Coordinated Firm-Level Work Processes and Macroeconomic Resilience*

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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 unexpected worker absences and adopt various strategies to mitigate such risk, the reliance on which we document. We also find that more coordinated employers suffer worse consequences of negative aggregate shocks. Finally, we discuss policies that may encourage firms to adopt more productive coordinated work processes by increasing the resilience of coordinated employers to negative idiosyncratic or aggregate shocks.

JEL Codes: E23, E24, J24, J65

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1 Introduction

The production processes at many firms rely on a sophisticated, highly choreographed, and interdependent network of workers performing specialized jobs. The theoretical literature discussed below has identified the productivity gains 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, and this limits the degree of specialization and coordination adopted by firms. 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. This paper takes the first steps toward filling this void.

The fundamental problem with studying these issues is the lack of data on the nature of firms' production processes, 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 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. Using these data, our objective in this paper is to provide novel and relatively wide-ranging empirical evidence on the relationship between workplace coordination, labor supply shocks, and economic outcomes that we hope will help guide and discipline future theoretical and quantitative work.

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 perfectly substitutable. 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 substitutable-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, e.g., the firm

size distribution or industries. However, even after conditioning for such observables, large heterogeneity remains, suggesting that the degree of coordination adopted by firms could be at least partly a choice that might respond to the economic environment and policies.

Having linked our employer-level survey data to various administrative data sets, we study the relationship between the degree of coordination at an employer and various economic outcomes. 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 worker outflow rates.

We complement our survey data with the German Microcensus to estimate the frequency and extent of unexpected worker absences. We find that in a typical, pre-pandemic work week 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 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 shocks such as business cycles or pandemics. 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. More coordinated production processes might also be particularly vulnerable to 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, including the one on remote

work. We find that high-coordination establishments have a smaller share of employees working from home.

The trade-off between aggregate 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. Unlike unemployment benefits that insure against income losses for unemployed workers, short-time work provides insurance for reduced earnings due to lower hours of employed workers, enabling 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 while mitigating the negative impact on macroeconomic resilience.

Literature. It is well recognized that modern production often features high coordination and interdependence 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 contributions have tried to understand the causes and consequences of labor specialization and the economic forces that limit the adoption of specialized and coordinated production processes. Adam Smith emphasized market size as a factor constraining the degree of labor division. In contrast, Becker and Murphy (1992) argued that the cost of coordinating specialized workers 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) emphasized 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, Garicano and Hubbard 2018).[1] We complement this literature by highlighting the role of unexpected worker absences as the force limiting the extent of specialization and coordination.

Although this stream of literature shares the assumption that specialization and coordination are choices made by firms and are associated with productivity gain, there is little analysis of the implications of these choices for firms' resilience. Dessein and Santos (2006) proposed that

[1] Impink, Prat, and Sadun (2020) discuss how communication data could be used in the future to study the internal coordination and cooperation within firms.

a potential goal of organizations is to adapt to changing business conditions and argued that organizations can reduce the level of (ex-ante) coordination and allow employees more flexibility in carrying out their tasks as the business environment becomes more uncertain. Our analysis suggests that in addition to the uncertain business environment, an important force shaping firms' coordination choices is the uncertainty regarding which and how many specialized workers may not be present at work at a given time.

Changing organizational structure is likely challenging, especially in the short run, e.g. 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. In order to do so, one must recognize that in addition to restructuring the organization from time to time, firms may self-insure by complementing the coordinated production structure with various mitigation strategies, such as, among others, efficiency wages (Stiglitz 1974, Salop 1979, Katz 1986, Raff 1988) to minimize worker absences or hiring of surplus workers who can step in for absent workers to help maintain the production process. As far as we know, no theoretical framework in the literature links the organization of production processes to firms' mitigation strategies and short- or long-run responses to shocks. Our contribution here is to provide novel empirical facts on the adoption of various mitigation strategies by firms with varying degrees of coordination essential for the development of such a framework.[2]

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), production networks between firms (Olsson 2019; Miranda-Pinto, Silva, and Young 2022), supply chain management (Ambulkar, Blackhurst, and Grawe 2015; Elliott, Golub, and Leduc 2022; Pellet and Tahbaz-Salehi 2022), and worker mobility between firms (Guerrero and Axtell, 2013). The Covid shock further enables explorations into the effect of ICT technology and remote work on worker resilience (Pierri and Timmer 2020, Hou et al. 2021). Among these studies, however, the economic resilience of employers which varies in the degree of coordination in work processes is absent and our study aims to fill this void.

Recently, there has been a growing interest in examining the effect of worker absence on firm

[2]We specifically focus on the worker coordination of the production process, which differentiates us from other aspects of the broad notion of organizational structure such as flexibility (Campbell and Fisher 1998; Pellet and Tahbaz-Salehi 2022) or complexity (Cirera et al. 2020; Kohlhepp 2022).

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. Adhvaryu et al. (2021) find that a 10 percentage-point increase in absenteeism decreases productivity by roughly 4 percentage points, even though sharing workers is implemented as common practice to mitigate worker absence in their sample of Indian garment factories. They also document that worker absenteeism shocks are frequent and large relative to firms' employment. Using French administrative data on secondary school teacher absence, Benhenda (2022) finds that, on average, one day of teacher absence reduces 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), Labanca and Pozzoli (2022a), Labanca and Pozzoli (2022b), Bick, Blandin, and Rogerson (2022), 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.[3] 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 variations in labor supply (Jäger and Heining, 2019) to quantify the substitutability of workers. Our findings on the widespread adoption of mitigation strategies by firms to insure against worker shortfall suggest that using unexpected worker absences as a natural experiment to identify the production function or other firm- or worker-level outcomes (e.g., productivity, wages) is informative only if the adopted mitigation strategies are controlled for. If mitigation strategies are not observed in the data – as is typically the case, the estimates based on this identification approach should be interpreted with caution.

The remainder of the paper is structured as follows. Section 2 introduces the new survey data 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 examines the economic consequences of worker shortfalls and how the severity of these consequences varies with the degree of coordination. Section 5 considers mitigation measures adopted by firms to deal with unexpected worker shortfalls. Section 6 discusses the efficiency implication of the short-time work policy in the presence of

[3]The O-ring production theory as in Kremer (1993) deviates from this assumption. See Bloesch, Larsen, and Taska (2022); Freund (2022) for recent developments.

coordination. Section 7 concludes. An online appendix contains 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) which started in August 2020 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 monthly survey wave, the establishment answers a set of recurring questions as well as questions from a special topical module. In total, 24 waves of the BeCovid survey were 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 interviewed in the previous wave and a refreshment pool of establishments yet to be surveyed. 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 interviews hovered around 60 percent.

The survey population is all establishments in Germany with at least one employee covered by social security legislation, so they must file with the German social security administration. The sampling relies on a stratified sample of establishments by employment size (four groups) and industry (five groups). Due to the limited number of large establishments and the repeated sampling, there is no stratification by industry 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 consented to record linking.

