capacity (reduced opening hours, service offer, or activity level) due to COVID-19 (2)
- oYes - has fully reopened after a temporary closure due to COVID-19 (3)
- oYes - has opened up with reduced capacity after a temporary closure due to COVID-19 (4)
- oNo - temporarily closed due to COVID-19, but we will reopen (5)
- oNo - temporarily closed due to COVID-19, and it is uncertain whether we will reopen (6)
- oNo - temporarily closed for other reasons (7)
- oNo - permanently closed due to COVID-19 (8)
- oNo - permanently closed for other reasons (9)

End of Block: Opening

Start of Block: Strategy and competition.

Block 2 intro

In the next part of the survey, we will ask questions related to the company's strategy and competitive conditions before the COVID-19 crisis, and how this has changed as a result of the crisis.

Q2.1 To what extent did the company emphasize the following in the competition with its closest competitors before the COVID-19 crisis began?

	Not important (1)	Not very important (2)	Somewhat important (3)	Important (4)	Very important (5)
Higher customer / user service (1)	o	o	o	o	o
Wider product/service range (2)	o	o	o	o	o
Lower prices (3)	o	o	o	o	o
Higher quality of products /	o	o	o	o	o

services (4)					
More customization / tailoring (5)	o	o	o	o	o
Reduction of operating costs (6)	o	o	o	o	o
Quality control / quality management (7)	o	o	o	o	o
Branding (8)	o	o	o	o	o
Innovation / R&D (9)	o	o	o	o	o
Reputation Building (10)	o	o	o	o	o
Process improvements (process optimization) (11)	o	o	o	o	o
Implementation of new solutions (technology, systems) (12)	o	o	o	o	o
Further development of existing products / services (13)	o	o	o	o	o
Launch of new products / services (14)	o	o	o	o	o

Q2.2 How has the following changed its significance for competition with their closest competitors - as a result of COVID-19?

	Much less important (- 2)	Less important (- 1)	Unchanged (0)	More important (1)	Much more important (2)
Higher customer / user service (1)	o	o	o	o	o
Wider product / service range (2)	o	o	o	o	o
Lower prices (3)	o	o	o	o	o
Higher quality of products / services (4)	o	o	o	o	o
More customization / tailoring (5)	o	o	o	o	o
Reduction of operating costs (6)	o	o	o	o	o
Quality control / quality management (7)	o	o	o	o	o
Branding (8)	o	o	o	o	o
Innovation / R&D (9)	o	o	o	o	o
Reputation Building (10)	o	o	o	o	o
Process improvements (process optimization) (11)	o	o	o	o	o

Implementation of new solutions (technology, systems) (12)	o	o	o	o	o
Further development of existing products / services (13)	o	o	o	o	o
Launch of new products / services (14)	o	o	o	o	o

Q2.3 Has the company as a result of COVID-19:

	No (0)	Yes, but to a small extent (1)	Yes, to some extent (2)	Yes, to a large extent (3)
Developed new products and / or services? (1)	o	o	o	o
Developed new or improved processes that differ significantly from previous processes? (2)	o	o	o	o
Target existing products or services to new customer groups or segments? (3)	o	o	o	o
Developed new or significantly changed logistics, delivery or distribution of products and / or services? (4)	o	o	o	o

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Q2.4 To what extent would you agree with the following statements:

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Something unique (4)	Totally agree (5)
The innovations were necessary to maintain a certain level of activity as a result of COVID-19 (1)	o	o	o	o	o
Necessary because we had to work differently as a result of COVID-19 (2)	o	o	o	o	o
The innovations were a response to a market need that arose due to COVID-19 (3)	o	o	o	o	o
The innovations will be important to us even after the COVID-19 pandemic is over (4)	o	o	o	o	o

Q2.5 In their main markets, how strong was the competition in the following areas before the COVID-19 crisis?

	Weak (1)	(2)	(3)	(4)	Strong (5)
Price (1)	o	o	o	o	o
Quality (2)	o	o	o	o	o
Product / service selection (3)	o	o	o	o	o
Innovation (4)	o	o	o	o	o
Branding / Marketing (5)	o	o	o	o	o
Customization of the products / service (6)	o	o	o	o	o
Relationship building (7)	o	o	o	o	o

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Q2.6 How would you characterize your own company compared to your competitors before the COVID-19 crisis started?

