

Rybalka, Marina

## Article

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Article

# Innovation Pattern Heterogeneity and Firm Strategic Agility: Push- and Pull-Effects of COVID-19 on Firms' Innovation Strategies

Marina Rybalka 

SSB—Statistics Norway, Postboks 2633 St. Hanshaugen, NO-0131 Oslo, Norway; marina.rybalka@ssb.no

**Abstract:** The coronavirus crisis hit both the world and national economies hard. By using a structural equation modelling (SEM) approach and microlevel data from the Community Innovation Survey (CIS2020) on a representative sample of 6437 Norwegian firms comprising a set of COVID-19-related questions, this paper explores the role of firms' innovation capabilities and strategic agility in times of crises. Our main hypothesis is that these two concepts are interrelated. More specifically, this paper investigates the 'push' and 'pull'-mechanisms of the pandemic on firms' innovation strategies, as well as which firms were most agile, adapted quickly, introduced innovation due to the COVID-19 crisis rapidly and became more effective with respect to their pre-crisis innovation capabilities. The results indicate that both mechanisms were active during the coronavirus crisis, and most of the firms carried out strategic reactions and changed their business operations on long-term basis. However, the results for innovation output and efficiency improvements vary significantly. "Process developers", "active R&D doers" and "radical innovators" (the firms that are persistent innovators with the highest score on performing in-house R&D continuously and on innovating in the pre-crisis period) are found to be most agile during the pandemic. They had both introduced innovation and improved their efficiency in quick response to COVID-19. However, firms with low innovation capabilities demonstrated poorer performance during the crisis. These results imply that pre-existing innovation capabilities are important for firms' strategic flexibility during crises and their ability to respond to changes quickly and efficiently.

**Keywords:** strategic business agility; innovation strategies; firm heterogeneity; corona crisis; Community Innovation Survey



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## 1. Introduction

The shutdown in connection with the coronavirus pandemic early in 2020 had major consequences for both the world and national economies. Many firms were affected by significant declines in turnover and reduced liquidity, and therefore had to make layoffs, cut costs, reorganize and, in some cases, close operations [1]. On the other hand, a sudden exogenous shock such as COVID-19 has given some companies a competitive advantage and opportunities to come into contact with new customer groups and markets. For example, a survey conducted among Norwegian companies during the pandemic by Solheim et al. [2] shows that already after the summer of 2020, several innovative companies seized new opportunities and made changes that contributed to the development of new goods/services. In addition, they explored new customer groups, markets and/or sales channels. This survey demonstrates that firms have been highly heterogeneous in their responses to the crisis caused by COVID-19 and indicates that the concept of strategic agility might be extremely important for firm survival in times of crisis.

There is no unique definition of firm agility in the literature. Bounfour et al. [3] summarise different definitions of agility found in previous studies. They mention enterprise agility, dynamic capabilities, strategic flexibility and business, operational, portfolio and organisational agility, referring among others to the early studies from the 1990s by Roth [4] and

Teece et al. [5]. The common understanding of agility in these and later studies is concerned with firms being *flexible* enough to renew themselves while staying operative [6–8]. All these types of agility are comparable to the strategic agility concept. Already in 1996, strategic agility (SA) was described as “the capability to produce the right products at the right place at the right time at the right price” [4] (p.30). In recent years, the term of SA has been widely used in the fields of planning and strategic development as an essential business success factor [9–14] and as a survival instrument [15,16], as well as in the economics of innovation literature as a factor stimulating innovation [17–20].

In this paper, we apply the concept of strategic agility that comprises the ability of the firm “to adapt and innovate and convert challenges into opportunities by anticipating unexpected internal events, in addition to rapid response, towards any emergency effectively and efficiently” [21] (p. 32). But which firms were most agile, adapted quickly, introduced innovation due to the COVID-19 crisis rapidly and became more efficient? While most of the previous studies on strategic agility concentrated on the conceptualisation of SA and the identification of its general impact on firm performance, there is still a lack of studies identifying mechanisms behind *successful* strategic agility. Few recent studies have used the COVID-19 crisis (as the exogenous shock) to demonstrate that SA has been important in times of crisis for tackling the negative effects of the crisis [3] and making proactive actions such as adopting new technologies [22] and attempts to reach new markets or customer groups [2]; however, these actions were found to be effective only for those firms that were ahead in digital transformation [2,3]. Nevertheless, these findings might be specific to the COVID-19 crisis that caused lockdowns in many countries and, hence, made it necessary to implement new digital (instead of physical) solutions that could give an advantage to early digitalised businesses.

This paper provides a unique insight into the mechanisms at work during the COVID-19 crisis in more general way. It describes the link between the impact of the COVID-19 crisis and the firm’s strategic response through various ‘push’ and ‘pull’ factors [23], demonstrates the importance of having the necessary knowledge and skills to handle exogenous shocks and studies whether the concepts of a firm’s *pre-existing innovation capabilities* and *successful* strategic agility are related. Why might pre-existing innovation capabilities matter in this context? While the concept of SA relates more to *the management of the organisation* with managers’ entrepreneurial mindset—“a way of thinking . . . that captures the benefits of uncertainty [24] (p.1)—being one of the key factors of SA [2], the concept of innovation capability—“a firm’s ability to identify new ideas and transform them into new /improved products, services or processes that benefit the firm” [25] (p.7)—relates to the culture of innovation throughout *the whole organisation*. It comprises a critical set of competencies, processes and resources that are essential for the creation of new ideas [26]. If managers foster a culture that encourages innovation and experimentation, it makes the whole organisation more adaptable and therefore resilient. Hence, companies that were innovative before the crisis may be better equipped to cope with the new situation, adapt faster and innovate further (what is often called “creative accumulation”, see [27]), making the company more resilient to the shocks [28]. For example, Rybalka and Mark [29] found that “firms with higher innovation capacity, in terms of formal R&D activity on a regular basis and frequent collaboration on R&D and innovation with others, were more resilient to the crisis, while the group appearing to be less resilient to the crisis clearly had a lower level of innovation capacity” [29] (p. 325). However, they could not say anything about the ability to adapt to the changed environment. This paper goes further and provides a better understanding of how the concepts of strategic agility, resilience and firms’ innovation capabilities are related. Our main hypothesis is that the concepts of agility and firms’ innovation capabilities are interrelated, i.e., not only is SA a factor that stimulates innovation [17,18,20] and has a positive impact on building innovation capacity [30], but also innovation capabilities are important for strategic agility to be *efficient* in response to crises.

It is worth noting that there is no single measure of innovation capability that is universally accepted, and different measures may be more or less appropriate depending on the context. The indicators for “product” and “process” innovation (as they are defined in the Oslo Manual for statistical purposes, [31]) are broadly used in the empirical literature to study the importance of innovation for economic growth [32–34], including the role of innovation in times of crises [28]. However, innovation capabilities may be reflected by a much broader set of innovative activities than just product and process innovation (as e.g., in [30]). They might also involve skills management (e.g., brainstorming sessions and cross-functional work groups, etc.), adoption of new technology and passive knowledge acquisition through collaboration, co-creation, etc. To consider the multi-dimensional character of this concept, we apply a more fine-grained taxonomy of Norwegian innovative companies introduced by Capasso and Rybalka [35].

The analysis in this paper is based on data from Statistics Norway’s Community Innovation Survey (CIS2020) for the period 2018–2020, where a representative sample of 6437 enterprises answered standard questions about their R&D and innovation activity. These questions are used to reveal how the innovation landscape had changed during the pandemic compared to the earlier period studied by [35]. In addition, the companies were also asked how particularly COVID-19 affected their financial situation, competitive position, innovation activity and strategic dispositions. These questions are used to construct latent variables for the negative and positive impact of COVID-19 and the strategic response by the firms and to study the links between them. Then, using structural equation modelling (SEM), we connect all elements together and study the links between the negative and positive impact of COVID-19, the firm’s strategic response and the firm’s outcomes in the form of the introduction of innovation due to COVID-19, long-term changes and increased efficiency. We also study how these connections vary among heterogeneous firms with respect to their pre-crisis approach to innovation. The fact that the introduction of innovation just short time after the major lockdown in March 2020 was a quite rare event gives us a plausible background to study factors behind the ability of the firm “to adapt and innovate and convert challenges into opportunities by anticipating unexpected internal events, in addition to *rapid response*, towards any emergency effectively and efficiently”.

