Subjective Uncertainty, Expectations, and Firm Behavior

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Abstract

Based on a large and representative panel of German firms, this paper relates a novel measure of subjective uncertainty to business expectations and firm decisions. Uncertainty is measured by asking managers directly how uncertain they are about their future business development. I show that the relationship between perceived uncertainty and expectations is strongly negative at the micro level and almost perfectly inverse in the aggregate. It is also state-dependent: uncertainty co-moves less with expectations in bad times. In a case study at the onset of the COVID-19 recession, I exploit the between-firm variation in firms' uncertainty and expectations to examine the implications of the "real options" theory. I find that changes in uncertainty during the aggregate downturn do not predict "wait and see" behavior. By contrast, first moment changes are related to investments deferral and a reduction of the workforce.

Keywords: subjective uncertainty, expectations, firms, survey data, corporate decisions, business cycles

JEL codes: C83, D22, D84, E32, E71

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1 Introduction

An active literature is interested in understanding how uncertainty affects individual economic decisions, and as a result, business cycle fluctuations. Similar to expectations, uncertainty is inherently subjective. Thus, a good starting point to analyze how uncertainty affects outcomes are the beliefs of decision makers in firms and households. To guide their actions, individuals form expectations in the presence of uncertainty. Hence, conceptually expectations and subjective uncertainty are closely related. Yet, due to a lack of adequate measures, little is known about their empirical relationship and their relative importance for economic decisions.

This paper presents a new measure of managers' perceived uncertainty and relates it to their expectations and corporate decisions. In particular, I use the results from a novel survey question that asks firms *directly* how uncertain they are about the development of their business. This question is part of the ifo Business Survey, a representative German business survey that covers roughly 9,000 firms each month. Both at the micro level and in the time series, it allows me to develop stylized facts about the relationship between managers' subjective uncertainty vis-à-vis their business expectations over the next six months and their assessment of their current business situation. All three variables are reported on visual analogue scales, which are essentially more differentiated versions of Likert scales. To establish my baseline results, I focus on the manufacturing sector from 2017 to 2019: during this time, it slipped from a boom to a moderate recession. To verify my findings, I extend the analysis to other sectors and to fluctuations of the economy during the subsequent COVID-19 crisis. Exploiting firm heterogeneity and the large aggregate variation in the onset of this crisis, I relate uncertainty and expectations to firms' investment and employment decisions.

My main findings are fourfold. First, asking managers directly about their uncertainty seems to be a sensible method to elicit beliefs. Second, firms' perceived uncertainty about their future business development is strongly negatively related to their business expectations. This stylized fact is manifest both at the micro level and in the time series. Third, I find that this relationship is weaker in bad times. Managers perceive high uncertainty in a period of low economic activity even if expectations improve. Fourth, in contrast to first moment changes, changes in uncertainty neither predict the postponement of investment projects nor a "freeze" of the number of employees in the onset of the COVID-19 crisis. This is not in line with the theoretical mechanism of "wait and see" behavior.

Regarding the measurement of subjective business uncertainty, my first result is that managers have a good understanding of the term "uncertainty"—in the sense of "difficult to predict". This is based on a comparison of the answers to two questions: one that asks respondents directly how *uncertain* they are about their business development and a second one that asks them for an assessment of the *difficulty to predict* this development. I document that the responses to the two questions essentially contain the same information. Conceptually, both questions are holistic and able to capture not only risk, but also Knightian uncertainty.[1] In case of risk, the second question is a measure of variance. In sum, this suggests that a direct question can be a sensible tool to measure firms' subjective uncertainty.

[1]The categorization of uncertainty in risk and Knightian uncertainty (or "ambiguity") dates back to Knight (1921). In today's understanding, risk refers to a situation in which individuals can assign probabilities to a set of future events, while this is not possible in the case of Knightian uncertainty.

Using firm-level data from the manufacturing sector, my second result is that perceived uncertainty is strongly negatively related to business expectations and respondents' assessment of the current business situation. Based on bivariate relationships, the more pessimistic a respondent or the worse her assessment of the business situation, the more uncertain she is. This holds true both for the pooled sample and within firms. However, the relationships are not linear. The negative relationship is stronger when firms are pessimistic compared to when they are optimistic. These findings recall the inverse relationship of expected returns and volatility observed in equity markets (see, for instance, Bekaert and Wu 2000). Managers' expectations and subjective uncertainty seem to behave similarly to these financial market outcomes.

Next, I study how perceived uncertainty is related to *combinations* of the assessment of the business situation and expectations. Two cases are of particular interest: a good business situation combined with unfavorable expectations, and a bad business situation combined with favorable expectations. From an aggregate view, many such instances might correspond to business cycle turning points. Based on the micro data, I find that uncertainty is high in both cases. Overall, it emerges as a stylized fact that managers are highly uncertain if either the situation is assessed as poor or expectations are unfavorable, or both. Since in a bad situation uncertainty is always high, the relationship between uncertainty and expectations is weaker in bad times. These findings suggest that managers' uncertainty increases when expectations deteriorate, it stays high in a bad business situation, and it only decreases when the business situation normalizes. Further below, I provide a tentative intuition for this pattern based on the negatively skewed distribution of firms' growth rates.

The stylized facts from the micro level carry over to the time series for the manufacturing sector. The central and novel result is that perceived uncertainty and expectations are almost perfectly inversely correlated in the aggregate. The same is true for the relationship between uncertainty and the business situation. This confirms the stylized fact from proxy measures which indicate that uncertainty is counter-cyclical. Moreover, in line with the micro evidence, the relationship between uncertainty and expectations appears to be state-dependent: uncertainty correlates less with expectations if the average business situation in unfavorable.

I demonstrate the validity of these time series results along several dimensions. First, the inverse relation between uncertainty and expectations holds for all major sectors—namely manufacturing, construction, retail and wholesale trade, and services—and the German economy as a whole. Moreover, it becomes especially apparent during the COVID-19 crisis in the first half of 2020. By mid-2020, expectations improve, but uncertainty persists, as the economy stays weak. These stylized facts hold true for three different measures of subjective uncertainty. Data from the Survey of Business Uncertainty administered by the Federal Reserve Bank of Atlanta displays a similar pattern for the US.

The simultaneity of aggregate movements in subjective uncertainty and expectations challenges traditional recursive identification schemes in vector-autoregressive frameworks that attempt to causally link uncertainty to outcomes. Due to possible endogeneity of uncertainty and growth, Ludvigson et al. (2020) also view other identification strategies used in time-series econometrics as problematic. This applies in particular to recessions, when uncertainty fluctuates the most. Using micro data offers an alternative way to learn about the effect of uncertainty on outcomes. It has two advantages. First, besides time-series variation, also differences in the cross section can be exploited. Second, it

provides the opportunity to directly test theoretical channels that connect uncertainty to outcomes: most mechanisms rely on the behavior of individuals. This motivates me to use firm-level data to study the role of subjective uncertainty and expectations for corporate decisions.

In particular, I conduct a case study focusing on the onset of the COVID-19 crisis. The aim is to empirically examine the theoretical "real options" channel. Its idea is that high uncertainty can make it rational for firms to delay (partially) irreversible investments and to "freeze" hiring. Decision makers "wait and see" until more information is available (Bernanke, 1983; Brennan and Schwartz, 1985; McDonald and Siegel, 1986). In the case of an aggregate downturn, uncertainty increases. At the same time, managers' expectations deteriorate, which may let them defer investments and reduce employment. To better understand the importance of uncertainty and expectations for firm behavior, I exploit the between-firm variation of these perceptions during the COVID-19 shock. I find that firms' decisions to postpone investment projects and to reduce the number of employees are related to first moment changes, but not to changes in uncertainty. While "wait and see" may describe some firms' behavior, the results from averaging over all firms are not in line with the predictions from the "real options" channel.

This paper contributes to several strands of the empirical literature about uncertainty, firms, and business cycles. First, it is part of the literature concerned with the measurement and analysis of subjective business uncertainty. Over the last decade, a handful of surveys have started to elicit the subjective uncertainty of businesses with respect to their own future development. For the US, Altig et al. (2020b) have developed the monthly Survey of Business Uncertainty for quantitative one-year ahead expectations and uncertainty regarding a firm's growth of sales, investment, and employment.[2] Respondents are asked for five scenarios from best to worst of the outcome variable. Subsequently, the survey elicits probabilities for these scenarios. Uncertainty is then calculated as a measure of variance of these probability distributions.[3] Bachmann et al. (2018) present an alternative approach for a quarterly supplement to the ifo Business Survey for Germany. They measure subjective uncertainty as the difference between sales growth expectations in the best and in the worst case. Both Altig et al. (2020b) and Bachmann et al. (2018) relate uncertainty to past growth and forecast errors at the micro level. I extend this growing strand of literature in three ways. First, I present a new direct and holistic measure of managers' perceived uncertainty. Second, I focus on the relationship between uncertainty and expectations. Third, by considering the business situation, I add a new dimension to the analysis: the relative level position of a firm in its cycle.

Due to the absence of survey-based measures of subjective uncertainty, almost all time-series studies in the literature on uncertainty shocks rely on proxy measures.[4] For a recent comprehensive overview, see Cascaldi-Garcia et al. (2020). A common finding from

[2]The resulting time series are available online at https://www.frbatlanta.org/research/surveys/business-uncertainty.

[3]Similarly, Bloom et al. (2017) describe quantitative questions on sales growth uncertainty in the Management and Organizational Practices Survey administered by the Census in 2015. For the UK, the Decision Maker Panel also includes questions that follow this methodology (Bloom et al., 2018a).

[4]Popular approaches include indices of implied or realized volatility of stock market returns (Bloom, 2009; Barrero et al., 2017), the cross-sectional dispersion of firm-level outcomes, expectations, or forecast errors (Bachmann and Bayer, 2013, 2014; Bloom et al., 2018b; Bachmann et al., 2013), the conditional volatility of statistical forecast errors from macro time series (Jurado et al., 2015), counts of uncertainty-related keywords in news publications (Baker et al., 2016), and time devoted to uncertainty-related topics in quarterly earnings conference calls (Hassan et al., 2019).

these time-series measures is that they are counter-cyclical. This paper differs from the literature on proxy measures by presenting aggregate time series of managers' subjective uncertainty about their firms' business development—jointly with their expectations and an assessment of their business situation.[5]

This paper also contributes to the survey-based micro-econometric literature that links the subjective uncertainty of economic decision makers to outcomes. Due to the scarcity of data on subjective uncertainty, the literature for households is small. In a recent contribution, Ben-David et al. (2018) relate households' expectations and subjective uncertainty about their personal income to economic decisions. They find that individuals with more uncertain expectations exhibit more precaution in their consumption and investment behavior.[6] The first contribution concerning firms stems from Guiso and Parigi (1999) who measure the uncertainty of managers about future sales growth. Based on a cross section of Italian firms, they find that businesses with similar expectations about sales growth, but higher uncertainty, invest less.[7] In the same spirit, Dibiasi et al. (2018) study the investment response of a small share of firms that were exposed to an uncertainty-inducing referendum in Switzerland. Their result is that uncertain firms with a high degree of irreversibility lower investment. My analysis during the COVID-19 shock differs from previous work due to the focus on corporate decisions on investment and employment and since I exploit the variation of uncertainty in an aggregate downturn.

Furthermore, this paper is part of the growing literature on uncertainty and expectations during the COVID-19 crisis. For the US and the UK, Altig et al. (2020a) and Baker et al. (2020) document large increases in both proxy measures of uncertainty and subjective business uncertainty. Using proxy measures, Baker et al. (2020) estimate that half of the aggregate drop in output can be related to second moment effects. Based on data of the ifo Business Survey, Buchheim et al. (2020a) study corporate mitigation strategies in the face of the COVID-19 shock. They highlight the relation of firms' actions with pre-existing business conditions and with expectations about the duration of the crisis. My analysis differs in that I focus on individual changes of uncertainty and expectations that constitute the aggregate variation in the onset of the COVID-19 recession.

My case study that examines firms' "wait and see" behavior is also reminiscent of the literature that studies the impact of uncertainty shocks on the aggregate economy using real business cycle models. As a prominent example, Bloom et al. (2018b) generate drops of 2.5% of GDP with a model that uses nonconvex adjustment costs and the variance of productivity shocks as a measure of risk. Bachmann and Bayer (2013) specifically study the impact of uncertainty on business cycle fluctuations through the "real options" channel. In line with the results from my case study at the onset of the COVID-19 crisis, they find rather small effects.

The paper is structured as follows. Section 2 explains the data and the survey questions. Section 3 compares two measures of perceived uncertainty. Section 4 analyzes the relationship between subjective uncertainty, business expectations, and managers' assessment of the business situation at the micro level. Section 5 presents time series of these

[5]To the best of my knowledge, to date there exists only one study that conducts econometric analyses with an aggregate time series of firms' subjective uncertainty. It is based on an Austrian business survey (Glocker and Hölzl, 2019).

[6]Other household studies that relate measures of subjective uncertainty to outcomes include Guiso et al. 1992, Guiso et al. 2002, and Leduc and Liu 2016.

[7]Bontempi et al. 2010 examine the same relationship for a panel of Italian firms from 1996 to 2004 and show that the relationship between uncertainty and investment varies over time and can become insignificant, which they attribute to changes in the competitive landscape.

variables for the manufacturing sector. Section 6 shows additional time series evidence that also covers the COVID-19 crisis. Moreover, it presents a micro-level case study at the onset of this crisis that relates uncertainty and expectations to corporate decisions about investment and employment.

2 Data

This paper is based on data from the monthly ifo Business Survey that currently covers roughly 9,000 German firms. The survey is conducted by the ifo Institute. Data in processible form is available since the German unification in 1990 (since 1980 for West Germany). The sample of firms is maintained to be representative of the German economy. To deal with attrition, ifo adds new respondents to the survey (see Sauer and Wohlrabe 2020). The survey covers firms in manufacturing (IBS-IND, 2020), construction (IBS-CON, 2020), retail and wholesale trade (IBS-TRA, 2020), and services (IBS-SERV, 2020). Its data on the firms' assessment of their business situation and business expectations form the basis of the ifo Business Climate Index, a leading indicator of the German business cycle. As a widely respected measure of business sentiment, it attracts considerable attention from the general public, practitioners, and policy makers. Moreover, ifo Institute is responsible for collecting data according to a set of EU-harmonized business survey questions. They feed into the EU-wide business sentiment index composed by the European Commission.[8]

A business participating in the survey can be a stand-alone firm or a division of a large conglomerate. The position of the personnel within the firms who fill out the questionnaire is high: Sauer and Wohlrabe (2019) find that more than 90% of the respondents are top-level managers, such as CEOs, CFOs, or department heads. Furthermore, the results from a meta survey from fall 2019 suggest that the respondents within a firm rarely change. Altogether, this ensures very high quality data.

2.1 Two Samples for the Micro Analysis

Besides the presentation of aggregate time series, I draw on two main samples of micro data for this paper. The first sample uses data from the manufacturing sector. It starts with the introduction of the direct question for firms' subjective uncertainty in the online part of the survey in July 2017 and ranges until January 2020. In contrast to the other major sectors, namely construction, wholesale and retail trade, and services, the manufacturing sector went through half a business cycle in this period: from a boom in 2017 to a recession that started in the third quarter of 2018. This makes it particularly interesting when studying fluctuations in uncertainty. The main analyses are based on the subsample of manufacturing firms that responded to the online part of the survey, as opposed to paper-based participation. In the sample period, roughly three quarters of all survey participants responded online. This is equivalent to about 1.500 manufactur-

[8] Aggregate survey results for Germany are presented at www.ifo.de/w/3fvxPxj2P, the harmonized European results, including the European Economic Sentiment Indicator, can be found here: https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/business-and-consumer-surveys_en.

ing firms each month.[9] The manufacturing sample ends in January 2020 to exclude the COVID-19 crisis. I study it in a separate section of this paper.

The second sample is comprised of data from manufacturing, construction, retail and wholesale trade, and services.[10] I use it for a case study at the onset of the COVID-19 crisis. The survey waves of interest range from January to April 2020. The baseline analysis only takes onto account the observations from online participants, but a robustness test also includes other respondents.

2.2 Survey Questions

The basis for this paper is a novel direct survey question on subjective business uncertainty. I compare the responses of this question to the answers of a second new question on subjective uncertainty. Moreover, I relate them to business expectations and an assessment of the business situation. This section explains the survey methodology and the exact wordings of the relevant questions.

In 2005, ifo introduced a new question design to capture firms' assessment of their current business situation and their expectations for the business development in the subsequent six months. Respondents of the online questionnaires provide their answer by clicking on a visual analogue scale with underlying values that range from 0 to 100.[11] In 2017, ifo started to elicit subjective uncertainty using the same technology. Visual analogue scales are essentially continuous versions of the well-known Likert scales. As such, they are qualitative in nature, and are used, for instance, in medical research to assess feelings and pain intensity (Jensen et al., 2003). Visual analogue scales are easy to understand and, in contrast to trichotomous questions, allow for a differentiated assessment of a respondent's beliefs.

Appendix A shows a screenshot of the original questions regarding the perceived business situation, expectations, and uncertainty from ifo's online questionnaire in the manufacturing survey. Translated into English, the questions are as follows:

1. We assess our current state of business as

   Respondents can click a the visual analogue scale that is labeled "bad" and "good" at its ends, respectively, and "satisfactory" at the center.

2. In the next 6 months, our state of business is likely to

   Respondents can click on a visual analogue scale that is labeled "become rather more unfavorable" and "become rather more favorable" at its ends, respectively, and "roughly stay the same" at the center.

[9] Appendix A shows that there are almost no differences between the answers of online participants compared to those who participated paper-based. There is only one notable difference: online participants are more frequently representing large firms (250 or more employees), and somewhat less frequently small firms (less than 50 employees). However, there is no significant difference in the variables capturing the respondents' the assessment of the current business situation and business expectations, which form the core of the analysis in the subsequent sections.

[10] I follow the data cleaning and harmonization procedure described in Link (2020). This involves the assignment of industry codes of the WZ08 classification to all observations and in some cases the aggregation of responses of subsidiaries to the entity level of firms. The German WZ08 classification, short for "Klassifikation der Wirtschaftszweige 2008" is closely related to the European industry classification system NACE Rev. 2.

[11] See Stangl (2009) for details on the design and a comparison to the traditional trichotomous questions.

3. We assess the uncertainty w.r.t. our business development in the next 6 months as:

   Respondents can click on a visual analogue scale that is labeled "low" and "high" at its ends, respectively, and "average / usual for the season" at the center.

In addition to eliciting firms' perceived business situation and expectations using visual analogue scales, ifo has continued to apply its more traditional trichotomous questions for these variables. These traditional questions on the business situation and expectations, in their English translation, read: 1) We assess our current state of business as (a) good (b) satisfactory (c) bad, and 2) Our state of business is likely to (a) become more favourable (b) stay more or less unchanged (c) become less favorable. Question 1) appears in the section with headline "Current situation" and question 2) in the section with headline "Expectations for the next 6 months". I will occasionally use its responses in the subsequent analyses when categorization is helpful.[12]

Following a proposal from the EU Commission's unit for "Economic Situation, Forecasts, Business and Consumer Surveys", ifo implemented a second question regarding uncertainty in April 2019. This question is going to become part of the set of EU-harmonized business survey questions in 2021. Hence, it is going to be available for all countries in the EU. It is based on a similar question included in the business survey of the Austrian Institute of Economic Research, which has been asked in different versions since the 1980s (Glocker and Hölzl, 2019). The second question dealing with uncertainty is part of the survey's section titled "Expectations for the next 6 months". It is asked both online and using paper questionnaires. Translated into English, the question reads:

4. The future development of our business situation is currently

   - ☐ easy to predict
   - ☐ rather easy to predict
   - ☐ rather difficult to predict
   - ☐ difficult to predict

The responses to questions 3 and 4 yield two separate measures of subjective uncertainty. Let *unc* denote the uncertainty measure based on the responses to question 3 and *diff_pred* be the variable that captures the responses to question 4.

3 Comparing Two Measures of Subjective Uncertainty

When characterizing and comparing the two measures of uncertainty *unc* and *diff_pred*, we note similarities and differences in the underlying questions. Conceptually, we can compare three dimensions. First, any uncertainty measure is characterized by its "object"– the variable over which an individual is uncertain. Second, since uncertainty is forward-looking, the time horizon matters. Third, the way we ask for uncertainty can differ.

