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# The COVID-19 Crisis, Digitalization, and Organizational Change



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## **ABOUT THIS PAPER**

This paper presents the findings of the research project “Automatization, digitalization and virtualization of work in the aftermath of the COVID-19 crisis”.

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Weizenbaum Discussion Paper

# The COVID-19 Crisis, Digitalization, and Organizational Change

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## \\ Abstract

The study explores the impact of the COVID-19 pandemic on the digitalization and organizational changes in companies across different sectors in Germany. The research addresses the extent to which the pandemic accelerated digitalization, the variations in digitalization focus among companies, and the interplay between technological and organizational changes. Data were collected through surveys conducted in two waves in 2021 and 2022, encompassing 540 and 605 companies, respectively. The research employed ordered logistic regression to analyze the factors influencing digitalization investments. Key findings indicate that the pandemic acted as a catalyst for digitalization, with management awareness and employee acceptance being significant drivers. Notably, there were disparities in digitalization efforts, influenced by the economic impact of the pandemic, sectoral differences, and prior levels of digitalization. While companies with existing digital infrastructure initially led the way, less digitalized companies began to catch up over time. Organizational changes, such as new leadership concepts, cross-functional cooperation, and flexible working hours, were also linked to increased digitalization efforts. The study concludes that the pandemic has not only accelerated technological changes but also necessitated parallel organizational transformations to support these developments.

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# 1 Introduction

The COVID-19 pandemic was widely viewed as a massive crisis and a rupture in the functioning of the economy and organizations. It caused an abrupt collapse of both the demand and supply side, which had a massive impact on the world of work. It was also perceived as an accelerator of technological change, as it was argued that digitalization and automation offered a great opportunity for overcoming the crisis (Amankwah-Amoah et al., 2021; Biondi, 2021; Korinek & Stiglitz, 2021; OECD, 2020). However, some studies question the positive effects of the pandemic on digitalization (Arntz et al., 2024).

The effects of the pandemic on the world of work have already been examined by a number of studies. However, these have mainly addressed the impact of remote work during the pandemic, emphasizing issues related to working and living conditions or inequalities between groups of employees (Aloisi & De Stefano, 2022; Babapour Chafi et al., 2021; Smite et al., 2023). The effects of the Covid-19 pandemic on organizational change beyond remote work have not yet been systematically researched. A few studies have investigated the development of investments in digitalization during the crisis (Bellmann et al., 2021) and the strategies of companies in different sectors (Butollo et al. 2024; Dyba & Di Maria, 2023), but a systematic picture of the relationship between the pandemic, the implementation of digital technologies, and organizational change, is lacking.

In this paper, we contribute to filling this gap by addressing the relationship between technological change and organizational change during the Covid-19 pandemic from the perspective of companies. To examine developments and changes over the course of the pandemic, we use a survey that we conducted in Germany of 540 companies in 2021 and 605 companies in 2022. We examine how the pandemic affected technological and organizational change in administrative processes, human resources (HR), product development, sales, and production and service processes. We operationalize our main research question on the relationship between the pandemic, the implementation of digital technologies, and organizational change, with three sub-questions:

1. To what extent did the COVID pandemic lead to a boost in the digitalization of companies?
2. How and why did the focus of digitalization during the pandemic differ between companies?
3. How were technical and organizational change processes linked during the COVID pandemic?

Our study provides differentiated insights on how the pandemic affected companies, highlighting exposure to the pandemic and its impact on management awareness and acceptance by employees as important conditions that facilitated investment in digitalization measures. We disaggregate the term “digitalization” to highlight core areas of activity and the unevenness of these activities according to sectors and prior levels of digitalization. We also track the sequence of events, indicating how a gap between pioneers and laggards was followed by previously less digitalized companies catching up. Finally, our study provides evidence for the entanglement of technological and organizational changes in digitalization projects.

First, we develop hypotheses on the relationship between the pandemic and digitalization, the possible reasons for the unequal exposure of companies, and the relationship between technological and organizational change, alongside a discussion of the relevant literature on these issues (Section 2). We then explain the research design and methods and provide a descriptive analysis of our sample (Section 3), before displaying the results on the relationship between the pandemic and digitalization (Section 4.1), inequalities of these developments between companies (Section 4.2) and sectors (Section 4.3), and the relationship between technological and organizational change (Section 4.4). In the discussion, we relate these findings to the hypotheses and outline the findings of our study in detail (5), which we then summarize with general conclusions on the impact of the pandemic on digitalization in companies.

## 2 State of research and hypotheses

### 2.1. The pandemic as a boost for digitalization

The COVID-19 pandemic caused a global economic crisis. It disrupted global supply chains and production and service processes (Borio, 2020; Pujawan & Bah, 2022) on a scale unseen for a long time. It led to massive government intervention (also long unseen) to support businesses and households, at least in Europe and North America (Greer et al., 2021). A number of experts expected that the economic, social, and health consequences of the COVID-19 crisis would also have long-term effects and would provide a strong push for digitalization (including automation) (Amankwah-Amoah et al., 2021; Biondi, 2021; Korinek & Stiglitz, 2021; OECD, 2020).

The COVID pandemic had a massive impact on companies. It broke out while economies were undergoing a socio-technical transformation known as digitalization (Brynjolfsson & McAfee, 2014). Digitalization is understood here as the establishment of networks between machines/computers as well as the use of software systems and digital databases for monitoring, controlling, and optimizing work processes (Krzywdzinski, 2021).

