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Abstract

The production processes at many firms rely on a highly choreographed and interdependent network of workers performing specialized jobs. We designed and implemented a targeted employer survey to measure the extent of coordination in work processes. We link this firm-level coordination measure to administrative data and find that firms with a more coordinated work process are more productive, pay higher wages, and experience lower worker turnover. Yet, these firms suffer more severe negative consequences from worker absences and adopt various strategies to mitigate such risk, the reliance on which we document. While the standard unemployment insurance policy pays benefits to workers who lose their jobs, the short-time work policy widely adopted in Germany compensates workers who remain employed with reduced hours for the associated loss of earnings. This policy can benefit employers with a more coordinated production process because they can lower the scale of production by reducing hours while keeping all workers needed for the production process employed, increasing the resilience of these employers to large idiosyncratic and aggregate shocks.

JEL Codes: E23, E24, J24, J65

Keywords: Labor markets, Coordination, Economic resilience, Work process, Covid-19

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1 Introduction

The production processes at many firms rely on a sophisticated, highly choreographed, and interdependent network of workers performing highly specialized jobs. The theoretical literature discussed below has identified the productivity gains arising from adopting coordinated production processes of specialized workers within firms. What remains less well understood is that an increase in the interdependence of workers within firms leads to an increase in the vulnerability of firms' production to idiosyncratic or aggregate shocks to labor supply. Individual firms represent nodes of a macroeconomic production network supplying intermediate or final goods to other firms, other countries, or consumers. To assess the resilience of macroeconomic networks to aggregate shocks, including the Covid-19 pandemic, and to design the appropriate policy response, it is thus essential to understand the resilience of coordinated production processes within firms. However, the consequences of adopting more coordinated work processes, the extent of risk mitigation efforts by firms, or the effects of macroeconomic policies on the resilience of production processes have not received much, if any, attention in the literature. In this paper, we take the first steps toward filling this void.

The fundamental problem with studying these issues is the lack of data on the nature of the production processes of firms, their resilience to idiosyncratic or aggregate shocks, mitigation mechanisms adopted by firms, and their response to macroeconomic policies. To overcome this problem, we designed a targeted survey that was administered to a large representative cross-section of German employers by the Institute for Employment Research (IAB) in May 2021. We linked the survey responses to administrative social security panel data about the surveyed employers and all their employees. The survey elicits information on the experience and actions of firms regarding coordinated work processes and resilience to labor supply shocks both during the Covid pandemic and over the pre-pandemic years.

Our main focus is on the degree of coordination of production processes as a determinant of employer resilience. Existing research often incorporates rich employer and worker heterogeneity but typically treats jobs in a firm as being representative. However, many modern production processes are highly specialized and integrated with teamwork, assembly lines, or clocked work processes. They require significant coordination between workers and imply interdependence of different jobs in the production process. The representative-job approach abstracts from such specialization and the resulting interdependence. Our data reveal that this abstraction is not innocuous. We find large heterogeneity in the degree of coordination across, for example, the firm size distribution or industries. However, even after conditioning on such observables, large heterogeneity remains, suggesting that the degree of coordination adopted by firms is at least partly a choice that might respond to the economic environment and macroeconomic policies.

Having linked our employer-level survey data to various administrative data sets, we proceed to study the relationship between the degree of coordination at an employer and various economic outcomes. We find that even after controlling for a wide range of observable employer characteristics, more coordinated employers have significantly higher labor productivity, lending support to the theoretical literature that postulates this relationship. Moreover, we find that more coordinated employers pay higher wages and experience lower rates of worker outflows.

We complement our survey data with data from the German Microcensus to estimate the frequency and extent of unexpected worker absences for employers in a normal, pre-pandemic work week. We find that more than 7 percent of German workers experience labor supply shocks leading to unexpected worker absences. We document that firms with more coordinated work processes are more concerned about these unexpected worker absences and are more likely to adopt mitigation strategies that we collected data on in the survey. One such strategy is to increase wages in an attempt to reduce worker turnover and absenteeism, reminiscent of Henry Ford's 5-dollar day strategy. More prominent, however, is the strategy to hire surplus labor that fills in for occasional individual worker shortfalls. The adoption of this strategy is strongly related to firm size. Clearly, the larger the firm, the smaller the uncertainty about the share of absent workers on a given day. The reason is that firms with a larger workforce can adhere to a law of large numbers with respect to idiosyncratic labor supply shocks. Thus, it is easier for larger firms to "self-insure" against such idiosyncratic shocks by hiring surplus labor. This better insurance against idiosyncratic risk offers a new interpretation of the widely documented size-productivity nexus: Large employers are more productive because they implement more coordinated production processes, exploiting more effective mitigation strategies for unexpected worker shortfalls that are available to them.

Such firm-level mitigation strategies are primarily targeted toward the consequences of idiosyncratic shocks, but they are potentially less effective against large aggregate pandemic or business-cycle shocks. Indeed, we find that employers with highly coordinated production processes report twice as often severe problems from Covid-related worker shortfalls than firms with little coordination. Even when considering only within-industry variation and controlling for rich observable characteristics of employers and their employees, we find that more coordinated employers report more severe consequences from unexpected worker shortfalls and experience larger revenue declines for the same decline in employment. Performing the analysis within industries controls for heterogeneous impacts of Covid depending on the required degree of interaction and exposure to co-workers, customers, etc. More coordinated production might also be particularly vulnerable to the effect of the pandemic if they require coordination on site. To study this question, we exploit that our survey is part of a panel where the same firms respond over time to different topical survey modules. One such module collects data on remote work, enabling us to study the relationship between coordination and the prevalence of remote work.

We find a relatively weak but systematic relationship.

The trade-off between productivity gains due to the adoption of coordinated work processes and negative consequences for macroeconomic resilience calls for the assessment of the appropriate policy response. One such policy is short-time work. While a traditional policy response to reduced labor demand is to offer unemployment benefits to laid-off workers, a short-time work policy allows employers to keep all their workers employed but at lower average hours. Instead of insurance against the income loss for a group of unemployed workers (extensive margin), short-time work provides insurance for reduced earnings due to lower hours of employed workers (intensive margin). We argue that short-time work allows employers to maintain worker coordination while reducing the scale of production when necessary. Thus, short-time work can provide the needed insurance to encourage firms to adopt coordinated work processes and raise productivity without decreasing macroeconomic resilience.

Literature. It is well recognized that modern production often features high coordination and interconnectedness of intra-firm production processes with workers performing highly specialized job tasks. Adam Smith, in the first three chapters of the *Wealth of Nations*, attributed the improvement of labor productivity to the division of labor (Smith, 1776). Since then, numerous pieces of research have tried to understand the cause and the consequence of labor specialization. Adam Smith emphasizes market size as a determinant factor in shaping the degree of labor division. On the other hand, Becker and Murphy (1992) point to the cost of combining specialized workers. They argue that coordination cost is far more important in restricting the degree of specialization. In this view, specialization increases until the higher productivity from a greater division of labor is balanced by the greater costs of coordinating a larger number of more specialized workers. In a related theoretical work, Yang and Borland (1991) emphasize the role of the transaction cost from a general equilibrium perspective: greater specialization must be accompanied by a higher level of trade, which is too costly if the transaction cost is high. Building on these insights, a large literature focused on the relationship between coordination, communication, knowledge, and specialization (e.g., Camacho 1991, Bolton and Dewatripont 1994, Garicano 2000, Garicano and Rossi-Hansberg 2006).

Although this stream of literature shares the common assumption, explicitly or implicitly, that specialization and coordination are choices made by firms and are associated with productivity gain, few discuss firms' resilience in changing environments with heterogeneous production processes. Dessein and Santos (2006) first proposes the idea that a potential goal of organizations is to adapt to changing business conditions and argue that organizations can reduce the level of (ex-ante) coordination as the business environment becomes uncertain and allow employees more flexibility in carrying out their tasks.

Although the change of organization structure is of interest in the medium to long run, it is

likely challenging at business-cycle frequency. As we document in this paper, firms with highly coordinated production processes are more likely to suffer from large aggregate shocks in the short run. From a macroeconomic perspective, it is thus important to understand how firms' cyclical behavior depends on their production structures and to tailor the counter-cyclical policies accordingly. Even in the medium to long run, in addition to restructuring the organization from time to time, firms may complement the coordinated production structure with various mitigation strategies, for instance, efficiency wages (see Stiglitz 1974, Salop 1979, Katz 1986, Raff 1988) or surplus workers, to keep the production process intact. As far as we know, a theoretical framework that could link the organization of production processes to firms' mitigation strategies and short-run and long-run responses to shocks does not exist in the literature.[1] We believe the empirical facts we provide in this paper can help guide the development of such a framework.

Despite rich theoretical work on the organization of production processes, relevant empirical work on the consequences of adopting more coordinated work processes, the extent of risk mitigation efforts by firms, or the role of macroeconomic policies in increasing the resilience of production processes remains limited. Existing literature on economic resilience focuses on global socioeconomic systems (Saavedra et al., 2014), regional economies (Neffke and Henning, 2008), job connectivity networks within cities (Moro et al., 2021), banking systems (May, Levin, and Sugihara, 2008), and worker mobility between firms (Guerrero and Axtell, 2013). The Covid shock further enables explorations into the effect of ICT technology and remote working on worker resilience (Pierri and Timmer 2020, Hou et al. 2021). Among these studies, however, the economic resilience of employers which vary in the degree of coordination in work processes is absent and our study aims to fill this void.[2]

Recently, there has been a growing interest in examining the effect of worker absence on firm productivity and firm behavior. This strand of the literature tends to identify a large and significant productivity loss due to absenteeism. For instance, Grinza and Rycx (2020) reports that an increase of 1 percentage point in the sickness absenteeism rate results in a productivity loss of 0.66 percent for Belgian private firms from 1999 to 2007. Adhvaryu et al. (2021) find that a ten percentage-point increase in absenteeism decreases productivity by roughly four percentage points, even though sharing workers is implemented as common practice to mitigate worker absence in the sample Indian garment factories. They also document that worker absenteeism shocks are frequent and large in firms. Using French administrative data on secondary school teacher absence, Benhenda (2022) finds that, on average, one day of teacher absence reduces

[1] For the general theory on the resilience of complex systems, see Perrings (1998), Albert and Barabási (2002), and Gao, Barzel, and Barabási (2016).

[2] This issue, however, receives some attention from the operational research. See Ambulkar, Blackhurst, and Grawe (2015) and Kontogiannis (2021).

pupil test scores by around 0.04 percent of a standard deviation. Moreover, substitute teachers are not able to mitigate this negative effect.

This implication of limited substitutability of workers is consistent with recent findings by Yurdagul (2017), Cubas, Juhn, and Silos (2019), Bick, Blandin, and Rogerson (2022), and Shao, Sohail, and Yurdagul (2022), that working hours are coordinated and complementary. However, in most macroeconomic models, workers of similar characteristics and their working hours are perfect substitutes, i.e., production processes are irrelevant. We provide novel evidence at the establishment level that higher coordination is associated with higher productivity, higher wages, and lower worker turnover, even after controlling for observable characteristics of firms and their employees. We also document that firms adopt specific mitigation strategies to deal with the consequences of unexpected worker shortfall. Unexpected worker shortfalls, specifically worker deaths, have recently been used as quasi-experimental variation in labor supply (Jäger and Heining, 2019) to quantify the substitutability of workers. We suggest using caution when mitigation strategies remain unobserved and unexpected worker shortfall is used as a natural experiment to identify the effect of worker shortfall on firm- or worker-level outcomes (e.g., productivity, wages).

The remainder of the paper is structured as follows. Section 2 introduces the new survey data that is at the heart of our empirical analysis. Section 3 studies how coordination correlates with observable employer characteristics, as well as economic outcomes such as productivity, wages, and worker turnover. Section 4 explores the distribution of coordination in the production process, the frequency of unexpected worker shortfalls, and the correlation between worker shortfall and coordination of the production process. Section 5 considers mitigation measures to deal with unexpected worker shortfalls and explores the employers' reliance on wages as a mitigation measure. Section 6 discusses the efficiency implication of the short-time work policy in the presence of coordination. Section 7 offers concluding remarks. An appendix follows with additional empirical results and robustness analyses.

2 New Survey Data

We rely on newly collected survey data from the IAB *BeCovid* panel survey (Bellmann et al., 2022). The BeCovid survey started in August 2020 as a specialized survey to track how German establishments managed the challenges of the Covid pandemic. The survey sample is taken from social security data and the survey responses of consenting participants can be linked back to social security records and employer information. When establishments enter the survey, a set of fixed characteristics is collected. In each of the monthly survey waves, the establishment provides the answers to a set of recurring questions on the current developments and challenges

of the Covid crisis and questions from a special topical module. In total, there have been 24 waves of the BeCovid survey fielded between August 2020 and June 2022.

The survey is conducted as a rotating panel such that about 40 percent of the sample is rotated out in each wave. Specifically, for each wave, the sample comes from two pools: a repeating pool of establishments that have been interviewed in the previous waive, and a refreshment pool of establishments that have not yet been surveyed before. Approximately 1,500 to 2,000 establishments are successfully surveyed per wave and the total response rate is about 20 percent. The proportion of (successful) repeat respondents hovered around 60 percent.

The survey population is all establishments in Germany with at least one employee covered by social security legislation so that the establishment has to file with the German social security administration. The sampling relies on a stratified sample of establishments by employment size (four groups) and sector (five industry groups). Due to the limited number of large establishments and the repeated sampling, there is no stratification by industry in the group of large establishments with more than 250 employees. Survey weights correct for non-response and higher response rates among establishments that receive short-time work benefits. For our analysis, we rely on the provided survey weights and restrict the sample to establishments that allow the linking of their survey responses to administrative records. More than 90 percent of all survey participants provided consent for record linkage.

The data on coordination, mitigation strategies, and consequences of worker shortfall, which are the core variables analyzed in this paper, come from the special survey module of wave 13 that was part of the BeCovid Survey in May 2021.[3] Our key challenge in designing this topical module was to ensure that respondents correctly interpret the questions and their answers reveal information that we seek as economists. At the same time, the average length of the interview for this topical module was limited to 10 minutes. To achieve these objectives, the module questionnaire went through a formal cognitive pretest (10 to 15 interviews) and a second pretest (approx. 100 interviews) via phone calls. Kantar Public, a survey institute, performed the pretest and the field data collection via computer-assisted telephone interviews. In total, wave 13 contains 2,001 successful interviews, of which roughly two-thirds are interviews from establishments that had already participated in a previous wave.