Both *unc* and *diff_pred* have essentially the same object and the same time horizon of uncertainty: the "business development" and the "development of the business situation" over the subsequent six months. The survey deliberately uses the holistic object of "business development". It can be understood as an umbrella term for all relevant firm-specific

[12]The responses to the visual analogue scale questions seem to measure essentially the same as the trichotomous questions: the two unweighted aggregate monthly time series for situation and expectations from 2005 to 2020, respectively, are highly correlated with correlation coefficients of 99% and 86%.

variables that affect the future path of the business. A meta survey conducted in the fall of 2019 sheds light on the variables that the respondents of the ifo Business Survey consider most important for their assessment of the business situation and expectations. The five factors most important to manufacturing firms are profits, turnover, demand, the stock of orders, and costs (see Appendix B). To further investigate the factors feeding into the holistic measures of business expectations and the business situation, in Appendix B I relate both variables in separate regressions to other variables from the ifo Business Survey. The main findings are that the highest share of the variation of the business situation is explained by the assessments of the profit and order situation, respectively, and by the capacity utilization at the time of the survey. Business expectations are most closely related to production expectations according to the R-squared metric.

Hence, *unc* and *diff_pred* are comprehensive uncertainty measures. By capturing a wide range of aspects in managers' information set, they differ from measures that focus on the uncertainty concerning the development of one particular firm variable, such as sales or employment, as in the surveys presented by Altig et al. (2020b) and Bachmann et al. (2018). Advantages of the comprehensive approach are its brevity and universality. A wide range of sources of uncertainty is covered. Moreover, *unc* and *diff_pred* capture both risk and Knightian uncertainty. However, this comes at the cost of a lack of transparency regarding the exact source of the uncertainty.

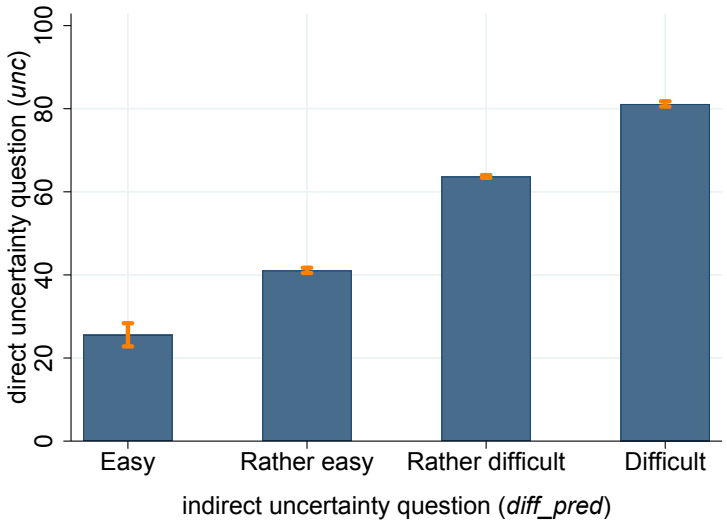
The main difference between *unc* and *diff_pred*, in addition to the mode of delivery, is the way they ask for uncertainty. Question 3 asks respondents *directly* how uncertain they are, while question 4 asks *indirectly* by inquiring about the degree of difficulty that respondents perceive in predicting the future business development. The responses to the indirect question 4 may either reflect uncertainty as risk, that is, a second moment, or as Knightian uncertainty. In the direct question, it is less clear a priori what respondents think when they are asked for their "uncertainty". Thus, by comparing *unc* and *diff_pred*, I analyze the influence that the type of question has on the responses, and whether managers in firms have a good understanding of the term "uncertainty".

Appendix B presents summary statistics of the variables *unc* and *diff_pred*. Most importantly, I find that *unc* covers the entire range of values between 0 and 100, and that the answer category "rather difficult to predict" is the clear mode of *diff_pred*, while only very few respondents choose the category "easy to predict".[13] Figure 1 presents the mean values of the responses from the direct uncertainty question 3, *unc*, for each of the categories of the indirect uncertainty question 4, *diff_pred*. The bar chart is based on the subsample covering the period from April 2019 to January 2020 for which both variables are available.

The main result is that the two variables are almost perfectly aligned: advancement by one category in the perceived difficulty of predicting the future development of the firms' business situation corresponds to a mean of *unc* that is roughly 20 points higher. In other words, the more difficult respondents perceive the prediction of the future development of their business situation, the more uncertain they report to be on the visual analogue scale. Appendix B presents a box plot instead of the bar chart and demonstrates that this finding is robust to using medians instead of means.

[13] One reason for few responses with the category "easy to predict" may be the stylized fact, based on proxy measures, that uncertainty behaves counter-cyclically (Bloom, 2014). In the period for which *diff_pred* is available, namely from April 2019 to January 2020, the manufacturing sector was in a recession. Thus, uncertainty is likely to be above a longer-term average at this time.

Figure 1: Comparison of two measures of subjective uncertainty



Notes: The figure illustrates the mean values of subjective uncertainty (*unc*), the responses to the direct uncertainty question 3 in Section 2.2, for each of the categorical answer options of the indirect uncertainty question 4 (*diff_pred*) in Section 2.2 (blue bars). The orange whiskers denote ±1.96 standard error bands for the mean values.

The fact that *unc* and *diff_pred* are very similar implies that respondents have a good understanding of the term "uncertainty" when they are directly asked for it. Hence, a direct question for managers' uncertainty appears to be an easy and sensible way to elicit firms' subjective beliefs. The remainder of the paper focuses on the direct uncertainty measure *unc*. It is available for a longer period of time than *diff_pred*, and it has advantage of being a near-continuous variable. However, I replicate most results using *diff_pred* for robustness.

4 Subjective Uncertainty at the Micro Level

Using survey data from businesses allows me to study the properties of uncertainty at the micro level. Moreover, it enables me to study the relationship between perceived uncertainty and expectations from the same respondent. In addition, I can relate subjective uncertainty to the self-assessed business situation of a firm. Given the stylized fact that proxy measures of uncertainty are counter-cyclical, I expect a negative relationship between uncertainty and the business situation. The panel dimension of the sample offers ample variation in the cross section and the time series.

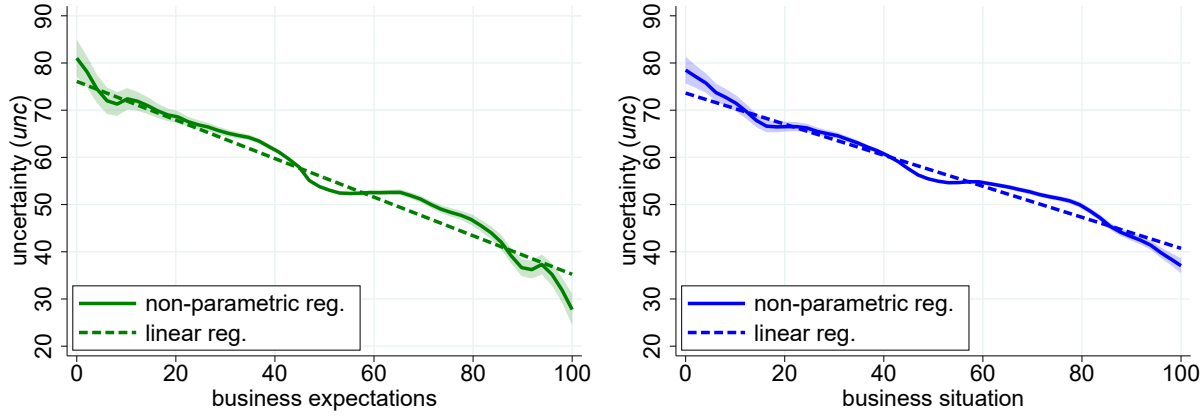
This section has three parts. I start by examining the bivariate relationships between perceived uncertainty vis-à-vis expectations and the business situation, respectively. Second, I study the uncertainty of respondents for combination of these variables. Third, I relate uncertainty to other variables of business activity that are likely to feed into managers' assessment of the business situation and expectations.

4.1 Uncertainty vs. Expectations and the Business Situation

Figure 2 illustrates two relationships in the pooled sample of manufacturing firms: the relationship between business uncertainty (*unc*) and business expectations in the left plot,

and the relationship between business uncertainty (unc) and the firms' assessment of their business situation in the right plot. Based on roughly 46,000 firm-time observations, I present non-parametric regression lines and linear fitted lines.

Figure 2: Relation of subjective uncertainty to expectations and the business situation



Notes: This figure shows non-parametric kernel regression lines of degree zero with shaded 95% confidence bands as well as fitted linear regression lines for the relationship between uncertainty (unc) and business expectations in the left plot, and between uncertainty (unc) and the business situation in the right plot. The non-parametric lines use an epanechnikov kernel and the "rule-of-thumb" bandwidth (Silverman, 1986). The assessment of the business situation, expectations, and uncertainty are based on questions 1, 2, and 3 in Section 2.2. Responses are elicited using visual analogue scales that range from 0 to 100, respectively.

First, I observe a very strong negative and near-linear relationship between subjective uncertainty and expectations. Hence, the more pessimistic respondents are about the development of their business situation over the next six months, the more uncertain they are about it. Moreover, subjective uncertainty is strongly negatively related to the respondents' assessment of the business situation, which indicates the position of a firm in its cycle. Managers perceive higher uncertainty the worse they assess the state of business of their firm. The raw correlations of both relationships in the pooled sample are -0.34.

I formalize this descriptive evidence by means of regressions. In doing so, I add significance levels and I further check for the asymmetries in high and low expectations and in good and bad business situations. I also specifically examine the within-firm time variation.[14] This can lead to a better understanding of the time variation in aggregate uncertainty, which is at the center of a large body of the literature on uncertainty and business cycle fluctuations.

[14]I note that the visual analogue scale is identical for all firms and, hence, is designed to show time-variation within businesses. However, due to the rather short period of time of the sample of less than three years, some firms might be above or below their longer-run average expectations or their "normal" business situation in most or all of the sample horizon.

Table 1: Relation of subjective uncertainty (*unc*) to expectations and the business situation

Dependent variable:	uncertainty (*unc*)				within-firm variation of uncertainty (*unc*)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Business expectations	-0.409***							
	(0.0213)							
Business situation		-0.329***						
		(0.0171)						
Business expectations low			-0.507***					
			(0.0353)					
Business expectations high			-0.323***					
			(0.0348)					
Business situation low				-0.387***				
				(0.0342)				
Business situation high				-0.294***				
				(0.0254)				
Demeaned: business expectations					-0.345***			
					(0.0143)			
Demeaned: business situation						-0.367***		
						(0.0128)		
Demeaned: business expectations low							-0.409***	
							(0.0185)	
Demeaned: business expectations high							-0.273***	
							(0.0177)	
Demeaned: business situation low								-0.401***
								(0.0157)
Demeaned: business situation high								-0.324***
								(0.0156)
Constant	76.10***	73.63***	54.63***	56.48***	0.0155***	0.00397	-0.545***	-0.352***
	(1.103)	(0.950)	(0.338)	(0.345)	(0.00519)	(0.00500)	(0.0918)	(0.0833)
No. of obs.	46394	46413	46394	46413	42802	42809	42802	42809
No. of firms	2598	2601	2598	2601	1766	1765	1766	1765
R-squared	0.11	0.12	0.12	0.12	0.080	0.11	0.081	0.11

Notes: Results from OLS regressions with firm-month observations. The dependent variable in columns 1 to 4 is subjective uncertainty, (*unc*); in columns 5 to 8 it is a variable capturing the within-firm time variation of *unc*. It is constructed as the difference of *unc* from the firm-specific mean of *unc*. The regressors in columns 1 to 4 are based on the responses from questions 1 and 2 in Section 2.2. The regressors in columns 5 to 8 are also based on these responses, but capture their within-firm time variation for firms with at least 10 observations. Columns 3 and 4 show results from piecewise regressions with a break at 50 for low and high values of expectations and situation on the visual analogue scale. Columns 7 and 8 present results from piecewise regressions for the demeaned regressors with a break at the firm-specific means, respectively. Standard errors in parentheses, clustered by firm; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 1 presents pooled ordinary least squares regressions of uncertainty (*unc*) on expectations and the business situation. The negative estimates in columns 1 and 2 correspond to the slopes of the linear predicted lines in figure 2. Both coefficients are highly significant. If expectations are 10 points lower on the visual analogue scale, uncertainty is 4.1 points higher on average. For a 10 point lower situation, on average, the uncertainty differential is 3.3 points. This captures both the variation between and within firms. The R-squared values of 0.11 and 0.12 in columns 1 and 2, respectively, indicate the presence of ample variation that is not captured by the bivariate relationships.

To detect asymmetries, I split the sample into high and low expectations, and into high and low values of the assessment of the business situation. I define numbers on the visual analogue scale of 50 or above as "high" and all others as "'low". In columns 3 and 4, I then regress uncertainty (*unc*) on expectations and the business situation, respectively, using piecewise linear models with a break at 50. Formally,

$$unc_{it} = \alpha_0 + \alpha_1^l x_{i,t}^l + \alpha_1^h x_{i,t}^h + \epsilon_{it},$$

where $x_{i,t}^l = x_{i,t} I(x_{i,t}<50)$, $x_{i,t}^h = x_{i,t} I(x_{i,t} \geq 50)$, $I(\cdot)$ is the indicator function, and $x_{i,t}$ denotes either expectations or the business situation of firm i at time t.

Column 3 demonstrates that the coefficients α_1^l for low and α_1^h for high expectations are both negative and highly significant. Moreover, uncertainty appears to correlate more strongly with low expectations than with high expectations. A Wald test clearly rejects the null hypothesis at the 1%-significance level that the two coefficients are equal. Hence, the relationship between uncertainty and expectations is asymmetric. More unfavorable expectations generally go along with higher uncertainty, but more so for low expectations. Column 4 shows that the coefficients of low and high business situations are both negative and highly significant. While the coefficient of the subsample of bad situations is larger in absolute terms, a Wald test cannot reject the null of equality at the 5%-level (p-value is 0.055). I conclude that a simple linear model captures the relationship between uncertainty and the business situation in the pooled sample with reasonable accuracy.

To isolate the within-firm variation in the panel, I subtract the firm-specific means from the firm-time values of uncertainty, expectations, and the business situation. I do so for a subsample of firms for which at least ten observations are available. More than 92% of the pooled sample remains. Columns 5 and 6 show OLS regressions with these demeaned variables, which produce the same results as fixed effect regressions. Similar to columns 1 and 2, columns 5 and 6 indicate negative and highly significant coefficients for both expectations and the business situation. Magnitudes are also similar.

To examine asymmetries in the within-variation, I define values at or above a firms' mean as "high" and all remaining values as "low". Columns 7 and 8 present results from piecewise linear regressions with the demeaned variables and a break at the firm-specific mean of expectations and the business situation, respectively. Technically, I estimate

$$\widetilde{unc}_{it} = \alpha_0 + \alpha_1^l \tilde{x}_{i,t}^l + \alpha_1^h \tilde{x}_{i,t}^h + \epsilon_{it},$$

where $\tilde{x}_{i,t}^l = \tilde{x}_{i,t} I(x_{i,t}<\bar{x}_i)$, $\tilde{x}_{i,t}^h = \tilde{x}_{i,t} I(x_{i,t} \geq \bar{x}_i)$, $I(\cdot)$ is again the indicator function, $\bar{x}_i$ is the mean of expectations or the business situation of firm i, and $\tilde{x}_{i,t} = x_{i,t} - \bar{x}_i$ denotes the demeaned expectations or the business situation of firm i at time t. $\widetilde{unc}_{it}$ is the analogously demeaned uncertainty variable.

Column 7 again points to an asymmetry in the relationship between uncertainty and expectation values that are above or below the firm mean. The difference in the coefficients is significant at the 1%-level. For the average firm, an increase in expectations by 10 points above its mean on the visual analogue scale goes along with a decrease in uncertainty by 2.7 points. A decrease in expectations of the same magnitude below the mean coincides with an increase of uncertainty by 4.1 points. Column 8 demonstrates the difference between the coefficients of above average and below average business situations is also statistically highly significant. However, the difference is somewhat smaller than that in expectations.

Based on plots similar to Figure 2, Appendix C shows that the stylized facts concerning the negative bivariate relationships between uncertainty and expectations, and between uncertainty and the business situation, also hold for the indirect uncertainty measure *diff_pred*. I conclude that, first, uncertainty is negatively correlated to a firms' cyclical position relative to its trend, which is measured by the business situation. Second, business expectations and the perceived uncertainty regarding these expectations are not only conceptually related. They are also clearly dependent with a negative relationship at the micro level.

The second finding recalls the stylized fact from the finance literature that conditional volatility is negatively correlated with expected returns at stock markets (see, for instance, Bekaert and Wu 2000 and Hibbert et al. 2008). However, it is unclear a priori whether managers' subjective uncertainty and expectations about their future business behave similarly to financial market outcomes. The new survey evidence suggests that this it indeed the case.

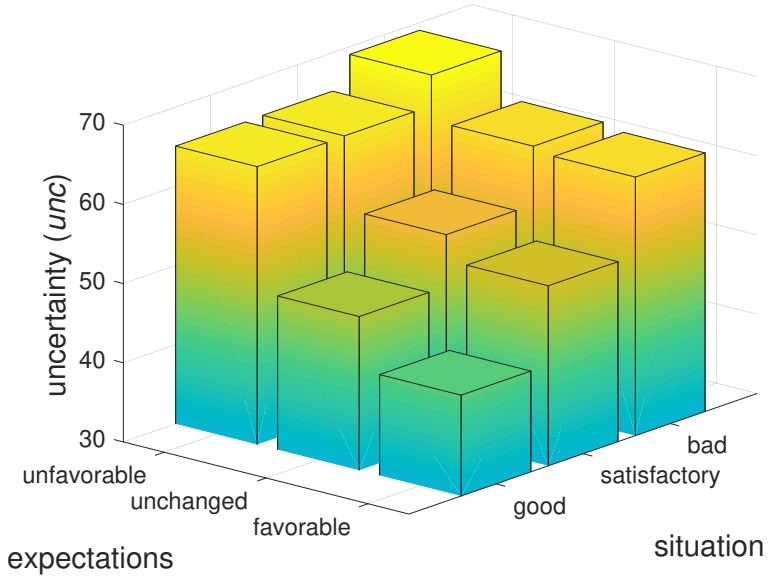
4.2 Uncertainty and Combinations of Situation and Expectations

Table 1 establishes negative bivariate relationships between uncertainty and business expectations as well as between uncertainty and the business situation. I now take this analysis one step further by asking what degree of uncertainty respondents perceive for combinations of their business situation and expectations. Overall, respondents' expectations and their assessment of the current business situation are positively related. The correlation coefficient is 0.63 in the pooled sample. However, there are numerous cases in which they differ.

Two cases are of particular interest: On the one hand, a firm can be in a good business situation, but its expectations are unfavorable. Is the uncertainty of such a business high, as the negative relationship between the uncertainty and expectations would suggest, or is its uncertainty low, since the business is still in a good situation? On the other hand, a business can be in a poor condition but have positive expectations. Does this go along with high or low subjective uncertainty?

Figure 3 presents the relationship between uncertainty (*unc*) and combinations of expectations and the business situation. To facilitate the comprehension of this trivariate relationship, I draw on the categorical responses to the trichotomous questions about expectations and the state of business in ifo's business cycle survey. The height of the bars illustrates the mean values of uncertainty for the nine combinations of the business situation assessed as good, satisfactory, or bad, and the expectations reported as favorable, unchanged, or unfavorable. Each combination is based on more than 880 firm-time observations.

Figure 3: Uncertainty by combinations of business situation and expectations



Notes: The bar chart illustrates the mean values of uncertainty (*unc*) by the nine combinations of the categorical responses to the trichotomous questions about the business situation and business expectations. Each mean is based on at least 889 firm-time observations.

The main result is that the respondents perceive high uncertainty if either their expectations are unfavorable or the assessment of their business situation is bad, or both. If expectations are unfavorable, respondents perceive high uncertainty even in a good business situation. If the situation is assessed as poor, uncertainty is high despite favorable expectations. Generally, the relationship between uncertainty and expectations is state-dependent: it is weaker in bad times. Given the bivariate relationships in figure 2, it does not come as a surprise that uncertainty is at its lowest if the business situation is good and expectations are favorable.

Appendix C presents results of regressions of uncertainty (*unc*) on dummies for combinations of the categorical business situation and expectations (corresponding to figure 3). The case of a good situation and favorable expectations constitutes the baseline. Replicating this estimation using fixed effects allows me to confirm that the main results also hold for the within-firm time variation. Moreover, in Appendix C I demonstrate that the stylized facts regarding the trivariate relationship between uncertainty, expectations, and the business situation are qualitatively the same for the uncertainty measure *diff_pred*.

