Article

Case Study: Assessing The COVID-19 Pandemic's Potential for a More Climate-Friendly Work-Related Mobility

Dennis Wilke [1,*] , **Henriette Rau** [2,*] **and Joachim W. Härtling** [1]

1   Institute of Geography, University of Osnabrück, Seminarstr. 19a/b, 49074 Osnabrück, Germany
2   Institute of Geography and Geology, University of Greifswald, Friedrich-Ludwig-Jahnstraße 16, 17489 Greifswald, Germany
*   Correspondence: dwilke@uni-osnabrueck.de (D.W.); henriette.rau@uni-greifswald.de (H.R.)

Abstract: The switch from working in-office to working from home in the context of the COVID-19 pandemic had a significant impact on people's mobility behavior. In view of the need for action arising from the ongoing challenge of climate change, these changes should be seen as an opportunity to reduce emissions in the traffic sector. The aim of this study was to analyze changes in work-related mobility that occurred during the COVID-19 pandemic using the case of a multinational medium-sized retail chain situated in semi-rural Germany. The case study allowed us to examine those changes in connection with individual attitudes and perspectives of the company and its employees. Thus, we quantitatively recorded the mobility behavior of the company's employees, followed by an expert interview to ascertain the company's perspective. We found a reduction in the frequency of commuting and business trips made by employees, which seemed to continue beyond the COVID-19 crisis. However, according to our findings these changes were not based on individual motivation to act in a climate-aware manner but are subject to the framework conditions created by employers for the adoption of climate-friendly behavior. The results of this work could be used by companies and policymakers to create such favorable framework conditions.

Keywords: mobility; COVID-19; home office; commuting; business travel; case study; climate awareness; climate behavior

1. Introduction

The emergence of the COVID-19 pandemic and the accompanying measures to protect individuals against infection brought about an abrupt and definite change in people's everyday lives. For example, first countermeasures in most countries were "lockdowns", which restricted all kinds of travel [1,2]. The resulting switch from working in-office to working from home has had an impact on people's mobility behavior. Therefore, the focus of this study is work-related mobility, which not only refers to daily commuting of employees, but also business trips, including trips to customers, fairs, or meetings [3].

Climate change and the global COVID-19 pandemic are referred to as the twin crises of the Anthropocene, because they have corresponding parallels: both have global impacts and are the result of unsustainable growth in human activities [4]. Mobility, in particular, is significantly involved in the emergence of both crises, because the greenhouse gases emitted in transport first triggered anthropogenic climate change and are now driving it forward, while COVID-19 only became a pandemic through the hyper-globalization of human mobility [5]. Given that the carbon emissions in the transportation sector experienced the smallest reduction in comparison to all other sectors between 1990 and 2019, a need for action is especially existent in this emission sector. Even policymakers see changing mobility behavior as one approach to reduce greenhouse gas emissions [1,6].

Interestingly, the emergence of the pandemic led to a reduction of 19 million tons CO_2e in the transport sector alone [7]. This points out the potential of the COVID-19 pandemic as a trigger to alleviate the climate crisis by emissions reduction.

In total, 50% of German employees experienced working from home over the course of the pandemic [8]. As a consequence, German commuting traffic was reduced by 20% [9], which led to a reduction of 813 kg CO_2e per teleworker per year. For the time after the pandemic, weekly days of working from home per teleworker are predicted to increase by 0.2 days [10]. As a consequence, a long-term reduction of commuting traffic by 11.75% in comparison to pre-pandemic levels is estimated [11]. However, it is still unclear how large the proportion of people is for whom this situation will continue in the long term. Consequently, in order for the pandemic's emission-reducing effects by breaking up everyday routines to prevail, either a continuous adaption of more climate-friendly behaviors and/or the creation of supporting framework conditions are required.

Usually, behavioral effectiveness of climate awareness can be positively or negatively influenced by individual factors such as routines, that are often practiced over long periods of time and difficult to modify despite high environmental and/or climate awareness [12]. Additionally, work-related climate behavior can be affected by social and interpersonal factors, such as individual orientation towards norms and values specific to the occupational group, as well as by external conditions, such as behavioral offers or incentives to act [12]. Furthermore, environmental behavior can be seen as a result of rational choice [12]; individually, the costs usually outweigh the benefits in work-related environmental behavior [13]. Accordingly, Torun et al. found the prices to be the most determining factor for means of shared mobility [14].