Crises can accelerate or slow down processes of technological transformation in organizations. We build on the concept of crisis as “a low probability, high-impact situation that is perceived by critical stakeholders to threaten the viability of the organization” (Pearson & Clair, 1998, p. 66). As Wenzel et al. (2021) elaborate, companies can respond to crises in four ways: they can act defensively and (1) retrench their operations or even (2) exit the market; they can (3) try to persevere without adapting their products and processes; they can finally (4) respond to the crisis with innovation. Due to the scale and the specific nature of this crisis, we can assume that the preservation of many established products and processes was challenging, leaving aspects of digital innovation as the most viable alternative to retrenching operations or exiting the market. Such innovation under crisis conditions, however, requires specific conditions: knowledge and other resources as well as opportunities for new products and/or processes.

The Covid-19 pandemic affected all companies and industries. As a result of the lockdowns, many companies had to find solutions for remote working, though the impact of the pandemic went beyond that. Administrative processes had to be digitalized. The restrictions also meant that traditional sales channels often collapsed and had to be digitalized. Supply chains were interrupted, creating incentives for the digitalization of supply chain management. However, the pandemic also created obstacles to digitalization. Many companies struggled with short-term financing problems, while others were overwhelmed by the task of quickly digitizing processes and products (Bellmann et al., 2021; Butollo et al., 2024). Arntz et al. (2024) show that digitalization investments during the pandemic were mainly related to remote work opportunities, while larger investment projects in digital technologies that were not directly useful for pandemic management were partly postponed.

Based on the existing literature, we can formulate the first hypothesis for the analysis. It relates to the first question of the extent to which a digitalization push can be observed at all as a result of the COVID pandemic. It is assumed that the need and opportunities for digitization provided a strong incentive for change during the crisis.

**H1:** Companies increased their digitalization investments during the COVID pandemic.

## 2.2. Unequal digitalization processes

Research emphasizes that digitalization is a process that takes place at different speeds and depths in different countries, sectors, and also types of companies (Corrocher & Ordanini, 2002). Our second research question asks whether such differences also accounted for the digitalization push in the wake of the COVID pandemic and the reasons for such differences. Several explanations for unequal digitalization during the pandemic can be found in the literature.

We can expect investment in digitalization to be related to the immediate pressures of the pandemic, management awareness, and employee acceptance of digitalization measures. The crisis came unexpectedly, but companies were affected differently and the perception of management and employees varied (Bellmann et al., 2021; Butollo et al., 2024).

**H2a:** Investment in digitalization during the COVID pandemic is related to the economic impact of the pandemic on the companies.

**H2b:** Investment in digitalization during the COVID pandemic is related to the awareness of management of the need for digitalization.

**H2c:** Investment in digitalization during the COVID pandemic is related to the acceptance of employees of the need for digitalization.

Path dependencies can also be expected. It can be expected that those companies that already had experience with digitalization had better conditions for pushing digitalization further during the pandemic. Avalos et al. (2023) show that the gap between more and less digitalized companies widened during the pandemic. Abidi et al. (2023) conclude that companies with a higher degree of digitalization showed greater resilience during the crisis.

**H2d:** Investment in digitalization during the COVID pandemic is related to the level of digitalization before the pandemic.

We can also expect differences between sectors. These differences are based on the specifics of the products and processes in different sectors. Seetharaman (2020) emphasizes that the type of product and processes influenced how companies responded to the crisis. He argues that companies with products and processes with a high potential for digitalization were those which used the crisis as a boost for investing in digitalization. Rapaccini et al. (2020) argue that the major point is the potential to develop digital services based on existing products. They expect significant differences between sectors or even subsectors based on how much the companies' products can be used to develop digital services. Ritter and Pedersen (2020) similarly emphasize that crises can lead to business model innovations. Customer behavior and demand can change significantly, forcing companies to adapt the value proposition and value demonstration of their products. This also requires companies to develop new capabilities (see also Kronblad & Envall Pregmark, 2021).

Previous studies provide a partial insight into these differences. Changes to customer relations was the focus of the study by Nanda et al. (2021). The authors argue that the COVID crisis challenged the retail sector; pure brick-and-mortar retail collapsed and retailers had to rely on multi-channel retail models combining physical and online sales. Other studies have focused on the digitalization potential of processes. Bellman et al. (2021), Butollo et al. (2024), and Dyba & Di Maria (2023) showed that service sectors invested much more in digitalization during the pandemic than manufacturing sectors. They explain this by the much higher potential for digitalization of processes in service sectors. Butollo et al. (2024) showed that digitalization was particularly strong in those sectors in which communication with customers and sales could be



digitalized and automated. In the case of logistics, Medyakova et al. (2020) argue that the partial collapse of global supply chains into the COVID crisis led to a reorganization of global transportation, creating favorable conditions for increased implementation of digital tools in logistics.

We expect the focus of investments and digitalization projects to differ between sectors. While some sectors may focus on the digitalization of the product and its marketing and distribution, other sectors will focus on the digitalization of processes, whereby the measures may be geared more towards administrative processes, supply chains, or production processes.

**H2e:** There is significant heterogeneity in the extent and focus of digitalization by sector.

Finally, we can expect inequalities based on company size. In particular, small and medium companies struggle to muster the skills and resources needed for digital transformation (Bellmann et al., 2021; Klein & Todesco, 2021). As these inequalities are well researched, we did not focus on them, but treat company size as a control variable.

### 2.3. Technical and organizational change

Our final research question focuses on the relationship between technical and organizational change. Research in the field of science and technology studies (STS) has emphasized that the implementation of new technologies has to be accompanied by changes to work practices, organizational routines, and roles (Barley, 2020).