As an alternative to the three-dimensional bar chart in Figure 3, Appendix C presents the trivariate relationship between uncertainty, expectations, and the business situation also in a more continuous version, similar to figure 2. Instead of one non-parametric regression line which illustrates the relationship between uncertainty and the business situation, three lines represent the answer options of the trichotomous question about business expectations. Again, it becomes clear that uncertainty is high if expectations are unfavorable, irrespective of the business situation. If expectations are unchanged or favorable, uncertainty is lower the better the situation. An analogous continuous illustration of *diff_pred* instead of *unc* confirms this pattern.

From an aggregate perspective of a stylized business cycle, these micro-level findings tentatively suggest that subjective business uncertainty is elevated from the begin of a downturn to the end of a recovery. In a good state, uncertainty starts to rise early when expectations worsen. In a recession, better expectations do not immediately lower perceived uncertainty. Rather, uncertainty prevails until the situation improves.

What may be reasons for this pattern? A starting point can be the asymmetry of the business cycle (or firm cycle), which implies that the distribution of a firms' growth rates is typically negatively skewed.[15] This implies that firms, in absolute terms, can expect the average negative shock to be larger than the average positive shock. Suppose a firm is in a good business situation and holds unfavorable expectations. Uncertainty perceived as risk then concerns the magnitude of the negative shock. It can be large due to the fat left tail of the demand shock distribution. This could explain why managers are more uncertain if they expect the business situation to deteriorate than when they expect an improvement. Orlik and Veldkamp (2014) provide a similar reasoning. They show how tail risks arising from negatively skewed growth rates can explain an increase of a forecasters' macroeconomic uncertainty in recessions.

A complementary intuition for low uncertainty in a good business situation with favorable expectations can be based on strong signals of high demand in that case. Knowledge about orders and being (temporarily) constrained by fix capacities can make it relatively easy for managers to predict future sales and profits.[16] Conversely, in case demand is perceived as weak, decision makers lack knowledge about future sales and profits. Hence, uncertainty is high in the case of unfavorable expectations or in a bad business situation. If an unfavorable business situation is a rather rare event for a firm, managers may also be uncertain since they are unfamiliar with that situation. Uncertainty in a bad situation may also originate from the question whether a realized negative shock is temporary or permanent (Bernanke, 1983). In case of a temporary shock, expectations eventually turn favorable. However, then again the potential magnitude of the expected positive change is large. This can make forecasts quantitatively difficult. High upward risk could explain the empirical finding of high perceived uncertainty in an unfavorable situation with positive expectations. Noisy estimates of the recovery can have the same effect (Van Nieuwerburgh and Veldkamp, 2006). Moreover, in the presence of increased risk aversion in a bad situation, there may be doubts about the reliability of positive demand signals.[17]

4.3 Uncertainty and Components of Situation and Expectations

As discussed in Section 2.2, the variables of business expectations and business situation are holistic concepts. For the purpose of robustness and traceability, in this section I study whether factors that might feed into these measures correlate with uncertainty in a similar way. Figure 4 relates uncertainty to six specific variables of business activity from the ifo Business Survey that reflect the situation and expectations of firms.

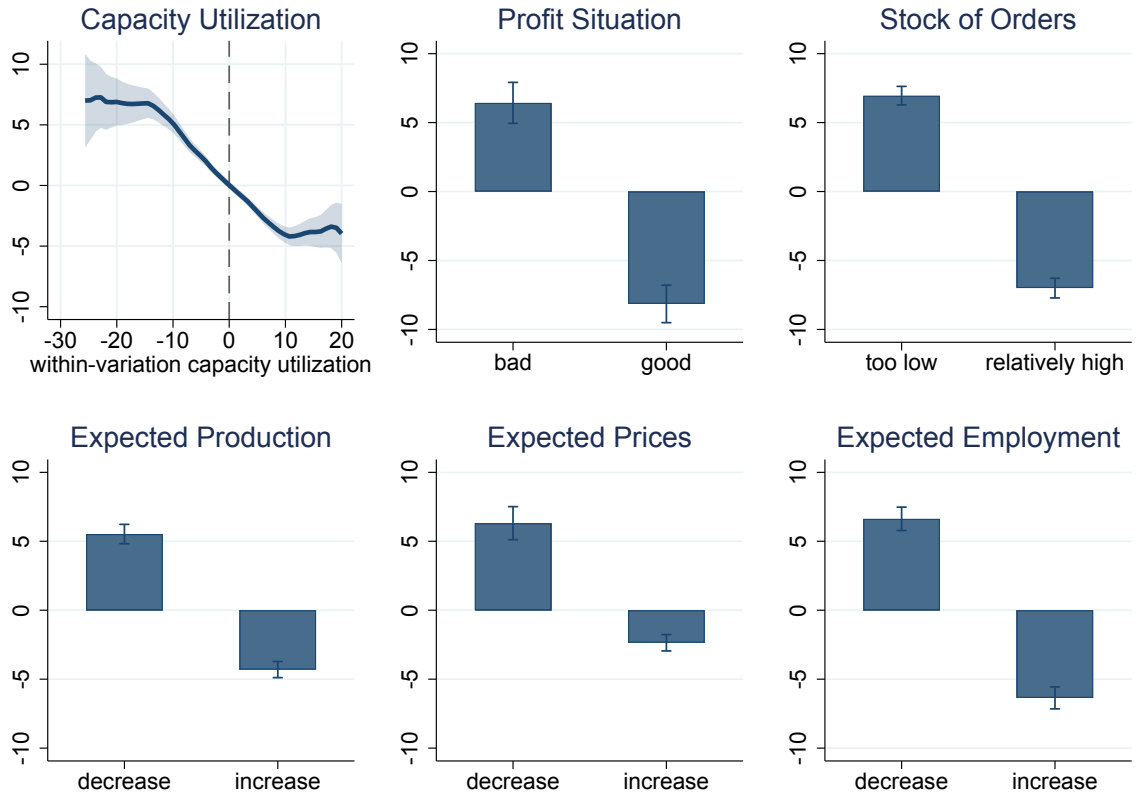
[15] Evidence for asymmetry in aggregate and firm-level growth is presented, for instance, by Salgado et al. (2020) and Ilut et al. (2018).

[16] In related research, Kuhn and George (2019) provide theoretical evidence that firms' capacity constraints can prevent them from fully exploiting positive demand shocks. They use this rational to explain the asymmetry of business cycles.

[17] Guiso et al. (2018) provide survey evidence that risk aversion was substantially elevated during the period of low activity in 2009, after the shock of the Great Recession.

The upper panel of figure 4 illustrates measures that are likely to be related to the business situation: capacity utilization in %, the profit situation, and the assessment of the stock of orders. The bottom panel presents expectations about production, prices, and the number of employees of the firm over the next three months. ifo elicits the capacity utilization in a respondent's business at the time of the survey by providing discrete answer options which range from 30% to 100%. The other five variables are based on questions with categorical answer options.

Figure 4: Within-variation of uncertainty by variables of business activity



Notes: The top left plot displays a non-parametric kernel regression line of degree zero with shaded 95% confidence bands for the relationship between the within-firm time variation in uncertainty (*unc*) and the within-variation of capacity utilization. The unit at the x-axis is percentage points. I exclude values below the 1%-percentile and above the 99%-percentile for better visibility. The figure further presents bar charts illustrating coefficients from separate fixed effect regressions of uncertainty (*unc*) on categorical variables from the ifo Business Survey, as denoted in the titles of the subplots. In particular, the regressors are dummies based on two categorical answers (labels at the x-axes). Thus, each bar corresponds to a coefficient relative to the middle category, which is "unchanged" in case of all variables except the stock of orders and the profit situation. For the latter two variables, the middle categories are labeled "sufficient" and "satisfactory", respectively. The whiskers at the bars are 95% confidence intervals. Capacity utilization is available once a quarter, the profit situation biannually, and all other variables in monthly frequency.

For capacity utilization, I show a non-parametric regression line in the top left plot. The bars in the other plots correspond to coefficients of fixed effect regressions on dummy variables for the categories indicated on the x-axes, with the middle category serving as the baseline. I focus on the within-firm time variation of uncertainty, but results are similar for the total variation in the pooled sample (see appendix C). The within-

variation is indicated at the y-axes of all plots. Technically, I take out firm fixed effects before analyzing the relationships between uncertainty and the firm variables.

I find negative relationships between uncertainty and all six factors. Lower capacity utilization in a firm, a worse profit situation, and a lower stock of orders are all connected to higher uncertainty. A linear regression using fixed effects shows that, on average, a 10 percentage points lower capacity utilization goes along with 3.6 point higher uncertainty on the visual analogue scale. A change in a firm's assessment of its profit situation from "good" to "bad" is associated with an increase of uncertainty of almost 15 points, on average. The discrepancy between a situation with a "too low" and a "relatively high" stock of orders is similar in magnitude. Respondents with less favorable expectations about production, prices, and employment are also more uncertain.

To sum up, I establish robustness of the results in Section 4.1 by showing that the negative relationships between uncertainty and expectations, and between uncertainty and the business situation also hold for specific variables that are likely to feed into these holistic measures.

5 Subjective Uncertainty in the Aggregate

In this section, I exploit the time series dimension of my sample, which extends over 31 months from July 2017 to January 2020. From an expansionary phase in the second half of 2017, the German manufacturing sector fell into a recession that started in mid 2018 and lasted until the end of the sample period.[18] Hence, the data allows me to study aggregate fluctuations of subjective uncertainty.

Since the Great Recession, many time series of proxy measures of uncertainty have been developed. For a recent overview, see Cascaldi-Garcia et al. (2020). With the new ifo data, however, I am among the first to construct a time series that is based on micro data on subjective uncertainty: it provides information on the uncertainty perceived by actual decision makers in firms.[19] The second key advantage of using survey data about businesses is that I can construct a time series of expectations from the same respondents. This allows me to compare micro-based time series of perceived uncertainty and expectations. Moreover, I relate these series to respondents' assessment of the business situation. Given the micro evidence presented in Section 4, I ask whether subjective business uncertainty is negatively related to expectations and the business situation also in the aggregate.

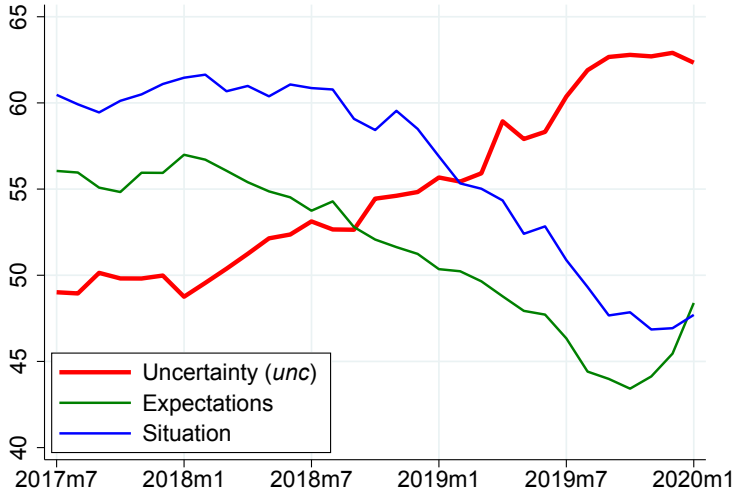
Figure 5 presents time series for the manufacturing sector of subjective uncertainty (*unc*) as well as of business expectations and the business situation. They are computed as unweighted averages of the firm-level responses. Appendix D shows that weighting these observations by firm size produces very similar time series and that the average

[18] To put this development in context, Appendix D displays a time series of seasonally and calendar adjusted gross value added of the German manufacturing sector for a longer time series, namely since 1999. In the sample period, quarter-on-quarter growth rates dropped from a maximum of 1.7% in Q3 2017 to a minimum of -1.7% in Q2 2019. Annual growth was 3.8%, 1.3%, and -3.4% in 2017, 2018, and 2019, respectively.

[19] Glocker and Hölzl (2019) present a time series of uncertainty for the Austrian economy that is based on micro data. Altig et al. (2020b) develop time series of firms' uncertainty and expectations based on firm-level data from the Survey of Business Uncertainty administered by the Federal Reserve Bank of Atlanta. Leduc and Liu (2016) use a time series of the uncertainty of households about purchasing a vehicle.

business situation closely follows the two official series of industrial production and gross value added in manufacturing.

Figure 5: Time series of subjective uncertainty, expectations, and the business situation



Notes: The figure presents time series of unweighted means of subjective uncertainty, business expectations and an assessment of the respondents' current business situation. These measures are based on the firm-level answers to questions 1, 2, and 3 in Section 2.2. The labels at the vertical axis are numbers from a visual analogue scale that ranges from 0 to 100.

The first observation from Figure 5 is that firms' subjective uncertainty is countercyclical: uncertainty increases as the assessment of the business situation deteriorates and the manufacturing sector slides into recession in mid-2018. In the short sample, uncertainty and the business situation are highly negatively correlated, with a correlation coefficient of -0.96. This confirms earlier findings based on proxy measures of uncertainty and the time series of subjective business uncertainty for Austria presented by Glocker and Hölzl (2019).

A second, and novel, observation is that the subjective uncertainty of businesses appears to be a mirror image of business expectations for most of the sample period: when expectations decrease, uncertainty increases, and vice versa. In fact, uncertainty and expectations are almost perfectly negatively correlated (-0.98). Revisiting the stylized fact of countercyclicality, I note that uncertainty already increases in the first half of 2018, that is, *before* the business situation declines. This early increase in uncertainty goes along with a deterioration in expectations. As a third observation, I note that if the situation at the end of the sample period is unfavorable, expectations increase while uncertainty remains essentially unchanged.

The second and third observations imply that the results from the micro level investigation in Section 4.2 also seem to hold for the time series: uncertainty is higher when either expectations or the situation are more unfavorable, or both. While the economy is still in a good state, along with deteriorating expectations, uncertainty already increases in the first half of 2018. In the rather bad state at the end of the sample, uncertainty remains at a high level despite an increase in expectations.

Next, I divide the sample into three firm size classes and construct unweighted time series for each of them.[20] The results are displayed in Appendix D. I find that the relationship between uncertainty and expectations as well as the business situation is similar in the aggregate series. In general, the patterns of an increase in uncertainty and deteriorating expectations and business situations between July 2017 and January 2020 are fairly consistent across all size classes.

To analyze whether the aggregate increase in uncertainty is subject to variation across industries in the manufacturing sector, Appendix E presents an analysis of the time variation for subsectors between 2017 and 2019. I find that uncertainty did not rise evenly across industries. In line with the micro evidence and the time series result, uncertainty increased more in industries that experienced a larger decline in expectations and in the business situation.

Is the negative relationship between uncertainty and both expectations and the business situation in the time series specific to the German manufacturing sector and the sample period between July 2017 and January 2020? To broaden the scope of the analysis and to test the validity of the results, I proceed by studying subjective uncertainty and expectations during the COVID-19 crisis.

6 Case Study: COVID-19 Crisis

The COVID-19 crisis constitutes an unprecedented disruption of economic activity worldwide. Shutdowns imposed by governments triggered severe recessions that unfolded at high speed. These characteristics of the COVID-19 crisis differ considerably from the gradual and rather moderate economic downturn in the German manufacturing sector in Germany in 2018 and 2019. Hence, the COVID-19 crisis provides fertile grounds for testing the robustness of the time series results from the previous section. This constitutes the first part of this case study. In the second part, I exploit cross-sectional differences in changes in managers' uncertainty and expectations at the beginning of crisis to investigate their role for decisions about investment and employment.

6.1 Time Series during the COVID-19 Crisis

In this section, I test the robustness of the new stylized facts about the relationship between subjective uncertainty and expectations by extending the sample until July 2020. In this way, I include the COVID-19 crisis. To establish the stylized facts in the first part of the paper, I have focused on data from the manufacturing sector in the time period from July 2017 to January 2020. To analyze time variation in uncertainty, it is most interesting to study. The reason is that, during this time, compared to the other major sectors and the economy overall, the manufacturing sector exhibits the largest fluctuations in economic activity.

With the longer sample that includes the COVID-19 crisis, I present time series for subjective uncertainty (*unc*), expectations, and the business situation for the German economy as a whole. As for all other time series in this section that are based on ifo data,

[20] Based on the number of employees, I define three size classes of firms. Following the definition of the German Federal Statistical Office, small firms have less than 50 employees, medium-sized firms between 50 and 249 employees, and large firms 250 or more employees.

I use the ifo weighting procedure described in Sauer and Wohlrabe (2020) to aggregate firm-level data.[21]

To further test the validity of the stylized facts, I broaden the time series analysis by considering additional measures of subjective business uncertainty. First, I present a monthly time series of *diff_pred* that starts in April 2019.[22] Second, since my previous results could be exclusive to the measures of subjective uncertainty *unc* and *diff_pred*, I present a quarterly time series of a third measure of subjective uncertainty. It is calculated as the difference between the quantitative quarter-on-quarter sales growth expectations in the best and the worst case in percentage points. The underlying data stems from a survey supplement to the ifo business cycle survey, which is conducted in the first month of a quarter. It also contains a question on expected sales growth in the most likely case. See Bachmann et al. (2018) for a detailed description. This time series is based on ifo survey data from firms in manufacturing, retail and wholesale trade, and services. For all of these sectors, it is available starting in April 2019.

Third, I compare the time series for Germany with time series on subjective uncertainty and expectations for the United States. In particular, I draw on the monthly quantitative survey results on firms' uncertainty and expectations about twelve-month-ahead sales growth from the Federal Reserve Bank of Atlanta. The survey elicits five sales growth scenarios from best to worst in percentage points and asks the respondents to assign probabilities to these scenarios. Uncertainty is computed as the standard deviation and the expectation as the mean of the resulting five-point distribution. The survey design is documented in detail by Altig et al. (2020b).[23]

Conceptually, I note that the four measures of uncertainty and expectations differ in several ways: *unc* and *diff_pred* are based on qualitative data and refer to the business development over the next six months, while the other measures are quantitative and refer to quarter-on-quarter and twelve-month-ahead sales growth. The four time series of subjective uncertainty and business expectations are displayed in Figure 6. The uncertainty measure *diff_pred* is depicted jointly with the balance statistics from the categorical questions on business expectations and the business situation in the top left plot. In the plots in the top row for *unc* and *unc_pred*, I also include the business situation.

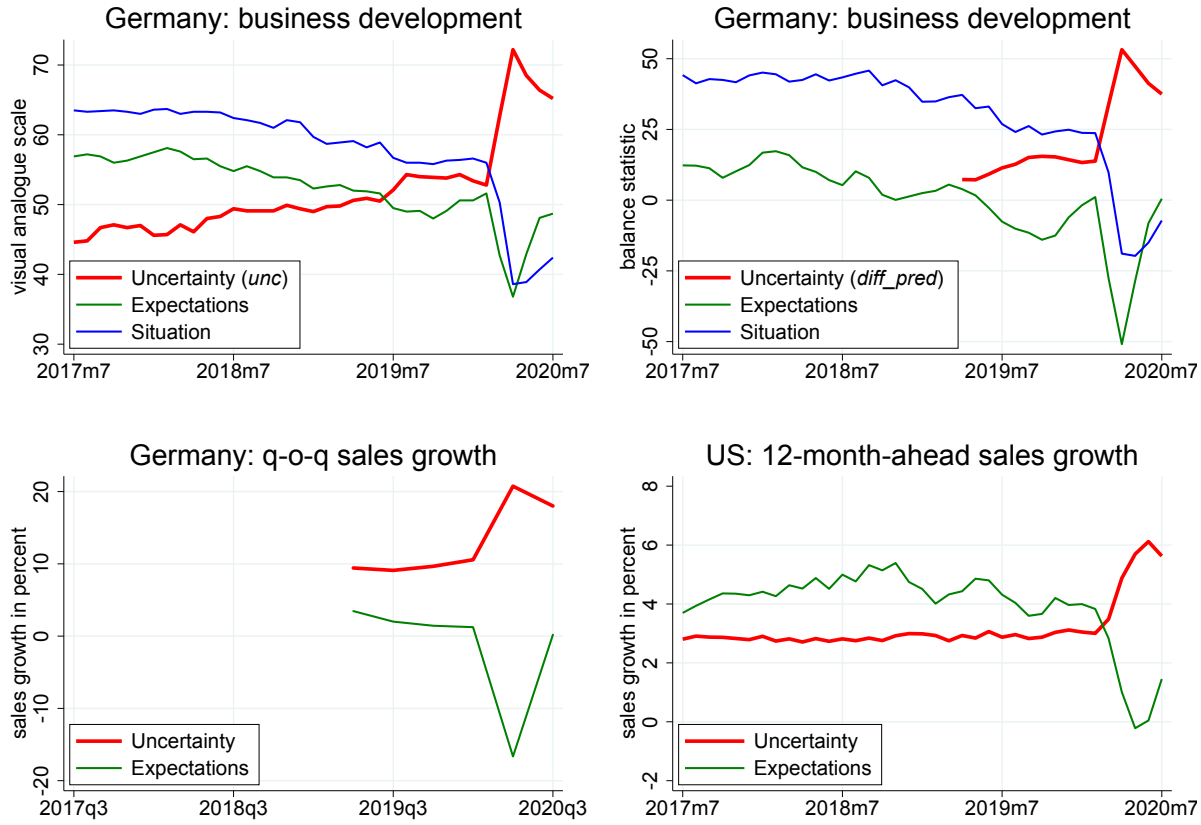
Despite the differences in the construction of the series, the evidence from the four plots is very similar. I make two observations. First, during the COVID-19 crisis the developments of perceived uncertainty and expectations are almost perfectly inversely related. From March 2020 onward, the sharp decline in expectations, followed by a recovery, is mirrored by a sharp increase in uncertainty and a subsequent decrease. Appendix F shows that this pattern is also present for the time series of all major sectors of the German economy. Based on admittedly rather short time series, these findings support the stylized fact of the negative relationship between uncertainty and expectations from the micro data and the time series of the manufacturing sector.