The data on coordination, mitigation strategies, and consequences of worker shortfalls, 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.[4] Our key challenge in designing this

[4]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/. The webpage also describes how to

topical module was ensuring that respondents correctly interpret the questions and that their answers reveal the information that we seek as economists. In addition, 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 May 2021 or at any point 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, 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. 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 shortfalls 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. In all survey and administrative data except for the Microcensus, the unit of observation is an establishment. In the discussion, we will interchangeably use establishment, employer, or firm when referring to this unit of analysis.[5]

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. Coordination 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

obtain access to the data for all survey modules.

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

is economically meaningful, as 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 that employees' work processes are closely related and the unexpected absence of one employee leads to significant adjustments for other employees.[6] The basic idea behind this survey question is that workers provide differentiated labor inputs and firms choose technology that determines the substitutability of these inputs in the production process. Under a linear technology, the absence of one employee has no effect on other employees. On the other extreme, with Leontief technology, the absence of one employee leads to a significant impact on other employees.[7]

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 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 or, in cases where the effects of interest appear nonlinear, into three groups of low (answer 1 to 3), medium (answer 4 to 7), and high (answer 8 to 10) coordination.

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

[6] 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 to measure the coordination of tasks in production and not the extent of communication among workers.

[7] A rigorous formalization of this idea is not trivial. First, it will require including worker absences in the theory as a clear feature of the data and in addition firms adopting mitigation strategies to self-insure against such shortfall. Second, it will require extending the representation of the production process as standard production functions (for instance a CES) with sufficiently complementary task inputs yield too stylized predictions for quantitative analyses as the absence of any single worker reduces the production to zero (or infinitely small).

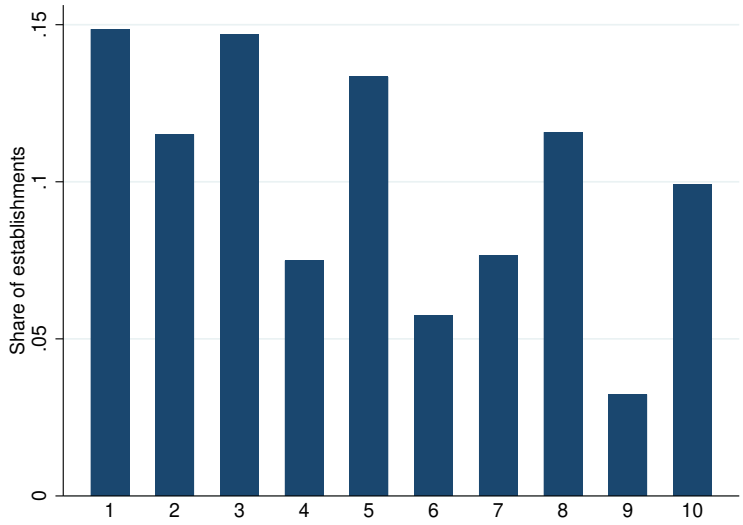


Figure 1: Share of establishments across coordination levels

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.

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 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. Among low-coordination establishments, 8.5 percent are manufacturing and 79 percent are service. Among high-coordination establishments, 14 percent are manufacturing and 72 percent are service. In addition to the systematic between-industry variation, we also observe substantial within-industry variation in the level of coordination. The lower panel of Table 1 reveals a systematic relationship between coordination and firm size as well as a substantial variation of coordination conditional on firm size. Larger firms are more likely to have more coordinated production processes. For instance, only slightly more than one-third of the smallest establishments (with 1–9 employees) report high coordination. By contrast, over half of the largest establishments (with 250 or more employees) report high coordination.

Appendix Table A.2 reports regression results for reported coordination and a high-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.

indicator (linear probability model) as dependent variables 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, consistent with 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 data on productivity aggregate over a group of establishments. That is, we are not allowed to merge firm level productivity information with our firm level survey data. As a result, we cannot directly implement the above establishment-level regression of productivity on coordination. To overcome this challenge, we rely on the two-stage decomposition of the regression detailed in Appendix C: in the first step, we regress both productivity and coordination dummies on a set of common control variables. In the second step, we sort productivity residuals from the first-stage regression into bins, aggregate them within bins, and then regress the aggregated residuals for productivity on the residualized coordination dummies.[8] For the common control variables in the first-stage regressions, we use information from the BHP data that, unlike the BeCovid survey data, can be merged with the BvD data at the establishment level. We use as control variables dummies for industry and firm size and firm's employment composition. In the case of the productivity regression, we also remove time effects by including year dummies.

The regression results presented in Table 2 reveal a very strong correlation between labor productivity and coordination. In column (1), we rely on the full sample from 2009 to 2020 for which we have productivity data.[9] We group establishments into the three groups of low, medium, and high coordination, as explained in Section 3.1. We find a significant effect of coordination on productivity for the medium- and the high-coordination group. The point estimate implies a more than 10 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. Hence, we find support for a positive relationship between productivity and coordination. These results are interesting—coordination is not well predicted

[8] Binning is required to minimize the bias from mean-reversion as explained in Appendix C.

[9] BvD data contain 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 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 2: Coordination and productivity

	Productivity: log (revenue per worker)	
Coordination	(1)	(2)
medium	0.129	0.137
	(0.055)	(0.058)
high	0.111	0.113
	(0.050)	(0.052)
R^2	0.0032	0.0034
Observations	2,089	1,935
Sample	2009-2020	2009-2019

Notes: This table reports regression results for the relationship between coordination and productivity. Columns (1) and (2) differ with respect to the years in the sample indicated in row *Sample*. Reported coefficients and R^2 are from second stage of regression of residuals for productivity and dummies for the medium and high coordination group. First-stage regressions include as controls industry and firm size dummies, occupation composition, and year dummies in the case of productivity. See Appendix C for details. Standard errors are reported in parentheses.

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

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

where $w_{i,j}$ is the daily 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, including 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 $\varepsilon_{i,j}$. Columns (1) and (2) of Table 3 show estimated regression coefficients ρ for two sets of specifications where we either control for firm size using employment size dummies or a linear term for employment (see row *firm size*). We consider wages in the pre-Covid year of 2019 but find very similar results for 2020 wages. We also find similar results if we drop the observations with daily wages above the

Table 3: Coordination, Wages, and Worker Outflows

	Wages		All outflows		Outflows to other employers	
coordination	(1)	(2)	(3)	(4)	(5)	(6)
medium	0.025	0.016	-0.046	-0.051	-0.032	-0.035
	(0.029)	(0.029)	(0.015)	(0.016)	(0.010)	(0.011)
high	0.070	0.064	-0.053	-0.050	-0.036	-0.035
	(0.027)	(0.027)	(0.017)	(0.018)	(0.011)	(0.012)
firm size	dummy	cont	dummy	cont	dummy	cont
R^2	0.544	0.548	0.141	0.130	0.127	0.118
Observations	79,711	77,245	8,281	8,281	8,281	8,281

Notes: This table reports in columns (1) and (2) regression results of log wages on worker and firm characteristics and coordination of the production process. Columns (3) to (6) report regression results of worker outflows on firm characteristics and coordination of the production process. Columns (3) and (4) show results for outflow rates including all outflows from an employer and columns (5) and (6) for outflows only to other employers. Wages are the average daily wages for full-time workers in 2019 and regressions include a full set of worker controls (age, sex, occupation, education) as dummy variables and employer controls. For worker flow rates, all regressions include employment composition controls. Employers have at least ten observations for flow rates. Row *firm size* indicates if firm size is controlled for using dummy variables or a continuous employment measure. For wage regressions, we cluster standard errors at the establishment level. Standard errors are reported in parentheses.

social security limits. These additional results are reported in Appendix Table A.3.