With regard to digitization processes during the COVID-19 pandemic, research has had a strong focus on the proliferation of remote work. In public discourse and in academic studies, the transition towards remote work has often been treated as a proxy for the digitalization push as a whole. Due to the containment measures implemented during the pandemic, large parts of the workforce—estimated at nearly 50% of total employment in the US (Brynjolfsson et al., 2020) and about 30% in Germany (Frodermann et al., 2021)—had to work from home and were not allowed into their offices. This led to new pressures (Hodder, 2020), with research focusing on the dangers of increasing surveillance of work through digital tools (Hodder, 2020) and the de-limitation of working hours (Shirmohammadi et al., 2022). Where remote work was not possible, employees were sometimes confronted with greater demands and stresses due to increasing work intensity, with employees reporting an overload during the pandemic—particularly in care professions and the retail trade (Cai et al., 2021; Chaudhry et al., 2021; Vermeerbergen et al., 2021).

By contrast, there has been relatively little research on the extent to which companies responded to the crisis by accelerating digitalization and changing their organization. Working in remote or hybrid teams requires digital work processes and the corresponding infrastructures. It must also be complemented by organizational adaptation. Activities to strengthen exchanges within teams and between different teams and functions are important (Krzywdzinski & Butollo, 2022). The roles of supervisors need to change, as noted in the management literature (Chamakiotis et al., 2021; Gierlich-Joas et al., 2020); because remote or hybrid teams are much harder to monitor, it might be necessary to shift supervisory roles towards coaching and supporting employees and strengthen the self-organization of teams. Finally, working time practices need to be changed. Remote work allows for more flexible working hours, but these must be regulated if they are not to lead to extensive working hours and stress (Möhring et al., 2021).

Our final hypothesis therefore focuses on the relationship between the successful deepening of digitalization during the COVID pandemic and organizational changes in the companies.

**H3:** There is a relationship between investments in digitalization during the COVID pandemic and organizational innovations implemented during this period.

### 3 Research design

Our analysis is based on a survey of companies conducted to investigate the extent to which the pandemic led to a strategic reorientation of digitalization measures in companies (Butollo et al., 2023). In line with the hypotheses, the aim was to investigate whether digitalization measures were newly established and intensified, in which areas digitalization took place, and how the digitalization measures differed depending on the company's level of digitalization, sector, and size. The data set is available with open access here: <https://www.weizenbaum-library.de/items/1256c72e-cd2a-4714-beec-225b8bb522f4>

A particular strength of our research design was that we conducted the survey in two waves: in summer 2021 and fall 2022. We expected that there could be differences between companies' approaches at the beginning and later in the course of the pandemic. We also wanted to check whether companies' strategies solidified over time or whether they were just short-term reactions.

For the survey, we selected six sectors which are economically highly relevant and in which strong effects of the COVID pandemic could be expected: automotive, chemical, and machine building as manufacturing sectors, and health, financial services, and logistics as service sectors. We compared the manufacturing and service sectors so we could discuss questions of heterogeneity of responses to the crisis. We excluded hospitality and construction—sectors which were strongly hit by the pandemic but where we did not expect a major digitalization push.

We surveyed 540 companies in the first wave and 605 companies in the second wave. 120 companies participated in both waves. The respondents belonged to the top management of the companies. The sampling combined random selection with quotas by sector.

The composition of the sample reflects this strategy (see Table 1). Two thirds of the companies interviewed are small companies with less than 50 employees, and another quarter are companies with 50 to 249 employees. Just under 9% of the companies surveyed had 250 employees or more. Only in the case of the automotive industry was the proportion of large companies in our sample significantly higher than in the overall population in this sector.

Table 1: Composition of the sample

	All companies		Companies participating in both survey waves	
	2021	2022	2021	2022
<b>Companies by size</b>				
1–49 employees	62.6% (n=338)	57.7% (n=349)	52.5% (n=63)	
50–249 employees	24.6% (n=133)	34.5% (n=209)	40.0% (n=48)	
> 249 employees	8.5% (n=46)	5.3% (n=32)	6.7% (n=8)	
No answer	4.3% (n=23)	2.5% (n=15)	0.8% (n=1)	
<b>Companies by sector</b>				
Automobile	8.0% (n=43)	3.1% (n=19)	8.3% (n=10)	
Chemical	19.1% (n=103)	11.9% (n=72)	20.0% (n=24)	
Financial services	17.4% (n=94)	25.0% (n=151)	17.5% (n=21)	
Health	17.8% (n=96)	22.2% (n=134)	16.7% (n=20)	
Logistics	18.9% (n=102)	26.1% (n=158)	17.5% (n=21)	
Machine building	18.9% (n=102)	11.7% (n=71)	20.0% (n=24)	

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**Impact of COVID pandemic on the company**

No impact	23.3% (n=126)	7.4% (n=45)	21.7% (n=26)	8.3% (n=10)
Weak impact	21.5% (n=116)	11.2% (n=68)	21.7% (n=26)	6.7% (n=8)
Moderate impact	29.3% (n=158)	34.2% (n=207)	38.3% (n=34)	30.0% (n=36)
Strong impact	14.1% (n=76)	26.1% (n=158)	15.0% (n=18)	35.8% (n=43)
Very strong impact	8.1% (n=44)	16.9% (n=102)	10.8% (n=13)	18.3% (n=22)
No answer	3.7% (n=20)	4.1% (n=25)	2.5% (n=3)	0.8% (n=1)
<b>Total</b>	540	605	120	120

Source: Authors

The extent to which companies were affected by the COVID pandemic varied greatly and changed over time. In 2021, only about a quarter of the surveyed companies reported being strongly or very strongly affected by the consequences of the pandemic. Just under 30% reported being partially affected. Almost 44% were hardly or not at all affected. There was hardly any difference in the degree to which companies were affected between the sectors surveyed. The picture changed in 2022. Then, over 40% of surveyed companies reported being strongly affected by the pandemic, and only slightly below 20% reported no or only a weak impact.

Prior to the pandemic, the companies in the sample were largely in good economic shape. Just under a quarter reported stagnant growth or declines in pre-pandemic sales. Three-quarters had grown before the pandemic, in some cases very strongly.