[21] Firm-level responses are first aggregated to the 2-digit level of the WZ08 classification using firm size weights, and then aggregated to the level of the total economy by using value added weights from the German Federal Statistical Office.

[22] To compute a balance statistic for *diff_pred*, I assign the values -1, -0.5, 0.5, and 1 for the answer options "easy", "rather easy", "rather difficult", and "difficult", respectively.

[23] The time series for subjective business uncertainty and expectations of US firms goes back to January 2015 and are available online at https://www.frbatlanta.org/research/surveys/business-uncertainty.

Figure 6: Subjective uncertainty and expectations in the COVID-19 crisis and before



Notes: The plot in the top left presents size-weighted time series of subjective uncertainty (*unc*), expectations, and the business situation elicited using visual analogue scales. The uncertainty (*diff_pred*) series in the top right plot is a size-weighted balance statistics constructed from the responses to question 4 described in Section 2.2. The other series in the top right plot are balance statistics from ifo's categorical questions on expectations and the business situation described in the same section. The plot in the bottom left shows size-weighted time series of quantitative expectations and uncertainty about q-o-q sales growth. Uncertainty is computed as the difference between best and worst case expectations as described in Bachmann et al. (2018). The data stems from a survey supplement to the ifo business cycle survey and is elicited from firms in manufacturing, wholesale and retail trade, and services. It is available for all of these sectors since Q2 2019. The plot in the bottom right shows business uncertainty and expectations with respect to twelve-month-ahead sales growth from the Atlanta Fed/Chicago Booth/Stanford Survey of Business Uncertainty. For comparability, the x-axis ranges from July 2017 to July 2020 for all plots.

Second, after the COVID-19 spike in April 2020, for all measures the increase in expectations is larger than the decrease in subjective uncertainty. For instance, the top left plot in Figure 6 shows that from April to July 2020 business expectations recover 80% of the initial drop from February to April, whereas *unc* only recovers 36%. This difference in the recovery rate is even more pronounced for the series in the other two plots for Germany. While only based on few data points, this second observation supports the previous microdata-based result—and the findings from the time series of the manufacturing sector before the COVID-19 recession—that the relationship between uncertainty and expectations is weaker in bad times. For Germany, low economic activity in mid-2020 is indicated by an unfavorable business situation in the aggregate. At this time, uncertainty remains elevated even though expectations improve.

To sum up, the stylized facts from the micro data and the time series of the manufacturing sector are also manifest during the COVID-19 crisis. They are robust to different

measures of perceived uncertainty, they hold for different sectors of the German economy, and they apply both for Germany and the US.

An implication of this finding is that, when using time series econometric analyses, it may be difficult to disentangle possible effects of subjective business uncertainty on macroeconomic variables, such as investment and GDP, from the effects of expectations. As an alternative approach, in the next section I use micro data to empirically study the predictions of a theoretical channel that links uncertainty to firm behavior.

6.2 Uncertainty, Expectations, and Corporate Decisions

When examining the effect of uncertainty on firms' economic decisions, one prominent theoretical channel is centered around "real options" (Bernanke, 1983; Brennan and Schwartz, 1985; McDonald and Siegel, 1986).[24] When decisions in firms cannot be easily reversed (or it is costly to do so) and when they affect the profitability of actions taken later, managers confronted with high uncertainty may prefer to "wait and see". More specifically, in such a case, it can be optimal for a business to postpone investment projects and to stop hiring and firing until the outlook becomes clearer. Due to the lack of suitable measures of subjective uncertainty at the firm level, empirical evidence on such behavior is scarce.

Perceived uncertainty seems to fluctuate most around recessions. Section 6.1 has provided evidence that the onset of the COVID-19 crisis was accompanied by a massive increase in uncertainty, while expectations plummeted. Based on the theoretical considerations above, in the presence of an uncertainty shock alone I would expect firms to postpone investments and to leave the number of employees largely unchanged.[25] A negative first moment shock is also likely to make firms defer investments. However, we would expect them to reduce employment as a consequence. The actual effect of each of the two shocks is unclear. Therefore, it is interesting to use micro data to study the relationship between uncertainty and firms' actions while the aggregate economy simultaneously experiences a first and a second moment shock.

In this case study, I exploit the cross-sectional heterogeneity in changes of subjective uncertainty and expectations between German firms in the onset of the COVID-19 crisis. I use the aggregate variation to find out whether differences in the impact of this shock on the subjective uncertainty of managers relates to differences in their investment and employment decisions.

Sample

[24] Other possible theoretical channels include precautionary behavior, borrowing constraints due to higher risk premia, and a loss in confidence caused by ambiguity aversion. Growth options and the Oi-Hartman-Abel effect constitute theoretical mechanisms that can explain positive investment and growth effects from uncertainty. Bloom (2014) provides an overview of these channels.

[25] According to the "real options" channel, uncertainty can lead managers to postpone investments if they are at least partially irreversible. Indeed, Guiso and Parigi (1999) find stronger negative effects of uncertainty on investment the more difficult or costly firms assess the possibility to resell investment goods after they were acquired. Surveying Swiss firms, Dibiasi et al. (2018) present evidence that 70% of the respondents consider their investments to be highly or fully irreversible; 94% view them as at least somewhat irreversible. The degree of irreversibility seems idiosyncratic to firms as the authors cannot predict it by observable characteristics such as size and sector. Given that almost all firms in the Swiss sample report at least some degree of irreversibility of their investments, I find it reasonable to assume that the "real options" theory would predict that also firms in my sample "wait and see" if they are confronted with high uncertainty.

To address this question, I use the micro data that underlie the top left plot in figure 6 in the previous section. The relevant sample comprises the February, March, and April waves of the ifo Business Survey from 2020 and contains responses from firms in the manufacturing industry, construction, retail and wholesale trade, and the service sector.[26] Based on this data, I relate subjective uncertainty (*unc*) and business expectations in March to subsequent self-reported information in April about whether firms have postponed investment projects and whether they have reduced employment, respectively, because of the COVID-19 crisis. Appendix F contains a translation of the special question in the April wave of the ifo Business Survey which asks firms about measures taken in response to the pandemic.

While the March wave of the ifo Business Survey was conducted from March 2 to March 24, I base my analysis on the subsample of firms that submitted their questionnaires in the nine days from March 16 to March 24.[27] Appendix F shows that this group of respondents is representative for the entire sample of firms that responded in March. Selecting this subsample ensures that managers are well-informed about the gravity of the crisis, and especially about the shutdown. As a result, I can exploit the full aggregate variation of the shock to uncertainty and expectations. Using data from the beginning of March would blur the within-variation of the aggregate shock as idiosyncratic changes in uncertainty and expectations are likely to dominate changes in beliefs due to the COVID-19 crisis.

Descriptive Evidence

To further motivate why I focus on the firms that responded between March 16 and 24, I present a series of descriptive evidence. Table F.1 in Appendix F presents a short time-line of events during the onset of the COVID-19 crisis in Germany. Due to the unprecedented character of the crisis, the negative consequences of the pandemic for the economy only became apparent gradually: on March 10, many federal states canceled mass events with more than 1,000 participants. On March 13, schools and childcare facilities were closed in most federal states. On March 16, the first day of the subsample period for the analysis, Germany closed its federal borders and the government announced the closing of shops and public facilities.

Along these events, subjective uncertainty (*unc*) increases and business expectations deteriorate.[28] Figure 7 divides the respondents of the March wave of the ifo survey into three groups and displays the change of their subjective uncertainty, expectations, and assessment of their business situation against the corresponding values from their responses in February. The first group of respondents who submit their survey responses before March 9, record an increase in uncertainty of 5.9 compared to February. For the second group, with a submission date between March 10 and March 15, it is 9.6 points. The third group, that responds between March 16 and 24, shows the largest increase: on average, these firms report an increase in their perceived uncertainty of 19.2 points on the visual analogue scale. The aggregate increase between February and April 2020 is likewise about 20 points on the visual analogue scale. Hence, by using the responses from the third group of firms, I can exploit the full variation of the aggregate shock. Figure

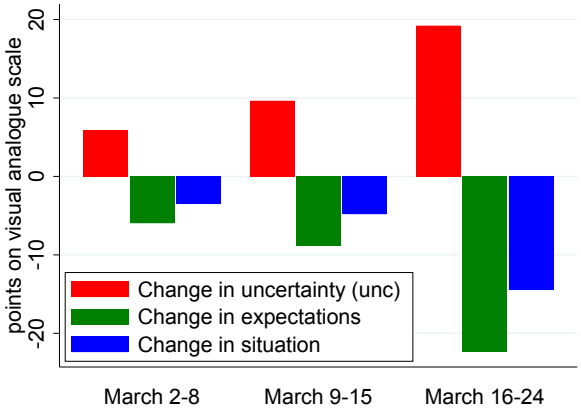
[26] I follow the data cleaning and harmonization procedure described in Link (2020).

[27] Appendix F presents a histogram of the submission dates in March. Information on this date is missing for 12% of all participants. I exclude these observations from all further analyses. Of the participants for which a submission date is available, 21% responded between March 16 and 24.

[28] Buchheim et al. (2020b) have first documented this shift in firms' expectations and uncertainty.

7 further indicates that the decrease in expectations is of a similar magnitude as the increase in uncertainty. The assessments of the current business situation also worsen, but the decline is less than the change in expectations.[29]

Figure 7: Changes of uncertainty, expectations, and the business situation in March 2020



Notes: The figure presents changes in subjective uncertainty (*unc*), business expectations and the business situation between three periods in March 2020 (indicated on the horizontal axis) against the averages of the responses from the same groups of firms in February, respectively. These measures are based on the firm-level answers to questions 1, 2, and 3 in Section 2.2. The labels at the vertical axis are numbers from a visual analogue scales that ranges from 0 to 100.

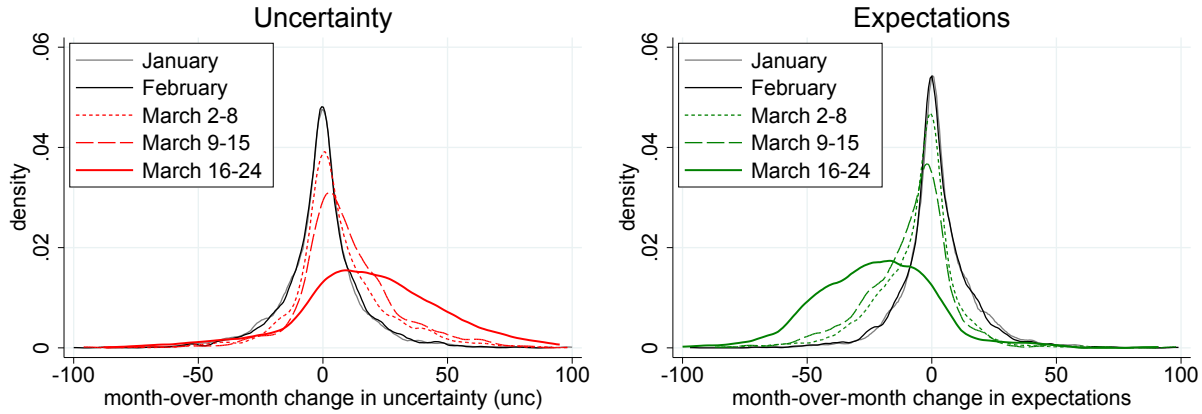
In the analysis, I use the variation between firms with respect to changes in their perceived uncertainty and expectations between February and March. The aim is to capture the variation that is due to the aggregate shock of the COVID-19 crisis, as opposed to idiosyncratic changes. Figure 8 presents distributions of changes between February and March in subjective uncertainty (*unc*) and expectations, respectively, for the three groups of firms identified above. The changes for all firms in January and February compared to the previous month, respectively, are also displayed as a reference. They are centered around zero. Thus, these changes are not driven by a common aggregate shock but reflect idiosyncratic variation at a lower level.

While the kernel density estimate for the first group of firms that responded between March 2 and 8 shows only minor deviations from the distributions of the changes in January and February, the kernel density estimates for the second group of firms (March 9-15) differ more. For the third group (March 16-24), the distribution is much wider and clearly positively skewed in case of the changes in uncertainty and negatively skewed for changes in expectations. This reflects the aggregate shock to uncertainty and expectations triggered by the events at the beginning of the COVID-19 crisis. Considering only the third group of firms, that responds between March 16 and 24, should allow me to mostly capture this variation. Moreover, I observe ample heterogeneity between firms: while on average, respondents become more uncertain and pessimistic, these changes in beliefs are more pronounced among some managers compared to others.

Econometric Model and Estimation

[29]The month-over-month changes in the three variables for the three weeks of the survey in March 2019 are tiny; they are all smaller than one point on the visual analogue scale in absolute terms. This suggests that there are no shifts in firms' perceptions that regularly occur during the month of March.

Figure 8: Distribution of changes in uncertainty and expectations



Notes: The figure shows kernel density estimates for month-over-month changes in subjective uncertainty (*unc*) in the left plot and month-over-month changes of expectations in the right plot for all firms in January and February, respectively, as well as for three groups of firms in March, split by the date of submission of their questionnaire. The density estimates are obtained using an epanechnikov kernel and the "rule-of-thumb" bandwidth (Silverman, 1986). The measures for uncertainty and expectations are based on the responses to questions 1, 2, and 3 in Section 2.2. The horizontal axes depict changes based on numbers from visual analogue scales that range from 0 to 100.

I exploit this between-firm variation to estimate the relationship between uncertainty (*unc*) and corporate decisions. As the baseline econometric specification, I choose a probit model of the form:

$$y_{it} = \beta_0 + \beta_1 \Delta u_{i,t-1} + \beta_2 u_{i,t-2} + \beta_3 \Delta e_{i,t-1} + \beta_4 e_{i,t-2} + \beta_5 \Delta s_{i,t-1} + \beta_6 s_{i,t-2} + \gamma' x_i + \epsilon_{it}$$

where y_{it} denotes a dummy variable for firm i's decision at time t, which can be either to postpone investments or to reduce employment. $\Delta u_{i,t-1}$, $\Delta e_{i,t-1}$, and $\Delta s_{i,t-1}$ are changes in uncertainty, expectations, and the business situation between periods $t-2$ and $t-1$. $u_{i,t-2}$, $e_{i,t-2}$, and $s_{i,t-2}$ are the levels of these variables in period $t-2$, respectively. x_i captures time-invariant firm characteristics, namely size and sector, and ϵ_{it} is an error term.

For the estimation, I use survey data from February, March, and April 2020, which refer to $t-2$, $t-1$, and t above. Unconditionally, 43% of the firms that responded between March 16 and 24 report in April that they have postponed investments and 16% state that they have reduced employment because of the COVID-19 crisis.[30] For the baseline regressions, I use the uncertainty measure *unc*, as well as business expectations and situation elicited with a visual analogue scale. These variables are based on questions 1, 2, and 3 in Section 2.2. To control for the size of the firms, I define dummy variables for three size classes based on the number of employees: small firms have less than 50 employees, medium-sized firms have between 50 and 249 employees, and large firms have 250 or more employees. This categorization is in line with the official definition of the German Federal Statistical Office. To take out sector-specific effects, I include dummies for sectors at the two-digit level of the German WZ08 classification, which is closely related to the European industry classification system NACE Rev. 2.

The econometric model contains both *levels* in period $t-2$ as well as *changes* in uncertainty, expectations, and the business situation between $t-2$ and $t-1$. The levels

[30]The responses of the April survey were collected between April 1 and April 23.

in February control for heterogeneity between firms before the aggregate shock. This is especially advantageous in view of the boundedness of the visual analogue scale. It allows me to compare changes between firms with the same level in February. As I want to relate changes of uncertainty caused by the aggregate shock of the COVID-19 crisis to managers' investment and employment decisions, my primary focus is on the coefficient of the change in uncertainty, β_1.[31]

Results

Table F.5 presents average marginal effects from ten probit regressions. The dependent variable in columns 1 to 5 is a dummy for firms' decisions to postpone investment, in columns 6 to 10 the dependent variable is a dummy for the decision to reduce employment.

From the regressions in columns 1 to 5, I find that there is a weak positive relationship between changes in uncertainty and the probability that firms postpone investments, when controlling for the base level of uncertainty. However, the coefficients are not significant at the 5%-level and they seem to be dominated by other variables. The level of uncertainty before the aggregate shock of the COVID-19 crisis appears to be a much better predictor of firms' decisions to postpone investments. Column 2 shows that, unconditionally, both the base level and the change in expectations are strongly negatively related to the dependent variable. The coefficients are quantitatively important: a decrease in expectations by ten points on the visual analogue scale goes along with an increase of the likelihood to postpone investments by roughly five percentage points. In the joint regression of levels and changes in uncertainty and expectations in column 3, the level of expectations becomes insignificant. When adding variables for the level and change of the business situation in column 4, only the change in the situation is significant. These results are robust to including firm size and sector dummies in column 5. To sum up, changes in expectations and the business situation triggered by the COVID-19 crisis are related to a higher likelihood to postpone investments, while changes in uncertainty are not. Moreover, firms with a higher level of uncertainty before the aggregate shock more often defer investments because of the crisis.

Columns 6 to 10 show that changes in uncertainty are not related to the decision to lay off employees. In case of a "freeze" of employment, I would have expected a significant negative coefficient. With higher uncertainty, firms would be less likely to lay off personnel. However, the coefficients in all specifications are quantitatively small and statistically not significant. In contrast, column 7 illustrates that the relationship between changes in expectations and the decision to reduce employment is strong. The more pronounced the deterioration in expectations, the more likely respondents downsize their workforce. The levels of uncertainty and expectations in February in columns 6 and 7 are also connected to a higher probability to lay off employees. In the joint regression in column 8, the level and change in expectations drive out the level of uncertainty.

[31] Given the negative relationships of uncertainty and expectations as well as uncertainty and the business situation documented in Section 4.1, there might be a concern of multicollinearity. Table F.3 in Appendix F shows that the main regressors in levels and changes are indeed correlated. However, none of the pairwise correlation coefficients exceeds 0.53. The R-squared from an OLS regression of $\Delta u_{i,t-1}$ on the level of uncertainty in $t-2$, as well as level and change variables of expectations and the business situation is 0.33. This leaves room for independent contributions of the regressors. Table F.3 also shows that individual firms seem to experience the aggregate uncertainty and expectation shocks quite differently: the correlation between changes in uncertainty and changes in expectations is merely -0.21.

Including levels and changes in the business situation in column 9, as well as size and sector dummies in column 10, emphasizes the role of pre-existing differences between firms for their decisions to lay off staff. Moreover, changes in the business situation seem most important as a transmission channel from the aggregate shock to the decision to reduce employment.

These results suggest that the first moment shock at the onset of the COVID-19 crisis dominates the effects that we expect from a pure uncertainty shock. I do not find evidence that firms postpone investment or "freeze" employment following changes in uncertainty. In contrast, negative changes of expectations and of the assessment of the business situation are significantly related to these corporate decisions. Moreover, perceptions and the business situation before the aggregate shock also predict firms' reactions to the crisis. This is in line with previous findings by Buchheim et al. (2020a).