There is already a range of empirical studies that quantify the effects of the COVID-19 pandemic on mobility behavior, including commuting and business trips [8,10,11,15–21]. Generally, public transport found itself most affected by the consequences of the pandemic, as passengers were often afraid to use public or shared mobility services due to hygiene issues [14]. In some European cities, public transport usage has dropped by over 90% throughout the crisis [22]. It is believed that this will lead to lower levels of public transport usage and respectively higher usage of other transport modes in the long term [23]. Regarding Mainland China, Huang et al. also found that the COVID-19 crisis altered transportation-related behaviors drastically [24]. However, since not only individual decisions but also the reactions of employers to the crisis play a role in work-related mobility, both aspects need to be considered in an interlinked way.

The aim of this study is to assess changes in work-related mobility that occurred over the course of the COVID-19 pandemic, to examine these changes for connections with individual attitudes and perspectives of employees, and to supplement and explain the findings obtained through the perspective of the company and their reaction to the politically induced changes that occurred during the pandemic. The research shall answer the question 'Does the COVID-19 pandemic have the potential to reduce emissions in the sector of work-related mobility on a long-term basis?' using the example of a company-based case study. To cover the question thoroughly, we examine four subordinate research questions, which we will answer by investigating two hypotheses each. Each hypothesis will be checked through the quantitative results of employee surveys. These findings will then be explained and supplemented by the qualitative material based on interviews regarding the company's perspective. The construct of research questions and hypotheses is structured as follows:

1. How did the pandemic affect work-related commuting?

Hypotheses 1. *Post-crisis commuting is still significantly lower than before.*

Hypotheses 2. *Less public transport is used after the crisis than before.*

2. How did the pandemic affect the business trip frequency?

Hypotheses 3. *During the crisis, significantly fewer business trips were made than before the COVID-19 pandemic.*

Hypotheses 4. *After the crisis, still significantly fewer business trips were made than before the COVID-19 pandemic.*

3. How do the observed changes in work-related mobility affect individual climate awareness?

Hypotheses 5. *There is a correlation between the change in individual commuting frequency and the increase in individual perception of the climate change problem.*

Hypotheses 6. *Employees of jobs with high affinity to work from home have a higher degree of climate awareness.*

4. Which aspects are important for the willingness to keep up working from home after the pandemic?

Hypotheses 7. *There is a correlation between the assessment of working conditions with reduced mobility and the individual willingness to work from home.*

Hypotheses 8. *There is a correlation between individual climate awareness and individual willingness to work from home.*

In this paper we firstly present the methods used in the study. This includes the justification and presentation of the selected case study, the presentation of the quantitative survey construction, the explanation of the statistical methods applied, as well as the explication of qualitative data collection and analysis. The following Section 3 is divided into quantitative and qualitative results. Both subchapters are again divided into four parts according to the four research-guiding questions. In the Section 4, the quantitative and qualitative results are integrated in relation to each of the four research-guiding questions and discussed against the theoretical background. In addition, the methods used are critically reflected upon. The paper concludes with a summary of the most important findings as well as possible applications for future research.

2. Methods

To answer the research question, we examined the specific case of a company from the trade business sector situated in a German medium-sized town with rural surroundings. In order to portray the case extensively and integrate both the quantitative mobility and attitude data of the employees, as well as the qualitative perspective of the employer, we used an explanatory mixed-methods design: a quantitative online survey for employees was used as the main assessment instrument, followed by a qualitative expert interview with one of the CEOs of the company, which was partially based on the findings of the quantitative examination. The qualitative findings should then explain, complement and assess the quantitative results. Therefore, this research design can be denoted as QUANT → qual [25].

Through communication with representatives of the company, we learned that this case study's company had 2.486 employees in Germany, and that it consisted of five departments: Logistics, Administration, Retail, Wholesale, and Field Service. In order to collect the data, we sent an invitation email with a link and in some departments a QR code that would lead to the online survey. Drawing a random sample was made impossible by this procedure, because participation was solely based on the willingness of the employees. Therefore, the results of the survey do not claim to be representative.