The results indicate that both ‘push’ and ‘pull’ mechanisms were active during the coronavirus crisis, and most of the firms carried out strategic reactions and changed their business operations on a long-term basis. However, the results for innovation output and efficiency improvements vary greatly depending on the pre-crisis innovation strategies. “Process developers”, “active R&D doers” and “radical innovators” (the firms that are persistent innovators with the highest scores in performing in-house R&D continuously and in innovating in the pre-crisis period) are found to be most agile during the pandemic. They both introduced innovation and improved their efficiency in quick response to COVID-19. These results imply that pre-existing innovation capabilities are important for firms’ strategic flexibility during crises and their ability to respond to changes quickly.

Our paper is structured as follows: Section 2 presents data and describes the extent to which Norwegian companies have been affected by the pandemic and whether typical innovation practices observed among Norwegian firms before the crisis have changed during the pandemic. Section 3 presents a quantitative model (based on structural equation modelling tools) for the connection between different innovation practices, different shocks (negative and positive) caused by the pandemic and the companies’ strategic dispositions in the form of the exploration of new customer groups/markets, the expansion of other external relationships, the introduction of new goods and services, changes in business processes, streamlining and permanent changes to operations. It also presents the estimation results. Finally, Section 4 draws conclusions and provides the discussion remarks.

## 2. Data Description and Construction of Indicators

### 2.1. Data Sources and Description of the Sample

For the analysis, we use Norwegian microdata on the firms included in the Community Innovation Survey (CIS2020), covering the three-year period of 2018–2020. These data are collected by Statistics Norway and contain detailed information on firms' innovation activities, including expenditures divided into intramural R&D, extramural R&D services and expenditures on other aspects of innovation activities. They also contain information on firms' strategies, whether the firm has introduced a new product or a process innovation (the definitions of these types of innovation comply with the recommendations of the Oslo Manual, [31]); whether it has cooperated with other firms/institutions in its innovation activities; and whether it has applied for a patent and/or other IPR over the corresponding three-year period. The Community Innovation Survey is part of the official statistics in Norway that provides high quality data with a 100 per cent response rate (by the Statistical Law Act, the response for the enterprises is compulsory) that is representative for the entire population of Norwegian enterprises. The survey is a census of all units within the population with at least 50 persons employed. Among the other units with 5–49 persons employed, a random sample is drawn within each stratum (NACE 2-digit and firm size class). The sample rate is either 35, 15 or 10 per cent, depending on size class and the number of enterprises in the strata. The entire population covers enterprises with at least 5 persons employed in NACE Rev.2 industries 03, 05–33, 35–39, 41–43, 46, 49–53, 55–56, 58–66, 70–74, 79 and 82. The survey is conducted using the Norwegian Central Register of Establishments and Enterprises as the sampling frame. Data collection for the innovation survey is conducted via an electronic questionnaire on the government platform Altinn. All responses undergo on-receipt controls. After all the data are made available electronically, more detailed controls are undertaken, including cross-referencing with data from the previous survey, financial account information, etc. (A more detailed description of sampling and data collection procedures is available at the official site of Statistics Norway <https://www.ssb.no/en/teknologi-og-innovasjon/forskning-og-innovasjon-i-naeringslivet/statistikk/innovasjon-i-naeringslivet> (accessed on 4 October 2024)). CIS2020 contains information on 6437 firms.

In addition to the standard questions, CIS2020 in Norway also included a set of COVID-19-related questions. The companies were asked how particularly COVID-19 affected their financial situation, competitive position, innovation activity and strategic dispositions. The standard questions were used to investigate how approaches to innovation had changed from the period 2016–2018, studied earlier by Capasso and Rybalka (2022). A set of COVID-19-related questions were used to describe the extent to which Norwegian companies have been affected by the pandemic and to study how different innovative firms had responded to the crises with respect to their innovation strategies and efficiency. These data were further merged with data from the Business Register to obtain information on various firms' characteristics (i.e., size, age, industry and location).

Table 1 presents descriptive statistics of the firms in the sample for their size, age and turnover in 2020, as well as for their innovation activity in 2018–2020, and specifically in 2020, due to COVID-19. As mentioned earlier, all firms with 50 or more employees were included in the Community Innovation Survey. At the same time, about 60 per cent of firms in our sample are small firms with fewer than 50 employees, and about 15 per cent are micro firms with 5–9 employees. Thus, our sample is representative of both small and large firms in terms of both employee numbers and turnover (the median turnover was about NOK 56 million or EUR 5.6 million in 2020). It is also representative of different industries by construction (the survey sample is selected using a stratified method for firms with 5–49 employees (larger firms are fully covered), where strata are based on industry classification (NACE codes) and firm size. Hence, the data are representative of industries and firm size groups by construction. Sample distribution figures by industry group can be provided upon request).

**Table 1.** Description of size, age, turnover and share of firms with innovation for the final sample.

Firm Characteristic	Obs.	Mean	Std. Dev.	Min	Median	Max
Number of employees	6437	95.7	344.8	5	32	18,415
Firm age (in years)	6437	20.9	16.9	0	18	177
Turnover (mill. NOK)	6437	399.3	2564.8	0	56	151,000
Introduction of new good in 2018–2020	6437	0.35	0.48	0	0	1
Introduction of new service in 2018–2020	6437	0.30	0.46	0	0	1
Introduction of new business process in 2018–2020	6437	0.53	0.50	0	1	1
Introduction of new good in 2020 due to COVID-19	6437	0.05	0.22	0	0	1
Introduction of new service in 2020 due to COVID-19	6437	0.07	0.25	0	0	1
Introduction of new business process in 2020 due to COVID-19	6437	0.15	0.36	0	0	1

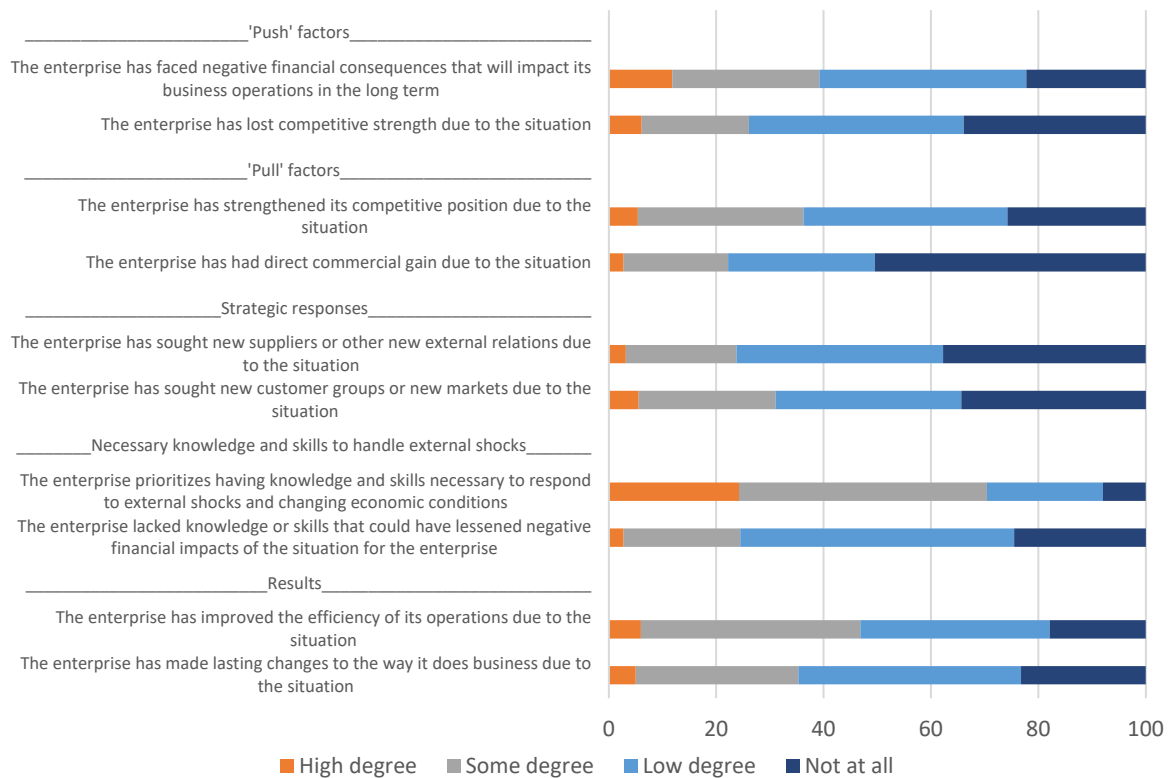
Regarding age, most of the firms in the sample are well-established, with a median age of 18 years since their establishment. Approximately 15 per cent of the firms in the sample were young in 2020 (i.e., 0–5 years old).