In the survey, we systematically asked to what extent companies had introduced new digitalization measures or accelerated existing digitalization measures in the areas of administration, training, recruiting & HR, sales & customer relations, production or services, supply chain management, and product development.

Table 2 shows the descriptive statistics for the major variables used in our analysis.

We measured the companies' level of digitalization before the pandemic as an ordinal variable with the values "no digitalization" (1), "low digitalization with isolated digital applications" (2), "partial digitalization with many individual digital applications in all departments" (3), "strong digitalization with digitally networked applications in all departments" (4), and "very strong digitalization with end-to-end and cross-departmental digital workflows" (5).

We operationalized the increase in investment in digitalization during the Covid-19 pandemic as an ordinal variable with the values “no increased investment in digitalization” (1), “partially increased investment in digitalization” (2), and “strongly increased investment in digitalization” (3). We measured the influence of the Covid-19 pandemic on managers’ awareness of the need to digitalize products and processes as an ordinal variable with the values “no increased awareness” (1), “partially increased awareness” (2), and “strongly increased awareness” (3). We measured the acceptance of digitalization measures by employees using an ordinal variable with the values “not increased at all” (1) to “strongly increased” (5).

We operationalized the impact of the Covid-19 pandemic on companies with an ordinal variable ranging from “no impact” (1) to “very strong impact” (5). For the variables relating to organizational changes (introduction of new management concepts, strengthening of cross-functional cooperation, more flexible working hours), we used a scale from “no new measures at all” (1) to “very strong implementation of new measures” (5). We measured the size of the companies using an ordinal variable ranging from “1-9 employees” (1) to “more than 2,000 employees” (7).

Table 2: Descriptive statistics of core variables (both survey waves)

<b>Variable</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>
Digitalization level before the pandemic	1,122	3.35	1.05	1	5
Covid-19 led to increased investments in digitalization	1,100	1.97	0.79	1	3
COVID-19 increased awareness of the need to digitalize	1,114	2.09	0.80	1	3
COVID-19 increased acceptance of digitalization	1,080	2.99	1.25	1	5
Impact of Covid-19 pandemic on company	1,100	3.00	1.24	1	5
Introduction of new leadership concepts	1,085	2.21	1.34	1	5
Strengthening cross-functional cooperation	1,096	2.66	1.44	1	5
More flexible working times	1,106	2.59	1.57	1	5
Company size	1,107	2.18	1.11	1	7

Source: Authors.

## 4 Empirical analysis

### 4.1. COVID as a push for investment in digitalization

The COVID crisis had a clear and abrupt impact on companies' digitalization strategies (hypothesis H1). In 2021, 46.7% of the surveyed companies reported that the COVID pandemic had increased management awareness of the need for digitalization. 39.8% of companies reported that they had increased investment in digitalization in the context of the COVID pandemic. 39.3% of companies stated that the COVID pandemic had increased the acceptance of digitalization measures among employees.

To examine how this impact of the COVID pandemic evolved over time, we focus on the 120 companies which participated in both survey waves in 2021 and 2022. This subsample shows that the impact of the pandemic on digitalization strategies was strongest in the first phase of the pandemic. In 2021, 47.5% of those companies reported that the COVID pandemic had increased management awareness of the need for digitalization; in 2022 the share dropped to 29.2%. Investments in digitalization due to the COVID pandemic were reported by 41.4% of companies in 2021 and 20.8% in 2022. Only the impact of the pandemic on acceptance of digitalization measures by employees remained constant; a positive impact was reported by 41.7% of companies in 2021 and by 45.8% in 2022.

Overall, the pandemic led to a sustained strengthening of digitalization efforts in 20-30% of the companies in our sample. For a further 10-20% of companies, the crisis resulted in short-term investments which were not continued. However, this decrease in investment between 2021 and 2022 does not necessarily mean that digitalization became less prominent over the course of the pandemic. Rather, it is to be expected that many companies invested in the modernization of their digital infrastructures right at the beginning of the pandemic, on the basis of which longer-term digitalization projects were then launched. We discuss this in Section 4.3.

### 4.2. Inequalities in digitalization during the pandemic

Before the pandemic, the level of digitalization differed significantly between sectors. The automotive sector was the most digitalized (40.5% of the surveyed companies reported strong or very strong digitalization), while mechanical engineering and the chemical sector were somewhat less digitalized (34.6% and 34.0%, respectively). Among the service industries surveyed, the financial services industry stood out (35.1%), followed by the healthcare sector (31.9%), with logistics trailing behind (21.5%). Overall, the manufacturing sectors were more digitalized than the services sectors. The relatively high level of digitalization in financial services is related to the strong shift toward online banking, which has been accompanied by branch closures for some time. The particularly low level of digitalization in logistics can be explained by the type of companies included in the sample. In this sector, it is predominantly small transport companies, not the large logistics groups.

The following ordered logistic regression (Table 3) analyzes how different conditions affected investment in digitalization measures.

Our hypothesis H2a focuses on the role of the economic impact of the pandemic, H2b on managerial awareness, and H2c on the acceptance of digitalization measures among employees. Companies that were directly hit by the effects of the pandemic showed a higher probability of increasing investments in digitalization (odds ratio 1.20;  $p > 0.05$ ). There was also a very strong correlation between investments and the increased level of managerial awareness of the need for digitalization as a result of the pandemic (5.88;  $p < 0.01$ ) and the increased acceptance of digitalization measures among employees (1.53;  $p < 0.01$ ). Hypotheses H2a, H2b, and H2c were confirmed. Size of the company did not play a big role in the first phase of the pandemic as small and big companies were forced to react to the new challenges. Over time, however, the bigger companies showed a higher propensity to continue investments in digitalization measures.