Besides the BeCovid panel, this paper relies on data from four other sources. First, we rely on social security data on employment histories and wages from the social security master file of the German social security administration. This sample contains the employment histories of all workers who have worked for the surveyed establishment at the time of the BeCovid survey in

[3]The survey was in the field from May 10 to May 26, 2021. In Appendix A, we provide the English translation of the German survey instrument for the special module. The entire survey instrument and its original German version can be accessed at the Research Data Center of the IAB at `https://fdz.iab.de/betriebsdaten/panel-betriebe-in-der-covid-19-krise-iab-becovid-welle-01-14/`.

May 2021 or at any point in time in the 10 years before the survey. Second, we rely on data from the Establishment History Panel (BHP) that tracks the history of establishment characteristics, for example, workforce composition and employment trends, of all employers since 1975. We provide details on the workforce composition variables in Appendix B. Additional BHP modules provide annual worker inflows and outflows for all establishments. The BHP data are aggregated from the universe of the social security master file. These two data sources can be linked to the BeCovid survey data using an employer identification number given the consent of the interviewed establishment representative. The third data source is anonymized revenue data from Bureau van Dijk (BvD). Due to data privacy concerns, we are restricted to using aggregated group-level data from the BvD database on productivity constructed as revenue per worker. The fourth data source is data from the German Microcensus that we use to construct quantitative estimates of worker shortfall for a representative sample of German workers. The Microcensus is maintained at the German statistical office and must not be linked to the social security data. All survey and administrative data except for the Microcensus are for establishments as the unit of observation. In the discussion, we will interchangeably use establishment, employer, or firm when referring to this unit of analysis.[4]

3 Coordination Across Employers in the Data

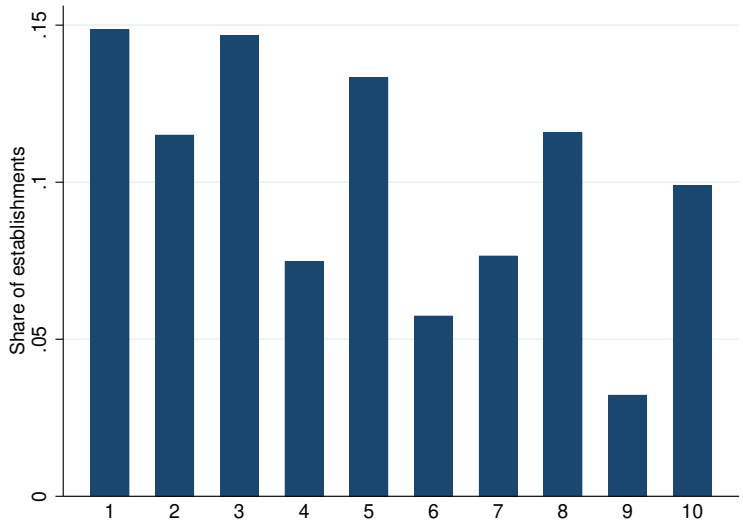
In this section, we first describe our measure of coordination of production processes within firms and document that measured coordination varies widely across firms. It is systematically correlated with observed firm characteristics, such as firm size and industry. The variation remains substantial even after conditioning on these variables. Moreover, coordination is economically meaningful, as we find that firms with more coordinated production processes are more productive, pay higher wages, and experience less worker turnover.

3.1 Empirical Measure of Coordination

To measure the degree of coordination in the production process, we asked respondents to think of the largest group of employees in their establishment and rate, on a scale from 1 to 10, the degree to which employees' work processes depend on each other. As part of the questionnaire, we described that a value of 1 means little coordination so that employees work largely independently of one another and the unexpected absence of one employee has no effect on other employees. We described a value of 10 as a highly interdependent production process so

[4]We will point out explicitly in some parts of the analysis when we will restrict the sample to single-establishment firms to reduce measurement error.

Figure 1: Share of establishments across coordination levels



Notes: This figure plots the share of establishments with different levels of work process coordination. Level 1 means very little coordination, and level 10 means strong interdependence of work processes of different workers in the production process. The number of observations is 1,786. See text for details.

that employees' work processes are closely related and the unexpected absence of one employee leads to significant adjustments for other employees.[5]

Figure 1 reports the distribution of responses on a scale from 1 to 10 for the question regarding the coordination of the production process. The answers are spread out over the entire spectrum, with 15 percent (10 percent) of establishments reporting the lowest (highest) level of coordination and slightly more than 12 percent reporting a level of coordination in the middle of the spectrum at 5. To ease the presentation, we aggregate observations into two groups of low (answer 1 to 5) and high (answer 6 to 10) coordination.[6]

3.2 Coordination and Observable Employer Characteristics

Before documenting the relationship between coordination and economic outcomes, we examine the heterogeneity of coordination across industries and firm size. Table 1 reports the share of low and high coordination establishments in each industry and firm size bin.

The last row of Table 1 shows that overall, four out of ten (38.1 percent) establishments report

[5]We provided interviewers with examples in case respondents had additional questions. The example of an independent work process is a case worker. The example of a coordinated production process is an assembly line. Note that we aim at measuring the coordination of tasks in production and not the extent of communication among workers.

[6]In some cases where the effects of interest appear nonlinear, we will use three groups of low (answer 1 to 3), medium (answer 4 to 7), and high (answer 8 to 10) coordination.

Table 1: Coordination across industries and firm size

Industry or firm size	Coordination low	Coordination high
Manufacturing, Energy, and Utilities	49.5%	50.5%
Construction, Mining, and Agriculture	59.2%	40.8%
Trade, Transportation, and Hospitality	66.6%	33.5%
Other Services	62.4%	37.6%
1-9 employees	63.5%	36.5%
10-49 employees	61.3%	38.7%
50-249 employees	51.7%	48.3%
250 employees or more	47.2%	52.8%
All	61.9%	38.1%

Notes: This table shows the distribution of low- and high-coordination establishments by firm size and industry. The upper part of the table shows the within-industry distribution of low-coordination (coordination level ≤ 5) and high-coordination (coordination level > 5) employers. The bottom part of the panel shows the distribution of coordination within the firm-size group (measured by the number of employees). The final row shows the average share of low- and high-coordination establishments.

a high level of coordination of their production process. The majority of plants report low levels of coordination in their production processes. As we will see, the majority of plants are small and small plants tend to be less coordinated.

The upper panel of Table 1 examines the variation of coordination across industries. The *Manufacturing, Energy, and Utilities* industry in the first row has 15 percentage points more high-coordination establishments than the service industries in the third and fourth rows. Appendix Table A.1 reports the distribution of industries for each level of coordination. We find that among low-coordination establishments, 8.5 percent are manufacturing establishments, smaller than their overall share of 11 percent. By contrast, 79 percent of low-coordination establishments are service industry establishments, over-represented relative to the economy-wide share of service industry of 76 percent. Among high-coordination establishments, we find the opposite relationship: Manufacturing employers with 14 percent of all employers are over-represented and service employers with 72 percent are under-represented. Although we observe systematic between-industry variation between the service and manufacturing sectors, we also observe substantial within-industry variation in the level of coordination. The lower panel of Table 1 reveals a systematic variation of coordination with firm size as well as a substantial variation

of coordination when conditioning on firm size. We find that smaller firms are more likely to have less coordinated production processes and the probability of having a highly coordinated production process increases with firm size. Nearly two-thirds of the smallest establishments (with 1–9 employees) report low coordination. By contrast, 47 percent of large establishments (with 250 or more employees) belong to the low-coordination group, but 53 percent belong to the high-coordination group.

Appendix Table A.2 reports the regression of reported coordination on a broad set of establishment characteristics, such as industry, size, workers' age and occupation compositions. We find observable characteristics to have only limited explanatory power for the level of reported coordination. Even when controlling for industry, firm size, employment composition in terms of skill and age groups, and the extent to which firms rely on temporary help workers, we find that less than 8 percent of the total variation in coordination on a scale from 1 to 10 can be accounted for ($R^2 = 0.076$). Across all specifications, we always find that coordination varies systematically across industries and is increasing in firm size as found in Table 1 .

3.3 Coordination and Productivity

While the theoretical literature has argued that more coordination in production leads to higher productivity (e.g., Becker and Murphy, 1992; Bolton and Dewatripont, 1994; Dessein and Santos, 2006; Garicano and Rossi-Hansberg, 2006), we are not aware of any direct empirical evidence supporting such a relationship. In this section, we examine the relationship between measured coordination and firm-level labor productivity, and find that more coordinated firms indeed tend to be more productive. This step is particularly challenging as the social security data do not contain information on output, revenue, or productivity. We utilize financial data from Bureau van Dijk (BvD) that provide information on firm revenue to calculate revenue productivity by dividing revenue by the number of employees. We are interested in estimating the following regression of (log) revenue productivity

$$a_{i,t} = \alpha_0 + \alpha_t + \beta X_{i,t} + \gamma C_i + \epsilon_{i,t} \tag{1}$$

where $a_{i,t}$ denotes log productivity of establishment i in year t, α_t year fixed effects, $X_{i,t}$ establishment characteristics for establishment i in year t, and C_i the coordination of establishment i. Note that the coordination measure is time invariant as we only observe it at the time of the survey.

Due to data privacy requirements, we are only permitted to link the coordination variable to aggregate data on productivity for a group of establishments. As a result, we cannot directly implement the above establishment-level regression of productivity on coordination. To over-

Table 2: Coordination and productivity

	Productivity: log (revenue per worker)			
	(1)	(2)	(3)	(4)
Coordination (linear)	0.020	0.022		
	(0.008)	(0.009)		
Coordination (dummy)			0.128	0.131
			(0.043)	(0.045)
industry & firm size	Y	Y	Y	Y
occupational composition	Y	Y	Y	Y
year fixed effects	Y	Y	Y	Y
Sample	2009-2020	2009-2019	2009-2020	2009-2019
Observations	2,089	1,935	2,089	1,935

Notes: This table reports regression results for the relationship between coordination and productivity. Columns (1) to (4) show different specifications for the coordination term and/or different regression samples. Column (1) shows the estimated coefficient for a linear coordination term for the full sample from 2009 to 2020. Column (2) follows the specification of column (1) but restricts the sample to 2009 to 2019, excluding the Covid crisis. Column (3) replaces the linear term from column (1) with a dummy variable for high-coordination establishments (coordination level > 5). Column (4) follows the specification from column (3) for the sample period from 2009 to 2019. Regression results are from the second stage regression of residualized variables with aggregated productivity information to respect the data privacy regulation. See text and Appendix C for details. Standard errors are reported below point estimates in parentheses.

come this challenge, we rely on the two-stage decomposition of the regression: in the first step, we regress both productivity and coordination on a set of common control variables. In the second step, we randomly aggregate productivity residuals from the first-stage regression, and then regress the aggregated residuals for productivity on the residualized coordination data. For the common control variables, we use information from the BHP data that unlike the Be-Covid survey data can be merged to the BvD data at the establishment level. We use as control variables dummies for industry and firm size and shares of the employment composition at the employer. See Appendix C for the details on the estimation strategy.

Table 2 presents the regression results for various specifications and samples. Overall, we find a very strong correlation between labor productivity and coordination. In column (1), we regress log productivity on a linear coordination term (level 1 to 10), along with the set of control variables: industry, firm size, worker composition by occupation, and dummies for year fixed effects (for the full sample over 2009-2020 for which we have productivity data).[7] The regres-

[7]BvD data contains productivity information from 2009 to 2020. For the measure of coordination, however, we only have cross-sectional information for the survey year. We thus assume that the level of coordination is

sion shows a significant effect of coordination on productivity. The point estimate implies a 20 log point difference in productivity between the most and least coordinated establishments, an economically significant difference. Column (2) restricts the sample to 2009-2019, omitting data from 2020, to eliminate the effect of the Covid crisis. The estimated coefficient barely changes. Columns (3) and (4) resemble Columns (1) and (2), but instead of continuously measured coordination, they use a dummy variable for high-coordination establishments (coordination levels 6-10). The high-coordination group is about 13 log points more productive than the low coordination group. In summary, we find support for a positive relationship between productivity and coordination. These results are interesting—coordination is not well predicted by observables, and yet it is a strong predictor of a firm's productivity.

3.4 Coordination and Wages

In the next step, we use the administrative worker-level social security data to analyze whether individual wages vary systematically with the level of coordination at the current employer, after controlling for individual characteristics. Due to the lack of hours information in the social security data, we only consider full-time employed workers and run the following regression for the daily (log) wage

$$w_{i,j} = \alpha + \beta X_i + \gamma Y_j + \rho C_j + \varepsilon_{i,j}, \tag{2}$$

where $w_{i,j}$ is the (log) wage of worker i at establishment j. The vector X_i contains worker characteristics such as dummy variables for age, sex, education, and current occupation, and the vector Y_j represents employer characteristics. For employer characteristics, we use firm size, industry, region (East/West), exporter status, and if the employer has apprentices and a work council. The coordination at establishment j is separately denoted by C_j. The error term is $\varepsilon_{i,j}$. Table 3 shows estimated regression coefficients ρ for different specifications. We consider wages in the pre-Covid year of 2019 but find very similar results for 2020 wages reported in Appendix Table A.3.

We find across all specifications that more coordinated employers pay higher wages to observationally identical workers. These wage differences are also economically large. Column (1) shows that being employed at the most coordinated employer as opposed to the least coordinated employer is associated with a 9-percent wage increase. Column (3) compares low, medium, and high coordinated employers and shows that highly coordinated employers pay 8 percent more than low-coordination employers to otherwise observationally identical workers.

In summary, we find a systematic positive relationship between the level of coordination in

persistent at the establishment level and extend the coordination information of each establishment to previous years. This treatment excludes the possibility of controlling for the establishment-level fixed effects.