Further, Table 1 shows that about 30–35 per cent of the firms in the sample had introduced product innovation in the form of a new good or service in 2018–2020; however, only 5–7 per cent of the firms in the sample did so due to COVID-19 (with CIS2020 being conducted in March 2021, the answers on COVID-19-related questions cover the period from March 2020, when the first infection control measures were implemented in Norway, to December 2020). Process innovation due to COVID-19 was introduced by approximately 15 per cent versus more than half of the firms in the sample during the whole period of 2018–2020 covered by CIS2020. These data demonstrate that the introduction of innovation just a short time after the major lockdown in March 2020 was a quite a rare event. That gives us a plausible background to study the factors behind the ability of the firm “to adapt and innovate and convert challenges into opportunities by anticipating unexpected internal events, in addition to *rapid response*, towards any emergency effectively and efficiently” (as SA defined in the introduction).

## 2.2. Construction of Indicators for Negative Shock, Positive Shock and Strategic Response

In the literature on sources of innovation, a distinction is made between ‘push’ factors that force companies to change, adapt and innovate, and ‘pull’ factors that give companies advantages and opportunities they can benefit from (see, i.e., [23] and the discussion in [2]). These two mechanisms became more evident in times of profound crises such as the Great Lockdown caused by COVID-19. On the one hand, it necessitated restructuring and changes in order to find more effective solutions for companies to survive. On the other hand, it gave some companies a competitive advantage and opportunities to come into contact with new customer groups and markets. For example, companies that offer digital solutions encountered increased demand for their services during the pandemic and they therefore gained a market advantage. Figure 1 shows the extent to which Norwegian companies were affected by the situation around COVID-19 (both negatively and positively), to what extent they were prepared by having the necessary skills to handle the crisis, and to what extent they reacted (where the answers are ranked from degree 1—“Not at all” to degree 4—“High degree”).

Figure 1 shows that 39 per cent of the enterprises experienced financial consequences to a large or some extent as a result of COVID-19. Almost 12 per cent largely agree that it will affect them negatively in the long term. At the same time, approximately 26 per cent agree that they lost competitiveness to a large or some extent due to COVID-19 (where 6 per cent agree to a large extent). These businesses have been negatively affected by the pandemic.



**Figure 1.** To what degree do the following statements align with the enterprises' experiences and responses to the altered market and operating conditions that arose due to the situation surrounding the COVID-19 pandemic and the societal reactions to dealing with it.

On the other hand, we find companies that have strengthened their market position. Five per cent agree with this to a large extent and thirty-one per cent to some extent. Twenty-two per cent respond positively to the question of whether they have received commercial gains as a result of the situation surrounding COVID-19. These enterprises were positively affected by the pandemic.

About 31 per cent state that they have sought new customers/markets (approximately 6 per cent agree to a large extent) and approximately 22 per cent have sought new suppliers and other external relationships (approximately 3 per cent agree to a large extent). Whether these strategic reactions were caused by negative ('push') or positive ('pull') effects of the pandemic will be studied later in a quantitative model.

Based on the answers to these three groups of questions and applying confirmatory factor analysis, we create the following indicators (for unobserved constructs) to be used further in the structural model (see Appendix A for the description of the method, tests for its validity and reliability and the importance of each question for the corresponding indicator):

- Negative shock (NS) as a result of COVID-19 ('push' factors)
  - NS1: Has the company experienced financial consequences, as a result of the situation surrounding COVID-19, that will affect the company negatively in the long term?
  - NS2: Has the company lost competitiveness due to the situation around COVID-19?
- Positive shock (PS) as a result of COVID-19 ('pull' factors)
  - PS1: Has the company made a commercial profit as a result of the situation surrounding COVID-19?
  - PS2: Has the company strengthened its position in relation to its competitors due to the situation around COVID-19?

- Strategic response (SR)
  - SR1: Has the company sought new markets or customer groups as a result of the situation around COVID-19?
  - SR2: Has the company sought new suppliers or other external relationships due to the situation around COVID-19?

Furthermore, Figure 1 shows that as many as 70 per cent agree (to a great extent or to some extent) that the company prioritizes having the necessary knowledge and skills to handle external shocks, while 30 per cent agree that they lack such knowledge. Finally, we see that approximately 47 per cent agree (to a great extent or to some extent) that the company has become more efficient as a result of the situation surrounding COVID-19 (6 per cent agree to a great extent). Thirty-five per cent say that the company has permanently changed its business operations as a result of the situation surrounding COVID-19 (give per cent agree to a large extent).

### 2.3. Greater Focus on Special Development of Goods and Services During the Pandemic

Previous analysis by Capasso and Rybalka [35] has mapped different approaches to innovation among Norwegian firms in the period 2016–2018 based on the comprehensive set of 88 indicators for R&D and innovation inputs and outputs at the firm level from the CIS2018 data. This includes information on formal R&D activities, investment in R&D and innovation, funding for innovation activities, types of innovation, innovation strategies, co-creation of innovation and with whom, use of IPR and factors hampering decisions to start innovation activities. Applying the same empirical approach to the CIS2020 data, we first studied how various practices were affected during the pandemic before we applied them in the structural model presented in Section 3 (see Appendix B for a brief description of the method used and the meaning of various indicators for each type of innovation practice based on CIS2020 data). Table 2 summarizes the main characteristics of each type of innovation practice and the changes observed during the pandemic.

**Table 2.** Description of different innovation practices before the pandemic and changes during the pandemic.

Type of Innovation Practice	Description Before the Pandemic *	Change During the Pandemic
“Active R&D doers”	Most important market: EU and the world R&D-work on a continuous basis Product and service innovation with a moderate degree of novelty High degree of collaboration at all levels Extensive use of public support for financing	The most important market became the EU (and not the world, as before) Purchase of services and equipment from others in connection with innovation activities on a larger scale than before
“Radical innovators”	Most important market: EU and the world R&D on a continuous basis Product and service innovation with a high degree of novelty Collaboration with clients in the private sector, typically outside Norway Active use of patents and secrecy and licensing out of their rights	Reorientation from the international to the national market when it comes to the sale of products even though the degree of novelty of innovation remains at world-class level Greater focus on new customers and special development of goods and services
“Process developers”	New or significantly improved processes at all levels Main strategy: Improvement of existing goods and services Collaboration with other companies in the same group at local/regional level Investment to a greater extent than others in machines, equipment and software	Greater focus on the application of new technology than before

Table 2. Cont.

Type of Innovation Practice	Description Before the Pandemic *	Change During the Pandemic
“Strategic adaptors”	Main strategies: High quality of goods or services; improvement of existing goods and services; priority on catering to established customer groups Offer customization of standard goods or services Invest in technological equipment that is largely based on new technology	Even greater focus on specialization when adapting existing products
“Innovation suppliers”	Most important market: Mot local/regional Active use of all types of IPR and licensing out of their rights Buy R&D services from others to a large degree and carry out own R&D to some extent	Increased orientation towards the world market (applies to both sales and business partners)
“Hard-trying innovators”	Sporadic execution of R&D internally with main investment in own staff Scores high on all types of obstacles to innovation Product and service innovation with a low degree of novelty Collaboration to some degree with competitors in the same industry and locally	Receives external financing in the form of loans and subsidies to a much greater extent
“Knowledge absorbers”	Active use of all types of channels/methods to acquire knowledge Practicing special development of goods/services where the public sector is involved in the development Practicing further education, skills development, and training internally within the company; broadly composed of working groups across job functions and areas; regular brainstorming sessions Do not carry out any formal R&D and innovation activity Investment in technological equipment that is largely based on existing technology	Specialization towards the public sector as a customer and on goods or services where the customer/user had an active role in conceptualization, design and development.
“Individual (standard) services suppliers”	Main market: Norway Main strategy: Development and launch of new standards for goods and services Oriented towards households or individuals Relatively high investment in staff and expect the same level of investment in innovation going forward Collaboration to some degree with other companies Introduced new or significantly improved services with a low and in some cases moderate degree of novelty	Reorientation from offering standard services to focusing on a wide range of specially developed services.

\* Based on descriptions in [35]. <https://doi.org/10.3390/businesses2010004> (accessed on 10 January 2023).

We identify the same eight main types of innovation practices among Norwegian enterprises during the period of 2018–2020 (which also covers the first wave of pandemic) as in the previous period [35], but with some changes regarding the main market for some enterprises and the special development of goods and services (most of the questions in CIS2020 apply to the period of 2018–2020, while the previous innovation survey used for the first mapping concerned the period 2016–2018. If we observe any changes in the contribution of various indicators to each type of innovation practice, we interpret this as mainly an effect or consequence of the corona crisis). In general, we observe a greater focus

on co-creation and the special development of goods and services for different customer groups for most types of approaches to innovation. In terms of main markets, “active R&D doers” have reoriented to a greater extent towards the EU market than the world market, and “radical innovators” have reoriented to a greater extent towards national rather than international markets (whereas the reverse orientation was observed before the pandemic). At the same time, “innovation suppliers” have gained a stronger orientation towards the world market than they had before the pandemic. This illustrates that the crisis can affect innovative enterprises differently, i.e., while some enterprises may be affected negatively, others gain opportunities for expansion.