There was no robust and statistically significant relationship between the initial digitalization level of companies before the pandemic and the propensity to invest in digitalization during the pandemic (hypothesis H2d). During the first phase of the pandemic, companies with no digitalization tended to invest less in digitalization than companies with at least low, partial, or even high levels of digitalization. This can be understood as increasing polarization—the least digitalized companies were left behind. However, in 2022 the coefficients changed and companies with no and low digitalization levels showed a higher probability of investing in digitalization; this could be a sign of a catch-up process.

Table 3: Higher investments in digitalization during the COVID pandemic (ordered logistic regression, odds ratios, standard errors in brackets)

<b>Independent variables</b>	<b>2021</b>	<b>2022</b>
Economic impact of the COVID pandemic on the company	1.20 (0.10)*	1.24 (0.12)*
COVID pandemic increased awareness of the need to digitalize	5.88 (0.93)**	8.51 (1.48)**
COVID pandemic increased acceptance of digitalization	1.53 (0.14)**	1.54 (0.15)**
Number of employees	1.14 (0.11)	1.53 (0.16)**
Digitalization level before the pandemic (reference: no digitalization)	Covid	Covid
Low digitalization	1.45 (0.73)	0.86 (0.56)
Partial digitalization	2.03 (0.98)	0.67 (0.40)
Strong digitalization	1.49 (0.74)	0.64 (0.39)
Very strong digitalization	1.86 (1.11)	0.59 (0.36)
N	469	540
Pseudo-R <sup>2</sup>	0.28	0.30

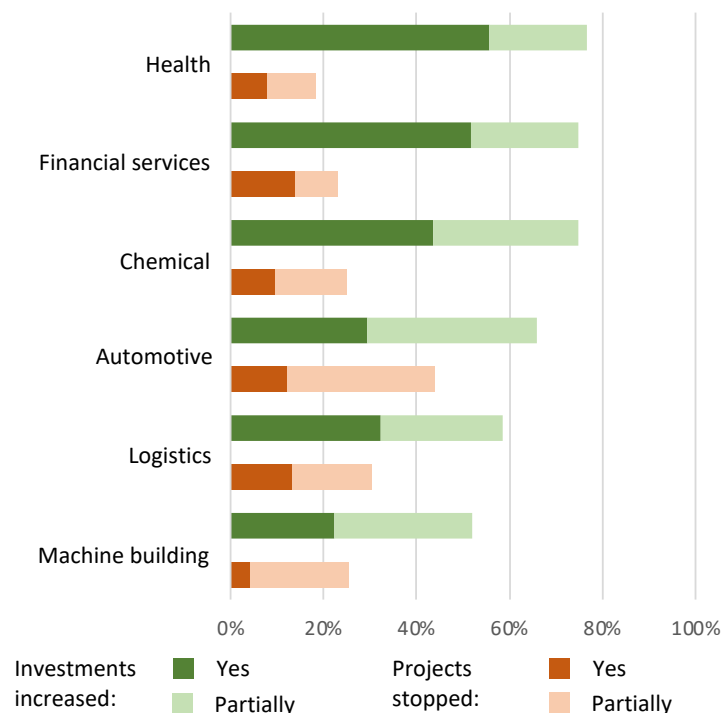
Source: Authors. Control variables: Sectors

While the COVID pandemic led to an increase in investment in some companies, in others it resulted in a halt or slowdown in digitalization processes, as companies ran into economic difficulties or had to set other priorities. This point is emphasized in particular by Arntz et al. (2024). The authors argue that a number of previously planned investment projects were halted during the pandemic. Although many companies invested in digitalization to enable remote working, this could not compensate for the halt of many other digitalization projects.

The findings of Arntz et al. (2024) are compatible with ours insofar as we have no information and hence make no statements regarding the amount of investments made or halted by the companies. Figure 1 shows that there was certainly a considerable proportion of companies that stopped investment projects during the pandemic, although there are considerable sectoral differences (H2e) in the relationship between the increase in investment and the halting of digitalization projects. Our data only tells us whether projects were started and stopped, but not how large they were in each case.

In some sectors, such as the automotive industry, the proportion of companies with halted projects was relatively high. This industry experienced a massive drop in demand and a disruption of supply chains, both of which impacted production and sales. Under these conditions, 43.9% of the companies surveyed in 2021 reported that digitalization projects were completely or partially stopped during the pandemic. The corresponding figures are 30.3% in logistics, 25.5% in machine building, and 25.0% in the chemical industry. The negative impact of the pandemic was lowest in financial services (23.0%) and the healthcare sector (18.4%). In 2022, very similar numbers were reported.

Figure 1: Investments in digitalization and halting of digitalization measures in six sectors, 2021





The sectoral differences are linked to market changes, particularly customer (demand side) expectations (Butollo et al., 2024). In the financial industry, there has long been a trend towards shifting services online. During the pandemic, many people were forced to use online financial services, changing demand behavior in the long term. In healthcare, digitalization had long suffered from a lack of resources. However, faced with the need to target pandemic measures, the German government changed its behavior and significantly increased investment in digitalization. In the chemical sector, the fact that the industry was significantly less affected by the disruptions to demand and production than the automotive and mechanical engineering sectors had a beneficial effect on investment in digitalization. Companies' revenues did not collapse, making it easier to mobilize investments in new technologies.

The automotive and mechanical engineering industries, by contrast, were hit hard by the economic collapse of the Covid-19 crisis. Demand structures did not change, but investments were partially postponed during the crisis.