Table 2: Relationship between corporate investment and employment decisions and past uncertainty, expectations, and situation

Dependent variable:	decision: postponement of investment					decision: reduction of the number of employees				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔUncertainty in $t-1$	0.00150*		0.000543	0.000631	0.000583	0.0000985		-0.000411	-0.000279	0.000278
	(1.84)		(0.67)	(0.77)	(0.71)	(0.15)		(-0.67)	(-0.46)	(0.45)
Uncertainty in $t-2$	0.00552***		0.00459***	0.00456***	0.00406***	0.00208***		0.000654	0.000679	0.00100
	(5.82)		(4.54)	(4.27)	(3.73)	(2.60)		(0.85)	(0.87)	(1.16)
ΔExpectations in $t-1$		-0.00534***	-0.00466***	-0.00312***	-0.00330***		-0.00325***	-0.00311***	-0.00147*	-0.00109
		(-5.93)	(-4.89)	(-2.96)	(-3.15)		(-3.88)	(-3.66)	(-1.77)	(-1.39)
Expectations in $t-2$		-0.00433***	-0.00216	-0.000945	-0.000599		-0.00568***	-0.00524***	-0.00374***	-0.00402***
		(-3.44)	(-1.60)	(-0.64)	(-0.40)		(-5.33)	(-4.74)	(-3.20)	(-3.23)
ΔSituation in $t-1$				-0.00330***	-0.00331***				-0.00315***	-0.00286***
				(-3.31)	(-3.14)				(-4.09)	(-3.75)
Situation in $t-2$				-0.00210*	-0.00166				-0.00214**	-0.00163*
				(-1.76)	(-1.29)				(-2.47)	(-1.69)
Dummy medium sized firms					0.0309					0.0305
					(0.71)					(0.86)
Dummy large firms					0.0279					0.0284
					(0.48)					(0.64)
Sector dummies					YES					YES
No. of firms	660	667	656	653	630	660	667	656	653	561
Pseudo R-sq.	0.037	0.039	0.066	0.078	0.15	0.019	0.077	0.080	0.11	0.24

Notes: Average marginal effects from probit regressions. The dependent variable in columns 1 to 5 is a dummy for the decision to postpone investment projects because of the COVID-19 crisis, in columns 6 to 10 it is a dummy for the decision to reduce employment because of the COVID-19 crisis. Information on these corporate decisions stems from the ifo Business Survey in April 2020. The regressors are levels of uncertainty (*unc)*, expectations, and business situation from February 2020, and month-over-month changes from March 2020. These measures are based on the responses to questions 1, 2, and 3 in Section 2.2. t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix F presents additional regressions for two related managerial decisions: the cancellation of investment projects and the implementation of short-time work. I use dummies for these actions as dependent variables in otherwise unchanged regressions. The data stems from the same special question in April as the data on the decisions to postpone investments and to reduce employment. Unconditionally, 19% of the firms that responded between March 16 and 24 report to have canceled investment projects, and 49% indicate to have introduced short-time work. In principal, uncertainty could also affect these decisions via precautionary behavior. However, this does not seem to be the case: once expectations are controlled for, again I find that only first moment changes—and pre-existing business conditions before the aggregate shock—are related to these investment and employment decisions.

Robustness

Did managers anticipate the economic consequences of the COVID-19 crisis before March 2020? News about the COVID-19 epidemic in Asia could have affected uncertainty and expectations of respondents in February. However, Buchheim et al. (2020b) show that there was basically no such effect. Instead, respondents of the ifo Business Survey only changed their beliefs once domestic policy imposed measures to contain the epidemic in March. The spread of the disease in Italy only became known on February 21, the last day of this month's survey wave. Hence, information about the outbreak in Europe is also unlikely to affect the results.

Appendix F presents several robustness checks for the baseline regression results above. First, instead of computing marginal effects from probit regressions, I estimate linear probability models. The results are almost exactly the same. Second, I estimate the baseline regressions excluding firms from the manufacturing sector. Due to the relatively poor performance of this sector relative to the other major sectors before the COVID-19 crisis, it may drive some of the results. However, this is not the case: the main regressions results are robust to excluding manufacturing firms from the sample.

Third, to account for possible measurement error in the variables for uncertainty, expectations, and the business situation, I apply the Obviously Related Instrumental Variable (ORIV) approach proposed by Gillen et al. (2019). To this end, in the sample from February to April 2020, I first regress the uncertainty variable *unc* on *diff_pred* and use the predicted values, as well as changes of the predicted values, as alternative regressors $\Delta u_{i,t-1}*$ and $u_{i,t-2}*$. These new variables capture the common variation in *unc* and *diff_pred* and are free of independent and identically distributed measurement error. By regressing expectations and the business situation measured using visual analogue scales on their categorical counter-parts, I analogously obtain predicted values for these variables, in levels and in changes. Table F.7 in Appendix F shows that the main results are robust to re-estimating the baseline regressions with these modified variables. A difference is that the coefficients of expectations and the business situation are substantially larger using the ORIV approach. This suggests the presence of an attenuation bias in the baseline regressions. As a consequence, in the regressions with the modified variables, uncertainty in February is driven out by expectations and the situation. In contrast to the baseline regressions, using the ORIV approach the level of uncertainty before the aggregate shock does not predict firms' investment and employment decisions anymore.

As another robustness test, Table F.8 replicates the baseline regressions in Table F.5 using the uncertainty measure *diff_pred* as well as the categorical variables for expecta-

tions and the business situation. This requires the definition of several dummy variables. Regarding *diff_pred*, I join the sparsely populated category "Easy" with the category "Rather easy" and create indicator variables for the resulting three levels of the difficulty to predict the future business development in periods $t-2$ and $t-1$. Based on these uncertainty states, I define dummy variables for positive and negative changes from $t-2$ to $t-1$. Moreover, I use the trichotomous variables on expectations and the business situation to create dummies for the levels in $t-2$ as well as positive and negative changes between $t-2$ and $t-1$, respectively. In the regressions, I define the lowest uncertainty level as well as the middle categories of expectations and the business situation as the baseline. The baseline for the variables in changes are the cases of no change, respectively.

The regression results in Table F.8 confirm the main findings from above. Unfavorable expectations in the level as well as negative changes in expectations drive out the effect captured by the dummy for increases in uncertainty. This holds true for both the decision to postpone investments and the decision to reduce the number of employees. In regressions with only uncertainty and expectation variables, the level of uncertainty in February is also significantly related to the outcome dummies. However, it turns insignificant once I control for levels and changes of the business situation.

7 Conclusion

The uncertainty of firms and households is inherently subjective. As for expectations, a good way to measure it is to ask actual decision makers about their perceptions. Based on data from a large and representative German business survey, this paper presents a novel direct measure of firms' subjective uncertainty about the development of their businesses. It appears to be a sensible measure since it contains essentially the same information as a second measure of perceived uncertainty that asks managers to assess the difficulty to predict their future business development. The collection of more data of this kind can facilitate research concerned with the effect of subjective uncertainty on decision making and the business cycle.

While conceptually closely related, there is little empirical evidence on the relationship between subjective uncertainty and expectations. I contrast managers' perceived uncertainty with their business expectations and an assessment of their business situation and find strong negative relations at the micro level and almost perfectly inverse relationships in the time series. Moreover, the relationship between uncertainty and expectations is state-dependent: in bad times, this relationship is weaker, since uncertainty is generally high. The new evidence highlights the simultaneity of movements in subjective uncertainty and both expectations and business activity in the aggregate. This impedes the identification of aggregate uncertainty shocks using time-series econometric methods. As an alternative approach, the availability of micro data of managers' perceptions allows me to analyze the impact of uncertainty on firm behavior.

Exploiting the between-firm variation at the onset of the COVID-19 crisis, I investigate the relation of uncertainty and expectations to firms' decisions to postpone investment projects and to reduce the number of employees. I find that changes in uncertainty during the aggregate downturn do not predict "wait and see" behavior. By contrast, first moment changes are related to the deferral of investment and a reduction of the workforce. These results may be particular to the sharp economic downturn in March 2020, which was extraordinary in many respects. More research should be devoted to examine the

link between perceived uncertainty and corporate actions. Of particular interest could be the business cycle stage of an early recovery, when expectations improve but uncertainty remains elevated.

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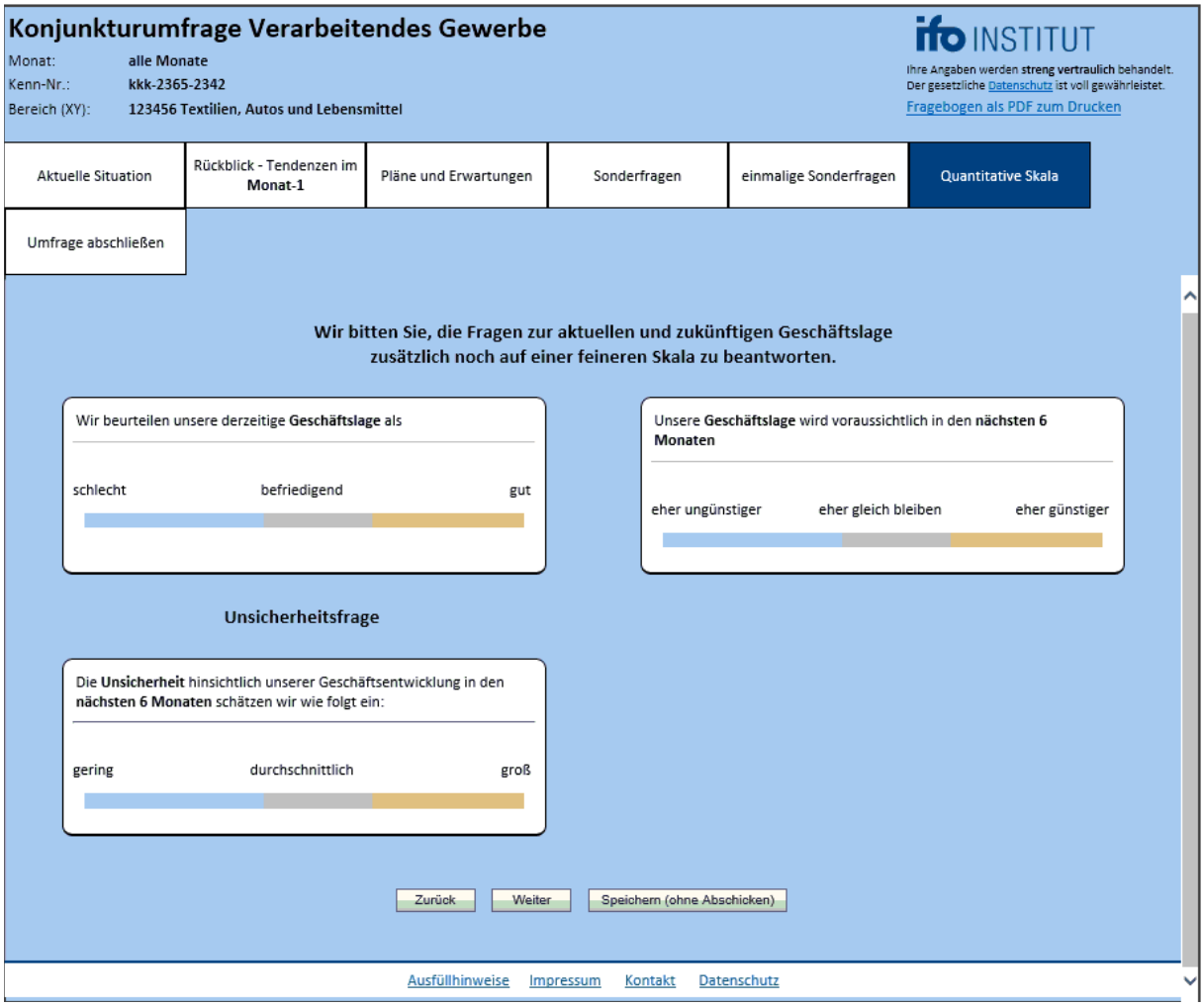
Appendix

Appendix A Data

Figure A.1: Online questionnaire with questions using visual analogue scales



Notes: In the original German, the screenshot shows the section of the online survey questionnaire that elicits an assessment of the business situation as well as expectations and subjective uncertainty about the future business development using visual analogue scales. They correspond to questions 1, 2, and 3 in Section 2.2.

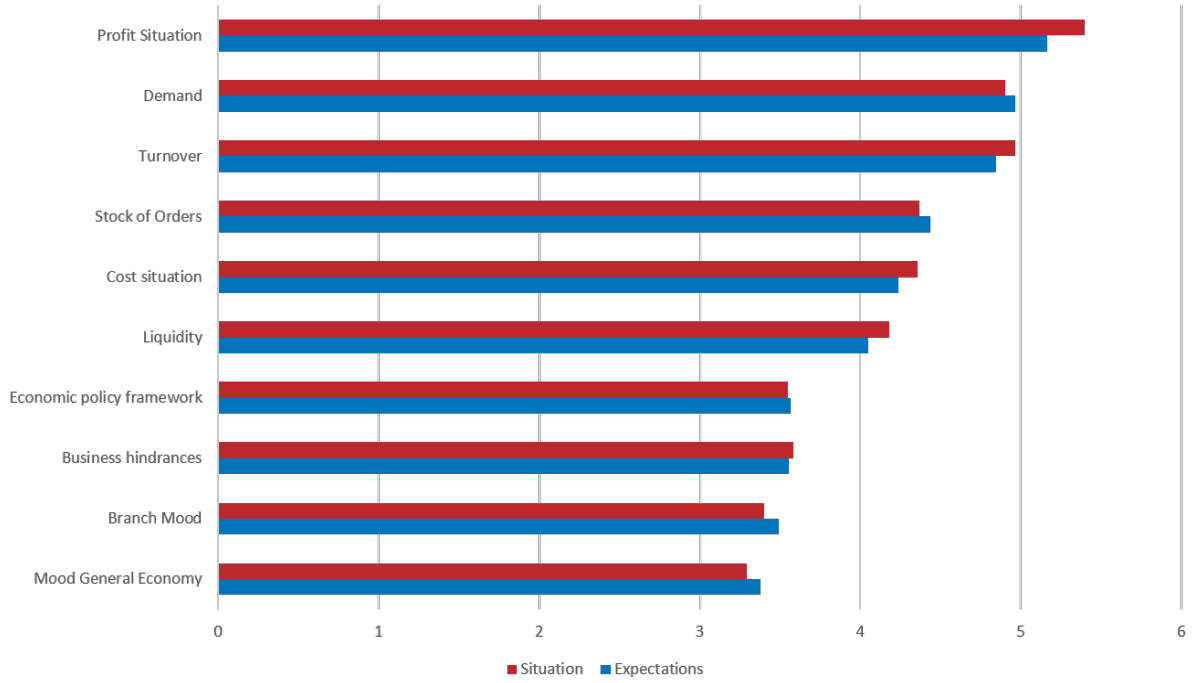
Table A.1: Representativeness of online participants in the ifo Business Survey

Dep. variable: dummy for online participation	(1) probit
Dummy medium sized firms	0.0177
	(0.0455)
Dummy large firms	0.250***
	(0.0591)
capacity utilization in %	0.0107***
	(0.00171)
Dummy production vs previous month: more	0.00133
	(0.0409)
Dummy production vs previous month: less	0.0996**
	(0.0431)
Dummy production vs previous month: no production	-0.101
	(0.239)
Dummy order vs previous month: higher	0.0405
	(0.0428)
Dummy order vs previous month: lower	0.0266
	(0.0418)
Dummy demand vs previous month: higher	0.113***
	(0.0431)
Dummy demand vs previous month: lower	0.0287
	(0.0406)
Dummy domestic prices vs previous month: increase	-0.0107
	(0.0418)
Dummy domestic prices vs previous month: decrease	-0.158*
	(0.0804)
Dummy capacity utilization, appraisal: more than enough	-0.0580
	(0.0582)
Dummy capacity utilization, appraisal: not enough	0.0564
	(0.0481)
Dummy state of business: good	-0.0330
	(0.0454)
Dummy state of business: bad	0.0680
	(0.0598)
Dummy expected commercial operations: favourable	0.0404
	(0.0435)
Dummy expected commercial operations: unfavourable	-0.00589
	(0.0428)
Dummy orders, appraisal: relatively high	-0.0433
	(0.0529)
Dummy orders, appraisal: too small	0.0924*
	(0.0550)
Dummy foreign orders, appraisal: relatively high	-0.0271
	(0.0643)
Dummy foreign orders, appraisal: too small	-0.0382
	(0.0611)
Dummy foreign orders, appraisal: no fexport	-0.372***
	(0.0689)
Dummy expected domestic prices: increase	0.000872
	(0.0387)
Dummy expected domestic prices: decrease	0.0599
	(0.0691)
Dummy expected number of employees: increase	0.0171
	(0.0520)
Dummy expected number of employees: decrease	0.0184
	(0.0528)
Dummy stock of inventories: too little	0.0141
	(0.0705)
Dummy stock of inventories: too much	0.0272
	(0.0578)
Dummy stock of inventories: no stock-keeping	0.103*
	(0.0584)
Dummy constraints to production: yes	0.196***
	(0.0423)
Constant	-0.444***
	(0.154)
No. of observations	17432
No. of firms	3182
Pseudo R-squared	0.035

Notes: Probit regression of a dummy variable that identifies online participants—vs. mainly paper-based respondents—in the manufacturing part of the ifo Business Survey on firm characteristics and variables of business activity. The underlying sample spans from July 2017 to January 2020. Standard errors in parentheses, clustered by firm; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix B Comparing Two Measures of Subjective Uncertainty

Figure B.1: Determinants of business situation and expectations from meta survey



Notes: The bar chart presents the results of two questions in a meta survey about the ifo Business Survey conducted in fall 2019. Respondents were asked to rate the importance of a list of variables for their assessment of the business situation and business expectations using numbers from 0 (unimportant) to 6 (very important).

Table B.1: Relationship of the business situation and variables of business activity

Dependent variable: business situation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Dummy production vs previous month: more	11.13***										
	(23.00)										
Dummy production vs previous month: less	-18.44***										
	(-38.73)										
Dummy orders vs previous month: higher		9.808***									
		(22.50)									
Dummy orders vs previous month: lower		-14.89***									
		(-34.39)									
Dummy demand vs previous month: higher			7.155***								
			(16.27)								
Dummy demand vs previous month: lower			-14.76***								
			(-33.05)								
Dummy domestic prices vs previous month: increase				7.367***							
				(12.33)							
Dummy domestic prices vs previous month: decrease				-16.43***							
				(-16.36)							
capacity utilization in %					0.715***						
					(29.89)						
Dummy stock of orders: relatively high						16.83***					
						(33.03)					
Dummy stock of orders: too small						-22.36***					
						(-44.99)					
Dummy profit situation: good							19.56***				
							(33.77)				
Dummy profit situation: bad							-19.48***				
							(-31.01)				
Dummy constraints to production: yes								-7.509***			
								(-12.64)			
Dummy expected production: increase									8.280***		
									(15.19)		
Dummy expected production: decrease									-16.73***		
									(-31.46)		
Dummy expected number of employees: increase										15.80***	
										(25.95)	
Dummy expected number of employees: decrease										-19.63***	
										(-31.22)	
Dummy expected domestic prices: increase											5.618***
											(10.16)
Dummy expected domestic prices: decrease											-15.43***
											(-17.04)
Constant	57.16***	57.19***	57.48***	55.90***	-3.934*	57.79***	54.24***	60.14***	56.73***	56.18***	55.92***
	(158.70)	(154.63)	(148.05)	(149.99)	(-1.91)	(187.26)	(159.97)	(146.06)	(154.77)	(158.23)	(148.54)
No. of observations	46006	45938	46056	45941	14492	45597	7222	16060	46127	46026	45852
R-squared	0.18	0.17	0.13	0.045	0.25	0.43	0.45	0.032	0.13	0.19	0.044

Notes: Results from OLS regressions. The dependent variable is the respondents' assessment of the business situation, based on question 1 in Section 2.2. The base category of the dummy variables constructed from the responses of the questions on changes in production, orders, demand, and prices, and of the expectations questions is "unchanged". The base level for the dummies for the stock of orders and profit situation is labeled "satisfactory", respectively. t-statistics in parenthesis. Standard errors are clustered by firm; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.2: Relationship of business expectations and variables of business activity