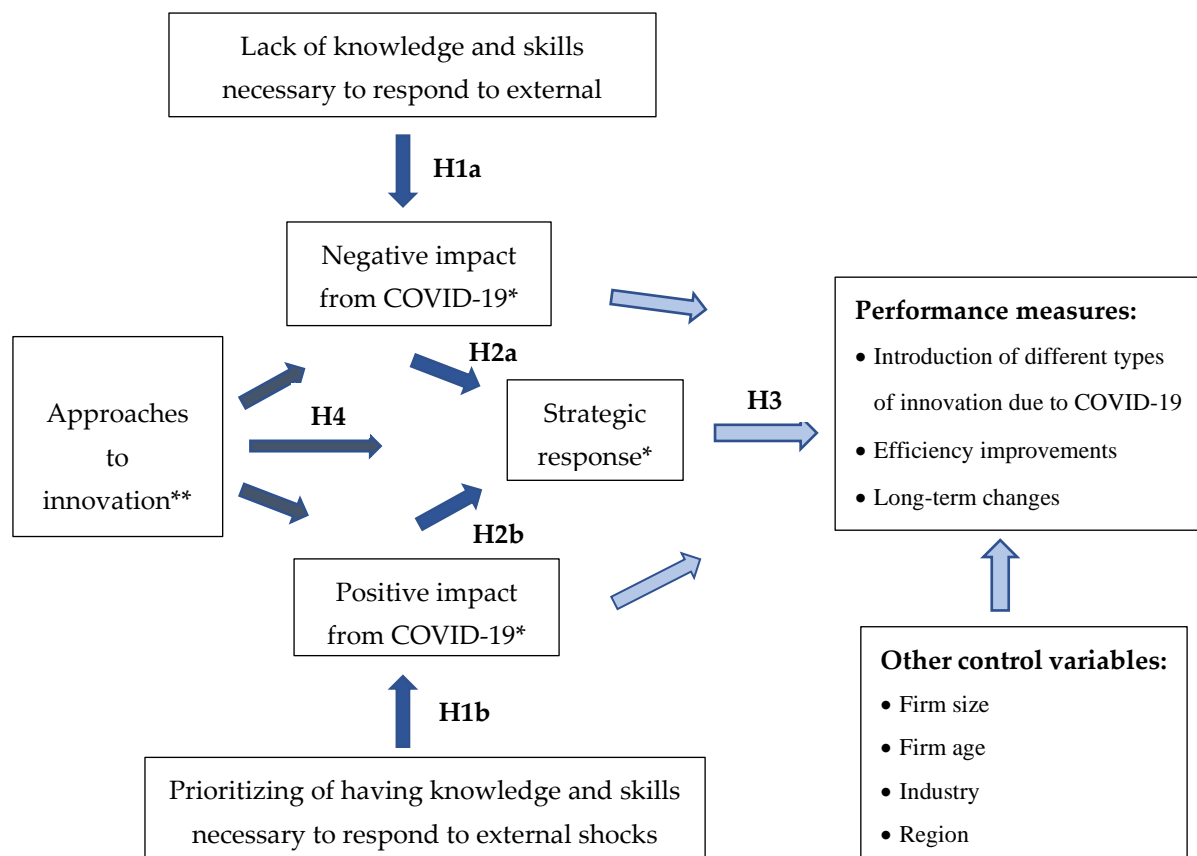
All in all, the results in Table 2 do not show any dramatic changes in the main approaches to innovation based on CIS2020 data compared to CIS2018 data. These findings can be explained partly by the fact that most of the questions in CIS2020 used so far apply to the period covering 2018–2020 (where two years represent the period before the pandemic) and partly by the fact that innovation processes usually take time until measurable results become observable. Hence, we treat these approaches to innovation as representing *pre-existing* innovation capabilities of the firm in the further analysis (which is not unproblematic and is discussed both in Section 3.1 describing the model and estimation approach and in Section 4 concluding the paper).

### 3. Empirical Model and Estimation Results

#### 3.1. Description of Quantitative Model and Estimation Approach

To investigate the connection between different shocks (negative and positive) caused by the pandemic, the company’s strategic reaction and the results, we use the model given in Figure 2. Using this quantitative model, we study how different innovative companies (based on different innovation practices) were affected by the pandemic. Which companies were affected most negatively, which most positively, which have introduced innovation in rapid response to the pandemic, and what types of innovation are we talking about? Which innovative companies have improved their efficiency and implemented strategic changes in their way to do business?

To analyse this comprehensive model, we use the structural equation modelling (SEM) method. This method is shown to be effective in estimating the complex relationships among multiple variables, especially when some of the variables are latent and inferred from other measured variables [36,37]. The use of such a quantitative approach is appropriate since statistical methods are shown to be useful in uncovering unobserved patterns and regularities from the observable dimensions [38]. In our case, both possible impacts of the COVID-19 crisis (negative and positive) as well as the strategic responses of the firms are not observable directly but are measured by confirmatory factor analysis (CFA) based on the observable measures described in Section 2.2 (see also Appendix A for the description of how the observed variables load the respective constructs of negative and positive impacts and strategic responses). We cannot observe and measure the firms’ innovation capabilities directly either, and to catch the multi-dimensionality of this concept, we apply a fine-grained taxonomy of Norwegian innovative companies introduced by Capasso and Rybalka [35] using exploratory factor analysis (EFA; see Appendix B for the details). Both CFA, EFA and SEM analysis were conducted using the maximum likelihood method (ML).



**Figure 2.** SEM model to study the impact of the COVID-19 pandemic on different innovative firms. \* Latent variables estimated by confirmatory factor analysis based on the COVID-19-related questions in CIS2020 presented in Figure 1 and Appendix A; \*\* Latent variables estimated by explorative factor analysis based on the broad set of indicators introduced by Capasso and Rybalka [35] and presented in Table 2 and Appendix B.

One of the main advantages of using the SEM approach is that it allows for testing hypotheses that involve latent variables, which can have an important impact for better understanding the “black box” processes and for theory development. The key elements of strategic agility are a clear vision and strong leadership that promote the “Three A’s” principle of SA—*Anticipate, Adapt, Act* [39]—through proactive risk management by preparing strategic responses to different future scenarios. Our first hypothesis, which is tested by the structural model presented in Figure 2, is the following:

**H1:** *Having the knowledge and skills necessary to respond to external shocks has been important for reducing the negative impact and for facilitating the positive impact of the COVID-19 crisis (this hypothesis reflects the first “A” in the “Three A’s” principle of SA—Anticipate).*

While several recent studies have used the COVID-19 crisis to demonstrate that SA has been important for tackling the negative effects of the crisis [3] and making proactive actions such as adopting new technologies [22], they have not explored the possible positive impacts of the crises on the firms’ strategic responses. Our second hypothesis, which is tested by the structural model presented in Figure 2, is the following:

**H2:** *Both ‘push’ and ‘pull’ mechanisms have been active under the COVID-19 crisis and led firms to make strategic responses to the crisis (this hypothesis reflects the second “A” in the “Three A’s” principle of SA—Adapt).*

The concept of SA is especially crucial in times of crisis for firm survival and overcoming negative effects [15,16]. Our third hypothesis, which is tested by the structural model presented in Figure 2, is the following:

**H3:** *Firms that have conducted strategic responses are more prompt to act quickly in response to the crisis and, hence, to have positive performance measures (this hypothesis reflects the third “A” in the “Three A’s” principle of SA—Act).*

As performance measures, we use different outcome variables, i.e., the introduction of various types of innovation (new good, new service or new business process due to COVID-19) presented by the binary variables in the CIS data with 1 for “Yes” and 0 for “No”; as well as indicators for efficiency improvements and long-term changes in business operations presented by the rank variables reflecting the extent to which Norwegian companies were affected by COVID-19, with a scale ranging from degree 1 “Not at all” to degree 4 “High degree”.