Table 3: Coordination and wages

Variable	(1)	(2)	(3)	(4)
coordination	0.009	0.0086		
	(0.004)	(0.004)		
medium coordination			0.0255	0.016
			(0.0303)	(0.0302)
high coordination			0.0795	0.0747
			(0.0285)	(0.0284)
firm size	dummy	cont.	dummy	cont.
Observations	82,090	79,619	82,090	79,619
R^2	0.4825	0.4851	0.4831	0.4858

Notes: This table reports regression results of log wages on worker and firm characteristics and coordination of the production process. Wages were the average daily wages for full-time workers in 2019. All regressions include a full set of worker controls (age, sex, occupation, education) as dummy variables. All employer controls are always included. Row *firm size* indicates if firm size is controlled for using dummy variables or a continuous employment measure. Column (1) includes coordination as linear control and firm-size dummies. Column (2) uses a quadratic term for employment to control for firm size. Columns (3) and (4) replace the continuous coordination variable with dummy variables for medium- and highly-coordinated firms in regressions of columns (1) and (2). Standard errors are clustered at the establishment level and reported in parenthesis.

the production process and wage levels. Higher wages at more coordinated employers could be either a consequence of higher productivity or the result of a strategy for worker retention that we discuss below. In fact, if worker retention is crucial for maintaining coordinated and, consequently, more productive production processes, then the two reasons for higher wages are two sides of the same coin.

3.5 Coordination and Worker Turnover

In this section, we document the relationship between worker flows and coordination of the production process. Specifically, we investigate whether there are differences in worker flows across employers with different levels of coordination in their work processes. To answer this question, we merge data on worker flows from the Establishment History Panel (BHP) with the BeCovid survey data. The BHP data provide the annual inflows and outflows for the reference date of June 30th of each year, based on the universe of social security records. We calculate flow rates by dividing flows over the previous year by the current employment stock. We focus on outflows and consider both all outflows and only outflows going to other employers. We regress these flow rates on coordination and control for the employment composition of the

Table 4: Coordination and worker-outflow rates

Variable	(1)	(2)	(3)	(4)
coordination	-0.0064		-0.0065	
	(0.0022)		(0.0026)	
medium coordination		-0.0463		-0.0506
		(0.0150)		(0.0161)
high coordination		-0.0528		-0.0503
		(0.0165)		(0.0177)
firm size	dummy	dummy	cont.	cont.
Observations	8,281	8,281	8,281	8,281
R^2	0.1374	0.1407	0.1266	0.1303

Notes: This table reports regressions of worker-flow rates for all employment outflows on coordination. It reports coefficients on linear coordination (row *coordination*) or dummies of coordination groups (rows *medium coordination* and *high coordination*). The columns differ in the specification of controls for firm size and coordination. Row *firm size* indicates if dummies or a quadratic polynomial in employment have been used to control for firm size. Column (1) shows the baseline specification. All regressions include employment composition controls. All employers have at least ten observations for flow rates.

establishment, industry dummies, and firm size. We pool data starting in 2000 (or the earliest year when an employer enters the sample after 2000) and restrict the sample to employers with at least ten observations for flow rates. The results are robust to using fewer observations per employer, see Appendix Tables A.4 and A.5. We estimate the following regression model for worker flows:

$$\pi_{t,j} = \alpha + \beta Y_j + \gamma S_{j,t} + \rho C_j + \varepsilon_{t,j}, \tag{3}$$

where $\pi_{t,j}$ denotes the worker-flow rate of establishment j in year t, Y_j contains controls for industry and firm size of establishment j, C_j is the measure of coordination and $S_{j,t}$ contains controls for employment composition of establishment j in year t. The variable $\varepsilon_{t,j}$ denotes the error term.

First, we consider all outflows from employment. The regression results in Table 4 show a consistent negative relationship between the level of coordination and worker outflows. The baseline specification in Column (1) shows that a firm with the highest coordination level of 10 has a 6.4pp lower outflow rate, which represents a large effect relative to the level of the average annual outflow rate of roughly 20 percent across all establishments. Column (2) shows that high-coordination firms have a 5.3pp lower outflow rate than low coordination firms. Columns (3) and (4) show results when we control for firm size using a continuous measure of employment instead of firm size dummies. Results align closely with the baseline specifications in columns

Table 5: Coordination and worker outflow rates to other employers

Variable	(1)	(2)	(3)	(4)
coordination	-0.0045		-0.0046	
	(0.0015)		(0.0018)	
medium coordination		-0.0322		-0.0348
		(0.0097)		(0.0107)
high coordination		-0.0363		-0.0351
		(0.0113)		(0.0123)
firm size	dummy	dummy	cont.	cont.
Observations	8,281	8,281	8,281	8,281
R^2	0.1238	0.127	0.1149	0.1184

Notes: This table reports regressions of worker-flow rates for outflows to other employers (job-to-job transitions) on coordination. Table reports coefficients on linear coordination (row *coordination*) or for dummies of coordination groups (rows *medium coordination* and *high coordination*). The columns differ in the specification of controls for firm size and coordination. Row *firm size* indicates if dummies or a quadratic polynomial in employment have been used to control for firm size. Column (1) shows the baseline specification. All regressions include employment composition controls. All employers have at least ten observations for flow rates.

(1) and (2). All effects of coordination are highly statistically significant.

In the second step, we restrict attention to outflows to other employers. We estimate the same regression specifications as underlying Table 4 but use outflows to other employers as the right-hand side variable and report the results in Table 5. We find that outflow rates to other employers are also negatively related to coordination. Specifically, we find in our baseline specification in Column (1) a 4.5pp gap in outflow rates between the least and most coordinated employers. Grouping employers into the three coordination groups in Column (2), we find a difference of 3.6pp in outflow rates between low- and high-coordinated employers. The effect of coordination on outflows to other employers is about two-thirds of the effect on all outflows. Again, the results are robust if we use a continuous measure of employment to control for firm size in Columns (3) and (4).

4 Coordination and Consequences of Worker Shortfalls

4.1 Worker Shortfall Faced by Firms

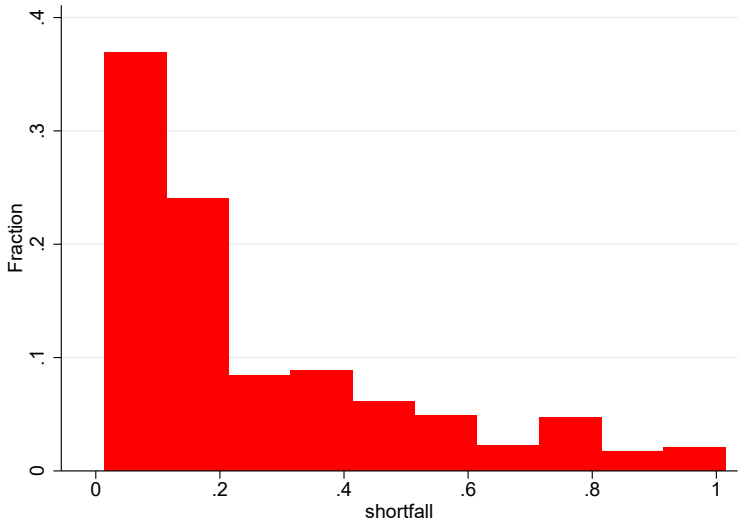
Before examining the consequences of unexpected worker shortfalls on coordinated production processes, we present evidence on their frequency and magnitude. In our employer survey module, we asked employers how frequently unexpected worker shortfalls occur in the pre-Covid period. Employers responded on a scale from 1 (never) to 5 (very often). As summarized in Appendix Table A.6, most employers responded that worker shortfalls happen rarely (answer 2) or from time to time (answer 3). Less than 5 percent of employers said this would happen often or very often (answers 4 and 5), and 15 percent said this would never happen. These responses suggest that unexpected worker shortfalls expose employers to some risk which requires further quantification.

To quantify the prevalence of unexpected worker shortfalls, we use data from the German Microcensus, which forms the basis of hours measurement for German NIPA accounting (Wanger, Weigand, and Zapf, 2016). We use the most recent microdata available from 2018. The survey asks respondents about the weekly working hours in a usual working week (usual hours). It then asks about the actual hours worked in the last week before the interview (actual hours). If respondents worked less than their usual hours in the last week, they are also asked to choose the reason for fewer hours from a list of 18 potential reasons. To construct a measure of worker shortfall, we compare the actual hours to the usual hours worked by all employed workers. As we are interested in unexpected worker shortfalls, we only consider cases if the worker reports sickness, personal or family reasons, or other reasons as the reason for fewer working hours.[8] Hence, we exclude reasons for shortfalls, including vacations, parental leave, adjustments in working time accounts, public holidays, or part-time work arrangements of older workers, as these are projectable events from the employer's perspective. Using this definition, we find that 92.6 percent of workers do not report unexpected shortfalls. At the same time, 3.8 percent of workers, about half of all workers with an unexpected shortfall, report an unexpected shortfall of 100 percent for the reference week. We exclude these workers from Figure 2 and show only the distribution of worker shortfalls for the remaining 3.6 percent of workers with unexpected worker shortfalls between 1 and 99 percent.

We find that almost two-thirds of workers report a shortfall of 20 percent or less, which corresponds to one working day for workers with a 5-day work week. The shares at higher levels of shortfall decline roughly linearly except for the spike at 80 percent, which corresponds to a shortfall of four days in a 5-day work week. Including the 3.8 percent of workers with a

[8] We also asked employers about the reasons for unexpected worker shortfalls in our survey. The by far most important reason of survey respondents was sickness and accidents. We report results in Appendix Table A.7.

Figure 2: Distribution of unexpected worker shortfall



Notes: This figure shows the Distribution of worker shortfall for employed workers with positive unexpected worker shortfall of less than 100%. Unexpected worker shortfall is constructed from the 2018 Microcensus. See text for details on the definition of unexpected worker shortfall.

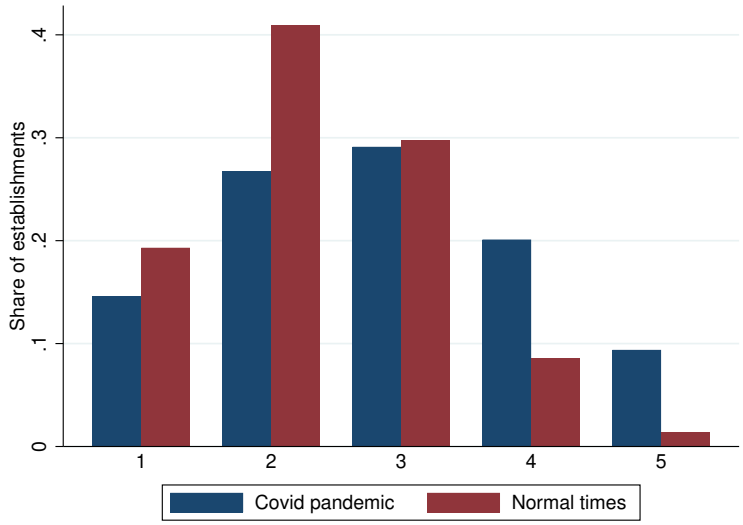
shortfall of 100 percent in the reference week, we find that 7.4 percent of employees report some unexpected worker shortfall each week that employers will have to deal with in the organization of their production process.

4.2 Coordination and Consequences of Worker Shortfalls

The evidence shows that worker shortfalls are prevalent. They are likely to be particularly challenging for employers with coordinated production processes, as worker shortfalls will require adjustments in the production process. Our survey included targeted questions to employers to elicit the consequences of worker shortfall for production processes. In the first question, we asked about the perceived problems in the production process for employers suffering from Covid-related worker shortfalls. In the survey, we find that exactly half of all employers (50.0 percent) report that they had experienced unexpected Covid-related worker shortfalls. Those employers were then asked to rank on a scale from 1 (no problems) to 5 (severe problems) the severity of the problems in the production process caused by Covid-related worker shortfalls. In another part of the survey, we asked the same question but referred to the "normal" times before the pandemic. Employers who reported non-zero worker shortfall for normal times were asked the follow-up questions on severity of problems from worker shortfall in normal times.

Figure 3 compares the frequency of responses regarding the severity of the problems from unexpected worker shortfalls during the Covid pandemic versus normal times. We observe that there

Figure 3: Problems in the production process from unexpected worker shortfalls



Notes: This figure shows the severity of problems in the production process from unexpected worker shortfalls during Covid times and during normal times. Answers range from 1 (no problems) to 5 (very severe problems). For the Covid period, only employers with Covid-related worker shortfalls have been asked (1,459 obs.) about problems of worker shortfall. For normal times, only employers who report having worker shortfalls are asked about problems of unexpected worker shortfalls during normal times (1,680 observations).

is large heterogeneity in the responses. For Covid-related worker shortfalls, about 15 percent of employers report no problems while 10 percent of employers report severe problems, and many employers report an intermediate value of 3 (29.6 percent). The reported consequences for normal times align qualitatively with the Covid pandemic, but we find fewer employers who report severe or very severe consequences during normal times but a substantially larger share reports mild consequences of worker shortfalls (value 2) which is likely related to the lower overall prevalence of worker shortfall outside the Covid pandemic.

In Table 6, we examine how the severity of problems resulting from unexpected worker shortfalls varies between establishments with high and low levels of coordination in their production processes. The upper panel of the table reports the results during the Covid pandemic and the bottom part reports the results for the pre-pandemic period.

We find that establishments that report fewer problems in the production process (Column 1, "severity 1") are typically low-coordination establishments, supporting the hypothesis that coordination is an important determinant of employer resilience. Three out of four employers who report no problems from Covid-related worker shortfalls report a low level of coordination. By contrast, about two out of three employers that report very severe problems (Column 5, "severity 5") have a highly coordinated production process. For the pre-pandemic period in the bottom panel of Table 6, we once again find large heterogeneity in the severity of the problems

Table 6: Severity of problems and coordination

	Severity				
coordination	1	2	3	4	5
Panel A. During Covid pandemic					
low	74.8%	65.7%	53.2%	45.4%	35.5%
high	25.2%	34.3%	46.8%	54.6%	64.5%
Panel B. Pre-pandemic "normal" times					
low	72.8%	66.8%	55.6%	45.0%	23.8%
high	27.2%	33.2%	44.4%	55.0%	76.2%

Notes: This table reports the severity of problems due to unexpected worker shortfalls by the level of coordination in the production process. Each column sums to 100 percent. For the Covid period, the sample is restricted to those that reported Covid-related worker shortfalls (1,459 observations). For pre-pandemic "normal" times, the sample is restricted to employers who report having worker shortfalls during normal times (1,680 observations).