The estimation results reported in Columns (1) and (2) show that compared to low-coordination employers, medium-coordination employers pay 1.6 to 2.5 percent more and high-coordination employers pay 6.4 to 7.0 percent more to otherwise observationally identical workers. Higher wages at more coordinated employers could be either a consequence of higher productivity or a strategy for worker retention, which 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 the next step, we study 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 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.[10] 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, $S_{j,t}$ contains controls for employment composition of establishment j in year t, C_j is the measure of coordination, and $\varepsilon_{t,j}$ denotes the error term.

First, we consider all outflows from employment. The regression results in Columns (3) and (4) of Table 3 show a consistent negative relationship between coordination and worker outflows. Column (3) shows that high(medium)-coordination firms have a 5.3pp (4.6pp) lower outflow rate than low-coordination firms. Column (4) show results when we control for firm size using a continuous measure of employment instead of firm size dummies. Results align closely with column (3) but the difference between medium- and high-coordination employers vanishes. All coefficients of coordination are statistically significant.

Second, we restrict attention to outflows to other employers. We estimate the same regression specifications but use outflows to other employers as the right-hand side variable and report the results in columns (5) and (6) of Table 3. We find that outflow rates to other employers are also negatively related to coordination. Specifically, the outflow rates at low-coordination employers are 3.6pp (3.2pp) lower than high(medium)-coordination employers. The effect of coordination on outflows to other employers is about two-thirds of the effect on all outflows in columns (3) and (4).

4 Coordination and Consequences of Worker Shortfalls

This section studies the economic consequences of worker shortfalls and how the severity of these consequences varies with the degree of coordination of the production process.

[10] The results are robust to alternatively restricting to at least 3, 5, or 7 observations per employer, see Appendix Table A.4.

4.1 Worker Shortfalls Faced by Firms

Before examining the consequences of unexpected worker shortfalls on coordinated production processes, we present evidence of their frequency and magnitude. Our employer survey module asked employers how frequently unexpected worker shortfalls occurred in the pre-Covid period. Employers responded on a scale from 1 (never) to 5 (very often). As summarized in Appendix Table A.5, 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.

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. As we are interested in unexpected worker shortfalls, we only consider cases if the worker reports sickness, personal or family reasons, or other reasons for fewer working hours. [11] Hence, we exclude reasons for shortfalls that are predictable from the employer's perspective, including vacations, parental leave, adjustments in working time accounts, public holidays, or part-time work arrangements of older workers. We translate the shortfall share in workdays by assuming that a 20 percent shortfall of regular working hours corresponds to one workday. Using this definition, Table 4 shows that 92.6 percent of workers do not report any unexpected shortfall. Among workers with a positive unexpected shortfall, more than half report a shortfall of 4 days or more, typically it is the entire workweek (5 days) that is missed in this group. About 30 percent of workers with positive shortfall report a shortfall of up to one workday. The remaining roughly 20 percent of workers with unexpected shortfalls are spread over the three middle groups with declining shares.

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.[12] Our survey included targeted questions to employers

[11] 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.6.

[12] Qiu (2022) studies the macroeconomic consequences of worker shortfalls in a frictional labor market with representative jobs.

Table 4: Distribution of unexpected worker shortfalls across workers with shortfall

Shortfall in workdays (per week)	≤ 1	1 - 2	2 - 3	3 - 4	4 - 5
Share of workers	28.7%	8.9%	5.3%	3.4%	53.8%
Share of workers without shortfall			92.6%		

Notes: This table shows the share of workers across bins of unexpected shortfalls for employed workers with positive unexpected shortfalls. Shortfall days are derived based on the hours share of reported regular weekly working hours with one day being 20 percent of weekly working time. Unexpected worker shortfalls are constructed from the 2018 Microcensus. See the text for details on the definition of unexpected worker shortfalls. Row *Share of workers without shortfall* shows the share of workers without unexpected worker shortfalls.

to elicit the consequences of worker shortfalls 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.[13] 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 experiencing worker shortfalls during normal times were asked follow-up questions on the severity of problems from worker shortfalls.

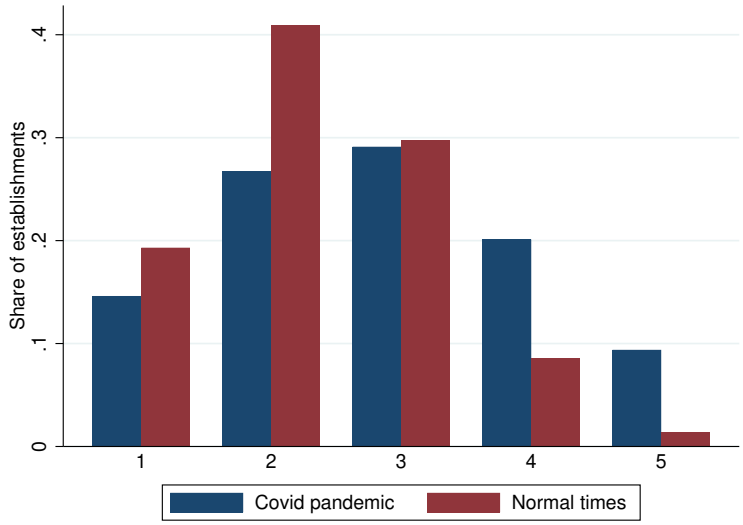
Figure 2 compares the frequency of responses regarding the severity of the problems from unexpected worker shortfalls during the Covid pandemic versus normal times. We observe that there is large heterogeneity in the responses. For Covid-related worker shortfalls, about 15 percent of employers report no problems, while 10 percent of employers report severe problems, and many employers report an intermediate value of 3 (29.6 percent). We find that fewer employers report severe or very severe consequences during normal times.