Dependent variable: business expectations	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Dummy production vs previous month: more	8.363***										
	(20.17)										
Dummy production vs previous month: less	-9.860***										
	(-22.29)										
Dummy orders vs previous month: higher		7.653***									
		(21.29)									
Dummy orders vs previous month: lower		-10.63***									
		(-29.02)									
Dummy demand vs previous month: higher			7.541***								
			(20.88)								
Dummy demand vs previous month: lower			-11.00***								
			(-29.67)								
Dummy domestic prices vs previous month: increase				5.005***							
				(11.28)							
Dummy domestic prices vs previous month: decrease				-11.31***							
				(-12.47)							
capacity utilization in %					0.254***						
					(13.44)						
Dummy stock of orders: relatively high						6.068***					
						(12.95)					
Dummy stock of orders: too small						-11.29***					
						(-24.93)					
Dummy profit situation: good							6.832***				
							(12.39)				
Dummy profit situation: bad							-8.582***				
							(-13.94)				
Dummy constraints to production: yes								-4.411***			
								(-10.22)			
Dummy expected production: increase									11.62***		
									(27.39)		
Dummy expected production: decrease									-15.81***		
									(-35.93)		
Dummy expected number of employees: increase										11.47***	
										(21.06)	
Dummy expected number of employees: decrease										-13.29***	
										(-23.26)	
Dummy expected domestic prices: increase											4.808***
											(10.97)
Dummy expected domestic prices: decrease											-13.35***
											(-17.49)
Constant	51.31***	51.81***	51.71***	51.07***	30.15***	52.60***	50.63***	53.61***	50.96***	51.15***	51.05***
	(209.07)	(208.25)	(209.68)	(189.94)	(18.38)	(202.73)	(155.89)	(168.91)	(228.92)	(210.63)	(193.40)
No. of observations	45989	45923	46039	45927	14488	45575	7219	16053	46111	46011	45841
R-squared	0.11	0.14	0.14	0.033	0.052	0.14	0.11	0.018	0.24	0.14	0.052

Notes: Results from OLS regressions. The dependent variable is business expectations, based on question 2 in Section 2.2. The base category of the dummy variables constructed from the responses of the questions on changes in production, orders, demand, and prices, and of the expectations questions is "unchanged". The base level for the dummies for the stock of orders and profit situation is labeled "satisfactory", respectively. t-statistics in parenthesis. Standard errors are clustered by firm; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B.3: Summary statistics of situation, expectations, and uncertainty (*unc*)

Variable	No. Obs	Mean	Std. Dev.	P1	P10	P25	P50	P75	P90	P99
Business situation	46413	56.1	20.7	6	30	45	53	71	85	99
Business expectations	46394	51.2	16.5	8	30	45	50	59	73	95
Uncertainty: *unc*	46740	55.2	19.9	5	28	47	53	69	81	97

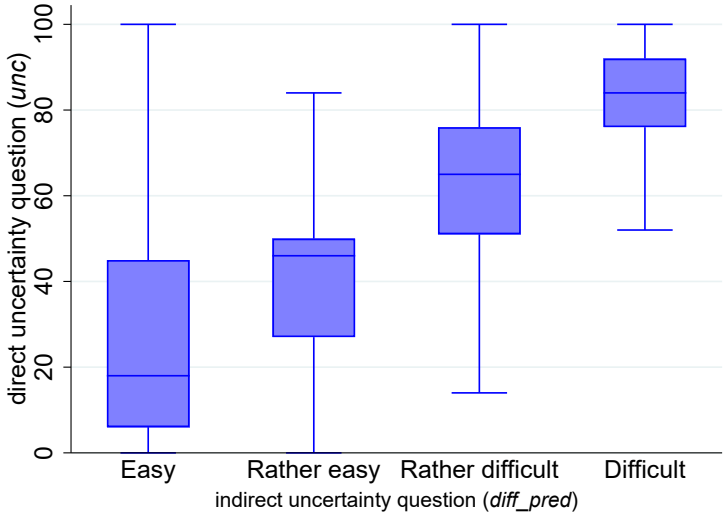
Notes: Summary statistics of the responses from questions 1, 2, and 3 in section 2.2 for the manufacturing sector. The sample ranges from July 2017 to January 2020.

Table B.4: Summary statistics of uncertainty: *diff_pred*

	No. Obs.	Share
Easy	277	0.02
Rather easy	3,282	0.20
Rather difficult	10,053	0.62
Difficult	2,499	0.16
Total	16,111	1.00

Notes: Distribution of the responses to question 4 in section 2.2 for the manufacturing sector. The sample ranges from April 2019 to January 2020.

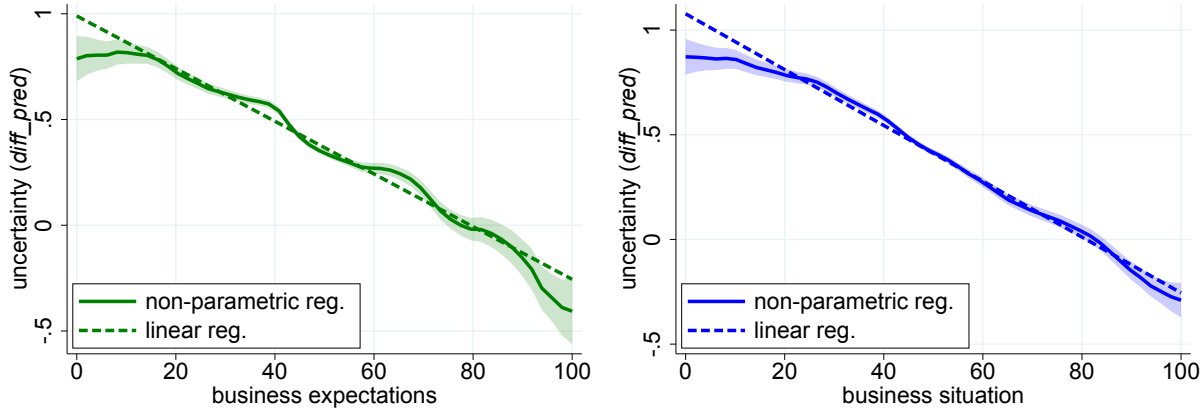
Figure B.2: Comparison of two measures of subjective uncertainty



Notes: The box plot illustrates the distribution of the responses of the direct uncertainty question 3 in Section 2.2 (*unc*) for each of the answer options of the indirect uncertainty question 4 (*diff_pred*).

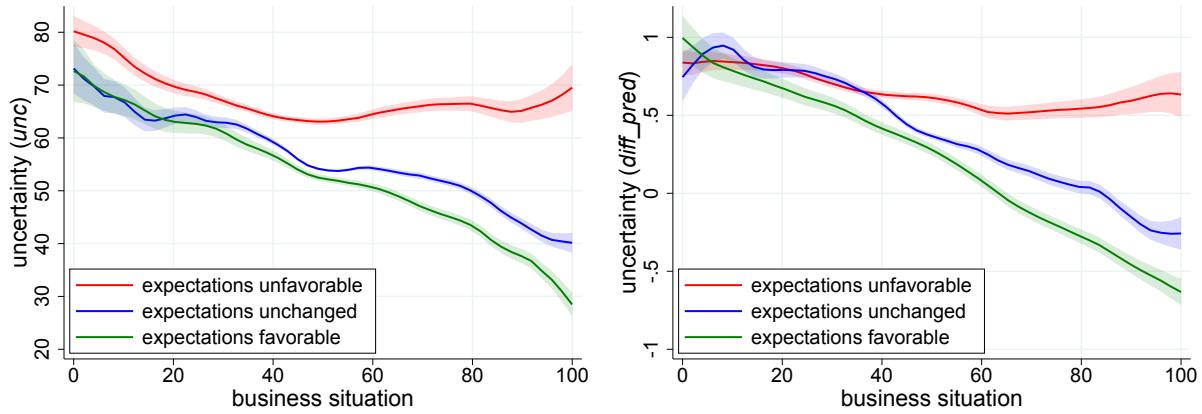
Appendix C Subjective Uncertainty at the Micro Level

Figure C.1: Relation of uncertainty (*diff_pred*) to expectations and the business situation



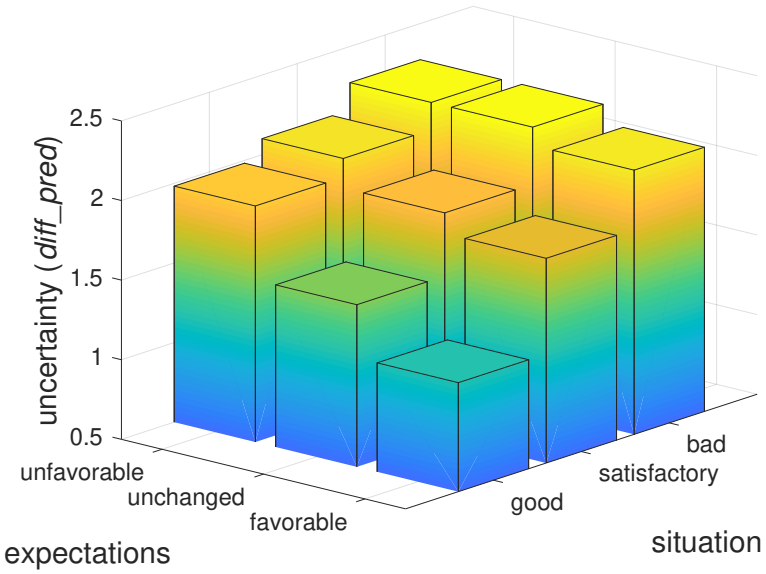
Notes: This figure shows non-parametric kernel regression lines of degree zero with shaded 95% confidence bands as well as fitted linear regression lines for the relationship between uncertainty (*diff_pred*) and business expectations in the left plot, and between uncertainty (*diff_pred*) and the business situation in the right plot. The assessment of the business situation, expectations, and uncertainty are based on questions 1, 2, and 4 in section 2.2, respectively. The categorical values of diff_pred "Easy", "Rather Easy", "Rather difficult", and "Difficult" are coded as -1.5, -0.5, 0.5, and 1.5, respectively.

Figure C.2: Relation of uncertainty to the business situation by expectation category



Notes: The figure shows two plots with non-parametric kernel regression lines of degree zero with shaded 95% confidence bands for the relationship between uncertainty and the business situation, for three subsamples according to the respondents' business expectations being unfavorable, unchanged, and favorable. The vertical axis of the left plot depicts the uncertainty measure *unc* that is based on question 3 in Section 2.2; for the right plot it is *diff_pred* that is based on question 4 in Section 2.2. The assessment of the business situation is based on question 1 in Section 2.2. The categorical values of *diff_pred* "Easy", "Rather Easy", "Rather difficult", and "Difficult" are coded as -1.5, -0.5, 0.5, and 1.5, respectively.

Figure C.3: Uncertainty (*diff_pred*) for combinations of business situation and expectations



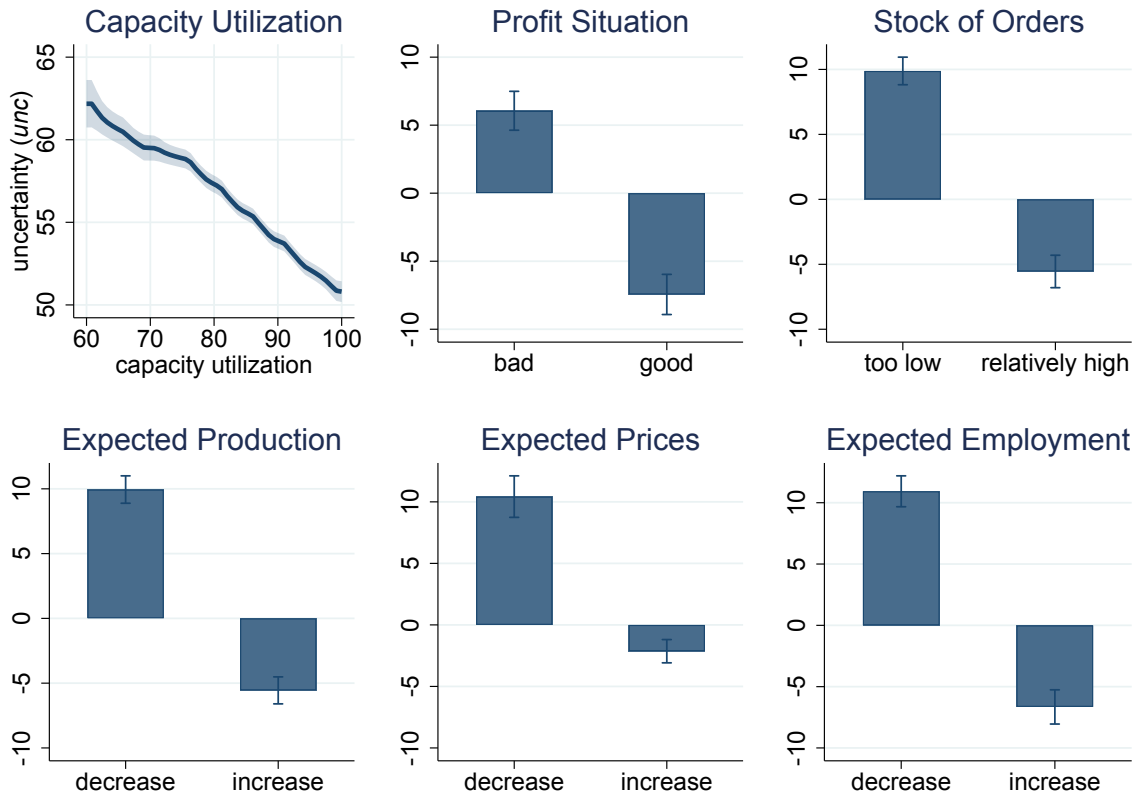
Notes: The bar chart illustrates the mean values of uncertainty (*diff_pred*) by the nine combinations of the categorical responses to the trichotomous questions about the business situation and business expectations described in Section 2.2. Each mean is based on at least 527 firm-time observations. For this illustration, the categories of *diff_pred* "Easy", "Rather Easy", "Rather difficult", and "Difficult" are coded as 0, 1, 2, and 3, respectively. The underlying sample from the spans from April 2019 to January 2020.

Table C.1: Uncertainty by interaction dummies of business situation and expectations

	(1) POLS	(2) FE
Situation good and expectations unchanged	6.677***	4.629***
	(0.774)	(0.409)
Situation good and expectations unfavorable	22.35***	14.49***
	(1.054)	(0.677)
Situation satisfactory and expectations favorable	10.01***	8.992***
	(0.899)	(0.544)
Situation satisfactory and expectations unchanged	13.21***	11.70***
	(0.834)	(0.506)
Situation satisfactory and expectations unfavorable	22.43***	16.89***
	(0.953)	(0.601)
Situation bad and expectations favorable	19.93***	17.63***
	(1.274)	(0.821)
Situation bad and expectations unchanged	20.57***	19.09***
	(1.325)	(0.740)
Situation bad and expectations unfavorable	26.31***	21.21***
	(1.223)	(0.834)
Constant	42.73***	45.06***
	(0.800)	(0.405)
No. of obs.	46248	46248
R-squared	0.14	0.55

Notes: Results from OLS and fixed effects regressions. The dependent variable is uncertainty (*unc*). The regressors are are based on the categorical questions on expectations and the business situation described in Section 2.2. In both regressions, the baseline category is a dummy for a good situation and favorable expectations. Standard errors in parentheses, clustered by firm; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

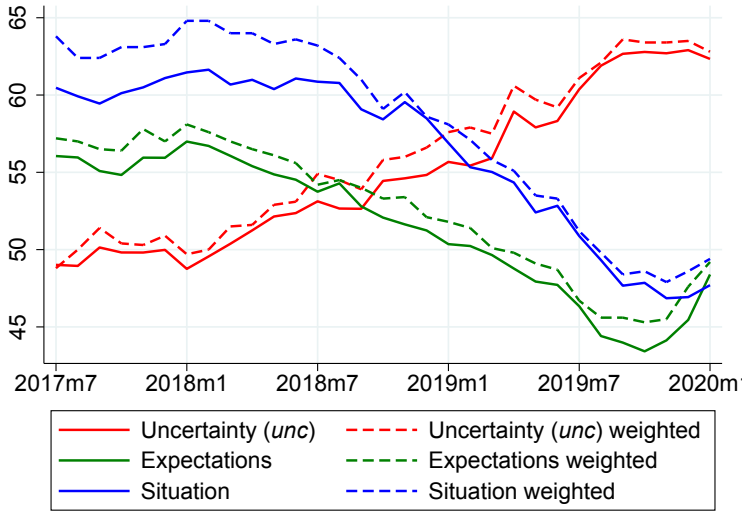
Figure C.4: Total variation of uncertainty by variables of business activity



Notes: The top left plot displays a non-parametric kernel regression line of degree zero with shaded 95% confidence bands for the relationship between uncertainty (*unc*) and capacity utilization in percent. I restrict the x-axis to the inter-decile range of capacity utilization for better visibility. The figure further presents bar charts illustrating coefficients from separate pooled OLS regressions of uncertainty (*unc*) on categorical variables from the ifo Business Survey, as denoted in the titles of the subplots. In particular, the regressors are dummies based on two categorical answers (labels at the x-axes). Thus, each bar corresponds to a coefficient relative to the middle category, which is "unchanged" in case of all variables except the stock of orders and the profit situation. For the latter two variables, the middle categories are labeled "sufficient" and "satisfactory", respectively. The whiskers at the bars are 95% confidence intervals. Capacity utilization is available once a quarter, the profit situation biannually, and all other variables in monthly frequency.

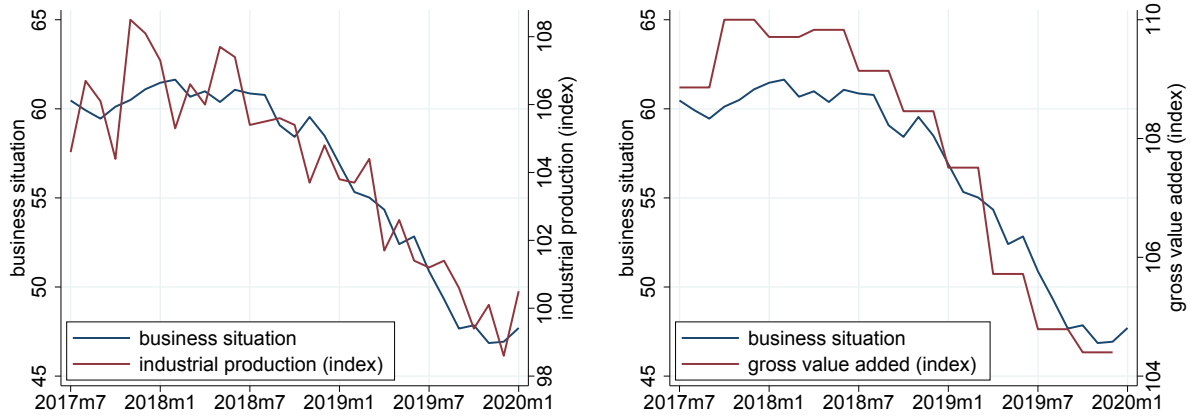
Appendix D Subjective Uncertainty in the Aggregate

Figure D.1: Weighted and unweighted time series



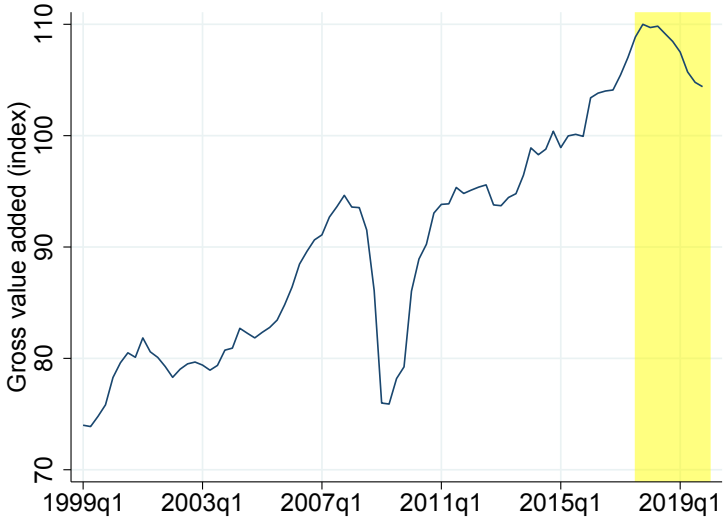
Notes: The figure presents weighted and unweighted aggregate time series of subjective uncertainty, business expectations and an assessment of the respondents' current business situation. These measures are based on the firm-level answers to questions 1, 2, and 3 in Section 2.2. The labels at the vertical axis are numbers from a visual analogue scale that ranges from 0 to 100. The weighted series are computed following the standard aggregation approach at ifo described in Sauer and Wohlrabe (2020). Weighting occurs in a two-step procedure: in the first step, observations are aggregated to the 2-digit WZ 08 sector level using firm size weights. In the second step, gross value added weights based on data from the German Statistical Office are used to aggregate from the 2-digit sector level to total manufacturing. The unweighted series are based on simple averages.