	Much weaker (-2)	Weaker (1)	Like (0)	Stronger (4)	Much stronger (5)
Innovation ability compared to our competitors (1)	o	o	o	o	o
Ability to respond quickly to threats and opportunities compared to our competitors (2)	o	o	o	o	o
Cost efficiency compared to our competitors (3)	o	o	o	o	o
Customer relations, brand names or reputations compared to our competitors (4)	o	o	o	o	o

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Q2.7 How hard was the company hit by COVID-19 compared to the competition?

- Not affected (0)
- Less affected (1)
- Equally affected (2)
- Harder hit (3)
- Do not know (9)

Q2.8 Please give a rough estimate of the composition of the company's sales before the COVID-19 crisis started

Share of sales to the private market in Norway (approx.%):_____(1)
Share of sales to the corporate market in Norway (approx.%):_____(2)
Share of sales to the public sector in Norway (approx.%):_____(3)
Share of sales to foreign customers (approx.%):_____(4)
Total: _____

Q2.9 Approximately what proportion of the company's sales ...

	Before COVID-19 (approx.%) (1)	Today (approx.%) (2)
... created via online channels (e.g., online shopping, online booking, etc.) (1)		
... distributed via online channels? (e.g., online services) (2)		

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Q2.10 How do you think the company's investments will change compared to the period before the COVID-19 crisis started?

	Big reduction (-2)	Slight reduction (-1)	Unchanged (0)	Slight increase (1)	Large increase (2)
Investments in physical capital (machinery, equipment, real estate, etc.) (1)	o	o	o	o	o
Investments in competence and learning (2)	o	o	o	o	o
Investment in marketing and branding (3)	o	o	o	o	o
Investments in innovation, research, and development (4)	o	o	o	o	o
Investments in organizational development and improvement projects (5)	o	o	o	o	o

End of Block: Strategy and competition.

Start of Block: Digitalization

Block 3 intro In the next part of the survey, we will ask about the company's digitalization before the COVID-19 crisis occurred and how digitalization has been affected by the crisis

Q3.1 What role did digitalization play in your company before the COVID-19 crisis started?

	Strongly disagree (1)	Disagree (2)	Neither or (3)	Only (4)	Totally agree (5)
Digital competence was considered important (1)	o	o	o	o	o
Digitalization played a key role in our company's strategy (2)	o	o	o	o	o
Digitalization represented a threat to our business (3)	o	o	o	o	o
Digitalization represented an opportunity for our business (4)	o	o	o	o	o
We were ahead of our competitors in terms of digitalization (5)	o	o	o	o	o

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Q3.2 How digitalized was the company before the COVID-19 crisis started?

	Strongly disagree (1)	Disagree (2)	Neither or (3)	Only (4)	Totally agree (5)
We delivered digital products / services (1)	o	o	o	o	o
Digital sales channels were more important to us than physical sales channels (2)	o	o	o	o	o
Digital distribution was more important to us than physical distribution (3)	o	o	o	o	o
We had come a long way in digitizing our internal work processes (4)	o	o	o	o	o
We had come a long way in digitizing our collection and processing of customer information (5)	o	o	o	o	o
We were ahead of our competitors in terms of to exploit digital technology (6)	o	o	o	o	o

Q3.3 What effect has COVID-19 had on the use of digital technology in the following areas:

	Decreased (-1)	Not changed (0)	Increased slightly (1)	Session (2)	Significantly increased (3)
Digital content in our products / services has ... (1)	o	o	o	o	o
The use of digital tools in our interaction with customers has ... (2)	o	o	o	o	o
The use of digital tools in our interaction with suppliers has ... (3)	o	o	o	o	o
The use of digital tools in our internal work processes has ... (4)	o	o	o	o	o

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Q3.4 What role does digitalization play in your company today?

	Strongly disagree (1)	Disagree (2)	Neither or (3)	Only (4)	Totally agree (5)
Digital competence is considered important (1)	o	o	o	o	o
Digitalization plays a key role in our company's strategy (2)	o	o	o	o	o
Digitalization represents a threat to our business (3)	o	o	o	o	o
Digitalization represents an opportunity for our business (4)	o	o	o	o	o
We are ahead of our competitors in terms of Digitalization (5)	o	o	o	o	o

Q3.5 How has the importance of digital competence changed over time for your company?

	Not important (1)	Not very important (2)	Somewhat important (3)	Important (4)	Very important (5)
Before the COVID-19 Pandemic (1)	o	o	o	o	o

Today (2)	o	o	o	o	o
One year from today (3)	o	o	o	o	o
Three years from today (4)	o	o	o	o	o

End of Block: Digitalization