In Table 5, 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 low-coordination establishments are with three out of four employers much more frequent among establishments that report the least severe consequences. The share of the

[13] We first asked *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.* For those employers answering yes, we also asked *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."*

Figure 2: 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 observations) about problems of worker shortfalls. For normal times, only employers who report having worker shortfalls are asked about problems of unexpected worker shortfalls during normal times (1,680 observations).

low-coordination establishments decreases with severity and among employers who report the most severe consequences we have two out of three employers that are in the high-coordination group. Hence, we find a striking pattern of the correlation between the severity of problems from unexpected worker shortfall and coordination. Establishments that report small problems in the production process are typically low-coordination establishments and establishments with severe problems are typically high-coordination employers. When we look at normal times in the lower part of the table, we find almost the same pattern, if anything, they become even stronger with now three out of four employers being in the high coordination group among those employers who report severe problems of unexpected worker shortfall.

In Appendix Table A.7, we alternatively condition on coordination and report the distribution of employer answers across the different levels of severity of problems. The alternative view strongly corroborates the current findings. We find that more than half of the low-coordination employers report only mild problems (answers 1 and 2), whereas only less than 30 percent of the high-coordination employers have such mild problems. By contrast, over 38 percent of the high-coordination employers report severe problems (answers 4 and 5), compared to only 22 percent of the low-coordination employers. The evidence suggests that the 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

Table 5: 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. In Panel A, the sample is restricted to those that reported Covid-related worker shortfalls (1,459 observations). In Panel B, the sample is restricted to employers who report having worker shortfalls during normal times (1,680 observations).

production.

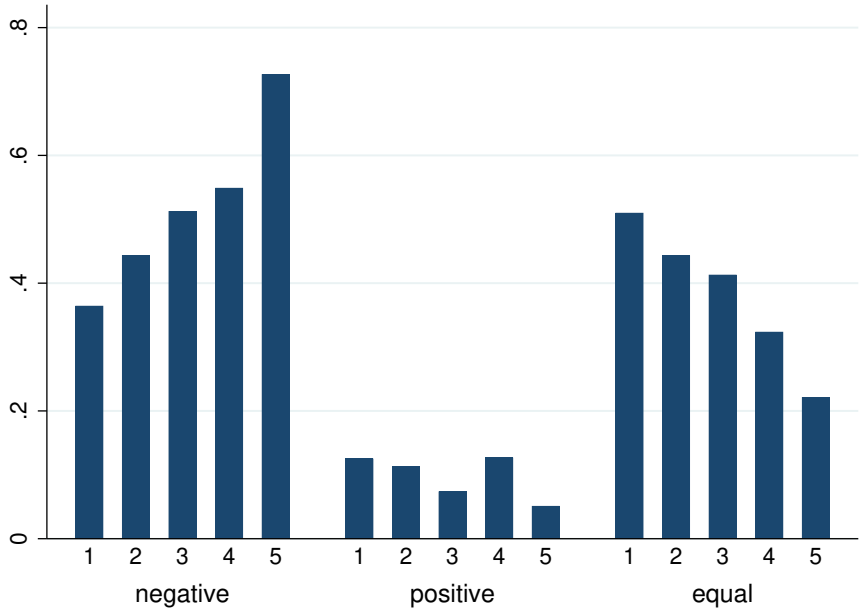
In Appendix Tables A.8 and A.9, we present additional regression results for the frequency and severity of problems from worker shortfalls during the Covid pandemic and normal times. We find the results on the relationship to coordination to be robust even after controlling for other establishment characteristics.

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 shortfalls. We now complement that analysis with answers to the question in the core BeCovid survey asking employers to assess overall current economic consequences of the Covid crisis as negative, positive, or equal.[14] These overall consequences may be due to any economic forces, including worker shortfalls, demand fluctuations, supply chain disruption, etc.

[14]The survey asks about the current situation in May 2020: *With regard to your establishment, is the Covid-19 crisis currently having predominantly negative (answer 1) or predominantly positive effects (answer 2) or roughly equal negative (answer 3) and positive effects or neither negative nor positive effects (answer 4)?* We combine the two latter answers into one answer for "equal."

Figure 3: Assessment of economic consequences of Covid crisis



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

Figure 3 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 less severe consequences from worker shortfalls 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 problems caused by unexpected worker shortfalls correlate strongly with the overall economic consequences to employers from the crisis.[15]

These findings raise an intriguing question. Were the firms that report more severe problems due

[15]In Appendix Table A.10, 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 reporting negative consequences is 20 percent lower at 40.4 percent.

Table 6: Economic consequences and shortfall problems

	Direction of economic consequences			Strength of negative economic consequences		
	(1)	(2)	(3)	(4)	(5)	(6)
shortfall problems	-0.059	-0.057	-0.041	0.153	0.151	0.156
	(0.025)	(0.025)	(0.025)	(0.060)	(0.060)	(0.053)
employment growth	Y	Y	Y	Y	Y	Y
firm size	N	Y	Y	N	Y	Y
industry	N	Y	Y	N	Y	Y
employment composition	N	N	Y	N	N	Y
R^2	0.017	0.019	0.037	0.039	0.055	0.169
Observations	1,383	1,383	1,346	1,005	1,005	976

Notes: This table reports regression results for the relationship between the severity of shortfall problems (level 1 (no problems) to 5 (very severe problems)) and the direction of economic consequences in columns (1) to (3) and strength of the negative economic consequences (1 (very weak) to 5 (very strong)) in columns (4) to (6). The direction of economic consequences can be negative (value -1), equal (value 0), or positive (value 1). In both cases, columns show regression results with different sets of control variables indicated in the rows below coefficient estimates. Standard errors are reported in parentheses.

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

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

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 the 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 exis-

tence of labor shortfalls. The estimates reported in columns (1) to (3) of Table 6 reveal that across specifications with different sets of controls, firms that reported more severe problems associated with worker shortfalls 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).[16] We repeat the regression from equation (4) with the strength of the negative consequences as the dependent variable. The estimates reported in columns (4) to (6) of Table 6 reveal that the coefficients on the shortfall problems are positive, indicating that establishments with more severe problems of unexpected worker shortfalls also suffered more severe negative consequences of the Covid crisis. Together with the results from columns (1) to (3) on the direction, this implies that establishments with more severe problems of unexpected worker shortfalls 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 5, employers with more coordinated work processes experience more severe problems from worker shortfalls. To directly assess the role of coordination, we repeat the regression underlying Table 6 but replace the severity of problems from worker shortfalls with a dummy variable for highly coordinated firms (coordination level 6 and above). We report results in columns (1) to (3) of Table 7. The results corroborate the conclusion that the negative consequences of the Covid pandemic were stronger for high-coordination establishments. Coefficients are positive and statistically significant in all three specifications that control for different establishment characteristics including employment growth between 2019 and 2020.