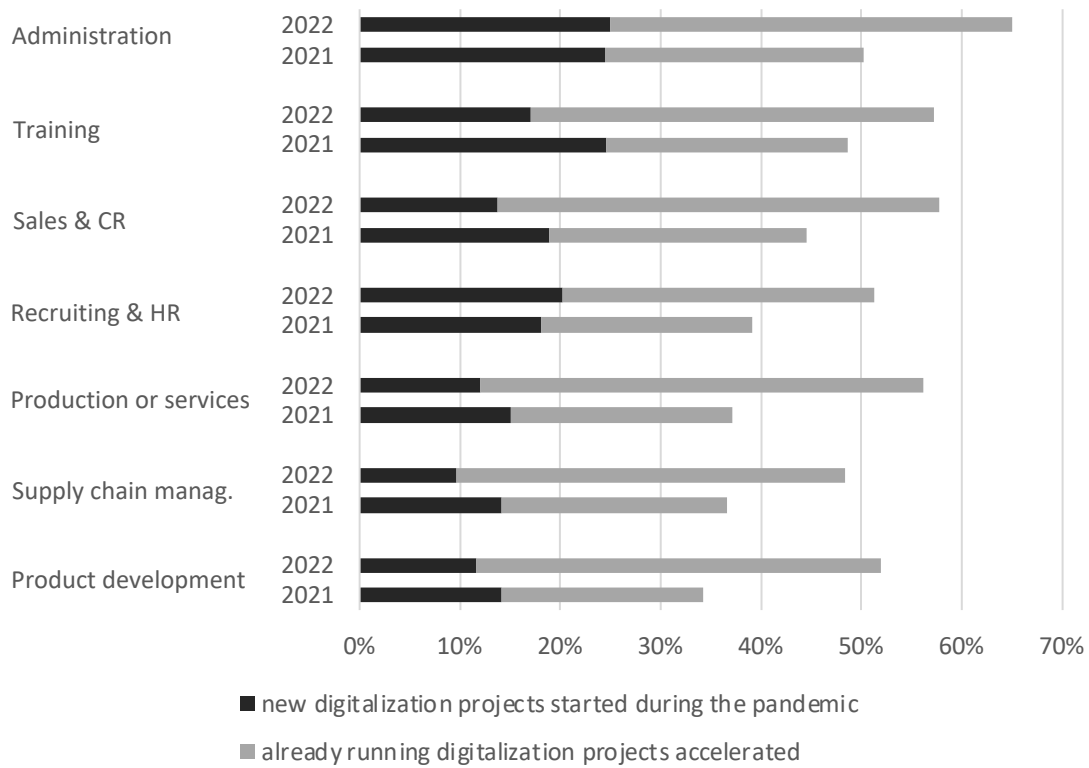
### 4.3. Sectoral differences in major domains of digitalization during the pandemic

The item "Investments in digitalization" does not yet indicate which specific digitalization projects are implemented. In addition, only some digitalization projects require major investments. The following argument therefore focuses on specific digitalization projects that were initiated or accelerated by companies during the pandemic.

At the beginning of the pandemic, it was expected that there could be a surge in automation in production and services, as lockdowns seemed to reinforce the advantages of automated processes over human labor. However, as Figure 2 shows, digitalization was particularly focused on administrative processes, training, sales, and customer relations (CR), closely followed by recruiting and HR. This point also confirms the findings of the study by Arntz et al. (2024), which found an accelerated digitalization of processes that are relevant for remote work, but at the same time emphasized the postponement of Industry 4.0 investment projects. The digitalization projects launched during the pandemic can therefore be described as less capital-intensive.

These focal points can be explained by the conditions of the pandemic. The need for remote work led to a pressure to convert administrative and HR processes to digital infrastructure; this was necessary for the functioning of organizations and also much easier than to automate production or service provision processes. On the other hand, the strengthening of online sales in view of the restrictions on face-to-face customer relations became a necessity for all sectors, and this was particularly pronounced in financial services. In contrast, there was considerably less activity in the areas of production, supply chain management, and product development, particularly in the first phase of the pandemic (2021).

Figure 2: Which digitalization processes were newly established or accelerated during the COVID-19 pandemic?



Source: Authors

The picture changed somewhat over the course of the pandemic. In almost all sectors, the proportion of companies reporting new digitalization projects decreased, while the proportion of companies reporting an acceleration of ongoing digitalization projects increased very sharply. This is to be expected, as many new projects were started in direct response to the pandemic. Companies then focused on their implementation. While Figure 2 includes data from the complete survey, the same picture also emerges if we only look at those companies that participated in both waves; the proportion of companies with new digitalization projects decreased slightly from 2021 to 2022, while the proportion of companies accelerating ongoing digitalization projects increased significantly.

A second change over the course of the pandemic was that projects in the areas of production, supply chain management, and product development gained in importance and caught up with projects in administration and HR.

There were sector-specific developments, as Table 4 shows (hypothesis H2e). Comparing sectors, administration was among the top three focus areas in five cases (with the exception of the chemical sector). Recruiting/HR and training were also often among the top three digitalization fields. Sales was among the top three fields in chemicals, financial services, and mechanical engineering.

In the automotive industry and logistics, supply chain management was one of the top three digitalization fields. These were the industries most affected by the collapse of supply chains.

While there were no changes in the focus of digitalization projects in the automotive, health, and logistics sectors over the course of the pandemic, the digitalization of training became slightly less important in the chemical sector, financial services, and machine building. On the other hand, digitalization projects in production and the provision of services moved up the priority list.