As mentioned in the introduction, very few attempts have been made to understand the mechanisms that lead to *successful* strategic agility [3,6,30]. Given the high heterogeneity of firms with respect to their approaches to innovation *prior* to the crisis [35] and anticipating that firm innovation capabilities might be important for strategic agility to be successful and efficient, we formulate our fourth and main hypothesis of this study:

**H4:** *Firms with high innovation capabilities have been more effective in achieving positive outcomes through their strategic response to the crisis than firms with low innovation capabilities.*

Testing this hypothesis is not a straightforward exercise. In addition to (possibly) having an impact on strategic responses, high innovation capabilities might have their own direct positive impact on the outcome variables in the form of innovation and efficiency improvements due to the crisis, demonstrating the general importance of innovation capabilities for firm performance [19] and especially in times of crisis [27]. Additionally, the degree of negative or positive impacts of the crisis might depend on the firm’s pre-crisis innovation capabilities. Applying the SEM method is very useful in this case, since it allows for testing causal pathways through path analysis [40]. In our model presented in Figure 2, we connect approaches to innovation both to the firm strategic response, the negative and positive impacts of COVID-19 and directly to the outcome variables. The whole system is estimated simultaneously by the ML method, providing efficient estimates.

While having unique data that give us a valuable insight, we have a weak point in the analysis. Given the timing of CIS2020 (which was conducted as part of a statistical production process and not for the purposes of this analysis only), we cannot claim the complete exogeneity of our indicators for approaches to innovation that are used to reveal firm innovation capabilities (since questions in CIS2020 also cover a short period during the pandemic in addition to the two years before). Potentially, it can lead to an upward bias in estimates for the direct relationship between some approaches to innovation (i.e., with a high score on general innovation outcome) and innovation outcomes due to the crisis. However, the general innovation output indicators are only a few among 88 indicators that have been used for the mapping of approaches to innovation [35]. The observed changes in approaches to innovation from CIS2018 to CIS2020, presented in Section 2.3, are small, and the main characteristics to each of the approaches to innovation have remained. Hence, we believe that this possible bias has a minor impact on our conclusions.

### 3.2. Skills to Deal with External Shocks Were Important During the Pandemic

At the first stage of the SEM model presented in Figure 2, we estimate the relationship between different approaches to innovation, having/lack of relevant skills to deal with external shocks, two types of shocks (negative and positive) and strategic response (see Table 3). All regressions are estimated using the weights that companies have been given for the rank variables. As Table 3 shows, the lack of knowledge or skills that could have

reduced the economic consequences of the situation surrounding COVID-19 led to a greater likelihood of experiencing a negative shock during the pandemic (here and further, only direct effects of various elements in the model on each other are documented, while the SEM method also allows for the calculation of indirect effects). In contrast, companies that prioritized having the necessary knowledge and skills to handle external shocks and changing economic conditions had an increased chance of experiencing positive shocks during the pandemic. These results support our first hypothesis, H1.

**Table 3.** Estimation results for the relationship between various approaches to innovation, two types of shock, having/lacking relevant skills to deal with external shocks and strategic response.

Control Variables	Dependent Variables					
	Negative Impact		Positive Impact		Strategic Response	
Approach to innovation:						
“Active R&D doers”	−0.095	***	−0.031	*	0.033	***
“Radical innovators”	0.002		0.188	***	0.056	***
“Process developers”	0.002		0.191	***	0.071	***
“Strategic adaptors”	0.160	***	0.148	***	0.040	***
“Innovation suppliers”	0.114	***	0.038	*	0.073	***
“Hard-trying innovators”	0.301	***	−0.026	**	0.028	***
“Knowledge absorbers”	−0.076	***	0.059	***	0.036	***
“Individual services suppliers”	−0.154	***	0.039	***	0.005	
Other control variables:						
Lack of necessary knowledge and skills	0.246	***				
Prioritizing of having necessary knowledge and skills			0.058	***		
Negative impact					0.878	***
Positive impact					0.805	***

Notes: The SEM model is estimated with the GSEM procedure in Stata version 16 for 6437 firms covered by CIS2020. All regressions are estimated using the weights companies are given for the rank variables. \*\*\*  $p < 0.01$ ; \*\*  $p < 0.05$ ; \*  $p < 0.1$ .

Furthermore, Table 3 shows that both enterprises that perceived they were affected negatively by the situation around COVID-19 and enterprises that perceived that they were affected positively were more inclined to carry out strategic reactions (which indicates that both ‘push’ and ‘pull’ mechanisms were active during the pandemic). A similar result for the ‘push’ mechanism is also reported by [20] for Norwegian companies that were negatively affected by COVID-19, in which the authors studied how the pandemic affected environmentally friendly innovation. The ‘pull’ mechanism was not investigated in this study. These results support our second hypothesis, H2.

If we look at different innovation practices, most innovative companies score positively on having a strategic response during the pandemic (except for “individual service suppliers”), but the mechanisms were different. While the ‘pull’ mechanism was stronger for “radical innovators”, “process developers” and “knowledge absorbers”, the ‘push’ mechanism was stronger for “innovation suppliers” and “hard-trying innovators”. “Strategic adaptors” experienced both shocks to an equal extent, while “active R&D doers” did not experience a shock, but still had a strategic reaction, probably for other reasons. It appears that even though “individual service suppliers” experienced negative shocks to a lesser extent than others and received opportunities in the form of competitive advantages and/or in the form of commercial gains, they did not make use of these opportunities, and they did not search for new customer groups or markets. The highest scores on strategic response are observed for “innovation suppliers”, “process developers” and “radical innovators”, the groups with high innovation capacity (given their high scores in innovation and formal R&D). These results are in favour of our fourth hypothesis, H4.

### 3.3. Those Who Tried to Find New Customer Groups and Markets Innovated Most During the Pandemic

In addition to questions about normal innovation activity during 2018–2020, we asked in the Innovation Survey (CIS2020) whether various innovations were introduced as a direct result of the situation surrounding COVID-19. If we first compare the innovation activity in general among different types of innovative enterprises in the period of 2018–2020 with the period of 2016–2018 (based on data from CIS2018), more innovation activity has been observed for “active R&D doers” and “radical innovators” in the period 2018–2020 (see columns 1 and 2 in Table 4). The innovation activity of “process developers”, “innovation suppliers” and “hard-trying innovators” is roughly at the same level, while “strategic adaptors”, “knowledge absorbers” and “individual service suppliers” experienced reduced innovation activity in the period of 2018–2020 compared to the period of 2016–2018.

**Table 4.** Estimation results for the relationship between various approaches to innovation, two types of shocks due to COVID-19, strategic response and innovation output based on CIS2020.

Control Variables	Any Type of Innovation (d_inno = 1)		Innovation due to COVID-19 (Conditional on d_inno = 1 in CIS2020)			
	CIS2020	CIS2018	Any Type of Innovation	New Good	New Service	New Process
Approach to innovation:						
“Active R&D doers”	12.800 ***	10.440 ***	0.682 ***	0.606 *	0.136	0.817 ***
“Radical innovators”	12.397 ***	8.664 ***	0.607 ***	1.612 ***	1.751 ***	0.371 **
“Process developers”	32.285 ***	33.687 ***	1.899 ***	1.135 ***	1.594 ***	2.547 ***
“Strategic adaptors”	6.155 ***	7.424 ***	0.306 *	1.290 ***	0.597 **	0.294
“Innovation suppliers”	4.291 ***	4.651 ***	−0.463 *	0.040	−1.482 ***	−0.445
“Hard-trying innovators”	4.927 ***	5.417 ***	0.275 *	0.356	0.673 ***	0.253
“Knowledge absorbers”	−0.922 ***	2.667 ***	0.033	−0.580 **	0.346	0.161
“Individual services suppliers”	4.910 ***	9.014 ***	0.229	1.205 ***	1.487 ***	−0.071
Other control variables:						
Negative impact of COVID-19			−0.140	−0.570 *	−0.183	0.120
Positive impact of COVID-19			0.193	−0.292	0.114	0.317
Strategic response			1.088 ***	1.559 ***	1.004 ***	0.910 ***
Constant term	−4.722 ***	−5.497 ***	−2.679 ***	−4.979 ***	−4.975 ***	−3.130 ***
Number of observations	6437	6360	4006	3946	3971	4006

Notes: Regressions for any type of innovation in 2016–2018 (based on CIS2018) and in 2018–2020 (based on CIS2020) were estimated as a logit model in Stata version 16. Separate estimation models, one for each type of innovation due to COVID-19 as a dependent variable, were estimated using the GSEM procedure in Stata for 6437 firms covered by CIS2020. All regressions include variables for firm size (number of employees and number of employees squared) and dummies for firm age, industry and location, and are estimated as weighted regressions using the weights companies were given for binary variables. The results for any type of innovation based on CIS2018 yield the period 2016–2018 and are reported here for comparison reasons. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

At the next stage of the SEM model presented in Figure 2, we examine the relation between different types of crisis shocks, strategic response and different types of innovation that were introduced as a direct result of the situation around COVID-19 (i.e., product, service, and process innovation). Table 4 shows that neither negative nor positive shocks had any significant direct effect on innovation during the pandemic (apart from a weak negative effect on product innovation from a negative shock). Rather, innovation was influenced indirectly via strategic responses. This means that the companies that *actively* tried to search for new customer groups and markets or expand other external relationships innovated the most during the pandemic. This relationship applies particularly to new goods but also to new services and changes in business processes. These results support our third hypothesis, H3.