The analysis of the economic consequences of the Covid pandemic so far focuses on survey responses. Relying on the BvD data, we complement the analysis by examining the relationship between the coordination of the work process at a firm 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. As this regression involves merging BvD data with the survey data like in Section 3.3, we again follow the 2-step anonymization procedure as before (see Appendix C for details). We regress revenue growth and the coordination dummy on observable characteristics (see bottom rows of Table 7), aggregate revenue growth residuals in 50 bins within the BvD data, merge the aggregated residual to

[16]The survey question is *How strong are these negative effects of the Covid-19 crisis for your establishment at present? Again, please give an assessment on a scale from 1 to 5. 1 means slight negative effects, 5 means very strong negative effects. You can graduate your assessment using the values in between.*

Table 7: Strength of negative economic consequences and coordination

	Strength of negative economic consequences			Revenue growth	
	(1)	(2)	(3)	(4)	(5)
high coordination	0.350	0.424	0.382	-0.096	-0.063
	(0.113)	(0.113)	(0.106)	(0.043)	(0.045)
employment growth	Y	Y	Y	N	Y
firm size	N	Y	Y	Y	Y
industry	N	Y	Y	Y	Y
employment composition	N	N	Y	Y	Y
R^2	0.033	0.085	0.166	0.034	0.014
Observations	1,267	1,267	1,234	139	139

Notes: Columns (1) to (3) report 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). The additional control variables are reported in the bottom rows. Columns (4) and (5) report regression results for the second stage regression of residual revenue growth (from 2019 to 2020) on residual coordination. Coordination residuals are from a first-stage regression of a dummy variable for high-coordination establishments (coordination level > 5) on observable characteristics reported in the bottom rows of the table. Columns (4) and (5) differ by the additional control for employment growth in the first stage regressions. Standard errors are in parentheses. See Appendix C for details of the anonymization procedure.

establishments, and regress revenue growth residuals on coordination residuals as a second stage.[17]

Columns (4) and (5) of Table 7 report the estimated coefficients from this regression with and without controlling for employment growth at the first stage. The results indicate that during the Covid crisis, revenue growth slowed down more in more coordinated establishments. Column (4) reveals that high-coordination employers experience a 10 percent lower revenue growth than low-coordination employers. The effect is statistically significant. Column (5) adds additional control variables for employment growth. The point estimate decreases but is still negative, suggesting that more coordinated employers experience a 6 percent lower revenue growth even for the same change in employment.

[17]Note that although there are only 139 observations in the final regression, the BvD sample where we do the aggregation is much bigger as it includes all establishments, not only the surveyed establishments with coordination information. Note further that the aggregation is only needed for the revenue data from BvD.

Table 8: Mitigation measures and coordination

	Coordination		
mitigation measure	low	high	all
Shifting in time	56.8%	48.9%	53.8%
Shifting across workers	92.8%	93.4%	93.0%
Replacement workers	24.5%	31.7%	27.2%
Replacement of products	11.2%	17.0%	13.4%

Notes: Share of employers by the level of coordination who rely on different mitigation measures to deal with worker shortfalls. Row *Shifting in time* describes that work is done later if the work is currently not done. Row *Shifting across workers* describes that work is done by other workers that would have been done by the worker not present. Row *Replacement workers* describes if the employer has additional workers to replace a currently absent worker. Row *Replacement of products* describes if the employer buys (intermediate) products from other producers to replace the own production shortfall. Employers can implement several mitigation measures and the number refers to the share of employers who had this mitigation measure in place (pre-Covid).

5 Coordination and Mitigation Measures for 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 asked employers if they implemented mitigation strategies to deal with unexpected worker shortfalls and if so, what those strategies were.

Specifically, we asked employers if they relied on the four specific mitigation measures to deal with worker shortfalls in the pre-pandemic period.[18] Employers were asked about each mitigation measure separately, as they could rely on multiple mitigation measures or none at all. Table 8 reports the share of employers by the level of coordination with each mitigation measure in place.

The four mitigation measures 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 up the lost hours at a later date. We expect such a mitigation strategy to be more prevalent 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 later.

[18] While our focus in this section is on "normal" times, we report in Appendix Table A.8 that more coordinated firms were significantly more likely to introduce measures to mitigate the consequences of worker shortfalls during the Covid pandemic.

Second, we asked if employers shift work across employees. Such a shifting of work can happen simultaneously and requires the remaining employees to adjust their workload. This 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 additional workers or products in the production process. Relying on replacement workers requires the employer to hire "surplus labor" to replace absent workers. Replacement workers might be more needed in more coordinated production processes to avoid more severe disruptions caused by unexpected worker shortfalls. Replacement of products allows employers to replace the final or intermediate products in the production process that are missing due to worker shortfalls with replacement products from other producers.[19]

The results in Table 8 show that the most common and almost universally utilized measure is the shifting of work among the remaining workers. On average, 93 percent of employers rely on this mitigation measure, and there is only a slight difference between high- and low-coordination employers. The second most widely used mitigation measure is shifting 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 than high-coordination employers if a worker is not at work (57 percent vs. 49 percent). This idea finds further support when one considers the reliance on replacement workers that slightly more than one out of four employers have in place. If work inputs are coordinated and a worker shortfall causes severe problems in the production process, then having replacement workers available can help avoid the associated problems of a worker shortfall. We find that 32 percent of high-coordination employers rely on replacement workers, whereas only 25 percent of low-coordination employers do so. Replacement of products is the least widely used mitigation strategy (13 percent overall). Still, the share of high-coordination employers using this strategy is more than 50% higher than that of low-coordination employers (17 percent vs. 11 percent). In summary, for the three mitigation strategies that allow for a contemporaneous adjustment of the production process (shifting across workers, replacement of workers, or replacement of products), more coordination is associated with more mitigation. Shifting production over time shows an opposite pattern, as establishments with more coordinated production processes rely less on intertemporal adjustment of production.

Section 4 highlights the relationship between establishment size and coordination. Table 9 examines the reliance on mitigation strategies by firm size and reveals two striking patterns. Larger establishments shift less production over time but are much more likely to have replace-

[19] As 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 9: 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 shortfalls. 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 entry refers to the percentage of employers who had this mitigation measure in place (pre-Covid).

ment 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. In contrast, only 18 percent of the smallest establishments have replacement workers to compensate for worker shortfalls, whereas 71 percent of the largest establishments have such workers. This pattern suggests that employer size is an important determinant for the cost efficiency of hiring replacement workers. Establishments with a large workforce can better adhere to the law of large numbers to predict the number of absent workers so that the number of replacement workers can be tightly determined. In contrast, in establishments with a small number of employees, this strategy is very costly. For example, a replacement worker in a firm with two employees represents 50% of employment and the chance of this worker being needed on a given day is relatively small. This type of economies of scale will allow larger employers to operate more coordinated production processes associated with higher productivity, as the risk of a worker shortfall can be more effectively mitigated by replacement workers. The result highlights a new mechanism potentially contributing to the empirical regularity that larger employers tend to be more productive.