Table 4: Most important areas of digitalization or automation by sector (% of companies indicating new projects or acceleration of running projects)

	2021	2022
<b>Automotive</b>	Administration (41.0%)	Administration (63.2%)
	Supply chain management (41.0%)	Recruiting and HR (57.9%)
	Recruiting and HR (39.5%)	Supply chain management (47.4%)
<b>Chemical</b>	Sales and CR (57.8%)	Administration (70.8%)
	Recruiting and HR (54.5%)	Sales and CR (66.7%)
	Training (51.7%)	Production/services (63.9%)
<b>Financial services</b>	Sales and CR (72.8%)	Sales and CR (70.9%)
	Training (71.1%)	Administration (67.6%)
	Administration (69.7%)	Production/services (66.2%)
<b>Health</b>	Training (66.7%)	Training (62.7%)
	Administration (34.1%)	Administration (56.0%)
	Recruiting and HR (31.3%)	Recruiting and HR (50.8%)
<b>Logistics</b>	Administration (48.0%)	Administration (70.3%)
	Recruiting and HR (38.1%)	Recruiting and HR (62.0%)
	Supply chain management (37.8%)	Supply chain management (59.5%)
<b>Machine building</b>	Administration (46.3%)	Administration (59.2%)
	Training (35.5%)	Sales and CR (56.3%)
	Sales and CR (34.0%)	Production/services (53.5%)

Source: Authors

## 4.4. Digitalization and organizational change during the COVID pandemic

The last research hypothesis relates to the connection between technical and organizational changes (H3). Our study examined the extent to which companies introduced new leadership concepts, new forms of cross-functional collaboration, and flexible working hours during the COVID-19 pandemic. Changes in all these areas were clearly correlated with each other (pair-wise correlation coefficients between 0.28 and 0.55).

A relatively large minority of companies introduced new measures during the pandemic. The importance of these measures also seemed to increase in the course of the pandemic. In 2021, 16% of the surveyed companies reported putting a strong emphasis on introducing new leadership concepts, 29% reported that they had introduced new measures to foster cross-functional cooperation in and across teams, and 33% that they had introduced new forms of flexible working times. In 2022, the share of companies increased to 29% in the case of new leadership concepts, 49% in the case of measures to foster cross-functional cooperation, and 43% in the case of measures to flexibilize working times.

This increase could be an artefact of the changed composition of the sample in the two survey waves. However, a close look at the 120 companies which participated in both waves confirms most of the findings. In this group, the share of companies which introduced measures to foster cross-functional cooperation increased from 33% in 2021 to 44% in 2022. The increase was from 29% to 55% in the case of measures to flexibilize working times. Only the share of companies introducing new leadership concepts remained nearly stable at 20% in 2021 and 18% in 2022. The trend to introduce organizational change accelerated during the pandemic.

Under what conditions did companies implement these organizational measures? There is a clear correlation between organizational measures and the investment in digitalization during the pandemic, with larger companies more likely to make organizational changes than smaller ones. In the first phase of the pandemic (2021), the direct economic impact of COVID-19 was not related to organizational measures. Companies tried to adapt their organization regardless of whether they were strongly or weakly affected by the pandemic. As Table 6 shows, this changed in 2022. In companies in which the COVID pandemic started to have lasting negative effects, the propensity to introduce organizational change decreased. As companies came under increasing economic difficulties over the course of the pandemic, they became less focused on organizational change and (we assume) more focused on short-term survival measures.

Table 6: Introduction of organizational changes due to COVID-19 pandemic

Independent variables	Dependent variables					
	New leadership concepts		Strengthening cross-functional cooperation		Flexible working times	
	2021	2022	2021	2022	2021	2022
Economic impact of the COVID pandemic on the company	1.04 (0.08)	0.83 (0.07)*	1.13 (0.08)	0.84 (0.06)*	1.01 (0.08)	0.96 (0.07)
COVID pandemic increased awareness of the need to digitalize	1.08 (0.16)	0.98 (0.15)	1.33 (0.18)*	1.06 (0.15)	1.11 (0.16)	0.91 (0.13)
Investments in digitalization during the pandemic	1.69 (0.24)**	1.75 (0.27)**	1.50 (0.20)**	1.64 (0.25)**	1.89 (0.27)**	1.86 (0.28)**
Number of employees	1.73 (0.14)**	1.87 (0.17)**	1.42 (0.11)**	2.07 (0.19)**	1.55 (0.12)**	1.92 (0.17)**
N	473	543	479	545	480	548
Pseudo-R <sup>2</sup>	0.08	0.06	0.06	0.08	0.09	0.07

Source: Authors. Control variables: Sector

A special feature of the Covid-19 pandemic was that it occurred at the same time as other crises. Before the pandemic, geopolitical tensions between the USA, Europe, and China had increased significantly. The final phase of the pandemic also coincided with Russia's attack on Ukraine and the resulting turbulences in world politics and global value chains.

In the second wave of the survey, we asked what impact the digitalization processes triggered by the COVID-19 pandemic had had on companies' resilience to the multi-layered crises. 27% of the surveyed companies responded that the digitalization measures introduced during the COVID-19 pandemic had made a major contribution to organizational resilience to crises, 38% saw a partial contribution, and 26% at least a small contribution to the company's resilience. Only 9% of the surveyed companies saw no contribution at all to the company's general resilience to crises or were unable to provide any information on this.

## 5 Discussion

### A push in digitalization

Our analysis shows that the Covid 19 pandemic certainly acted as a boost to digitalization, although there were also countervailing processes. Digitalization primarily related to remote work and associated administrative and organizational processes (HR, training), while investments in automation were of rather minor importance. In some cases, digitalization projects were halted or slowed during the pandemic due to a lack of resources or a shift in management focus. Overall, the impact of the Covid 19 pandemic on investments was therefore ambivalent. However, the crisis was an event that led to a reinforcement of digitalization strategies in many companies, through new digitalization projects, higher awareness of the need for digitalization by managers, and higher acceptance of digitalization measures among employees. Hypothesis 1 was confirmed.