Figure D.2: Business situation vs. industrial production and gross value added



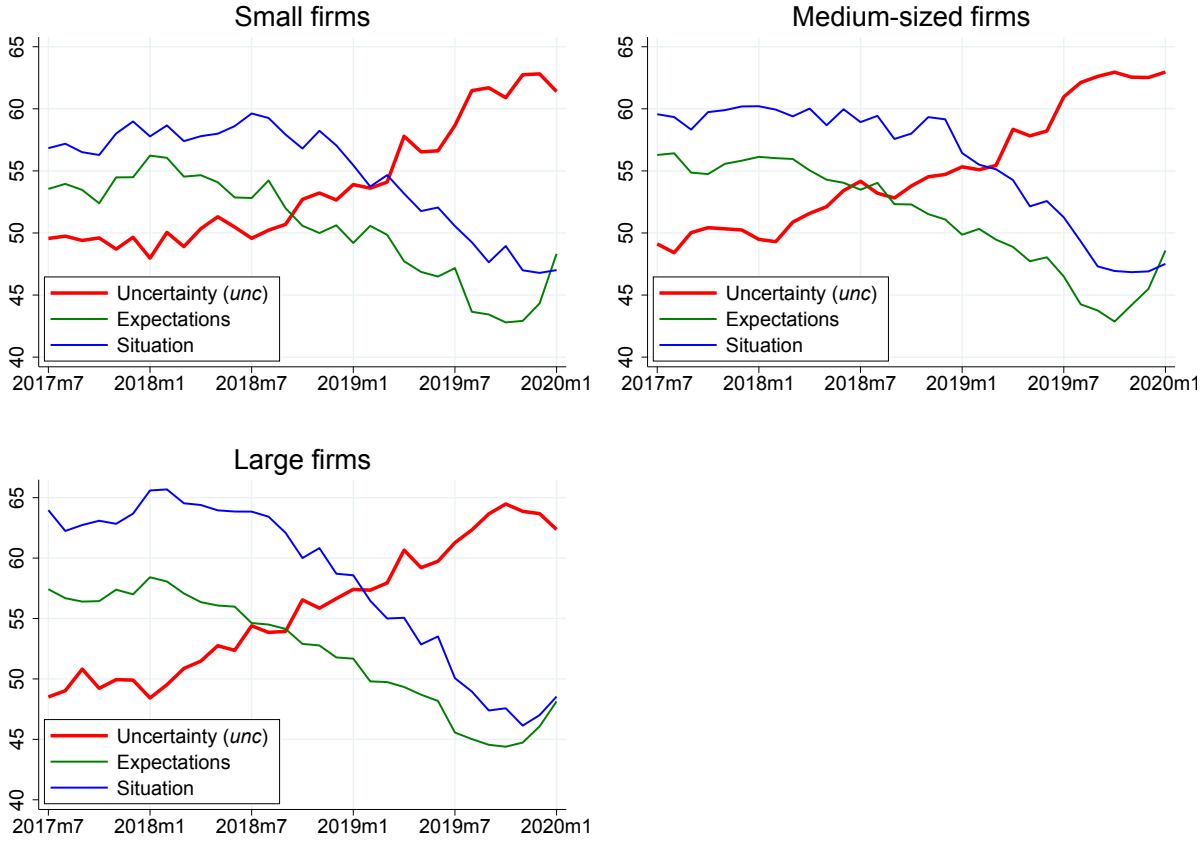
Notes: The left plot shows the unweighted average of the assessment of the business situation by manufacturing firms described in Section 2.2 and a monthly index of seasonally and calendar adjusted industrial production in the manufacturing sector from Eurostat. The right plot depicts the unweighted average of the business situation from manufacturing firms with a quarterly series of seasonally and calendar adjusted gross value added in constant prices for the manufacturing sector, provided by the German Federal Statistical Office.

Figure D.3: Long time series of gross value added in manufacturing



Notes: The figure depicts a quarterly index of seasonally and calender adjusted gross value added in manufacturing from Q1 1999 to Q4 2019. The sample period from Q3 2017 to Q4 2019 is marked in yellow. Note that the sample also includes January 2020. However, due to the impact of the COVID-19 crisis in March 2020, I leave out the value of the gross value added series for Q1 2020.

Figure D.4: Time series of uncertainty, expectations, and situation by firm size

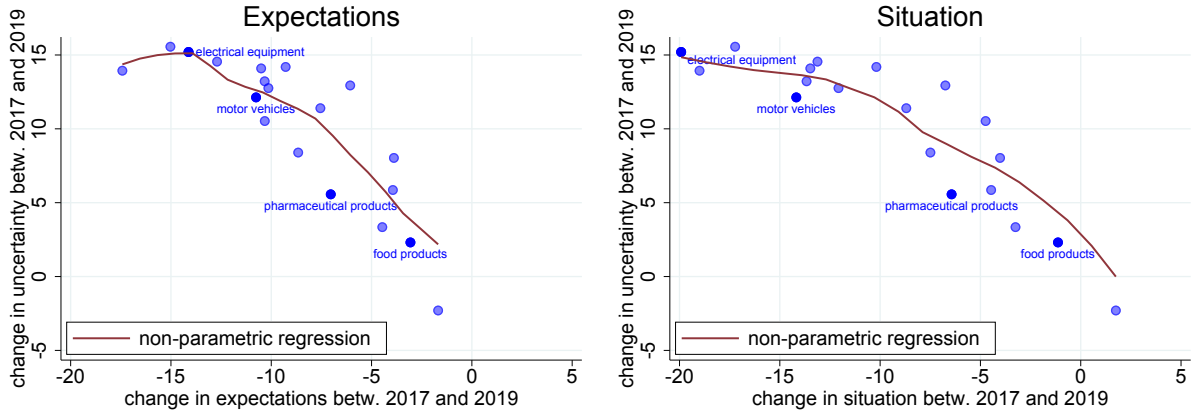


Notes: The figure presents time series of unweighted means of subjective uncertainty, business expectations and an assessment of the respondents' current business situation. These measures are based on the firm-level answers to questions 1, 2, and 3 in Section 2.2. I categorize firms in three size classes based on the number of employees, following the definition of the German Federal Statistical Office: small firms have less than 50 employees, medium-sized firms between 50 and 249 employees, and large firms 250 or more employees.

Appendix E Variation in Uncertainty and Sectoral Performance

Industries in the manufacturing sector are typically affected differently by an economic downturn. More cyclical sectors such as vehicle production or machinery tend to contract more than industries with rather stable demand, such as the food or pharmaceutical industries. The aim of this appendix is to better understand the drivers of the aggregate increase in perceived uncertainty. Does uncertainty increase fairly evenly in all sectors, or are different sectoral paths in the economic downturn related to sectoral heterogeneity in uncertainty?

Figure E.1: Changes in uncertainty, expectations, and the situation by sector



Notes: The left plot of the figure presents a scatter plot and a non-parametric kernel regression line of degree zero with an epanechnikov kernel and the "rule of thumb" bandwidth for the relationship between the change in average uncertainty (*unc*) and the change in average business expectations between 2017 and 2019 at the 2-digit WZ08 sector level. In particular, for each sector, I take averages of uncertainty and expectations over two periods, respectively: July through December in 2017 and July through December in 2019, before computing the time-differences between these averages. The right plot replicates the left plot, but replaces business expectations with the assessment of the business situation. For both plots, I exclude sectors 12, 15, 19, 30, and 33, for which I have less than 10 observations in at least one month of the two time periods. The assessments of the business situation, expectations, and uncertainty are based on questions 1, 2, and 3 in Section 2.2. Responses are elicited using visual analogue scales that range from 0 to 100, respectively.

To answer this question, I compare uncertainty (*unc*), expectations, and the business situation for a time period of low aggregate uncertainty in the beginning of the sample with a time period of high aggregate uncertainty in the end of the sample. For each 2-digit sector from the WZ08 classification, I compute averages of the three variables for the six months from July to December 2017, and from July to December 2019, respectively.[32] Taking differences of these averages allows me to compare changes in uncertainty to changes in expectations and changes in the business situation at the industry level. These comparisons are illustrated in Figure E.1.

As expected, the two scatter plots show a sectoral heterogeneity in the change in expectations and the change in the assessment of the business situation between the second half of 2017 and the second half of 2019. This is the variation along the horizontal axes of the two plots, respectively. For instance, cyclical sectors, such as the industries producing motor vehicles and electrical equipment, underwent a large decline of their business

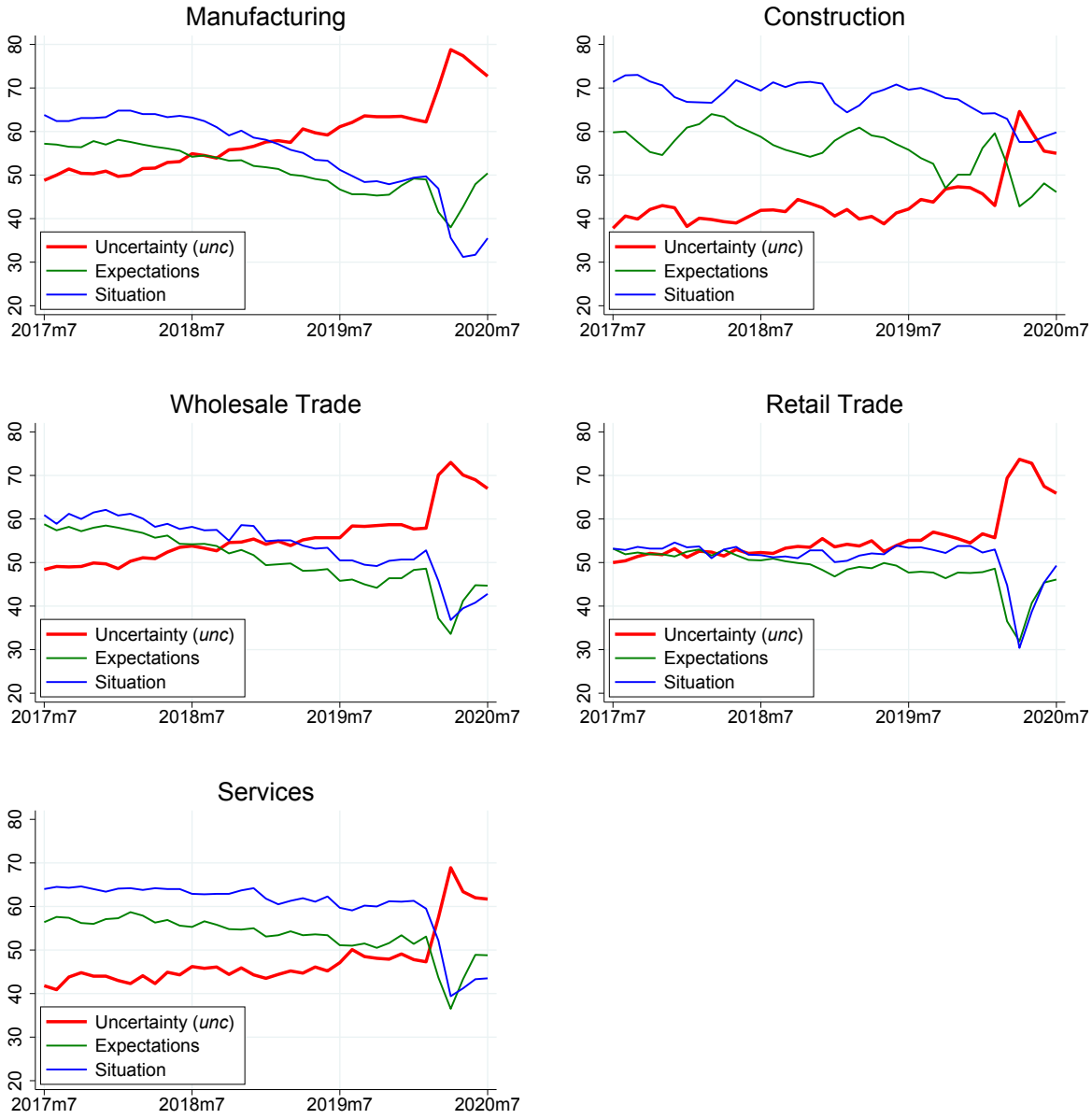
[32]The German WZ08 classification, short for "Klassifikation der Wirtschaftszweige 2008" is closely related to the European industry classification system NACE Rev. 2.

situation by approximately 14 and 20 points on the visual analogue scale, respectively. The food and pharmaceutical sectors, on the other hand, reported a decline of only one and six points, respectively.

As the main result of this exercise, I find that uncertainty increased more in industries that experienced a larger decline in expectations and in the business situation. The negative correlations are high: the coefficient between changes in uncertainty and changes in expectations is -0.83; for changes in uncertainty vs. changes in the business situation the coefficient is -0.87. Thus, uncertainty did not rise evenly across all industries. Heterogeneity in sectoral performance is reflected in heterogeneity in uncertainty. This implies that the aggregate increase in uncertainty in the sample period was driven by industries whose situation and expectations deteriorated the most.

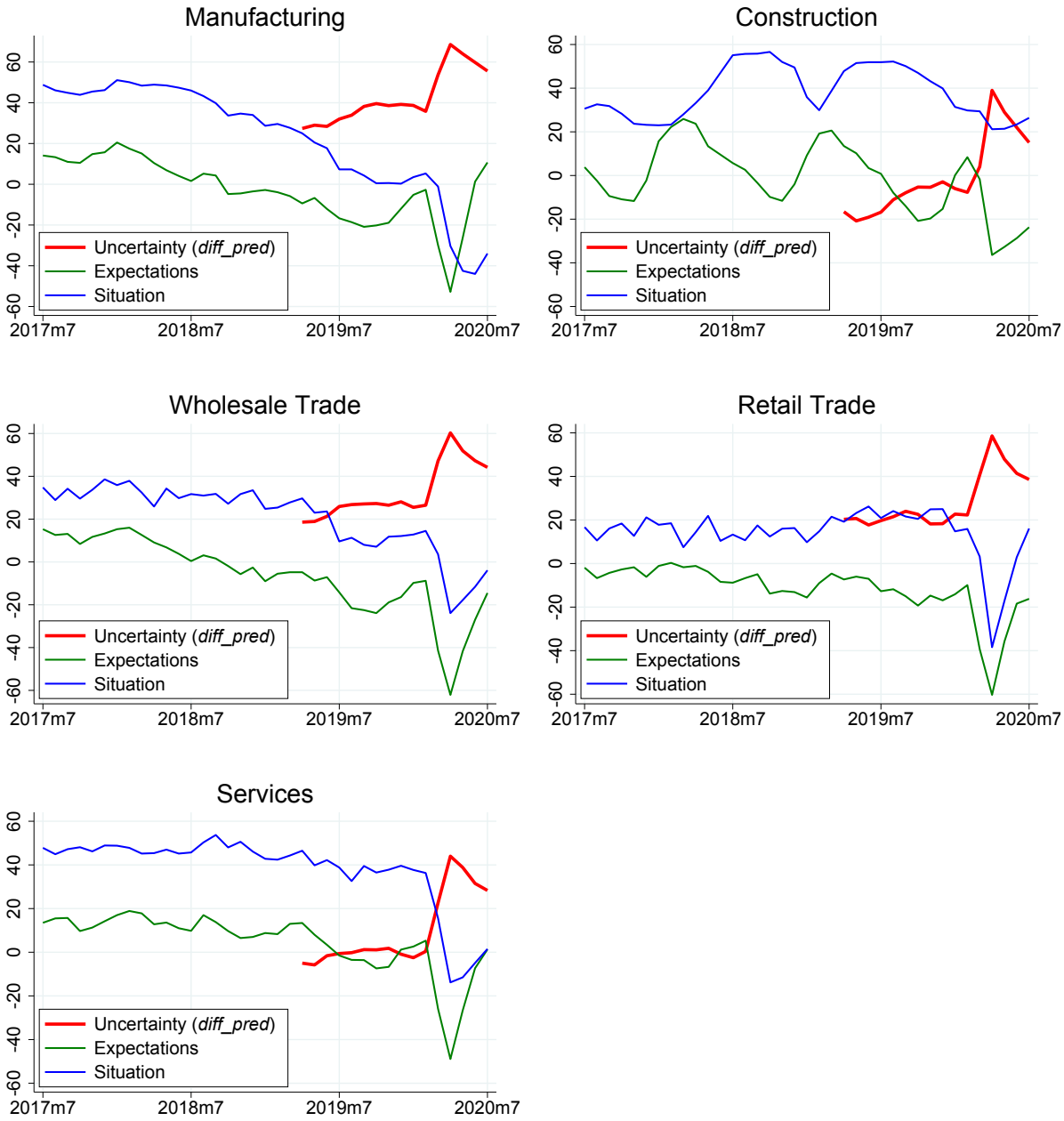
Appendix F Case Study: COVID-19 Crisis

Figure F.1: Uncertainty (*unc*), expectations, and business situation by major sector



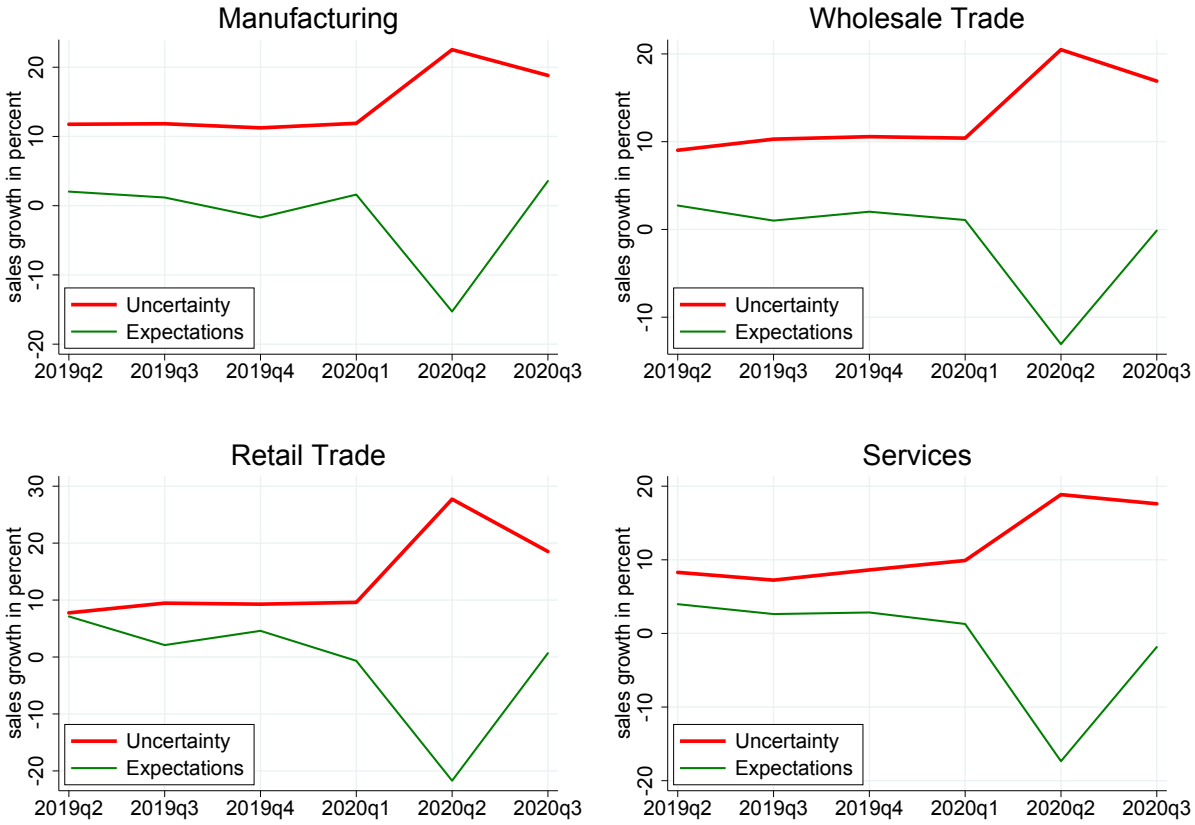
Notes: The figure presents size-weighted time series of subjective uncertainty (*unc*), expectations, and the business situation for five major sectors of the German economy. The survey responses are elicited using visual analogue scales as described in Section 2.2.

Figure F.2: Uncertainty (*diff_pred*), expectations, and business situation by major sector



Notes: The figure shows size-weighted time series of uncertainty (*diff_pred*) for five major sectors of the German economy. They are constructed as balance statistics using the responses to question 4 described in Section 2.2. The weights are -1 for the answer option "easy", -0.5 for "rather easy", 0.5 for "rather difficult", and 1 for "difficult". The other series are balance statistics from ifo's categorical questions on expectations and the business situation.