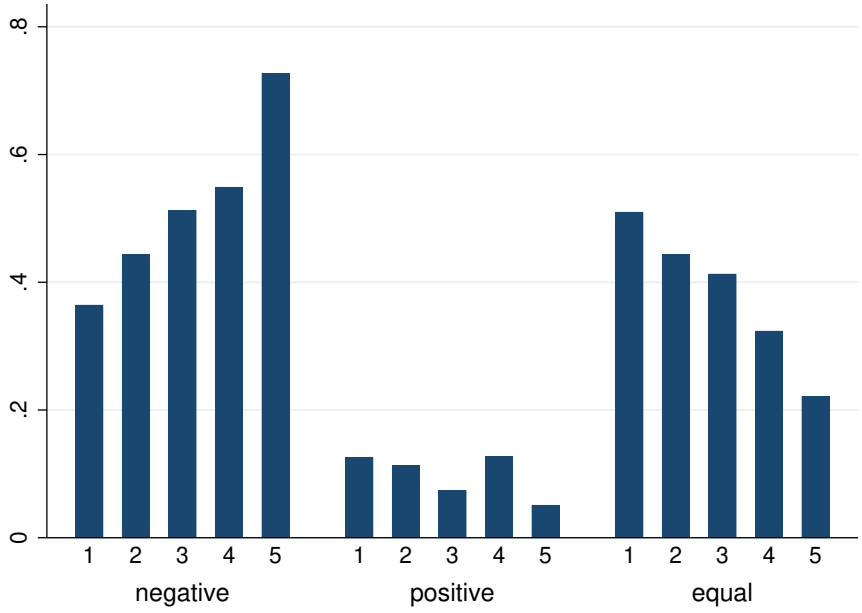
from worker shortfalls and a systematic variation with the level of the coordination in the production process. In fact, the conditional distributions for each level of severity across levels of coordination are very similar between normal times and during the Covid pandemic.

In Table 6, we condition on the severity of the problem and consider the distribution across employers with different levels of coordination. In Appendix Table A.8, we alternatively condition on the level of coordination, and find that more than half of the low-coordination employers report only mild problems (answers 1 and 2), whereas only about 30 percent of the highly coordinated employers answer having such mild problems. By contrast, over 38 percent of the highly coordinated employers report severe problems (answers 4 and 5) in contrast to only 22 percent of the low-coordination employers.[9] In Appendix Tables A.9 and A.10, we present additional regression results for the frequency and severity of problems from worker shortfall during the Covid pandemic and normal times. We find the results on the relationship to coordination to be robust even after controlling for other establishment characteristics.

The evidence suggests that severity of problems due to worker shortfalls is tightly related to the degree of coordination in the production process. Unexpected worker shortfalls lead to more severe problems for employers with more coordinated production.

[9]If we consider the average answer, we find that low-coordination employers report 2.6 and high-coordination employers report 3.1 for the level of severity. This difference in average answers is statistically significant at the 5 percent level.

Figure 4: Assessment of economic consequences of Covid crisis



Notes: This figure shows the economic consequences of the Covid crisis by the level of problems caused by worker shortfall. Bars indicate the share of employers. For each answer, the shares are shown separately by the assessment of problems of unexpected worker shortfall from 1 (no problems) to 5 (very severe problems).

4.3 Coordination and Economic Consequences of the Covid Crisis

In this section, we consider in more detail the impact of a large aggregate shock represented by the Covid crisis on firms depending on the extent of worker coordination in their production processes. Before, we focused only on the answer to the question in our special module of BeCovid survey describing the severity of problems caused by individual worker shortfall. We now complement that analysis with answers to the question in the core BeCovid survey asking employers to assess current economic consequences of the crisis as negative, positive, or equal.[10]

Figure 4 depicts these assessments of the current economic consequences from Covid across employers that report different levels of severity of the problems caused by unexpected worker shortfalls. We find that among those employers who report more severe problems due to worker shortfalls, the economic consequences of the crisis are also more often assessed negatively. Whereas employers who report the least severe problems caused by worker shortfalls also report negative consequences in only slightly more than one third of cases, the share is almost twice as high among employers who report the most severe problems due to unexpected worker shortfalls. We find the mirror image for the category of equal consequences that employers with

[10]We combine in the equal category the options that (1) consequences have been equally negative and positive and (2) there have been neither positive nor negative consequences at all.

Table 7: Direction of economic consequences and shortfall problems

	(1)	(2)	(3)	(4)	(5)	(6)
shortfall problems	-0.0588	-0.0569	-0.0583	-0.0567	-0.0408	-0.0404
	(0.0252)	(0.0250)	(0.0254)	(0.0253)	(0.0253)	(0.0252)
employment growth	0.0631	0.06	0.0631	0.0601	0.0848	0.0854
	(0.0275)	(0.0294)	(0.0277)	(0.0295)	(0.0697)	(0.0689)
firm size	N	N	Y	Y	Y	Y
industry	N	Y	N	Y	Y	Y
employment composition	N	N	N	N	Y	Y
age composition	N	N	N	N	N	Y
R^2	0.0165	0.0184	0.0168	0.0186	0.0365	0.0592
Observations	1,383	1,383	1,383	1,383	1,346	1,346

Notes: This table reports regression results for the relationship between the direction of economic consequences and severity of shortfall problems (level 1 (no problems) - 5 (very severe problems)). The direction of economic consequences can be negative (value -1), equal (value 0), or positive (value 1). Columns (1) to (6) show regression results with different sets of control variables indicated in the rows below coefficient estimates. Standard errors are reported in parentheses.

less severe consequences from worker shortfall report more often. There are few firms reporting positive consequences and they are not systematically distributed across the severity spectrum. In summary, we find that the differences in the severity of the consequences of unexpected worker shortfalls correlate strongly with the overall economic consequences to employers from the crisis.[11]

These findings raise an intriguing question. Were the firms that report more severe problems due to worker shortfalls more affected by the Covid pandemic and forced to reduce their employment by more, or is the fact that labor shortfalls cause problems itself an important driver of the employers' negative economic experience during Covid pandemic? To answer this question, we regress reported overall economic consequences on the severity of shortfall problems, controlling for the observed employment growth at each firm from 2019 to 2020. We use this regression to test whether there is still any predictive power of perceived shortfall problems on economic consequences after controlling for the actual employment changes.

Specifically, we estimate the following regression

$$e_i = \alpha + \beta X_i + \gamma S_i + \xi G_i + \varepsilon_i, \tag{4}$$

[11]In Appendix Table A.11, we report in addition results on the economic consequences for low- and high-coordination establishments. We find that high-coordination establishments report in almost half of the cases that their current economic consequences are negative (48.6 percent). For low-coordination employers, the share of employers reporting negative consequences is 20 percent lower at 40.4 percent.

Table 8: Strength of negative economic consequences and shortfall problems

	(1)	(2)	(3)	(4)	(5)	(6)
shortfall problems	0.1532	0.1532	0.1518	0.1514	0.156	0.1579
	(0.0602)	(0.0597)	(0.0603)	(0.0599)	(0.0527)	(0.0528)
employment growth	-0.3009	-0.2808	-0.2996	-0.2785	-0.283	-0.2789
	(0.1189)	(0.1124)	(0.1182)	(0.1114)	(0.1179)	(0.1197)
firm size	N	N	Y	Y	Y	Y
industry	N	Y	N	Y	Y	Y
employment composition	N	N	N	N	Y	Y
age composition	N	N	N	N	N	Y
R^2	0.0391	0.0539	0.0402	0.055	0.1686	0.2071
Observations	1,005	1,005	1,005	1,005	976	976

Notes: This table reports regression results for the relationship between the strength of the negative economic consequences (1 (very weak) to 5 (very strong)) and shortfall problems (level 1 (no problems) to 5 (very severe problems)). Columns (1) to (6) show regression results with different sets of control variables. The rows below point estimates indicate additional control variables. Standard errors are in parentheses.

where e_i denotes the direction of economic consequences of establishment i (coded -1 for negative, 0 for equal, 1 for positive), α denotes the constant term, X_i are controls of establishment characteristics for establishment i, such as firm size, industry, and the worker composition by occupation and age. S_i is the severity of shortfall problems and G_i is the employment growth rate of establishment i during 2019-2020. The coefficient γ captures the effect of reported severity of worker shortfall problems on the economic outcome, with actual employment change controlled for. The regression includes all establishments in the survey that report the existence of labor shortfalls. The estimates reported in Table 7 reveal that across specifications with different sets of controls, firms that reported more severe problems associated with worker shortfall were significantly more likely to experience negative economic consequences of Covid pandemic, even when the actual employment growth rate is controlled for.

The question on economic consequences only asked about the direction of the economic consequences, so that we learn how many firms experienced positive, negative, or equal consequences (extensive margin). In a follow-up question, the survey also asked the group of respondents who reported negative consequences about the strength of the negative consequences (intensive margin) on a scale from 1 (very weak) to 5 (very strong). We repeat the regression from equation (4) with the strength of the negative consequences as the dependent variable. The estimates reported in Table 8 reveal that the coefficients on the shortfall problems are positive, indicating that establishments with more severe problems of unexpected worker shortfall

Table 9: Strength of negative economic consequences and coordination

	(1)	(2)	(3)	(4)	(5)	(6)
coordination	0.3500	0.4113	0.3663	0.4235	0.3823	0.3727
	(0.1126)	(0.1124)	(0.1131)	(0.1131)	(0.1062)	(0.1054)
employment growth	-0.237	-0.2063	-0.2319	-0.1999	-0.1633	-0.1491
	(0.1292)	(0.1187)	(0.1285)	(0.1183)	(0.1273)	(0.1302)
firm size	N	N	Y	Y	Y	Y
industry	N	Y	N	Y	Y	Y
employment composition	N	N	N	N	Y	Y
age composition	N	N	N	N	N	Y
R^2	0.0327	0.0757	0.0426	0.0849	0.1662	0.1947
Observations	1,267	1,267	1,267	1,267	1,234	1,234

Notes: This table reports regression results for the relationship between the strength of the negative economic consequences (1 (very weak) to 5 (very strong)) and coordination. Coordination is a dummy variable for high-coordination employers (coordination level > 5). Columns (1) to (6) show regression results with different sets of control variables. Control variables are indicated in rows below point estimates. Standard errors are in parentheses.

also suffered more severe negative consequences of the Covid crisis. Together with the results from Table 7, this implies that establishments with more severe problems of unexpected worker shortfall were not only more likely to experience negative consequences of Covid pandemic but these negative consequences were also stronger.

As we have seen in Table 6, employers with more coordinated work processes experience more severe problems from worker shortfall. To directly assess the role of coordination, we repeat the regression underlying Table 8 but replace the severity of problems from worker shortfall with a dummy variable for highly coordinated firms (coordination level 6 and above). The results reported in Table 9 show that the negative consequences of the Covid pandemic were indeed stronger for high-coordination establishments.

The analysis of economic consequences of the Covid pandemic so far focused on survey responses. We now complement the analysis by examining the relationship between coordination of the work process at an employer and the impact of the pandemic on its revenue. To do so, we construct aggregated revenue growth rates from the BvD data between 2019 and 2020 and regress the variable on observable employer characteristics. Because this regression involves merging BvD data with the survey data like Section 3.3, we again follow the 3-step anonymization procedure as before (see Appendix C for details).

Table 10 presents the estimated coefficients for the coordination and employment growth. The

Table 10: Revenue growth and coordination

coordination	(1)	(2)	(3)	(4)
linear	-0.023	-0.016		
	(0.010)	(0.010)		
dummy			-0.136	-0.089
			(0.047)	(0.044)
empl. growth		0.454		0.446
		(0.142)		(0.144)
industry	Y	Y	Y	Y
firm size	Y	Y	Y	Y
employment composition	Y	Y	Y	Y
R^2	0.1471	0.2527	0.1603	0.2613
Observations	137	119	137	119

Notes: This table reports regression results of revenue growth (from 2019 to 2020) on coordination. Column (1) shows regression with linear coordination (value 1-10). Column (2) shows results with additional control for employment growth. Column (3) replaces the linear coordination term by a dummy variable for high-coordination establishments (coordination level > 5). Column (4) adds to the specification in column (3) a control variable of employment growth. All columns control for industry, firm size, and employment composition. Standard errors are reported below estimates in parentheses.

results indicate that during the Covid crisis, revenue growth slowed down more in more coordinated establishments. The linear specification in Column (1) reveals a revenue growth gap of 20 log points between the least and the most coordinated firms during the Covid crisis. More coordinated firms that should have suffered more from the widespread unexpected worker shortfall also experienced a larger contraction of their revenue. The effect is also statistically significant. Column (2) adds additional control variables for employment growth. The point estimate decreases only slightly, indicating that more coordinated employers did not experience larger employment declines, but rather large revenue declines for the same change in employment.[12] Columns (3) and (4) use the same specifications as columns (1) and (2), but the coordination variable is a dummy for high-coordination establishments (coordination level 6 and above). The message remains the same: more coordinated establishments suffered more from the macroeconomic increase in labor supply risk induced by the Covid pandemic.

[12]Indeed, we directly verify in the data that employment changes during Covid pandemic were quite similar across firms with different degree of coordination of work processes.

Table 11: Mitigation measures and coordination

	Coordination			
mitigation measure	low	medium	high	all
Shifting in time	57.3%	55.0%	46.8%	54.0%
Shifting across workers	89.5%	95.4%	95.1%	93.0%
Replacement workers	22.4%	27.9%	35.0%	27.3%
Replacement of products	8.2%	14.8%	19.0%	13.1%

Notes: This table reports the share of employers by the level of coordination who rely on different mitigation measures to deal with worker shortfall. Row *Shifting in time* refers to rescheduling unfinished work to a later time. Row *Shifting across workers* refers to reallocating unfinished work to other employees, including supervisors or owners. Row *Replacement workers* refers to using temporary workers, agency workers, substitute workers, or in-company replacement workers. Row *Replacement of products* refers to purchasing goods or services from other establishments. Employers can implement several mitigation measures, and the share always gives the percentage of employers who had this mitigation measure in place (pre-Covid).

5 Coordination and Measures to Mitigate the Impact of Worker Shortfalls

As we have seen, firms with more coordinated production processes tend to be more productive but at the same time they experience more problems associated with worker shortfalls. Thus, we expect firms to adopt various mitigation strategies to reduce the risk associated with unexpected worker absences. In our special targeted module of the BeCovid survey, we therefore asked employers if they implemented mitigation strategies to deal with unexpected worker shortfall and if so, what those strategies were. This section describes what we learned from the responses.