Our analysis offers particular added value because we conducted the survey twice during the course of the pandemic and can therefore track developments in investments and digitalization projects over time. We can also rely on qualitative case study data to confirm our analysis (Butillo et al., 2024). We can show that the impact of the pandemic on new investments in digitalization was strongest in the first phase of the pandemic and then decreased. The proportion of companies that initiated new investments in digitalization decreased from 2021 to 2022, while the proportion of companies that accelerated ongoing digitalization measures increased. Attention shifted from initiating digitalization investments towards continuous implementation of measures. A majority of companies saw their resilience to crises strengthened due to these measures.

### Inequalities of digitalization

Our research design allows us to systematically analyze the factors that influenced investments in digitalization measures, and we are able to identify the factors responsible for the differences between companies. It can be confirmed that exposure to the pandemic had a positive influence on strengthening the digitalization of companies during the pandemic. Exposure to the pandemic was strongly correlated with increasing managerial awareness of the need for digitalization and increasing employee acceptance of digitalization measures—both are strongly related to investment in digitalization during the pandemic. The influence of these variables remains constant during the course of the pandemic. Hypotheses H2a, H2b, and H2c were confirmed.

Our research offers a differentiated result with regard to the role of path dependencies and the exacerbation of inequalities between more and less digitalized companies, factors that have been highlighted in previous studies (Abidi et al., 2023; Avalos et al., 2023). Our study shows that in the first year of the pandemic, companies with a particularly low level of digitalization actually lagged behind companies that were already more digitalized. However, this ratio was reversed in the second wave of our survey. Less digitalized companies began catching up, although we do not have enough data to assess how strong this catch-up process was. We could not confirm hypothesis H2d.

Finally, an important contribution of our study is in the analysis of sectoral differences. We show that the spread of mobile working forced a digitalization of processes in the administrative and HR areas across many sectors. In sectors with previously low digitalization levels (e.g., health), the need for remote work led to a strong push of digitalization measures. On the other hand, there are sector-specific focal points. In some sectors, the demands and expectations of customers changed strongly, opening the way to digitalizing sales and customer relations (e.g., financial services). Other sectors like the automotive industry and logistics were strongly hit by supply chain disruptions and invested in digitalizing supply chain management.

Our analysis also shows temporal shifts in the focus of digitalization measures in some sectors. Contrary to original expectations (Biondi, 2021; Korinek & Stiglitz, 2021), there was no boost to the digitalization and automation of production and services at the beginning of the pandemic. In none of the sectors we examined was this area among the three most important areas of digitalization in 2021. However, the picture changed a year later. The digitalization and automation of production and services was now reported as one of the three most important areas, at least in machine building and financial services. One explanation is that measures to digitalize and automate work processes are costly and could not be undertaken as short-term crisis measures. Only once the necessary short-term changes to administrative processes had been mastered was it possible to focus on more far-reaching automation measures. Overall, hypothesis H2e was confirmed.

## Organizational change

While previous research on organizational change during the Covid-19 pandemic has mainly focused on the practice of remote work, an important contribution of our analysis is to examine the relationship between digitalization measures and organizational change. We show that there is a clear correlation between investment in digitalization and increasing organizational change, although the strength of this relationship varies from sector to sector and is most pronounced in financial services, where technical change experienced a huge boost from the pandemic.

Our research design allows us to show that the proportion of companies that introduced organizational changes increased over the course of the pandemic. The most widespread changes were measures to make working hours more flexible, but as many as 15% of the surveyed companies in 2021 and 29% of the surveyed companies in 2022 stated that they were introducing measures to change management concepts to accompany digitalization measures.

With our temporal perspective, we can show that while the prevalence of organizational change measures increased over the course of the pandemic, the companies most affected by the pandemic introduced fewer and fewer such measures. Management priorities shifted. On the one hand, the pandemic led to a greater awareness of the need for digitalization and organizational change in the business world. On the other hand, as the pandemic progressed, the companies that were hardest hit had to devote more and more attention to survival and less and less to organizational adjustments.

## Limitations

One limitation of our analysis is the relatively general indicators that were available to us for organizational change. Particularly with regard to leadership concepts and practices to promote cross-functional collaboration, our study shows a need for further research—specific change practices need to be explored through in-depth analyses in sectors and companies, including qualitative studies (Butollo et al., 2024)

In addition, we have no information on the level of investment. The high number of projects started during the pandemic may therefore go hand in hand with a rather restrained investment behavior overall, as found by Arntz et al. (2024). During the pandemic, companies concentrated on those projects to digitalize their processes that were absolutely necessary and feasible with the reduced resources available during the crisis.



## 6 Conclusions

While the relationship between the pandemic and the digitalization activities of companies has attracted significant attention in public discourse and academic research, there have been few contributions that have explored this relationship systematically. Our study provides differentiated data on how the pandemic affected companies in Germany, highlighting exposure to the pandemic, management awareness, and acceptance by employees as important conditions that facilitated investment in digitalization measures.

Instead of limiting our analysis to the digital enabling of remote work, we disaggregate the term “digitalization”, enabling us to highlight the core areas of activity and the unevenness of these activities according to sectors and prior levels of digitalization. By using data from two consecutive waves of digitalization, we are furthermore able to track the sequence of events, which indicates that a gap between pioneers and laggards was followed by a partial catch up of previously less digitalized companies and a progression from initial investments to continuous efforts to implement digital solutions. This shows that the crisis was such a profound event that initial path dependencies weakened and even companies that had previously been less digitalized began to make corresponding technical changes.

This suggests that the digitalization of companies is a continuous challenge that requires processes of organizational adaptation that go beyond initial investments. It is accompanied by changes in leadership practices and work organization, such as cross-functional cooperation and more flexible working times schemes. Our study highlights the interdependencies between organizational and technical aspects of digitalization.

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