In Appendix Table A.11, we further split the implementation of mitigation measures by the level of coordination and firm size. The most striking finding is the differences in replacement workers. High-coordination, large establishments (250 and more workers) have, in more than 80 percent of cases, replacement workers. In low-coordination and small establishments, this number is less than 20 percent. We find that throughout the size distribution, high-coordination employers rely more often on replacement workers. The opposite is true for the mitigation measure of shifting across time: throughout the firm size distribution, high-coordination employers rely

less often on shifting across time. The high reliance on shifting across workers is true for all firm-size-coordination cells.

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 total number of implemented mitigation strategies by firm size. We find that over 50 percent of establishments have at least 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, virtually none of the large establishments has no mitigation measure in place (0.6 percent).

5.1 Wages and Worker Shortfalls

A complementary mitigation strategy could be to reduce worker shortfalls ex ante. One such strategy is to offer bonuses or other rewards to incentivize workers to minimize work absences. We asked in our survey about such incentive schemes and find that on average 17 percent of employers use them 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, 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.[20]

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 that more coordinated employers pay higher wages in Section 3.4. Higher wages may also induce higher work effort as is commonly assumed in the efficiency wage theories. 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 establishment's wage level (from the actual one) will lead to fewer workers leaving the establishment, fewer unexpected worker absences, or workers exerting more effort. 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 10 across all employers, conditional on their level of coordination.

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

Table 10: 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 include fewer workers leaving the establishment, fewer unexpected worker shortfalls, or more effort provision. The table reports the share of employers in each group who report a specific consequence.

Overall, the support for each of these consequences is relatively weak. Only one out of four employers thinks that higher wages will induce more work effort, 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 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 that this question only addresses the base wage level, not the incentive pay programs discussed above. Moreover, the question discussed here is 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.[21]

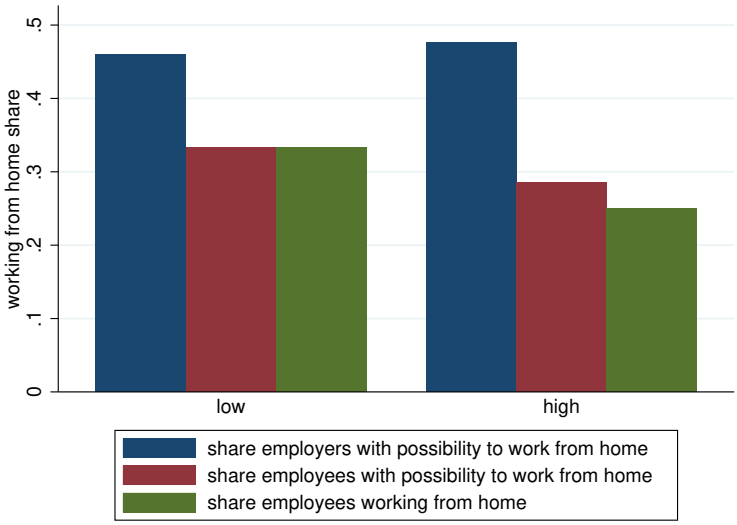
5.2 Coordination and Working from Home

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 if they require on-site coordination. We rely on the information on the possibility and the usage of WFH from the predecessor Wave 12 of the BeCovid survey. 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.[22] The first question is about the share of employers with a WFH option, and the other two are about worker shares.

[21] 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).

[22] Survey participants typically respond with the number of employees, and we transform these responses into shares for easier comparison. As there can be response errors in the number of workers with the possibility to work from home and the number of workers at the establishment, we report median employment shares that are less liable to be distorted by outliers.

Figure 4: 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.

Figure 4 shows that overall, 47 percent of employers report that WFH is possible at their establishment. Comparing high- and low-coordination employers, we find this share almost identical. However, the share of workers with the possibility to work from home and the share of workers actually working from home are both lower at high-coordination employers than at low-coordination employers. In general, only about one-third of employees can work from home, while the remaining two-thirds do not have this possibility. We observe large differences along the firm size distribution: 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

This section discusses the efficiency implication of the short-time work policy in the presence of coordination.

6.1 Coordination and Employment Adjustment

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).

In a follow-up question, we asked employers who prefer intensive margin adjustment in response to a shortfall in demand to rate the importance of the following two reasons for their decision.[23] 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 11 shows that coordination and labor hoarding are both important motives for employers' decisions 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 12, 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 points

[23] We relegate the discussion of the minority of employers who opted for the extensive margin adjustment to Appendix E.

Table 11: 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-month) demand shock. A value of 1 corresponds to no agreement and 5 to full agreement. Both rows sum to 100 percent.

Table 12: Agreement with coordination as motive for intensive margin adjustment

	coordination	
agreement	low	high
1	11.7%	2.7%
2	7.8%	3.5%
3	14.3%	12.1%
4	16.9%	21.8%
5	49.3%	59.9%

Notes: This table reports the agreement with maintaining coordinated work processes as a motive for intensive margin adjustment after a negative (6-month) demand shock. Columns show shares for low- and high-coordination 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.

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.[24] Taken together, these findings support the hypothesis that coordination of work processes is an important consideration for employers when undertaking labor adjustments.

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

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 shortfalls. We have also shown that firms adopt various mitigation strategies to insure against worker shortfalls 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 the 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 fully assess this hypothesis 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 was 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 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, in Table 13 we first consider their answers to a question we added to a previous wave of BeCovid survey regarding the reasons for using STW. 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. Similar to Table 11, we also asked about the importance of labor hoarding as a motive to rely on STW. 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

Table 13: 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%

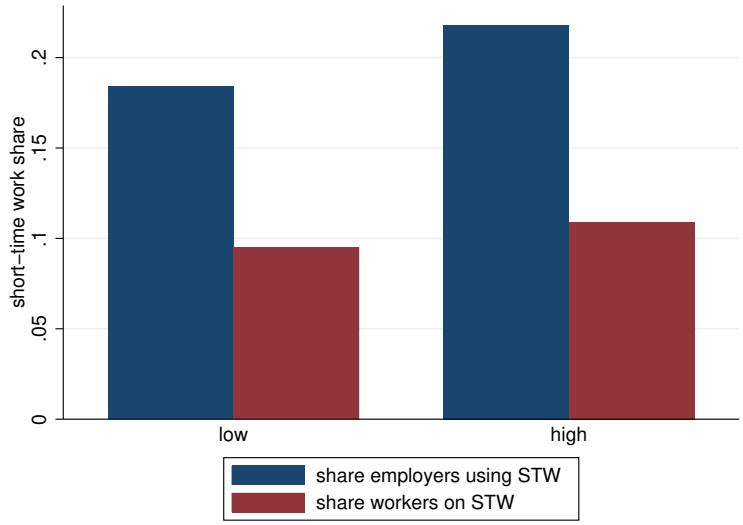
Notes: This table reports the agreement with different motives to use STW by employers. Surveyed motives include maintaining coordinated work processes, costs of future rehiring (labor hoarding), liquidity provision from wage subsidy, and spreading the costs of the negative economic conditions in solidarity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

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 use the BeCovid survey that collects information in each wave on the usage of STW and the share of workers in STW at the establishment. Figure 5 shows for low- and high-coordination employers the share of establishments that currently have workers on short-time work and the average share of workers on short-time work in the two 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. We find a lower level but the same qualitative difference between high- and low-coordination employers for the share of workers on STW (11 vs. 9 percent).