Specifically, we asked employers if they were relying on four specific mitigation measures to deal with worker shortfall in the pre-pandemic period.[13] Employers were separately asked about each mitigation measure, as they could rely on multiple mitigation measures or none at all. Table 11 reports the share of employers by the level of coordination that have each mitigation measure in place.

The four mitigation measures that we surveyed employers about focus on qualitatively different mitigation approaches. First, we asked if employers shift production across time if they experience unexpected worker absences. In this case, the worker who does not work today makes

[13]While our focus in this section is on "normal" times, we report in Appendix Table A.9 that more coordinated firms were significantly more likely to introduce measures to mitigate the consequences of worker shortfall during Covid pandemic.

up the lost hours at a later date. We expect such a mitigation strategy to be prevalent, and more likely if the production process is little coordinated. At a low level of coordination, the work process of one worker does not affect the work process of coworkers and missed work can be completed at a later time. Second, we asked if employers shift work across workers. Such a work shifting can happen simultaneously and requires the remaining workers to adjust their workload. These first two mitigation strategies do not involve additional workers or resources to be held in reserve by the employer. In the event of work shifting across workers, it can result in overtime and a reduction in working hours in the future, for example, through working-time accounts. The next two mitigation strategies involve either additional workers or additional products in the production process. Relying on replacement workers requires that the employer hires "surplus labor" that can jump in to replace absent workers. Replacement workers might be in particular required in more coordinated production processes to avoid more severe disruptions caused by unexpected worker shortfall. Replacement of products allows employers to replace the final or intermediate products in the production process that are missing due to worker shortfall with replacement products from other producers.[14]

The results in Table 11 show that the most common and almost universally utilized measure is shifting of work among the remaining workers. On average, 93 percent of employers rely on this mitigation measure and there is only a small difference between high- and low-coordination employers. The second most widely used mitigation measure is shifting of work across time. On average, more than half of all employers rely on this measure (54 percent). In line with the idea that low coordination allows workers to work independently, we find that low-coordination employers shift work across time more often if a worker is not at work (57 percent). For high-coordination employers, we find a 10 percentage point lower reliance on this mitigation strategy (47 percent), in line with the idea that coordination requires the work input of several workers into production so that shifting work inputs becomes less feasible or even infeasible. These ideas find further support when looking at the reliance on replacement workers that slightly more than one out of four employers have in place. If work inputs are coordinated and worker shortfall causes severe problems in the production process, then having replacement workers available can help avoid the associated problems from worker shortfall. We find that 35 percent of highly coordinated employers rely on replacement workers, whereas only 22 percent of low-coordination employers do so. Replacement of products is the least widely used mitigation strategy overall (13 percent) but the share of highly coordinated employers using this strategy is more than twice as high as the corresponding share of low-coordination employers (19 percent

[14]To give a concrete example of the latter mitigation strategy, consider an artisan bakery that mills its own flour and bakes birthday cakes. If it promised to supply a cake on a given day but a worker did not show up, it can purchase a cake elsewhere and deliver it or it may choose not to mill its own flour but to purchase this intermediate input elsewhere. Note also that the survey question explicitly ruled out including the reliance on temporary help workers as part of this mitigation measure.

Table 12: Mitigation measures and establishment size

	Firm size				
mitigation measure	1-9	10-49	50-249	250 and more	all
Shifting in time	60.0%	47.7%	33.6%	41.5%	54.7%
Shifting across workers	87.6%	96.4%	94.1%	95.9%	90.7%
Replacement workers	17.5%	31.5%	54.7%	71.2%	24.5%
Replacement of products	13.9%	13.4%	12.8%	20.2%	13.7%

Notes: This table reports the share of employers by establishment size (number of employees) who rely on different mitigation measures to deal with worker shortfall. Row *Shifting in time* refers to rescheduling unfinished work to a later time. Row *Shifting across workers* refers to reallocating unfinished work to other employees, including supervisors or owners. Row *Replacement workers* refers to using temporary workers, agency workers, substitute workers, or in-company replacement workers. Row *Replacement of products* refers to purchasing goods or services from other establishments. Employers can implement several mitigation measures, and the share always gives the percentage of employers who had this mitigation measure in place (pre-Covid).

vs 8 percent). Looking across all mitigation strategies, we find that for the three mitigation strategies that allow for a contemporaneous adjustment of the production process (Shifting across workers, replacement of workers or products), more coordination is associated with more mitigation. Shifting production over time shows an opposite pattern, with establishments with more coordinated production processes relying less on intertemporal adjustment of production.

Section 4 highlights the important connection between establishment size and coordination. In Table 12, we consider the reliance on mitigation strategies by firm size. Looking across the size distribution reveals two striking trends. Larger establishments shift less production over time but are much more likely to have replacement workers. Shifting over time is a mitigation measure for worker shortfalls in 60 percent of the smallest establishments but only in 42 percent of the largest establishments. The reason that larger establishments need to rely less on this measure is likely related to the striking differences regarding replacement workers. Only 18 percent of the smallest establishments have replacement workers to compensate for worker shortfalls, whereas 71.2 percent of the largest establishments have replacement workers to mitigate the consequences of worker shortfalls. This pattern supports the idea that employment size is an important determinant for the cost efficiency of the latter mitigation measure. Establishments with a large workforce can adhere to the law of large numbers for worker shortfalls so that the number of replacement workers can be tightly determined. In contrast, in establishments with a small number of employees it is likely that replacement workers are either not needed because all workers are at work or that even more than one replacement worker is needed because of the discreteness of worker shortfall. This type of economies of scale will allow larger employers

to operate more coordinated production processes, as the risk of a worker shortfall can be more effectively mitigated by having replacement workers. The result highlights therefore a new mechanism contributing to the empirical finding that large employers tend to be more productive.

In the survey setup, each establishment is allowed to report implementing none or more than one mitigation measure to deal with worker shortfalls. Appendix Table A.12 reports the sum of implemented mitigation strategies by firm size. We find that over 40 percent of establishments have two mitigation measures in place. We also find that among the smallest establishments, almost one out of four (23.3 percent) has no mitigation measures in place, whereas among the largest establishments, almost one third (31.6 percent) has three or more mitigation measures in place and virtually none of the large establishments has no mitigation measure in place (< 1 percent).

5.1 Wages and Worker Shortfalls

A complementary mitigation strategy could be to aim at reducing worker shortfall ex ante. One such strategy is to pay wage or non-wage bonuses to workers if their shortfall is low. We asked in our survey about such wage and non-wage bonuses and find that on average 17 percent of employers use such bonus programs to reduce worker shortfalls. We also find that the reliance on such bonus programs varies systematically with the coordination level of employers. Whereas only 13 percent of low-coordination employers have such programs in place, the share is almost twice as high for high-coordination employers, at 23 percent. Hence, we find that those employers who report the most severe consequences of worker shortfalls for their production processes are also substantially more likely to have economic incentive mechanisms in place to avoid worker shortfalls.[15]

In addition to relying on bonuses for not missing work, firms may also set the level of base wages to lower the probability of worker absences (making the opportunity cost of not coming to work higher). Higher wage levels at an employer are commonly thought to lower the probability of a worker quitting to non-employment or another job (e.g., Burdett and Mortensen, 1998). We provide evidence for such higher wage levels in Section 3.4. Higher wages may also induce higher work effort as is commonly assumed in the efficiency wage theories. In an attempt to disentangle the different effects, we asked employers which margins they think will be affected by a wage increase at their establishment. Specifically, we asked whether a hypothetical 10 percent increase in the wage level (from the actual one) is going to lead to fewer workers leaving the

[15] Appendix Table A.13 corroborates the finding that more coordinated establishments rely more on wage and non-wage benefits to avoid worker shortfall. It reports regression results controlling for additional establishment characteristics.

Table 13: Consequence of a wage increase

	coordination		
	low	high	all
fewer workers leaving	21.7%	23.7%	22.5%
fewer shortfalls	7.0%	11.4%	8.7%
more effort	25.3%	29.0%	26.7%

Notes: This table reports the share of low- and high-coordination employers who report a specific consequence after a 10-percent wage increase at the establishment. Potential consequences employers are asked for as consequences of the wage increase are fewer workers leaving the establishment, fewer unexpected worker shortfalls, or more effort provision. The table reports the share of employers in each group who support a specific consequence.

establishment, fewer unexpected worker absences, or workers exerting more efforts. Employers could agree with all, some, or neither of these effects. We report the share of employers who agree with the described consequence of the wage increase in Table 13 across all employers, conditional on their level of coordination.

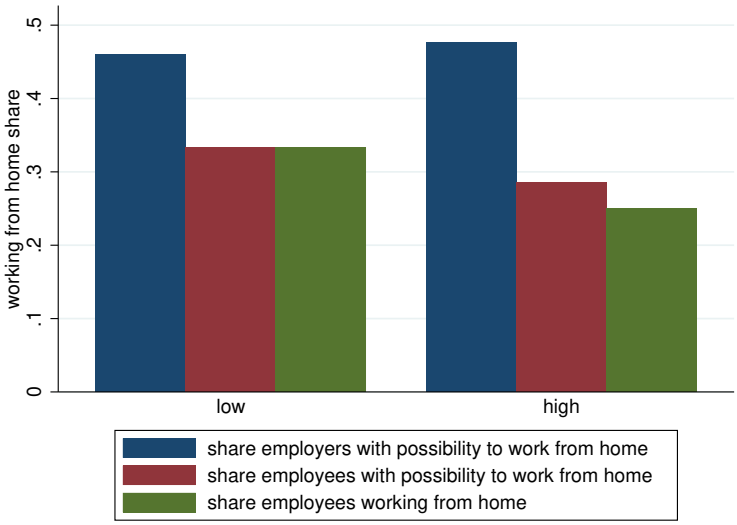
Overall, we find the support for each of these consequences to be relatively weak. We find that only one out of four employers thinks that higher wages will induce more work efforts and slightly less than one out of four employers think that fewer workers will leave the establishment. Less than 9 percent of employers expect the wage level increase to result in fewer worker absences. For all three consequences, we find that highly coordinated employers are more positive with respect to the consequences of a wage increase, but the difference is not large. Note again that this question only addresses the base wage level and not incentive pay as would be the case with wage or non-wage bonus programs. Moreover, we have documented in Section 3.4 that employers with more coordinated work processes pay significantly higher wages. The question discussed here was about a hypothetical wage increase on top of the already optimized wage potentially set in a way such that employers do not think that employment outcomes could be further improved by changing the wage.[16]

5.2 Coordination and Working from Home

Working from home (WFH) was a widespread response by governments and employers to reduce the spread of the Covid virus. WFH can be in conflict with coordinated production processes,

[16] As a follow-up question, we asked employers who think that there is a positive effect of higher wages on the different margin about how strong they think this effect will be. Typically only around 25 percent of employers think that the effect is strong or very strong (level 4 or 5) on a scale from 1 (very weak) to 5 (very strong).

Figure 5: Working from home and coordination



Notes: This figure shows the share of employers and the share of workers with the possibility to work from home and the share of workers who actually work from home by the level of coordination of the employer. *share of employers* shows the share of employers who offer (at least to some) workers the possibility to work from home. The *share of employees with possibility* is the (median) share of workers at the establishment for whom working from home is possible. The share of *employees working from home* is the (median) share of workers at the establishment who are working from home at the time of the survey. The unit of observation is the establishment. Worker shares are the (median) worker shares across establishments.

which may require on-site coordination. The possibility of working from home might be lower if the production process is more coordinated. We rely on information on the possibility and the usage of WFH from the predecessor wave of the BeCovid survey (wave 12). In the special module of that wave, employers were asked if WFH is a possibility at the establishment, for what share of workers this possibility exists, and the actual share of workers working from home.[17] The first question is about the share of employers with a WFH option, while the other two questions are about worker shares. This difference implies that a large firm might say that the possibility for WFH exists but only for a small share of its workforce so that the employer and worker share typically do not match. Figure 5 shows the shares of employers with a WFH possibility, the worker shares with this possibility, and the actual usage of WFH for low- and high-coordination firms.

Overall, we find that 47 percent of employers report that WFH is possible at their establishment. Comparing high- and low-coordination employers, we find this share to be almost identical. For worker shares, we find that at highly coordinated employers the share of workers with the

[17]Survey participants typically respond with the number of employees and we transfer these responses into shares for easier comparison. As there are response errors in the number of workers with the possibility to work from home and also the number of workers at the establishment, we always report median employment shares to avoid having the results driven by outliers.

possibility to work from home and the share of workers working from home is always lower than at low-coordination employers. In general, we find that only about one out of three employees has the possibility to work from home, meaning that two out of three workers do not have this possibility at the moment. This small share is also a result of the industry composition. In all industries except for *other services*, we find that less than 40 percent of employers report that there is a possibility to work from home. Other services, which cover a large part of all employers and also include education and research, have a share of almost two-thirds of establishments reporting that WFH is a possibility. In all other industries, we find that less than half of employers offer the possibility to work from home. Also along the firm size distribution, we observe large differences: whereas less than half of small employers with less than 10 employees offer WFH, over 95 percent of the largest employers with 250 and more employees do so. The large share of large employers offering WFH, however, only covers a small fraction of its employees. Only about one out of four employees actually works from home. One reason that smaller employers might not offer WFH is that if workers are on-site, it might be easier to adjust the production process in case of unexpected worker shortfalls if no other mitigation measures are in place (Section 5).