Figure F.3: Sales growth uncertainty, expectations, and business situation by major sector



Note: The figure shows size-weighted time series of quantitative expectations and uncertainty about quarter-over-quarter sales growth for four major sectors of the German economy. Uncertainty is computed as the difference between expectations in the best and in the worst case, as described in Bachmann et al. (2018). Its unit for uncertainty at the vertical axis is percentage points. The data stems from a survey supplement to the ifo Business Survey. It is available for all four major sectors since Q2 2019.

Below is the author's English translation of a special question in the ifo Business Survey from April 2020. For the baseline analysis in section 6.2, I use the responses on whether or not businesses reduced employment and whether or not they postponed investment projects. Additional regressions use the responses on short-time work and the cancellation of investment projects.

Which measures has your firm taken in response to the Corona pandemic?

Operations:

☐ Intensified use of working from home

☐ Short-time work

☐ Reduction of time accounts and leave days

☐ Reduction of employment (e.g., lay-offs, desist from extensions)

☐ Plant closure, stop of production

☐ Increased stock-keeping

☐ Change of suppliers / diversification of supply chains

Finances / Investment:

☐ Use of existing credit lines

☐ Acquisition of new credit lines

☐ Application for public liquidity facilities

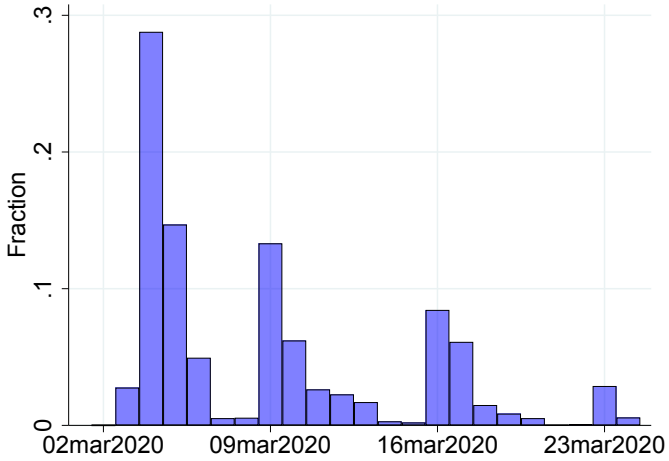
☐ Postponement of investment projects

☐ Cancellation of investment projects

Table F.1: Selected events in the onset of the COVID-19 crisis in Germany

Date	Event
March 2	The German Robert Koch Institute raises the threat level for the population to "moderate" because of COVID-19.
March 6	The German Health Minister rules out "any measure leading to restrictions on travel" within the European Union.
March 8	Recommendation of the German Health Minister to cancel events with more than 1000 participants.
March 9	Second death because of COVID-19 in Germany; more than 1,200 verified infections.
March 12	Federal and State governments recommend to avoid gatherings and social contacts.
March 13	Schools and childcare facilities close in almost all federal states.
March 16	German federal borders are closed; start of shutdown in which most shops and many public facilities are being closed.

Figure F.4: Histogram of the submission dates of the responses in March 2020



Note: Histogram of the submission dates of the questionnaires of the ifo Business Survey in March 2020. It was conducted from March 2 to March 24.

Table F.2: Representativeness of subsample of firms responding from March 16 to 24

	March 2 to 15		March 16 to 24	
	Mean	N	Mean	N
Firm characteristics				
Dummy small firms	0.557	4,767	0.546	1,269
Dummy medium firms	0.297	4,767	0.284	1,269
Dummy large firms	0.143	4,767	0.164	1,269
Dummy manufacturing	0.319	4,767	0.251	1,269
Dummy construction	0.093	4,767	0.128	1,269
Dummy wholesale & retail trade	0.245	4,767	0.199	1,269
Dummy services	0.342	4,767	0.422	1,269
Responses in February 2020				
Situation (visual analogue scale)	53.5	3,367	54.7	809
Expectations (visual analogue scale)	51.2	3,370	52.0	806
Uncertainty (*unc*) (visual analogue scale)	55.4	3,367	54.5	804
Dummy situation bad	0.157	4,251	0.136	920
Dummy situation good	0.335	4,251	0.370	920
Dummy expectation unfavorable	0.213	4,251	0.192	920
Dummy expectation favorable	0.178	4,251	0.184	920
Dummy uncertainty (*diff_pred*): easy or rather easy to predict	0.343	4,224	0.357	908
Dummy uncertainty (*diff_pred*): rather difficult to predict	0.532	4,224	0.537	908
Dummy uncertainty (*diff_pred*): difficult to predict	0.125	4,224	0.106	908
Responses in April 2020				
Dummy investment postponed	0.405	4,248	0.426	1,004
Dummy employment reduced	0.151	4,248	0.161	1,004
Dummy investment canceled	0.196	4,248	0.187	1,004
Dummy short-time work	0.471	4,248	0.488	1,004

Notes: The table presents means and the number of observations for a list of variables for two subsamples: firms the responded between March 2 and March 15, and firms that responded between March 16 and March 24. The top panel of the table presents the shares and frequencies of the responses from three size classes and four major economic sectors, respectively. The second panel considers past responses of the firms from February 2020 about the business situation, expectations, and uncertainty. The last panel shows the firms' subsequent responses in April 2020 about investment and employment decisions.

Table F.3: Correlation of regressors, levels and changes

	ΔUnc. in $t-1$	Unc. in $t-2$	ΔExp. in $t-1$	Exp. in $t-2$	ΔSit. in $t-1$	Sit. in $t-2$
ΔUnc. in $t-1$	1.00					
Unc. in $t-2$	-0.53	1.00				
ΔExp. in $t-1$	-0.21	0.05	1.00			
Exp. in $t-2$	0.18	-0.32	-0.46	1.00		
ΔSit. in $t-1$	-0.23	0.19	0.47	-0.24	1.00	
Sit. in $t-2$	0.31	-0.49	-0.20	0.53	-0.36	1.00

Notes: Pairwise correlations of main regressors in Table F.5: uncertainty (*unc*), expectations, and business situation as levels in February ($t-2$) and as month-over-month changes in March 2020 ($t-1$). These variables are based on the responses to questions 1, 2, and 3 in Section 2.2

Table F.4: Relationship between other corporate investment and employment decisions and past uncertainty, expectations, and situation

Dependent variable:	decision: cancellation of investment projects					decision: short-time work				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔUncertainty in $t-1$	0.000500		-0.000694	-0.000678	-0.000323	0.000403		-0.0000603	-0.000119	0.000232
	(0.62)		(-0.86)	(-0.81)	(-0.37)	(0.60)		(-0.10)	(-0.20)	(0.35)
Uncertainty in $t-2$	0.00314***		0.00113	-0.0000990	0.000368	0.00303***		0.00142*	0.00102	0.00121
	(3.14)		(1.08)	(-0.09)	(0.35)	(3.90)		(1.96)	(1.33)	(1.36)
ΔExpectations in $t-1$		-0.00559***	-0.00571***	-0.00251**	-0.00207**		-0.00312***	-0.00288***	-0.00189**	-0.00194**
		(-6.31)	(-6.09)	(-2.57)	(-2.14)		(-4.14)	(-3.65)	(-2.31)	(-2.36)
Expectations in $t-2$		-0.00686***	-0.00616***	-0.00139	-0.000962		-0.00630***	-0.00557***	-0.00384***	-0.00481***
		(-5.54)	(-4.68)	(-0.97)	(-0.68)		(-6.37)	(-5.46)	(-3.39)	(-4.11)
ΔSituation in $t-1$				-0.00705***	-0.00659***				-0.00221***	-0.00318***
				(-8.13)	(-6.88)				(-2.87)	(-3.55)
Situation in $t-2$				-0.00820***	-0.00618***				-0.00259***	-0.00244**
				(-7.53)	(-5.19)				(-2.82)	(-2.31)
Dummy medium sized firms					0.0919**					0.00321
					(2.14)					(0.09)
Dummy large firms					0.116**					0.0670
					(2.08)					(1.41)
Sector dummies					YES					YES
No. of firms	660	667	656	653	602	660	667	656	653	586
Pseudo R-sq.	0.012	0.052	0.057	0.14	0.22	0.029	0.072	0.080	0.099	0.17

Notes: Average marginal effects from probit regressions. The dependent variable in columns 1 to 5 is a dummy for the decision to cancel investment projects because of the COVID-19 crisis, in columns 6 to 10 it is a dummy for the decision to implement short-time work because of the COVID-19 crisis. Information on firms' decisions stems from the ifo Business Survey in April 2020. The regressors are levels of uncertainty (*unc)*, expectations, and business situation from February 2020, and month-over-month changes from March 2020. These measures are based on the responses to questions 1, 2, and 3 in Section 2.2. t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table F.5: Robustness linear probability model: relationship corporate decisions and past uncertainty, expectations, and situation

Dependent variable:	decision: postponement of investment					decision: reduction of the number of employees				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔUncertainty in $t-1$	0.00148*		0.000567	0.000682	0.000660	0.000156		-0.000399	-0.000237	0.000215
	(1.86)		(0.70)	(0.83)	(0.75)	(0.23)		(-0.59)	(-0.36)	(0.36)
Uncertainty in $t-2$	0.00551***		0.00457***	0.00452***	0.00394***	0.00210***		0.000564	0.000474	0.000719
	(5.85)		(4.61)	(4.28)	(3.41)	(2.60)		(0.68)	(0.56)	(0.90)
ΔExpectations in $t-1$		-0.00528***	-0.00464***	-0.00312***	-0.00317***		-0.00297***	-0.00289***	-0.00133*	-0.000779
		(-6.06)	(-5.01)	(-3.00)	(-2.91)		(-4.55)	(-4.17)	(-1.80)	(-1.05)
Expectations in $t-2$		-0.00437***	-0.00234*	-0.00127	-0.00105		-0.00572***	-0.00535***	-0.00408***	-0.00402***
		(-3.46)	(-1.77)	(-0.89)	(-0.70)		(-5.57)	(-4.83)	(-3.68)	(-3.58)
ΔSituation in $t-1$				-0.00327***	-0.00324***				-0.00324***	-0.00271***
				(-3.19)	(-2.84)				(-3.93)	(-3.27)
Situation in $t-2$				-0.00194*	-0.00141				-0.00222***	-0.00156*
				(-1.70)	(-1.08)				(-2.89)	(-1.93)
Dummy medium sized firms					0.0339					0.0302
					(0.74)					(0.85)
Dummy large firms					0.0289					0.0222
					(0.47)					(0.51)
Constant	0.0788	0.526***	0.169*	0.210*	-0.195	0.0337	0.385***	0.344***	0.390***	0.195*
	(1.25)	(8.58)	(1.75)	(1.87)	(-1.37)	(0.63)	(7.21)	(4.04)	(4.10)	(1.87)
Sector dummies					YES					YES
No. of firms	660	667	656	653	653	660	667	656	653	653
R-sq.	0.048	0.052	0.085	0.100	0.21	0.016	0.064	0.066	0.094	0.24

Notes: Results from OLS regressions. The dependent variable in columns 1 to 5 is a dummy for the decision to postpone investment projects because of the COVID-19 crisis, in columns 6 to 10 it is a dummy for the decision to reduce employment because of the COVID-19 crisis. Information on firms' decisions stems from the ifo Business Survey in April 2020. The regressors are levels of uncertainty (*unc)*, expectations, and business situation from February 2020, and month-over-month changes from March 2020. These measures are based on the responses to questions 1, 2, and 3 in Section 2.2. Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table F.6: Robustness manufacturing excluded: relationship corporate decisions and past uncertainty, expectations, and situation

Dependent variable:	decision: postponement of investment					decision: reduction of the number of employees				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔUncertainty in $t-1$	0.00213**		0.000985	0.00115	0.00142	0.000637		-0.000101	0.000104	0.000730
	(2.31)		(1.10)	(1.26)	(1.53)	(0.82)		(-0.15)	(0.16)	(1.09)
Uncertainty in $t-2$	0.00493***		0.00428***	0.00407***	0.00457***	0.00288***		0.00154*	0.00151*	0.00220**
	(4.37)		(3.51)	(3.25)	(3.58)	(3.12)		(1.71)	(1.71)	(2.29)
ΔExpectations in $t-1$		-0.00576***	-0.00525***	-0.00345***	-0.00304**		-0.00384***	-0.00364***	-0.00137	-0.000935
		(-5.70)	(-4.96)	(-2.89)	(-2.49)		(-3.96)	(-3.74)	(-1.51)	(-1.15)
Expectations in $t-2$		-0.00300**	-0.00116	0.000363	0.00101		-0.00508***	-0.00420***	-0.00199	-0.00229
		(-2.05)	(-0.74)	(0.21)	(0.57)		(-3.81)	(-3.08)	(-1.44)	(-1.62)
ΔSituation in $t-1$				-0.00336***	-0.00295**				-0.00376***	-0.00291***
				(-3.18)	(-2.56)				(-4.82)	(-3.92)
Situation in $t-2$				-0.00268*	-0.00197				-0.00297***	-0.00189*
				(-1.93)	(-1.31)				(-2.80)	(-1.78)
Dummy medium sized firms					0.00302					0.0127
					(0.06)					(0.34)
Dummy large firms					0.0506					0.0165
					(0.71)					(0.31)
Sector dummies					YES					YES
No. of firms.	487	492	484	481	464	487	492	484	481	424
Pseudo R-sq.	0.028	0.049	0.071	0.088	0.15	0.032	0.082	0.091	0.16	0.27

Notes: Average marginal effects from probit regressions that exclude firms from the manufacturing sector. The dependent variable in columns 1 to 5 is a dummy for the decision to postpone investment projects because of the COVID-19 crisis, in columns 6 to 10 it is a dummy for the decision to reduce employment because of the COVID-19 crisis. Information on firms' decisions stems from the ifo Business Survey in April 2020. The regressors are levels of uncertainty (*unc)*, expectations, and business situation from February 2020, and month-over-month changes from March 2020. These measures are based on the responses to questions 1, 2, and 3 in section 2.2. t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table F.7: Robustness measurement error: relationship corporate decisions and past uncertainty, expectations, and situation

Dependent variable:	decision: postponement of investment					decision: reduction of the number of employees				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔUncertainty* in $t-1$	0.000358		-0.00137	-0.00182	-0.00202	0.00121		0.000334	-0.0000395	-0.000562
	(0.18)		(-0.65)	(-0.87)	(-0.98)	(0.74)		(0.21)	(-0.03)	(-0.39)
Uncertainty* in $t-2$	0.00469***		0.00316*	0.000726	-0.000465	0.00336***		0.00133	-0.000279	-0.00150
	(2.95)		(1.84)	(0.39)	(-0.25)	(2.62)		(0.99)	(-0.20)	(-1.03)
ΔExpectations* in $t-1$		-0.0108***	-0.0106***	-0.00872***	-0.00857***		-0.00928***	-0.00875***	-0.00575**	-0.00522*
		(-4.53)	(-4.38)	(-3.52)	(-3.48)		(-3.31)	(-3.13)	(-2.20)	(-1.86)
Expectations* in $t-2$		-0.00906***	-0.00751***	-0.00512**	-0.00511**		-0.00948***	-0.00867***	-0.00607***	-0.00622***
		(-4.53)	(-3.57)	(-2.38)	(-2.42)		(-4.42)	(-3.99)	(-3.07)	(-2.92)
ΔSituation* in $t-1$				-0.00609***	-0.00666***				-0.00607***	-0.00691***
				(-3.71)	(-3.84)				(-4.86)	(-5.11)
Situation* in $t-2$				-0.00526***	-0.00488***				-0.00419***	-0.00460***
				(-4.14)	(-3.44)				(-4.50)	(-3.87)
Dummy medium sized firms					0.0249					0.0335
					(0.55)					(0.95)
Dummy large firms					0.0202					-0.0107
					(0.33)					(-0.23)
Sector dummies					YES					YES
No. of firms	654	650	639	629	606	654	650	639	629	542
Pseudo R-sq.	0.013	0.029	0.038	0.062	0.13	0.017	0.064	0.064	0.12	0.25

Notes: Average marginal effects from probit regressions. The dependent variable in columns 1 to 5 is a dummy for the decision to postpone investment projects, in columns 6 to 10 it is a dummy for the decision to reduce employment. Information on firms' decisions stems from the ifo Business Survey in April 2020. The right hand side variables marked with a star contain predicted values from regressions of the levels of uncertainty (*unc)*, expectations, and business situation elicited using visual analogue scales in February 2020 on their categorical counter-parts, respectively. The other regressors marked with a star are predicted values from regressions of monthly changes in the visual analogue scale variables on changes in the categorical variables in March 2020. In case of uncertainty (*unc*), the predicted values stem from regressions on *diff_pred*. This implements the Obviously Related Instrumental Variable approach to account for independent and identically distributed measurement error. The regressors are based on the responses to questions 1, 2, 3, and 4 as well the categorical questions on business expectations and the situation presented in Section 2.2. t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table F.8: Robustness uncertainty *diff_pred*: Relationship corporate decisions and past uncertainty, expectations, and situation

Dependent variable:	decision: postponement of investment					decision: reduction of the number of employees				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Uncertainty: negative change in $t-1$	0.101		0.0741	0.0857	0.0881	0.0294		0.0153	0.00843	0.0298
	(1.30)		(0.96)	(1.11)	(1.18)	(0.54)		(0.28)	(0.16)	(0.54)
Uncertainty: positive change in $t-1$	0.0974**		0.0381	0.0254	0.0193	0.0664**		0.0334	0.0180	-0.00291
	(2.51)		(0.92)	(0.61)	(0.45)	(2.26)		(1.08)	(0.60)	(-0.09)
Uncertainty: dummy 'rather difficult' in $t-2$	0.0958**		0.0620	-0.00130	-0.0344	0.0485*		0.0105	-0.0246	-0.0353
	(2.55)		(1.56)	(-0.03)	(-0.77)	(1.73)		(0.35)	(-0.78)	(-1.03)
Uncertainty: dummy 'difficult' in $t-2$	0.267***		0.163**	0.0727	0.0251	0.192***		0.102**	0.0551	-0.000124
	(4.04)		(2.30)	(0.96)	(0.33)	(4.20)		(2.02)	(1.09)	(-0.00)
Expectations: negative change in $t-1$		0.221***	0.194***	0.170***	0.155***		0.170***	0.156***	0.114***	0.0959**
		(5.18)	(4.26)	(3.63)	(3.24)		(4.17)	(3.70)	(2.75)	(1.98)
Expectations: positive change in $t-1$		-0.111	-0.106	-0.0853	-0.0649		-0.0670	-0.0625	-0.0323	-0.0383
		(-1.07)	(-1.02)	(-0.85)	(-0.65)		(-0.82)	(-0.79)	(-0.43)	(-0.55)
Expectations: dummy 'favorable' in $t-2$		0.00652	0.0217	0.0245	0.0279		-0.0218	-0.0185	-0.0151	-0.00840
		(0.16)	(0.51)	(0.57)	(0.64)		(-0.71)	(-0.58)	(-0.48)	(-0.24)
Expectations: dummy 'unfavorable' in $t-2$		0.314***	0.262***	0.183***	0.203***		0.265***	0.240***	0.175***	0.167***
		(5.75)	(4.49)	(2.95)	(3.24)		(5.71)	(4.87)	(3.70)	(3.22)
Situation: negative change in $t-1$				0.117***	0.139***				0.130***	0.139***
				(2.98)	(3.38)				(4.70)	(4.53)
Situation: positive change in $t-1$				-0.0389	-0.0628				-0.0594	-0.0836
				(-0.60)	(-0.99)				(-1.23)	(-1.63)
Situation: dummy 'good' in $t-2$				-0.137***	-0.144***				-0.0696**	-0.0544
				(-3.31)	(-3.29)				(-2.30)	(-1.57)
Situation: dummy 'bad' in $t-2$				0.104*	0.0865				0.112***	0.129***
				(1.81)	(1.47)				(3.05)	(3.12)
Dummy medium sized firms					0.0437					0.0483
					(1.07)					(1.56)
Dummy large firms					0.0558					0.0276
					(1.01)					(0.67)
Sector dummies					YES					YES
No. of firms	796	782	782	775	750	796	782	782	775	670
Pseudo R-sq.	0.019	0.036	0.043	0.060	0.11	0.029	0.065	0.073	0.12	0.24

Notes: Average marginal effects from probit regressions. The dependent variable in columns 1 to 5 is a dummy for the decision to postpone investment projects because of the COVID-19 crisis, in columns 6 to 10 it is a dummy for the decision to reduce employment because of the COVID-19 crisis. Information on firms' decisions stems from the ifo Business Survey in April 2020. The regressors are levels of uncertainty (*diff_pred)*, expectations, and business situation from February 2020, and month-over-month changes from March 2020. These measures are based on the responses to question 4 and the categorical questions on business expectations and the situation presented in Section 2.2. t-statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.