### 3.4. Changes in Business Processes During the Pandemic

Further, for exploratory purposes, we look closer at which business processes were particularly affected by the situation around COVID-19 for different types of innovative enterprises. Table 5 shows that firms that experienced a negative shock during the pandemic had to make changes within “Distribution of responsibilities, decision-making or human resources management (HRM)”, while those that experienced a positive shock made changes within “Accounting or other administrative purposes”. Again, it is those who scored high on strategic reaction, i.e., those who experienced a need to search for new customer groups and markets or expand other external relationships, who made changes within several business processes, primarily within “Logistics, delivery or distribution methods”, “Marketing, presentation, packaging, product placement or after-sales services” and “Methods for producing goods or providing services”.

**Table 5.** Estimation results for the relationship between various approaches to innovation, two types of shocks due to COVID-19, strategic response and different types of process innovation based on CIS2020.

Control Variables	Process Innovation due to COVID-19 (Conditional on d_inno_pcs = 1)						
	Methods for Producing Goods or Providing Services	Logistics, Delivery or Distribution Methods	Methods for Information Processing or Communication	Methods for Accounting or Other Administrative Operations	Business Practices for Organising Procedures or External Relations	Methods of Organising Work Responsibility, Decision-Making or HR Management	Marketing Methods for Promotion <sup>1.</sup> or After Sales Services
Approach to innovation:							
“Active R&D doers”	0.393	−0.381	0.831 ***	0.528	1.211 ***	0.559	0.462
“Radical innovators”	1.155 ***	0.264	0.035	−0.728 *	0.732 **	0.454	0.661 ***
“Process developers”	1.473 ***	2.244 ***	2.077 ***	1.925 ***	3.827 ***	3.459 ***	2.412 ***
“Strategic adaptors”	0.726 **	0.633	0.578 **	−0.352	0.397	−0.277	0.553 *
“Innovation suppliers”	−0.759	−0.711	−0.398	−0.538	−0.658	−1.099 **	0.069
“Hard-trying innovators”	0.797 ***	−0.024	0.134	−0.41	0.726 ***	−0.21	0.201
“Knowledge absorbers”	−0.002	−0.265	0.233	0.577	1.127 ***	0.338	−0.265
“Individual services suppliers”	−0.042	0.777 **	0.430 **	−0.582	−0.533 *	−0.443	−0.006
Other control variables:							
Negative impact of COVID-19	−0.029	−0.586	−0.082	0.788	0.083	0.901 **	−0.293
Positive impact of COVID-19	0.457	−0.200	0.160	0.914 *	0.110	0.335	0.002
Strategic response	0.950 ***	1.666 ***	0.727 ***	0.133	0.707 *	0.201	1.307 ***
Constant term	−4.517 ***	−3.701 ***	−4.272 ***	−2.952 **	−6.086 ***	−6.514 ***	−4.616 ***
Number of observations	3327	3236	3344	3208	3246	3300	3307

Notes: Separate estimation models, one for each type of process innovation due to COVID-19 as a dependent variable, were estimated using the GSEM procedure in Stata version 16 for 6437 firms covered by CIS2020. All regressions include a constant term, variables for firm size (number of employees and number of employees squared) and dummies for firm age, industry and location, and were estimated as weighted regressions using the weights companies were given for binary variables. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

### 3.5. Increased Efficiency and Long-Lasting Changes in Business Operations

Finally, we look at how efficiency and business operations were affected in Norwegian companies during the pandemic. Table 6 shows that both negative and positive shocks, as well as strategic reactions, contributed to the enterprises becoming more efficient and permanently changing their business operations as a result of the situation surrounding COVID-19.

**Table 6.** Estimation results for relationship between various approaches to innovation, two types of shocks, strategic response and changes in efficiency and business operations based on CIS2020.

Control Variables	Efficiency Improvements		Long-Term Changes in Business Operations	
Approach to innovation:				
“Active R&D doers”	0.288	***	0.296	***
“Radical innovators”	0.030	*	0.251	***
“Process developers”	0.351	***	0.389	***
“Strategic adaptors”	0.288	***	0.195	***
“Innovation suppliers”	−0.011		0.150	***
“Hard-trying innovators”	−0.080	***	0.192	***
“Knowledge absorbers”	0.257	***	0.215	***
“Individual services suppliers”	−0.048	*	−0.081	***
Other control variables:				
Negative impact of COVID-19	0.284	***	0.609	***
Positive impact of COVID-19	0.707	***	0.541	***
Strategic response	0.391	***	0.371	***
Cut1	−0.266	**	−0.299	*
Cut2	0.949	***	1.067	***
Cut3	2.716	***	2.615	***
Number of observations	6385		6385	
Log likelihood	−51,821.853		−51,726.519	

Notes: The SEM model was estimated separately for each output variable using the GSEM procedure in Stata version 16 for 6437 firms covered by CIS2020. All regressions include constant term, variables for firm size (number of employees and number of employees squared) and dummies for firm age, industry and location, and were estimated using the weights companies were given for the rank variables. \*\*\*  $p < 0.01$ ; \*\*  $p < 0.05$ ; \*  $p < 0.1$ .

If we look at different innovation practices, the most innovative companies score positively on permanently changing their business operations as a result of the situation around COVID-19 (apart from “individual service suppliers”), while only “active R&D doers”, “process developers”, “strategic adaptors” and “knowledge absorbers” scored on becoming more effective during the pandemic. “Hard-trying innovators” and, to some extent, “individual service suppliers”, on the other hand, became less effective during the pandemic.

Table 7 summarizes the findings regarding how different innovative firms were affected by the pandemic in terms of experiencing negative and/or positive shocks, executing strategic responses, introducing innovations, increasing efficiency and permanently changing their business operations. All these results should be seen in combination to determine whether we receive support for our fourth hypothesis, H4, or not. The results for each group of innovative firms with respect to H4 are discussed in the next and final section.

**Table 7.** Overview of the impact of the COVID-19 pandemic on different innovative firms based on CIS2020.

Approach to Innovation	Negative Shock	Positive Shock	Strategic Response	Product Innovation	Service Innovation	Process-Innovation	Efficiency Improvements	Long-Term Changes
“Active R&D doers”	−		+	(+)		+	+	+
“Radical innovators”		+	+	+	+	+	(+)	+
“Process developers”		+	+	+	+	+	+	+
“Strategic adaptors”	+	+	+	+	+		+	+
“Innovation suppliers”	+		+		−			+
“Hard-trying innovators”	+	−	+		+		−	+
“Knowledge absorbers”	−	+	+	−			+	+
“Individual services suppliers”	−	+		+	+			−

Note: Based on the results with  $p < 0.05$  (with  $p < 0.1$ ).

#### 4. Concluding Remarks and Discussion

This paper examines the role of strategic agility and pre-existing innovation capabilities of the firm in its response to profound crises such as the COVID-19 pandemic. More specifically, based on a representative sample of Norwegian firms covered by Community Innovation Survey (CIS2020) comprising a set of COVID-19-related questions, we study the connection between different shocks (negative and positive) caused by the pandemic, the knowledge and skills necessary to respond to external shocks and the firms' strategic response.

While all firms experienced a shock due to the overnight lockdown of Norwegian society in March 2020, only a small share of firms introduced innovations due to COVID-19 in a short period after that. With particular attention to the role of pre-existing innovation capabilities, we further study how different innovative companies were affected by the pandemic. We investigated which companies were affected most negatively, which most positively, which introduced innovation in rapid response to the pandemic, and which improved their efficiency and implemented strategic changes in their way of doing business. Our main hypothesis is that pre-existing innovation capabilities matter for how efficiently firms respond to crises.

Our results indicate that both 'push' and 'pull' mechanisms were active during the pandemic, and most firms carried out strategic reactions and changed their business operations on a long-term basis in response to the situation around COVID-19 (see summary of the results in Table 7). However, the results for innovation output and efficiency improvements vary significantly. We observed that persistent innovators that have a high score in performing in-house R&D continuously (i.e., "active R&D doers" and "radical innovators") together with "process developers", have introduced different types of innovation and improved their efficiency due to the crisis and, hence, demonstrating high agility. While "hard-trying innovators" with weak innovation capabilities have also demonstrated weak innovation and efficiency performance in response to COVID-19. The first two groups have also been identified as being among most resilient firms to the crisis both in the short and long run, while the latter group is among the less resilient [29].