6 Coordination and Short-Time Work Policy

6.1 Coordination and Employment Reduction in Response to Negative Demand Shocks

In coordinated work processes, employers who face a shortfall in demand and need to adjust labor inputs face extra challenges because of the interdependence of workers in the production process. In this case, a reduction in the number of workers through layoffs will affect other workers and the production process itself, whereas a reduction in hours for all workers potentially allows for scaling down production without adjustments in the setup of the coordinated work process. With a uniform reduction in hours, all workers can continue to perform the same tasks in the production process but on a lower scale. To shed light on this hypothesis, we asked employers in our targeted BeCovid module whether they would rather adjust labor inputs at the intensive margin (hours) or extensive margin (number of workers) if they had to do so in response to a negative demand shock lasting for the next six months. On average, we found that three out of four employers in Germany would adjust at the intensive margin (76 percent). Hence, layoffs are not considered the better alternative for the large majority of employers in the German labor market. We focus here on the majority of employers who opt for the intensive margin adjustment and relegate the discussion of employers who opted for the extensive margin

Table 14: Reasons for intensive margin adjustment after negative demand shock

	agreement				
	1	2	3	4	5
coordination	7.9%	6.1%	12.0%	19.1%	54.9%
labor hoarding	17.2%	10.4%	16.4%	14.2%	41.8%

Notes: This table reports the agreement with two motives for intensive margin adjustment of labor inputs after a negative demand shock. Motives are either maintaining coordinated work processes or labor hoarding. The sample consists only of establishments that stated before that they would adjust labor inputs at the intensive rather than the extensive margin after a negative (6-months) demand shock. A value of 1 corresponds to no agreement and 5 to full agreement. Both rows sum to 100 percent.

adjustment to Appendix E.

For those employers who would opt for intensive margin adjustment in response to a shortfall in demand, we asked them to rate the importance of the following two reasons for their decision. First, we described the idea of coordination, namely, that even if workers work fewer hours, it is important for the employer to keep the entire workforce at the establishment to preserve the production process. Second, we mentioned labor hoarding, namely, that hiring a worker in the future will be costly.

Table 14 shows that coordination and labor hoarding are both important motives for employers' decision to adjust along the intensive margin. Comparing the two motives, we find stronger support for coordination. Almost three out of four asked employers (74 percent) agree with coordination as a motive for their choice of an intensive margin adjustment (answers 4 and 5). For labor hoarding, the share of agreement is 18 percentage points lower, at 56 percent.

In Table 15, we further distinguish the agreement with coordination as an important motive for intensive margin adjustment by the reported level of coordination in the production process. We find that 60 percent of employers with high coordination in their production process strongly agree with the motive that keeping all workers and work processes intact is an important motive for intensive margin adjustments. For low-coordination employers, we find 11 percentage point lower but still strong support at 49 percent. In the group of employers with high coordination, only about 6 percent of all employers are on the two lowest levels of agreement. By contrast, almost one out of five employers report only low agreement with coordination as a motive for intensive margin adjustments at a low level of coordination in the production process.[18]

In summary, these results highlight support for intensive margin adjustments to demand shocks.

[18]We demonstrate the robustness of these results in Appendix Table A.14 where we report regression results when controlling for additional establishment characteristics.

Table 15: Agreement with coordination as motive for intensive margin adjustment

	coordination		
agreement	low	high	all
1	11.7%	2.7%	8.4%
2	7.8%	3.5%	6.2%
3	14.3%	12.1%	13.5%
4	16.9%	21.8%	18.7%
5	49.3%	59.9%	53.3%

Notes: This table reports the agreement with maintaining coordinated work processes as a motive for intensive margin adjustment after a negative (6-months) demand shock. Columns show shares of low- and high-coordination employers and all employers. The sample consists only of establishments that stated before that they would adjust labor inputs at the intensive rather than the extensive margin after a negative demand shock. Agreement varies from disagreeing (value 1) to fully agreeing (value 5). Each column sums to 100 percent.

Of the 76 percent of employers who would adjust labor inputs along the intensive margin, 72 percent agree or strongly agree that keeping work processes intact is the motive for their decision of an intensive margin adjustment. In combination, these findings strongly support the hypothesis that coordination of work processes is an important consideration for employers when undertaking labor adjustments.

6.2 Coordination and Short-Time Work

A traditional policy response to a negative labor demand shock is to offer unemployment benefits to laid-off workers. The short-time work policy (STW) is a prominent alternative in Germany. STW allows employers to keep their workers employed but at fewer hours. As opposed to unemployment benefits that provide insurance against income loss for laid-off workers, STW allows employers to cut the hours of some or all employed workers and provides insurance against the resulting fall in worker earnings.

This policy might be particularly beneficial to more coordinated establishments. As we have shown, these establishments suffer the most from unexpected worker shortfall. We have also shown that firms adopt various mitigation strategies to insure against worker shortfall driven by worker-level idiosyncratic factors, such as sickness, childcare needs, or unexpected worker quits. However, these mitigation strategies are not geared towards insuring against large fluctuations in demand or productivity caused by, e.g., aggregate shocks driving business-cycle fluctuations. In

Table 16: Agreement for different short-time work (STW) motives

	agreement				
motive	1	2	3	4	5
coordination	2.8%	1.6%	14.1%	19.8%	61.8%
labor hoarding	2.0%	2.2%	8.3%	11.2%	76.4%
wage subsidy/liquidity	3.7%	4.5%	17.4%	20.4%	54.1%
spreading of costs	9.7%	11.2%	31.7%	19.4%	28.0%

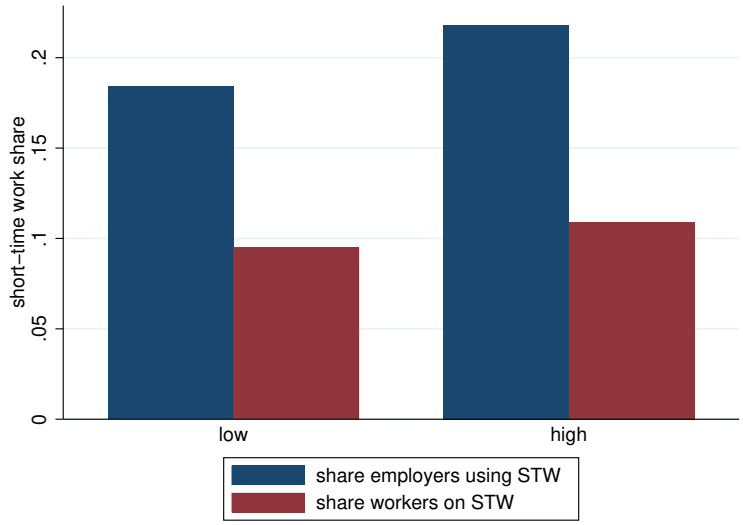
Notes: This table reports the agreement with different motives to use STW by employers. Surveyed motives are maintaining coordinated work processes, costs of future rehiring (labor hoarding), liquidity provision from wage subsidy, and spreading the costs of the negative economic conditions in solidarity among employees. Agreement for each motive varies from 1 (disagree) to 5 (fully agree). Each row sums to 100 percent.

face of such large shocks, STW allows employers to maintain worker coordination while lowering the scale of production when necessary. Thus, STW might provide the necessary insurance to encourage firms to adopt coordinated work processes and raise productivity without decreasing macroeconomic resilience.

Unfortunately, we cannot do full justice to answering this question because our data come from the experience during the Covid pandemic. It did represent a large negative aggregate shock and we have seen that the consequences were significantly more negative for more coordinated employers. However, it is largely caused by shocks that induce exceptionally high employee absences due to sickness or quarantine requirements. Short time work is only of limited use to coordinated employers as an insurance against such shocks. This is in contrast to demand shocks that require a temporary reduction in production while keeping all workers in place and preserving their coordinated work processes. Nevertheless, many establishments needed to adjust the scale of production and this provides some useful variation to assess the interaction between employer coordination and the STW policy.

Before studying the usage of the short-time work policy by firms, we first consider their answers to a question we added to a previous wave of BeCovid survey regarding the reasons for using STW. Table 16 provides the results. When asked if they agree that STW is instrumental to maintaining the organization of the production process at a lower scale of production, almost two-thirds of employers (62 percent) fully agreed with this statement and eight out of ten employers agreed or fully agreed with it. This finding corroborates the idea that coordination of the production process is an economically relevant consideration for employers. Similar to Table 14, we also asked about the importance of labor hoarding as a motive to rely on STW.

Figure 6: Short-time work and coordination



Notes: This figure shows the share of low- and high-coordination employers using STW at the time of the survey and the average share of workers in STW at low- and high-coordination employers.

We observe strong support for this motive, as 76 percent of employers strongly agree with the statement that they rely on STW to keep workers that would otherwise be challenging to rehire. We also asked about STW as a wage subsidy that frees up liquidity at the establishment. Over half of the establishments strongly agree with this motive (54 percent). We find the weakest support for the motive to spread the cost of the crisis in solidarity among the employees. Only 28 percent of employers strongly agree with this motive.

To investigate if employers with more coordinated work processes actually rely more on STW, we rely on the BeCovid survey, which collects information in each wave on the usage of STW and the share of workers in STW at the establishment. Figure 6 shows for low- and high-coordination employers the share of establishments that currently have workers on short-time work and also the average share of workers on short-time work in the different groups. We find that both employer and worker shares are higher in the high coordination group, although the differences are modest. In the high-coordination group, the share of establishments relying on STW is 22 percent, compared to 18 percent in the group of low-coordination employers, i.e., a roughly 20 percent higher share of employers using STW in the high-coordination group. We find a lower level but the same qualitative difference between high- and low-coordination employers for the share of workers on STW, we find 11 percent and 9 percent, respectively.

Table 17 explores the differences between low- and high-coordination establishments in the usage of STW after controlling for observable characteristics of establishments. We first explore the share of establishments using STW by running a linear probability model for the usage of STW in 2021. Columns (1) to (3) report the estimated coefficient on the dummy for the high-

Table 17: Usage of short-time work (intensive and extensive margin)

	Extensive margin			Intensive margin		
	(1)	(2)	(3)	(4)	(5)	(6)
high coordination	0.034	0.050	0.043	0.162	0.241	0.149
	(0.024)	(0.025)	(0.026)	(0.114)	(0.120)	(0.111)
firm size & industry	Y	Y	Y	Y	Y	Y
shortfall problems & frequency	N	Y	Y	N	Y	Y
employment & age composition	N	N	Y	N	N	Y
(Censored) observations	1,786	1,680	1,641	1,444	1,361	1,324
R2 / uncensored observations	0.0579	0.0602	0.1103	342	319	317

Notes: This table reports regression results for the usage of short-time work. Columns (1) to (3) show results for a linear probability model for the usage of STW in 2021. The reported coefficient is for a dummy variable for high-coordination establishments (coordination level > 5). Columns (4) to (6) show the coefficient estimate for the marginal effect from a Tobit regression with the share of workers in short-time work as the dependent variable. The rows below coefficients indicate what additional controls are included in the regression. The last two rows show the number of observations and R^2 for the linear probability model and censored and uncensored observations for the Tobit model with censoring from below zero. Standard errors are reported below point estimates in parentheses.

coordination group. We generally find that high-coordination firms rely more on STW, in line with the descriptive analysis. The differences are also quantitatively at the order of magnitude of the descriptive analysis. When we take into account the severity and frequency of worker shortfall, the differences between establishments in the usage of STW becomes significant at the 5-percent level. When we also control for the employment composition at the establishment in column (3), the coefficient is only significant at the 10-percent level.

In the second step, we also look at the share of workers in STW at establishments. To take into account that the establishments that rely on STW are selected, we rely on a tobit regression for the worker share regression. Table 17 reports the estimated marginal effects of being in the high-coordination group on the share of workers in STW. As for the share of establishments, we corroborate the descriptive analysis. We find that high-coordination establishments have a larger share of workers in STW conditional on relying on STW. Quantitatively, we find larger effects compared to the descriptive analysis. We find that the share of workers is between 15 percent and 24 percent higher in high-coordination firms. Indeed, it is the largest effect of 24 percent in column (5) that is statistically significant at the 5-percent level. Similarly to the regressions in column (2), the effect turns significant after controlling for the frequency and severity of problems associated with unexpected worker shortfall. When we control also for the employment composition at the establishment in column (6), the effect is smaller and also no

longer significant. Note, however, that although the Covid crisis saw a widespread use of STW, the sample for the regression remains still limited (317 uncensored observations).

In summary, the results support the idea that employers with more coordinated production processes also rely more on STW and have a larger fraction of workers in STW. However, the feature of how STW policy is actually implemented in Germany limits its current effectiveness in promoting the adoption of highly coordinated production processes. Specifically, to be eligible for STW benefits, an employer must argue that it faces a transitory negative shock that forces it to reduce earnings of at least 30 percent of employees by at least 10 percent. For employers with most workers working in a highly coordinated production process, this combination of eligibility criteria can be more challenging to satisfy. To see this, consider two firms with 100 workers each. In one firm, workers work fully independently of each other, but in the other, all workers must be present to produce. The uncoordinated firm will benefit from the STW policy if it needs to decrease output by at least 3 percent by reducing ours of 30 workers by 10 percent. In contrast the highly coordinated firm will benefit from the STW policy only if the shock requires it to reduce output by at least 10 percent. This is because it cannot reduce hours of only 30 percent of workers, but it must reduce hours of all 100 workers by at least 10 percent. This implies that while the STW policy can encourage the adoption of more productive coordinated processes by firms by providing them with additional insurance, the details of the design of the system could be crucial in its ability to achieve this goal.

7 Conclusions

In some firms, workers perform their jobs independently of each other, while in firms at the other extreme, all workers must be present to execute specialized tasks in a coordinated fashion to produce output. In this paper, we take the first step towards understanding the relationship between the degree of coordination of work processes within firms and economic outcomes in the data. While the theoretical literature has explored various models featuring such a relationship, the empirical analysis was hampered by the lack of the necessary data to study this question.

To overcome this limitation, we designed a targeted survey administered to a large representative cross-section of German employers by the Institute for Employment Research (IAB) in May 2021. Given the constraints of the survey, we decided not to impose a narrow notion of coordination as implied by a particular theoretical model. Instead, we asked a relatively broad question where employers ranked on a scale of one to ten the degree of worker dependence on each other in the production process. We linked the firm-level coordination measures from our survey to various administrative data sets. The analysis of the resulting data sets revealed a number of interesting patterns.

First, the measure of coordination is tightly linked to various economic outcomes. Even after controlling for observable characteristics of firms and their employees, more coordinated firms are significantly more productive, pay higher wages, and have lower worker turnover. Second, firms with more coordinated production processes experience more severe negative consequences from unexpected worker absences both during the Covid pandemic and in pre-pandemic times. Third, depending on the degree of coordination of work processes among their employees, firms adopt different strategies to mitigate the potential consequences of unexpected worker shortfalls.