Table 14 explores the differences between low- and high-coordination establishments in using STW after controlling for observable characteristics of establishments. We first examine the share of establishments using STW in 2021 via a linear probability model. Columns (1) to (3) report the estimated coefficient on the dummy for the high-coordination group. 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 shortfalls, the differences between establishments in the usage of STW become significant at the 5-percent level. When we also control for the

Figure 5: 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.

employment composition at the establishment in column (3), the coefficient is only significant at the 10-percent level.

Second, we also look at the share of workers in STW at establishments. To address that the establishments that rely on STW are selected, we rely on a Tobit regression for the worker share regression. Table 14 reports the estimated marginal effects of being in the high-coordination group on the share of workers in STW. 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, the largest effect of 24 percent in column (5) is statistically significant at the 5 percent level. Note that although the Covid crisis saw widespread use of STW, the regression sample remains 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. In practice, however, the implementation of the STW policy 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,

Table 14: 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	0.058	0.060	0.110	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.

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 hours 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 for 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 from unexpected worker absences. This trade-off likely serves as an important determinant of the equilibrium adoption of specialized and coordinated production processes. Moreover, in response to 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

Coordinated Firm-Level Work Processes and Macroeconomic Resilience

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April 21, 2023

A Survey Instrument for Special Module on 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/. The survey data for all waves can also be obtained at the Research Data Center of the IAB (see the same webpage for details).

Introduction to special module read out to survey participants: *"With the following questions we would like to find out more about the consequences of unexpected employee absence in your establishment in the course of the Covid-19 crisis and the way your establishment has dealt with such absences."*

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 then typically the problems 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 arrangements for substituting absent workers, recruitment of temporary workers or replacement workers, more flexible regulations concerning working hours and overtime, changes in work processes, etc. (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 establishments with 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 absences? (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 standard practice in the establishment in such a situation

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. 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.[25] 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 2-step procedure to recover the coefficient of interest γ while adhering to the privacy protection regulation.

1. **Step 1.**

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

(a) **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 $\hat{\varepsilon}^C_{i,t}$.

(b) **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.[26]

2. **Step 2. 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.

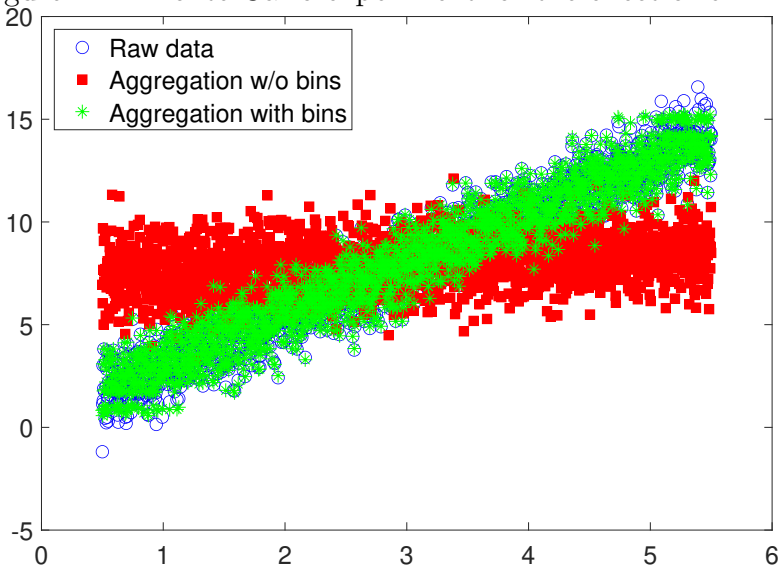
Hence, the regression follows a standard two-stage estimation approach where residuals at the second stage are group-level aggregates. The fact that we are using residuals implies already that the data only contain residual variation relative to the implied reference establishment from the regression 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. As a result, 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 A.1 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

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

Figure A.1: 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.

as we see that without bins shows there is strong mean reversion whereas the bin-aggregated data align closely with the true observations.

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)	(5)	(6)	(7)	(8)
Construction, Mining, Agriculture	-0.672	-0.766	-0.770	-0.845	-0.085	-0.099	-0.099	-0.109
	(0.420)	(0.431)	(0.431)	(0.431)	(0.071)	(0.073)	(0.073)	(0.072)
Trade, Transportation, Hospitality	-0.895	-0.623	-0.606	-0.755	-0.161	-0.122	-0.121	-0.137
	(0.338)	(0.416)	(0.415)	(0.415)	(0.056)	(0.067)	(0.067)	(0.066)
Other Services	-0.779	-0.982	-0.874	-0.992	-0.121	-0.165	-0.154	-0.172
	(0.327)	(0.446)	(0.451)	(0.449)	(0.055)	(0.073)	(0.074)	(0.073)
10 to 49 employees	0.414	0.256	0.269	0.184	0.019	-0.000	0.001	-0.011
	(0.216)	(0.220)	(0.220)	(0.224)	(0.036)	(0.037)	(0.037)	(0.038)
50 to 249 employees	0.780	0.434	0.549	0.472	0.108	0.053	0.065	0.051
	(0.301)	(0.239)	(0.234)	(0.237)	(0.049)	(0.041)	(0.041)	(0.042)
more than 250 employees	0.893	0.670	0.725	0.629	0.127	0.095	0.101	0.084
	(0.324)	(0.349)	(0.347)	(0.352)	(0.056)	(0.059)	(0.059)	(0.061)
Occupation composition	N	Y	Y	Y	N	Y	Y	Y
Temporary help worker share	N	N	Y	Y	N	N	Y	Y
Age composition	N	N	N	Y	N	N	N	Y
N	1,786	1,743	1,743	1,743	1,786	1,743	1,743	1,743
R^2	0.017	0.046	0.052	0.075	0.014	0.042	0.044	0.066

Notes: Columns (1) to (4) show regression results of coordination (level 1-10) on firm characteristics. Columns (5) to (8) show regression results of a high-coordination dummy (coordination level > 5) on firm characteristics (linear probability model). 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. Standard errors are reported in parentheses below coefficient estimates.

Table A.3: Wages and coordination

Variable	(1)	(2)	(3)	(4)
medium coordination	0.031	0.022	0.027	0.018
	(0.026)	(0.025)	(0.029)	(0.029)
high coordination	0.058	0.054	0.073	0.067
	(0.025)	(0.024)	(0.027)	(0.027)
firm size	dummy	cont	dummy	cont
N	73,766	71,048	79,543	77,077
R^2	0.489	0.500	0.544	0.549

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. Column (1) and (2) are for full-sample wages in 2020 and column (3) and (4) are for wages in 2019 but excluding observations with daily wage above the social security contribution limit. All regressions include a full set of worker controls (age, sex, occupation, education) as dummy variables. Regression specifications in columns (1) to (2) differ in control variables for employer characteristics and samples. Column (1) includes firm size dummies while column (2) uses a quadratic term for employment to control for firm size. Column (3) and (4) differ in the same way as column (1) and (2). Standard errors are in parentheses.