An interesting result involves "individual service suppliers", which operate mainly in the Norwegian market and usually introduce innovations with a low level of novelty ("new only for the firm"). These firms seemed to gain an advantage during the global crisis of the COVID-19 pandemic (they experienced positive shock) and introduced both product and service innovations. However, they have not scored on efficiency improvements and long-term changes, demonstrating that their agility is rather occasional than permanent.

Another interesting group is "innovation suppliers", which comprises firms that are active users of all types of IPR and usually operate on the world market. These firms experienced a negative shock during the COVID-19 pandemic and tried to find new customer groups and markets but failed in developing any innovations, demonstrating non-agility in the short run. However, they conducted changes in their business operations that could later result in more innovations. Indeed, firms in this group have been identified to be more resilient to the crisis in the long run than the average firm [29].

Finally, we have two special cases that demonstrate completely different results. On the one hand, we have the group of "strategic adaptors" (i.e., firms with a primary strategy of *producing high-quality products for a specific group of customers*). This group is the only one that experienced both types of shock during the COVID-19 pandemic. Firms that scored high on being "strategic adaptors" did try to find new customer groups and markets; they introduced product innovations and claimed that they had become more efficient. However, firms in this group have been identified as the least resilient to the COVID-19 crisis, both in the short and long run [29]. They had the highest probability of a marked loss of turnover and, hence, of compensation use during the whole period of the pandemic in Norway (between March 2020 and February 2022). These results imply that firms of this type, while trying to react strategically, were highly restricted in adapting their products and finding new customer groups, demonstrating low innovation capabilities. Hence, the

strategy of producing high-quality products for a specific group of customers was far from the optimal strategy with respect to the COVID-19 crisis.

On the other hand, we have “Knowledge absorbers”. Firms in this group have no formal R&D expenditure, and they do not score on innovation (neither before nor during the crisis). Hence, the concept of innovation capabilities seems to be irrelevant for them. However, these firms seemed to gain an advantage during the pandemic, and in addition, they made strategic moves and became more efficient, demonstrating high agility. They were also found to be among the firms with the lowest probability of a marked loss of turnover [29]. Their main customer group is often public sector organisations, which is a possible explanation for why this non-R&D group was more resilient to the crisis than other innovative firms (at least with respect to no marked loss in turnover). Moreover, this group probably has high absorptive capacity, which is related to a firm’s ability to recognize the value of new information, assimilate it, and apply it to commercial ends [41]. This has also been proven to have a positive impact on strategic agility [12].

In summary, our results indicate that COVID-19 has imposed a strategic response in most of the firms, but only firms with high innovation capacity, in terms of formal R&D activity on a regular basis and frequent collaboration on R&D and innovation with others, were more effective in their strategic response to the crisis and introduced innovation rapidly due to COVID-19. These results support our main hypothesis that the concepts of agility and firms’ innovation capabilities are interrelated, i.e., that not only SA is a factor that stimulates innovation, but innovation capabilities are also important for strategic agility to be *efficient* in response to crises.

Our results provide valuable insight for “innovation capacity building”-policy implementation in the companies. Capacity-building is not easy to measure, but it becomes evident in times of crisis. If managers foster a culture that encourages innovation and experimentation, it makes the whole organisation more adaptable and, therefore, resilient. Our results indicate that firms with higher pre-crisis innovation capabilities had a higher probability of being affected positively by COVID-19. They also scored higher on strategic response, the introduction of innovation and efficiency improvements in rapid response to the pandemic, demonstrating that they were more efficient in their strategic agility.

It is also important to keep in mind the limitations of this study. First, our study links the degree of innovation capacity of the firm to the efficiency of its strategic response to the crisis. However, other factors can also affect the efficiency of such a response. As pointed out by [2] and [3], the level of pre-crisis digital transformation was also important for the strategic agility being effective under COVID-19. Hence, further extension of the model with other important factors for strategic agility would be interesting to explore, but this is out of the scope of this study.

Second, we cannot claim the complete exogeneity of our indicators for approaches to innovation that are used to reveal firm innovation capabilities (since questions in CIS2020 also cover a short period during the pandemic in addition to the two years before). However, the observed changes in approaches to innovation from CIS2018 to CIS2020 are small, and the main characteristics for each of the approaches to innovation have remained. Therefore, irrespective of this limitation, by addressing the issue of measuring strategic agility and its efficiency, we believe that our study contributes to a better understanding of what makes firms stronger and more prepared for future challenges.

Finally, given the uniqueness of our data and their specificities regarding the COVID-19 crisis, the replication of our analysis in a different context might be difficult. However, we believe that some of our ideas can be applied in the future when studying firms’ responses to crises, given their heterogeneity in innovation strategies.

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**Institutional Review Board Statement:** The study was conducted in accordance with the Declaration of Helsinki. Ethical review and approval was not required for this study as per policy of the national

institution, Statistics Norway [<https://www.ssb.no/en/data-til-forskning>] (accessed on 13 September 2024), due to its retrospective nature.

**Informed Consent Statement:** Informed consent for participation was collected by Statistics Norway.

**Data Availability Statement:** The data from the 2020 Norwegian Innovation Survey can be requested to Statistics Norway at <https://www.ssb.no/en/data-til-forskning/utlan-av-data-til-forskere> (accessed on 13 September 2024).

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**Conflicts of Interest:** The authors declare no conflict of interest.

### **Appendix A. Construction of the Indicators ‘Negative Shock’, ‘Positive Shock’ and ‘Strategic Response’ as a Result of the Situation Surrounding COVID-19**

In order to construct indicators that capture negative and positive shocks as a result of the situation surrounding COVID-19 and the strategic response that companies carried out during the pandemic, we use confirmatory factor analysis (CFA). Table A1 shows which coronavirus-related questions have been used, their factor loadings and various tests showing that the model works well. All factor loadings are excellent (i.e., >0.71), indicating high individual item reliability [42]. AVE (average variance extracted) is higher than 0.5; CR (composite reliability) is higher than 0.6; and Cronbach’s alpha and RRC (Raykov’s reliability coefficients) are higher than 0.7, which support the validity of the measurement model used [36,38,43]. Other tests for the model (see values for RMSEA, CFI and TIL below the table) also have satisfactory values, indicating an appropriate model fit [38,44].

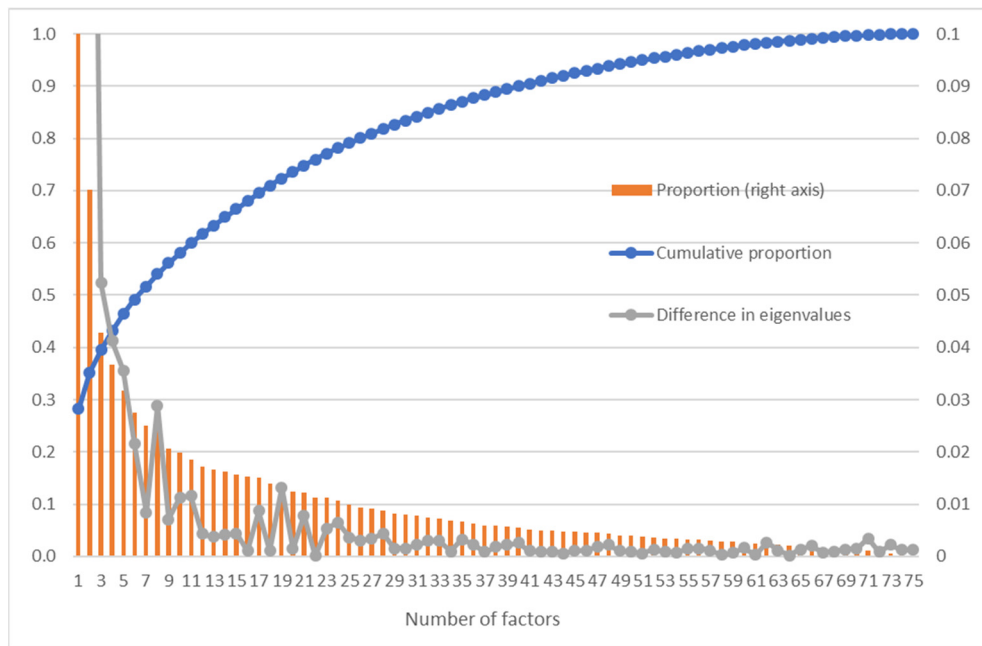
**Table A1.** Estimation results for the construction of the indicators ‘Negative shock’, ‘Positive shock’ and ‘Strategic response’ as consequences of the COVID-19 pandemic based on COVID-19-related questions in the Community Innovation Survey 2020.