These basic facts imply several insights that we find important. First, our simple question to measure the degree of coordination is able to elicit relevant information from employers and can be adopted in other surveys. Second, the most prevalent strategy used by highly coordinated firms is to employ additional workers who can substitute for production workers absent from work for idiosyncratic reasons. This strategy is cheaper to implement in larger firms. Thus, larger firms can more efficiently mitigate risks, allowing them to adopt more productive coordinated work processes. This offers a new potential explanation for the well-known positive relationship between firm size and productivity. Third, our results reveal an inherent trade-off: more coordinated production processes are more productive but are more at risk if firms suffer temporary negative productivity or demand shocks. It is difficult for coordinated firms to lay off individual workers who are essential to the coordinated production process. Instead, firms prefer to lower the scale of production by keeping all workers employed but at lower hours. Policies such as short-time work subsidize a coordinated reduction of work hours. Thus, if properly designed, such policies may encourage firms to adopt more productive coordinated work processes by increasing the resilience of coordinated employers to negative idiosyncratic or aggregate shocks.

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APPENDICES FOR ONLINE PUBLICATION

A Survey Instrument for Special Module on Work Coordination

Here we report the English translation of the German survey instrument for the special module. The entire survey instrument and its original German version can be accessed at the Research Data Center of the IAB at `https://fdz.iab.de/betriebsdaten/panel-betriebe-in-der-covid-19-krise-iab-becovid-welle-01-14/`.

1. Since the start of the Covid-19 crisis in February 2020, have there been cases of unexpected employee absence in your establishment as a result of Covid-19? This may be, for example, because of quarantine measures, Covid-19 infection, closure of childcare facilities, or other events. (1 = yes, 2 = no)

2. How serious were the problems typically for business operations? Please give your assessment on a scale from 1 to 5. 1 means "no problems", 5 means "severe problems." (This question is only asked to respondents who answered "yes" to question 1.)

3. Since the start of the Covid-19 crisis, have you taken any measures to reduce the potential consequences of such absences on business operations? This means, e.g., additional regulations concerning substitution, recruitment of temporary workers or replacement workers, more flexible regulations concerning working hours and overtime, changes in work processes or similar. (1 = yes, 2 = no)

4. Were there cases of unexpected employee absence in your establishment before the Covid-19 crisis? (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = very often)

5. When employees of your establishment were unexpectedly absent before the Covid-19 crisis, how serious were the problems typically for business operations? Please give your assessment on a scale from 1 to 5. 1 means "no problems", 5 means "severe problems." (This question is only asked to respondents who report at least "rarely" (= 2) to question 4.)

6. When employees were unexpectedly absent before the Covid-19 crisis, which of the following measures did you take in response? (This question is only asked to respondents who report at least "rarely" (= 2) to question 4.)

   A Rescheduling of the work lost to a later point in time

B Reallocation of the work to other employees, including supervisors or owners

C Use of temporary workers, agency workers, substitute workers, or in-company replacement workers

D Purchasing of goods or services from other establishments

7. Before the Covid-19 crisis, how often did unexpected absences occur in your establishment due to the following reasons? Please use a scale from 1 to 5, whereby 1 stands for "never" and 5 for "very often."

   A employees' sickness or personal accidents

   B cancellation of childcare or other family-related reasons

   C employees resigning or terminating their employment relationship

   D unauthorised absence

8. Now please think about the largest employee group in your establishment and describe on a scale from 1 to 10 how strongly these employees' work processes are dependent on one another. The value 1 describes a very low dependency, i.e. the employees work largely independently of one another and one employee's absence has no impact on the other employees. The value 10 describes a very high dependency, i.e. the employees' work processes are closely related and one employee's absence results in other employees having to adapt. What value best describes the situation in the largest employee group in your establishment? (This question is only asked to respondents who answered in the first part of the questionnaire that their establishment have more than two employees.) (1: The employees work independently of one another, 10: The employees' work processes are very strongly dependent on one another)

9. Does your establishment use bonus payments or non-financial rewards in order to prevent or reduce unexpected employee absence? (1 = yes, 2 = no)

10. If you think about the wage level in your establishment, which effects do you think it would have if you raised the wage level by 10%?

    A Fewer employees would leave the establishment

    B There would be less unexpected employee absence

    C Employees would make even more effort at work

11. And how strong do you think these effects would be? Please use a scale from 1 to 5, whereby 1 stands for "very weak" and 5 for "very strong."

A Fewer employees would leave the establishment (this option only appears to respondents that answered "A" in question 10)

B There would be less unexpected employee absence (this option only appears to respondents that answered "B" in question 10)

C Employees would make even more effort at work (this option only appears to respondents that answered "C" in question 10)

12. If you had to reduce the volume of work in your establishment for the next six months due to a decline in demand, which of the following measures would your establishment be more likely to select?

    1 Reduction in the number of employees, e.g., by means of redundancies, not filling vacancies, not extending contracts when they expire, not taking on apprentices on completion of training, and early retirement, or

    2 Reduction in working hours for some or all of the workforce combined with wage adjustments that are in accordance with common practice in the establishment

13. How important are the following reasons for this decision? Please use a scale from 1 to 5, whereby 1 means "not true at all" and 5 means "completely true." (This question is only asked to respondents who answered "2" to question 12.)

    1 Even if less work is carried out in total, it is very important for business operations that the entire workforce remains in the establishment if possible.

    2 The costs incurred in recruiting skilled workers later on would be very high.

B Additional Data Details

In the regression analysis, we rely on detailed information on the employment composition at the establishment level. The data come from BHP, which is derived from the social security master file. For each establishment, we observe the number of workers in different occupational groups, age groups, or with particular contracts such as temporary help workers. We construct shares of these worker groups by dividing the number of workers in a group by the total employment at the establishment. We use these employment shares as control variables in the regression. For some parts of the regression analysis, we also use the information on total employment and industry from the BHP data. These data are equivalent to the survey information as the universe of establishments of the BHP data form the sample universe of the BeCovid survey. The BHP information on employment and industry serves for the sample stratification of the BeCovid survey data.

Specifically, we use information on the following worker groups from the BHP data. As specific groups of workers, we use data on temporary help workers and low-skilled workers. Low-skilled workers are workers without a vocational degree. To describe the composition of the workforce, we use different occupation and task groupings of workers. To group workers by task complexity, we rely on the last digit of the 2010 KldB occupation codes that describe the occupational activities according to four degrees of complexity. For the occupational composition, we use 12 occupation groups following the Blossfeld classification of occupations.[19] Finally for the age composition, we use workers in 10 age groups with the youngest age group from 15 to 19 years and the oldest age group from 60 to 64 years.

C Productivity Regression Details

Recall the regression of (log) productivity that we are interested in estimating

$$a_{i,t} = \alpha_0 + \alpha_t + \beta X_{i,t} + \gamma C_i + \varepsilon_{i,t}, \tag{5}$$

where $a_{i,t}$ denotes log productivity of establishment i in year t, α_t year fixed effects, $X_{i,t}$ establishment characteristics for establishment i in year t, and C_i the coordination of establishment i. We use establishment characteristics for industry, firm size, and employment composition from the BHP data. Productivity is constructed by dividing total revenue from the BvD (Bureau van Dijk) data by the number of employees. Disclosure regulation in Germany does not require small firms to publish income statements. Medium and large firms are therefore overrepresented in the regressions with productivity data and the constructed survey weights are not appropriate so that we abstain from any weighting of the regression.

The coefficient of interest is γ capturing the relationship between coordination and productivity. Ideally, we would run this regression directly on the merged BvD and BeCovid survey data to report the coefficient of interest γ. However, the data privacy protection regulation prohibits merging individual establishment productivity information with the survey information. To follow data privacy rules, we rely on group-level aggregates for productivity. We thus take a 3-step procedure to recover the coefficient of interest γ while adhering to the privacy protection regulation.

1. **First stage regression.** We regress log productivity $a_{i,t}$ on $\{\alpha_0, \alpha_t, X_{i,t}\}$ to get residual $\hat{\varepsilon}^a_{i,t}$. We separately regress coordination C_i on $\{\alpha_0, \alpha_t, X_{i,t}\}$ to get the residual $\hat{\varepsilon}^C_{i,t}$.

[19] These groups are predefined in the BHP data. See `https://doku.iab.de/fdz/reporte/2022/DR_03-22_EN.pdf)` for further details.

2. **Anonymization via randomization.** We then sort and group $\hat{\varepsilon}^a_{i,t}$ into N bins. For each observation, we mix the log productivity with n other random establishment from the same bin. This allows us to obtain a group-specific unbiased estimate of residual productivity $\tilde{\varepsilon}^a_{i,t}$. Note that residual productivity is constructed from merging BvD data with BHP data which has a much larger sample size than the survey sample: the first-stage productivity regression has about 1.17 million observations. Thus the grouping and anonymization procedure is not very restrictive. We choose $N = 50$ to avoid too strong mean reversion that distorts the point estimates, and $n = 9$ to make sure that individual firms are not identifiable and data privacy is respected.[20]

3. **Second stage regression.** Finally, we regress $\tilde{\varepsilon}^a_{i,t}$ on $\hat{\varepsilon}^C_{i,t}$ to obtain the coefficient $\tilde{\gamma}$ as an estimate of γ.

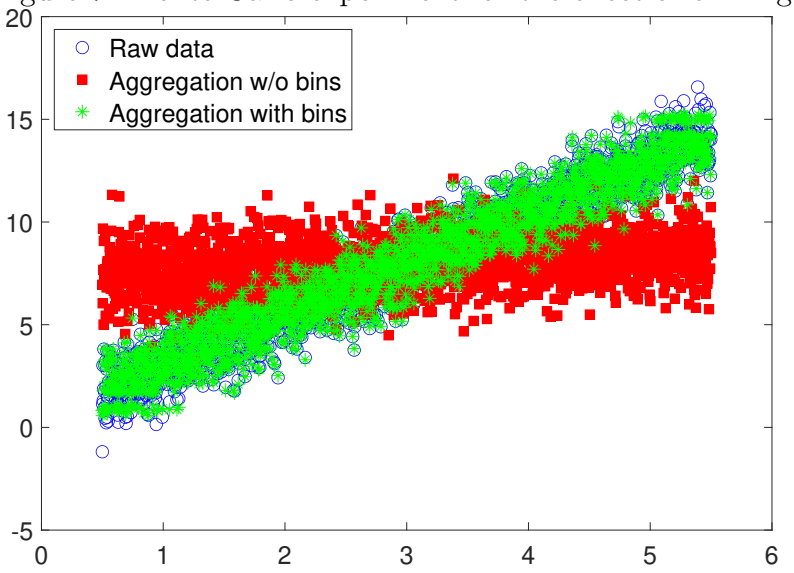
Hence, the regression follows a standard two-stage estimation approach where residuals at the second stage are group-level aggregates. The fact that we are using residuals implies already that the data only contain residual variation relative to the implied reference establishment from the regression setup. By construction, the average residual is zero. Although we rely on mean-zero residuals on average, unconditional randomization without grouping in bins would lead to biased results. The reason is that we combine a specific residual from a part of the residual support with in expectation the unconditional residual so that, for example, a high residual establishment would be combined with in expectation mean-zero residuals so that an unconditional randomization would lead to strong mean reversion and biased estimates. The conditioning on randomization from the N bins leads to randomization across establishments from a similar part of the residual support, thus limiting mean reversion. We implement a Monte Carlo simulation to demonstrate this effect. We assume a linear data-generating process

$$y_i = \alpha + \beta x_i + \varepsilon_i$$

where we are interested in estimating the coefficient β. To follow our aggregation procedure, we group y_i observations into $N = 50$ bins and then aggregate each observation within a bin with $n = 9$ randomly selected observations from the bin. We obtain the observations $\tilde{y}_i$. Alternatively, we do not group in bins and aggregate each observation with $n = 9$ randomly selected observations from the pool of all observations. We label this set of observations $\bar{y}_i$. Figure 7 shows a scatter plot for 2,000 observations for y_i (blue circles), $\tilde{y}_i$ (green stars), and $\bar{y}_i$ (red squares) using $\alpha = 0.5$ and $\beta = 2.5$. The figure immediately shows the source of the bias as we see that without bins shows there is strong mean reversion whereas the bin-aggregated data align closely with the true observations.

[20] We provide a detailed discussion of the procedure together with a Monte Carlo simulation below.

Figure 7: Monte Carlo experiment for the effect of binning



Notes: This figure shows the simulated and aggregated data from the Monte Carlo experiment. Blue dots show true observations (raw data), and green dots show binned and aggregated observations for 50 bins (10 observations for aggregation). Red squares show aggregated observations using 10 observations for aggregation without grouping in bins. The raw data follows the linear relationship $y_i = \alpha + \beta x_i + \varepsilon_i$ with $\alpha = 0.5$ and $\beta = 2.5$. The error term ε follows a standard normal distribution.

D Additional Results

Table A.1: Coordination and industry

	Industry			
Coordination	manufacturing	construction	trade	other services
low	8.5%	12.5%	32.4%	46.7%
high	14.0%	13.9%	26.4%	45.6%
total	10.6%	13.0%	30.1%	46.3%

Notes: Distribution across industries by level of coordination. Each row sums to 100%.

Table A.2: Regression results of coordination on firm characteristics

Variable	(1)	(2)	(3)	(4)
Construction, mining and, agriculture	-0.6723	-0.7664	-0.7698	-0.8452
	(0.4195)	(0.4308)	(0.4306)	(0.4309)
Trade, Transportation, and Hospitality	-0.8947	-0.6231	-0.6058	-0.7548
	(0.3375)	(0.4156)	(0.4149)	(0.4145)
Other Services	-0.7794	-0.9819	-0.8735	-0.9916
	(0.327)	(0.4456)	(0.451)	(0.4494)
10 to 49 employees	0.4144	0.2563	0.2685	0.1838
	(0.2158)	(0.2204)	(0.2199)	(0.224)
50 to 249 employees	0.7796	0.4337	0.5487	0.4718
	(0.3012)	(0.2387)	(0.2341)	(0.2371)
more than 250 employees	0.8927	0.6703	0.725	0.6286
	(0.3239)	(0.3494)	(0.3472)	(0.3523)
Occupation and age composition	N	Y	N	Y
Shortfall frequency	N	N	N	Y
N	1,786	1,743	1,743	1,743
R^2	0.0169	0.0457	0.0516	0.0750

Notes: Regression results of coordination (level 1-10) on firm characteristics. Upper part of the table reports regression coefficients for industry and firm size. Lower part reports if additional controls for employment and age composition are included. Shortfall frequency are dummies for the frequency of unexpected worker shortfall (1 = never, 5 = very often). Standard errors are reported in parentheses below coefficient estimates.