Table A.4: Worker-outflow rates

	all outflows			outflows to other employers		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
	minimum 3 observations					
medium coordination	-0.033	-0.040	-0.045	-0.029	-0.036	-0.040
	(0.017)	(0.020)	(0.021)	(0.012)	(0.013)	(0.014)
high coordination	-0.035	-0.049	-0.044	-0.034	-0.044	-0.041
	(0.017)	(0.020)	(0.020)	(0.012)	(0.014)	(0.015)
Observations	14,456	9,196	9,196	14,456	9,196	9,196
R^2	0.090	0.109	0.101	0.101	0.118	0.107
	minimum 5 observations					
medium coordination	-0.035	-0.048	-0.052	-0.027	-0.036	-0.039
	(0.015)	(0.018)	(0.019)	(0.011)	(0.013)	(0.013)
high coordination	-0.032	-0.048	-0.045	-0.029	-0.040	-0.038
	(0.017)	(0.019)	(0.019)	(0.012)	(0.014)	(0.014)
Observations	14,260	9,051	9,051	14,260	9,051	9,051
R^2	0.102	0.144	0.132	0.103	0.123	0.119
	minimum 7 observations					
medium coordination	-0.044	-0.055	-0.059	-0.031	-0.039	-0.041
	(0.015)	(0.018)	(0.019)	(0.011)	(0.012)	(0.013)
high coordination	-0.044	-0.063	-0.061	-0.033	-0.043	-0.042
	(0.017)	(0.018)	(0.019)	(0.012)	(0.013)	(0.014)
Observations	13,942	8,825	8,825	13,942	8,825	8,825
R^2	0.103	0.151	0.141	0.111	0.141	0.134
single establishment	N	Y	Y	N	Y	Y
firm size	dummy	dummy	cont.	dummy	dummy	cont.

Notes: This table reports regression results of worker outflow rates on firm characteristics and coordination of the production process. Columns (1) for outflow rates including all outflows from an employer. All regressions include employment composition controls. The top, middle, and bottom panel report the results of employers that have at least 3, 5, or 7 observations for flow rates. All standard errors are reported in parentheses.

Table A.5: 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 shortfalls.

Table A.6: 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 shortfalls. Each column shows one reason and frequencies sum to 100% within a column.

Table A.7: 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, the sample is restricted to employers who report having worker shortfalls during normal times (1,680 observations).

Table A.8: Worker shortfalls, severity of consequences, and mitigation during Covid

	Worker Shortfall		Severity of Problems		Mitigation Measures	
	(1)	(2)	(3)	(4)	(5)	(6)
Medium Coordination	0.106	0.093	0.408	0.390	0.102	0.120
	(0.042)	(0.041)	(0.126)	(0.124)	(0.043)	(0.043)
High Coordination	0.120	0.097	0.610	0.477	0.131	0.139
	(0.045)	(0.045)	(0.141)	(0.139)	(0.046)	(0.047)
firm size & industry	Y	Y	Y	Y	Y	Y
employment & age composition	N	Y	N	Y	N	Y
R^2	0.143	0.168	0.060	0.127	0.062	0.087
Observations	1783	1740	1363	1329	1781	1738

Notes: Regression results for Covid-related worker shortfalls, severity of consequences of worker shortfalls, and additional mitigation measures. *Worker shortfall* is an binary variable indicating if employers experienced Covid-related unexpected worker shortfalls, severity of problems captures the severity of the consequences of unexpected worker shortfalls on work processes (1 = no problems, 5 = very severe), and mitigation measures is an binary variables indicating 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.9: Worker shortfalls and severity of consequences during normal times

	Worker Shortfall		Severity of Problems	
	(1)	(2)	(3)	(4)
Medium Coordination	0.190	0.190	0.206	0.225
	(0.053)	(0.051)	(0.083)	(0.080)
High Coordination	0.106	0.086	0.429	0.422
	(0.069)	(0.067)	(0.095)	(0.064)
firm size & industry	Y	Y	Y	Y
employment & age composition	N	Y	N	Y
R^2	0.077	0.140	0.101	0.136
Observations	1,766	1,724	1,680	1,641

Notes: Regression results for worker shortfalls and severity of consequences of worker shortfalls 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 shortfalls 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.10: 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.11: Mitigation measures, coordination, and firm size

		firm size				
	coordination	1-9	10-49	50-250	>250	all
shifting in time	low	60.2%	53.8%	43.2%	42.4%	56.8%
	high	59.3%	37.8%	24.0%	40.7%	48.9%
shifting across workers	low	90.9%	95.6%	93.7%	98.4%	92.8%
	high	90.6%	97.8%	94.3%	93.7%	93.4%
replacement workers	low	18.8%	28.4%	51.7%	58.9%	24.5%
	high	23.2%	36.8%	56.7%	82.5%	31.7%
replacement of products	low	10.4%	11.9%	13.2%	23.8%	11.2%
	high	18.5%	15.7%	12.5%	16.9%	17.0%

Notes: This table reports the share of employers by coordination and establishment size (number of employees) who rely on different mitigation measures to deal with worker shortfalls. 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).

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 the 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: Bonus payments and non-financial rewards use to prevent worker shortfalls

	(1)	(2)	(3)
Medium Coordination	0.029	0.046	0.045
	(0.029)	(0.030)	(0.028)
High Coordination	0.154	0.162	0.163
	(0.038)	(0.004)	(0.038)
firm size & industry	Y	Y	Y
employment & age composition	N	N	Y
shortfall frequency and severity	N	Y	Y
R^2	0.048	0.056	0.079
Observations	1,778	1,673	1,635

Notes: Regression results for existence of bonus payment and/or non-financial reward schemes to prevent worker shortfalls. The dependent variable is a binary variable indicating if such schemes are used at the establishment. Coefficient estimates for dummies of medium- and high-coordination establishments are reported. Additional controls are indicated below regression coefficients. Shortfall frequency and severity are dummies for how often during normal times employers report worker shortfalls and how severe the consequences of such worker shortfalls 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	0.000	-0.020	0.329	0.051
	(0.037)	(0.038)	(0.148)	(0.174)
High Coordination	-0.037	-0.026	0.569	0.311
	(0.044)	(0.042)	(0.152)	(0.194)
firm size & industry	Y	Y	Y	Y
shortfall frequency and severity	Y	Y	Y	Y
employment & age composition	N	Y	N	N
R^2	0.072	0.105	0.069	0.061
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 is 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.

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).