Indicators (Latent Variables)	Standardized Factor Loading	AVE	CR	Alpha	RRC
Negative shock (NS) as a result of COVID-19 (‘push’ factors)		0.617	0.763	0.732	0.764
NS1: The enterprise has faced negative financial consequences that will impact its business operations in the long term	0.824 ***				
NS2: The enterprise has lost competitive strength due to the situation surrounding COVID-19 pandemic	0.745 ***				
Positive shock (PS) as a result of COVID-19 (‘pull’ factors)		0.562	0.719	0.672	0.719
PS1: The enterprise has had direct commercial gain due to the situation surrounding COVID-19 pandemic	0.787 ***				
PS2: The enterprise has strengthened its competitive position due to the situation surrounding COVID-19 pandemic	0.710 ***				
Strategic response (SR)		0.575	0.730	0.721	0.732
SR1: The enterprise has sought new customer groups or new markets due to the situation surrounding COVID-19 pandemic	0.794 ***				
SR2: The enterprise has sought new suppliers or other new external relations due to the situation surrounding COVID-19 pandemic	0.721 ***				

Note: RMSEA: 0.090; CFI: 0.937; TLI: 0.843. \*\*\*  $p < 0.01$ .

### Appendix B. Mapping of Approaches to Innovation Based on CIS2020 for Norwegian Firms

As in [35], we use an exploratory factor analysis to reveal different approaches to innovation practiced by Norwegian companies (innovation practices) in the period of 2018–2020. We construct the same indicators for R&D and innovation activity in the company, including innovative collaboration, as well as different types of investments, strategies and organization of work in the company, etc. as in [35]. According to various criteria, we retain eight factors for further analysis (see Figure A1 for a list of the different criteria), which almost correspond to the eight main criteria in [35], with slight changes, during the pandemic (see Table 2 in Section 2.3 for a comparison and the details on the changes).



**Figure A1.** Proportion of variance explained by each factor; cumulative proportion of variance and difference in eigenvalues by factor number based on CIS2020.

Table A2 below reports which factors were identified in the data from Statistics Norway’s Innovation Survey (CIS2020), the factor loadings different indicators and our interpretation of the identified factors.

**Table A2.** Factor loadings of the indicators for the eight approaches to innovation. The table rows correspond to the indicator variables, built on the firms' answers to the 2020 Norwegian Innovation Survey (CIS2020); the columns correspond to the eight approaches to innovation retrieved by the factor analysis. The names of the approaches to innovation have been chosen according to the indicator variables with highest factor loadings.

Main topic	Variable	Active R&D Doers	Radical Innovators	Process Developers	Strategic Adaptors	Innovation Suppliers	Hard-Trying Innovators	Knowledge Absorbers	Individual Services Suppliers
		Faktor1	Faktor2	Faktor3	Faktor4	Faktor5	Faktor6	Faktor7	Faktor8
Market for the firm's main product	d_sigmarloc	-0.285	-0.354			-0.265			
	d_sigmarnat		0.233						0.375
	d_sigmareur	0.274							-0.261
	d_sigmaroth	0.186				0.269			-0.321
Firm's strategies	d_straimp				0.691				
	d_straint		0.476		0.523	0.246			
	d_stralow				0.498				
	d_straqu		0.203		0.860				
	d_straran				0.645				0.218
	d_strafoc				0.287				-0.399
	d_straest				0.756				
	d_stranew		0.208		0.655				
	d_strasta				0.536				-0.242
d_stracus				0.626					
Co-creation and customisation	d_specoc	0.216	0.427		0.212			0.285	0.313
	d_specom	0.286	0.552		0.263	0.275			0.220
	d_specus		0.389		0.346				0.341
Use of IPRs	d_propat	0.462	0.293			0.596			-0.285
	d_prodes	0.245				0.674			
	d_protm	0.257	0.280	0.207		0.576			
	d_prosec	0.394	0.380			0.502			
	d_procp					0.638			
Sales and purchases of IPRs to/from other firms	d_intoth					0.658			
	d_intlic	0.239	0.224			0.657			
	d_intsha	0.307	0.245			0.520		0.244	
	d_intbpr	0.225				0.652			
	d_intbpu	0.282				0.558		0.268	

Table A2. Cont.

Main topic	Variable	Active R&D Doers	Radical Innovators	Process Developers	Strategic Adaptors	Innovation Suppliers	Hard-Trying Innovators	Knowledge Absorbers	Individual Services Suppliers
		Faktor1	Faktor2	Faktor3	Faktor4	Faktor5	Faktor6	Faktor7	Faktor8
Acquisition of knowledge	d_kno_research	0.455		0.230	0.302			0.514	
	d_kno_proforg	0.310		0.222	0.230			0.540	
	d_kno_data	0.419				0.334		0.370	
	d_kno_network		0.246	0.262				0.551	
	d_kno_other	0.215				0.247		0.444	
Skills management	d_worrot			0.271	0.336				
	d_worbra	0.199	0.261	0.287	0.362	0.206		0.331	
	d_worwor	0.295	0.216	0.312	0.325	0.222		0.400	
	d_worcom			0.263	0.389			0.491	
Product innovation and the degree of its novelty	d_inpd_good	0.333	0.595	0.223	0.262	0.302			
	d_inpd_serv	0.210	0.565	0.401					0.279
	d_newmktloc	0.224	0.686	0.226					
	d_newmktnat	0.299	0.802						
	d_newmkteur	0.336	0.778						
	d_newmktoth	0.302	0.746				0.251		−0.211
	d_newfrm	0.240		0.303	0.256				0.274
Process innovation	d_inpcs_prod	0.332	0.362	0.576					
	d_inpcs_log			0.704					
	d_inpcs_ict			0.785					
	d_inpcs_adm			0.766					
	d_inpcs_nw			0.783					
	d_inpcs_hr			0.805					
	d_inpcs_mkt			0.738					
Formal R&D activities	d_rrd_int	0.648	0.504			0.288	0.223		
	d_rrd_ext	0.732	0.270			0.245			
	d_rrd_cont	0.563	0.507			0.324			
Other innovation activities	d_invinno_perc	0.203	0.397				0.271	0.204	
	d_invinno_ext	0.310		0.240			0.281	−0.258	
	d_invinno_tech	0.208		0.397			0.201	−0.349	
	d_invinno_zero	−0.408	−0.292	−0.383			−0.378		−0.209

Table A2. Cont.

Main topic	Variable	Active R&D Doers	Radical Innovators	Process Developers	Strategic Adaptors	Innovation Suppliers	Hard-Trying Innovators	Knowledge Absorbers	Individual Services Suppliers
		Faktor1	Faktor2	Faktor3	Faktor4	Faktor5	Faktor6	Faktor7	Faktor8
Expectations regarding innovation expenditures next period	d_exp_up		0.249				0.258		−0.226
	d_exp_fixed	0.242							0.190
	d_exp_down								0.109
	d_exp_zero	−0.205				−0.284	−0.298		
	d_exp_not								
Collaboration in innovation activities (including formal R&D) by type of collaborator	d_coop_group	0.701							
	d_coop_consult	0.793							
	d_coop_suppl	0.784		0.255					
	d_coop_custom	0.652	0.349						
	d_coop_compet	0.569		0.260					
	d_coop_otherf	0.478							0.248
	d_coop_high	0.792	0.204						
	d_coop_publ	0.562	0.255					0.400	
d_coop_noinno	0.580						0.231		
Collaboration in innovation activities (including formal R&D) by location of collaborator	d_coop_loc	0.721					0.223		
	d_coop_norw	0.811	0.204						
	d_coop_nordic	0.709							
	d_coop_eur	0.766				0.271			
	d_coop_world	0.679	0.282			0.256			
Hampering factors for innovation	d_hemp_fin	0.254	0.241				0.742		
	d_hemp_cost						0.789		
	d_hemp_skills						0.718		
	d_hemp_mkt	0.225					0.671		
Funding for innovation activities	d_fin_owni	0.257	0.519			0.241	0.253		−0.505
	d_fin_loan	0.274	0.402	0.206			0.361		−0.280
	d_fin_publ	0.583	0.426				0.284		−0.159
Technology adoption	d_tech_pro	0.208		0.300	0.258				0.203
	d_tech_new	0.284	0.237	0.403					

Note: For a definition of the variables, see Appendix A in [35].

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