Table A.3: Wages and coordination

Variable	(1)	(2)	(3)	(4)
coordination	0.0074	0.0070		
	(0.0035)	(0.0034)		
medium coordination			0.0295	0.0200
			(0.0274)	(0.0267)
high coordination			0.0651	0.0617
			(0.0252)	(0.0247)
N	75,696	72,964	75,696	72,964
R^2	0.4223	0.4299	0.4227	0.4303

Notes: Regression of log wages on worker and firm characteristics and coordination of the production process. Wages are average daily wages for a sample of full-time workers in 2020. All regressions include full set of worker controls (age, sex, occupation, education) as dummy variables. Regression specifications in columns (1) to (4) differ in control variables for employer characteristics and samples. Column (1) includes coordination as linear control and firm size dummies. Column (2) uses quadratic term for employment to control for firm size. Columns (3) and (4) replace coordination variable by dummy variables in regressions of columns (1) and (2). Standard errors in parenthesis.

Table A.4: Worker-outflow rates

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				minimum 3 observations			
coordination	-0.0072		-0.0067		-0.0054		-0.0076
	(0.0029)		(0.0030)		(0.0026)		(0.0029)
medium coordination		-0.0398		-0.0450		-0.0328	
		(0.0202)		(0.0213)		(0.0172)	
high coordination		-0.0496		-0.0447		-0.0350	
		(0.0195)		(0.0197)		(0.0172)	
firm size	cont.	dummy	cont.	dummy	cont.	dummy	cont.
Observations	9,196	9,196	9,196	9,196	14,456	14,456	9,196
R^2	0.1092	0.1094	0.1005	0.1012	0.0896	0.0897	0.1278
				minimum 5 observations			
coordination	-0.0069		-0.0066		-0.0048		-0.0072
	(0.0027)		(0.0029)		(0.0025)		(0.0027)
medium coordination		-0.0476		-0.0525		-0.0354	
		(0.0174)		(0.0184)		(0.0152)	
high coordination		-0.0494		-0.0457		-0.0318	
		(0.0183)		(0.0189)		(0.0167)	
firm size	cont.	dummy	cont.	dummy	cont.	dummy	cont.
Observations	9,051	9,051	9,051	9,051	14,260	14,260	9,051
R^2	0.1429	0.1447	0.1295	0.1322	0.1012	0.1019	0.1568
				minimum 7 observations			
coordination	-0.0089		-0.0090		-0.0065		-0.0092
	(0.0026)		(0.0029)		(0.0023)		(0.0026)
medium coordination		-0.0553		-0.0595		-0.0435	
		(0.0174)		(0.0187)		(0.0152)	
high coordination		-0.0636		-0.0616		-0.0435	
		(0.0182)		(0.0191)		(0.0164)	
firm size	cont.	dummy	cont.	dummy	cont.	dummy	cont.
Observations	8,825	8,825	8,825	8,825	13,942	13,942	8,825
R^2	0.1493	0.1513	0.1389	0.1411	0.1017	0.1025	0.1618

Table A.5: Worker outflow rates to other employers

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				minimum 3 observations			
coordination	-0.0060		-0.0057		-0.0048		-0.0061
	(0.0021)		(0.0022)		(0.0018)		(0.0021)
medium coordination		-0.0363		-0.0397		-0.0292	
		(0.0132)		(0.0141)		(0.0116)	
high coordination		-0.0450		-0.0417		-0.0342	
		(0.0141)		(0.0144)		(0.0122)	
N	9,196	9,196	9,196	9,196	14,456	14,456	9,196
R^2	0.1195	0.1211	0.1062	0.1084	0.1009	0.1016	0.1367
				minimum 5 observations			
coordination	-0.0053		-0.0051		-0.0040		-0.0053
	(0.0019)		(0.0020)		(0.0017)		(0.0019)
medium coordination		-0.0366		-0.0396		-0.0271	
		(0.0124)		(0.0132)		(0.0111)	
high coordination		-0.0413		-0.0391		-0.0296	
		(0.0131)		(0.0136)		(0.0117)	
N	9,051	9,051	9,051	9,051	14,260	14,260	9,051
R^2	0.1285	0.1313	0.1177	0.1212	0.1030	0.1040	0.1433
				minimum 7 observations			
coordination	-0.0060		-0.0061		-0.0049		-0.0060
	(0.0018)		(0.0020)		(0.0016)		(0.0018)
medium coordination		-0.0393		-0.0419		-0.0317	
		(0.0123)		(0.0132)		(0.0108)	
high coordination		-0.0436		-0.0426		-0.0332	
		(0.0128)		(0.0136)		(0.0114)	
N	8,825	8,825	8,825	8,825	13,942	13,942	8,825
R^2	0.1405	0.1428	0.1324	0.1349	0.1103	0.1111	0.1549

Table A.6: Frequency of unexpected absences from work before the Covid crisis

Frequency of absence	Proportion
never	15.5%
rarely	62.2%
from time to time	18.8%
often and very often	3.6%

Notes: Share of employers who report a certain frequency of unexpected worker shortfall.

Table A.7: Frequency and reason of worker shortfalls

	reason			
frequency	sickness/accident	childcare	quitting	unexcused absences
never	14.7%	58.5%	64.6%	89.3%
rarely	44.0%	28.0%	25.7%	7.2%
from time to time	16.0%	8.2%	7.1%	2.5%
often	8.7%	3.4%	1.8%	0.7%
very often	16.7%	1.9%	0.8%	0.3%

Notes: Frequency of reasons for unexpected worker shortfalls. Only answers of employers who report at least rarely unexpected worker shortfall. Each column shows one column and frequencies sum to 100% within a column.

Table A.8: Severity of problems and coordination

	Severity				
coordination	1	2	3	4	5
Panel A. during Covid pandemic					
low	19.6%	30.6%	28.1%	16.3%	5.4%
high	8.6%	20.8%	32.3%	25.4%	12.9%
Panel B. normal times					
low	22.6%	44%	26.6%	6.2%	0.5%
high	13.9%	35.9%	34.9%	12.5%	2.8%

Notes: Severity of problems in the production process from worker shortfalls by level of coordination in the production process. Each row sums to 100 percent. The Covid-related sample is restricted to those employers that reported Covid-related worker shortfalls (1,459 observations). For normal times, sample is restricted to employers who report to have worker shortfalls during normal times (1,680 observations).

Table A.9: Worker shortfall, severity of consequences, and mitigation during Covid

	Worker Shortfall		Severity of Problems		Mitigation Measures	
	(1)	(2)	(3)	(4)	(5)	(6)
Medium Coordination	0.1055	0.0925	0.4082	0.3899	0.1023	0.1196
	(0.0422)	(0.0411)	(0.1259)	(0.1240)	(0.0426)	(0.0425)
High Coordination	0.1196	0.0971	0.6095	0.4771	0.1306	0.1391
	(0.0445)	(0.0451)	(0.1407)	(0.1385)	(0.0461)	(0.0469)
firm size & industry	Y	Y	Y	Y	Y	Y
employment & age composition	N	Y	N	Y	N	Y
R^2	0.1432	0.1677	0.0600	0.1274	0.0624	0.0868
Observations	1783	1740	1363	1329	1781	1738

Notes: Regression results for Covid-related worker shortfall, severity of consequences of worker shortfall, and additional mitigation measures. Worker shortfall is an indicator variable if employers experienced Covid-related unexpected worker shortfalls, severity of problems captures the severity of the consequences of unexpected worker shortfall on work processes (1 = no problems, 5 = very severe), and mitigation measures is an indicator variables if additional mitigation measures have been implemented because of Covid. Low and high coordination dummies for employer groups. Rows *firm size & industry* and *employment & age composition* report if also additional controls have been used in the regression. Standard errors are reported in parentheses below coefficient estimates.

Table A.10: Worker shortfall and severity of consequences during normal times

	Worker Shortfall		Severity of Problems	
	(1)	(2)	(3)	(4)
Medium Coordination	0.1904	0.1895	0.2060	0.2247
	(0.0529)	(0.0513)	(0.0826)	(0.0799)
High Coordination	0.1064	0.0861	0.4288	0.4224
	(0.0685)	(0.0671)	(0.0948)	(0.064)
firm size & industry	Y	Y	Y	Y
employment & age composition	N	Y	N	Y
R^2	0.0772	0.1403	0.1011	0.1358
Observations	1,766	1,724	1,680	1,641

Notes: Regression results for worker shortfall and severity of consequences of worker shortfall during normal times. Worker shortfall is reported on a scale from 1 (never) to 5 (very often) and severity of problems captures the severity of the consequences of unexpected worker shortfall on work processes (1 = no problems, 5 = very severe). Low and high coordination dummies for employer groups. Rows *firm size & industry* and *employment & age composition* report if also additional controls have been used in the regression. Standard errors are reported in parentheses below coefficient estimates.

Table A.11: Economic consequences and coordination

	Economic Consequence		
coordination	negative	positive	equal
low	40.4%	8.5%	51.1%
high	48.6%	9.5%	42.0%

Notes: Distribution over the current economic consequences of the Covid crisis by coordination of the production process. Each row sums to 100%.

Table A.12: Mitigation and firm size

	firm size				
mitigation	1 - 9	10 - 49	50 - 249	250 +	total
0	23.3%	7.2%	5.8%	0.6%	17.9%
1	28.3%	29.7%	26.2%	12.4%	28.4%
2	37.2%	47.7%	48.9%	55.4%	40.7%
3	9.3%	13.8%	14.8%	24.3%	10.9%
4	2.0%	1.7%	4.3%	7.3%	2.1%

Notes: Distribution of the number of mitigation measures across establishments. Column 1 shows number of mitigation measures (maximum 4). Columns show establishments of different size and all establishments in the last column. Each column sums to 100%.

Table A.13: Wage and non-wage benefits against worker shortfall

	(1)	(2)	(3)
Medium Coordination	0.0289	0.0457	0.0446
	(0.0290)	(0.0301)	(0.0279)
High Coordination	0.1538	0.1617	0.1625
	(0.0379)	(0.0040)	(0.0383)
firm size & industry	Y	Y	Y
employment & age composition	N	N	Y
shortfall frequency and severity	N	Y	Y
R^2	0.0475	0.0560	0.0794
Observations	1,778	1,673	1,635

Notes: Regression results for existence of wage and non-wage benefits to prevent worker shortfall. Dependent variable indicator if benefits are used at the establishment. Coefficient estimates for dummies of medium- and high-coordination establishments. Additional controls are indicated below regression coefficients. Shortfall frequency and severity are dummies for how often during normal times employers report worker shortfall and how severe the consequences of such worker shortfall are. Standard errors are in parentheses below estimated coefficients.

Table A.14: Extensive-intensive adjustment decision and motives for intensive margin adjustment

	Intensive-Extensive Adjustment		Maintain Production Process	Labor Hoarding
	(1)	(2)	(3)	(4)
Medium Coordination	0.0003	-0.0204	0.3288	0.0505
	(0.0374)	(0.0384)	(0.1481)	(0.1743)
High Coordination	-0.0373	-0.0260	0.5693	0.3114
	(0.0443)	(0.0422)	(0.1524)	(0.1937)
firm size & industry	Y	Y	Y	Y
shortfall frequency and severity	Y	Y	Y	Y
employment & age composition	N	Y	N	N
R^2	0.0715	0.1045	0.0685	0.0607
Observations	1,540	1,505	983	967

Notes: Regression results for the decision to adjust labor inputs at the extensive vs. intensive margin after a negative (6-months) demand shock in columns (1) and (2). Extensive margin adjustment coded as value 1 intensive margin adjustment as value 2. Columns (3) and (4) show regression results for support of different motives for intensive margin adjustment for the sample of employers who report intensive margin adjustment after demand shock. Reported coefficient estimates are dummies for medium- (coordination level 4-7) and high-coordination (coordination level ≥ 8) employers. Additional control variables reported in rows below point estimates. Standard errors reported in parentheses below point estimates.

E Employer differences in extensive margin adjustment

In Section 6.1, we discuss in detail employers who opt for an intensive margin adjustment after a negative demand shock. This group is with 76 percent the majority of employers in the German labor market. In this section, we discuss the smaller group of employers who responded that they would react to a negative demand shock with an extensive margin adjustment.

Looking at these employers, we find that more coordinated firms adjust slightly more than less coordinated firms at the extensive margin: 23 percent of low-coordination employers opt for extensive margin adjust compared to 27 percent among the high-coordination employers. One important reason for this finding is that larger establishments are more coordinated and they also adjust more at the extensive margin. In Table A.15, we report the share of employers who would adjust at the extensive margin to a demand shock across employers of different sizes and from different industries by level of coordination. The upper panel shows that within employers with low coordination, less than 16 percent of the smallest firms with 1–9 employees report that they would adjust labor at the extensive margin, whereas the share is more than four times higher among large establishments with 250 or more employees (64 percent). We find a similar pattern among employers with a high coordination in production processes. In this group, 19 percent of small employers would adjust at the extensive margin and the fraction is 2.8 times as high for the largest employers in this group (53 percent). Hence, firm size seems to play a dominant role in how labor inputs are adjusted in response to shocks. The bottom panel reports the extensive margin adjustment by industries. The *Construction, Mining, and Agriculture* sector stands out with a higher share of extensive margin adjustments. High coordination firms tend to adjust more at the extensive margin across all industries.

Table A.15: Extensive margin adjustment to demand shock by coordination and firm size

	coordination	
	low	high
1-9 employees	15.7%	19.3%
10-49 employees	24.6%	29.5%
50-249 employees	33.5%	44.1%
250 or more employees	63.9%	53.0%
Manufacturing, Energy, and Utilities	16.0%	24.6%
Construction, Mining, and Agriculture	29.3%	30.9%
Trade, Transportation, and Hospitality	20.5%	23.8%
Other Services	17.6%	24.4%

Notes: Share of low- and high-coordination employers who would lay off workers (extensive margin) to reduce labor input after a negative (6-month) demand shock. The top panel of the table shows shares for low- and high-coordination establishments of different firm size. The bottom panel shows the share for low- and high-coordination establishments in different industries. Other employers who do not adjust at the extensive margin answer that they adjust hours (intensive margin).