2.1. Survey

For the design of the survey (see Supplementary Materials), mainly validated or successfully used items from previous studies were applied [3,8,10,15–18,26–30]. The survey consisted of six parts: the first three parts A, B, and C collected work-related mobility data of the employees surveyed. Among these, part A referred to the time before the COVID-19 pandemic, part B to the period from the legal obligation to work from home during the beginning of the crisis in Germany in March 2020 until the abolition of this

obligation in June 2021 [31], and part C to the period from July 2021 until the time of data collection. Although the pandemic was not over during this period of part C, it was of low collective significance due to low infection rates [32], which is why we designated the third period as the time "after the crisis". Therefore, we assumed a low influence of ongoing infection protection measures on work-related mobility. Part D comprised mobility and attitudes when working from home, part E assessed the participants' climate awareness, and part F collected socioeconomic and demographic data. Table A1 in Appendix A provides a schematic overview of the survey's structure including questions asked.

To ensure comparability, parts A, B, and C were largely structured in the same way. Questions *A1*, *B2*, and *C2* recorded the subjective perception of individual commuting frequencies in relation to the three study periods [3]. Questions *A2*, *B3*, and *C3* were used to survey the perceived number of business trips [3]. Furthermore, questions *A3*, *B4*, and *C4* recorded which means of transport the participants usually used for commuting and, if applicable, for their business trips during the three study periods. We constructed this question by adding further means of transport to the respective question from the DLR studies [8,15–18]. However, we differentiated between "car (as driver)" and "car (as passenger)", as well as "bus" and "train" because of differing emissions of these means [10]. Multiple responses were allowed to record multimodality. Questions *B1* and *C1* captured changes in respondents' occupational situations with respect to transitions between the study periods [26]. Furthermore, part B was supplemented by the specially elaborated item *B5*, which measured the perceived degree of limitation of social contacts during the crisis.

In section D, firstly, the overall perception of work-related mobility was recorded by question *D1* [3]. The following three questions were only displayed to those participants who selected at least one mobility-relevant answer option for at least one of the items *B1* and *C1*, in order to not burden other participants with questions that were irrelevant to them. The questions *D2* and *D3* recorded several indicators for working conditions, of which the variable *autonomy* was operationalized by items 1 and 2, *quantitative overload* by items 3 and 4, and *appreciation* by item 6 [3]. In addition, we added the variable *calmness*, which we operationalized by the specially elaborated items 5 and 7. Question *D3* was supplemented by four additional sub-questions, the first of which measured the need for more contact with colleagues [27]. The remaining three specially elaborated items determined the importance of monetary as well as ecological aspects within the scenario of reduced mobility. In order to capture the *willingness to work from home*, we constructed items *D4* and *D5*, the former of which referred to the ideal relationship between working from home and having face-to-face contact [28]. Item *D5* quantified the preferred frequency of working from home in the hypothetical scenario of non-existent infection control measures [29].

Section E of the survey consisted of three questions. Firstly, we determined the *problem perception* of climate change through question *E1* [30]. Question *E2* measured the risk perception of climate change in relation to different regions on Earth [30]. We elaborated item *E3* specifically to capture the perceived impact of the crisis on work-related mobility.

Finally, section F contained six questions regarding the variables *age*, *gender*, *post code*, *department affiliation*, *vehicle drive*, and *commuting distance*. Due to the high relevance of the variable *department affiliation* for the statistical evaluation, we placed the three work-related items *F4*, *F6*, and *F7* at the beginning of the survey after the first data collection wave of the survey.

Following the construction of the survey, we conducted a pretest. In order to generally check the survey's intelligibility, the pretest sample consisted of employees with and without a university background from occupations with low and high affinity to working from home. After completion of the pretest, the survey was slightly revised again and then released for use.

The quantitative survey started on 7 October 2021 and was initially limited to a two-week period. In order to increase the sample size, we started a second assessment, which lasted from 1 November until 23 November. Afterwards, we used SPSS 27.0 to analyze the collected data [33].

2.2. Statistical Analysis of Survey Data

Despite the non-representativeness of the sample, we attempted to substantiate the hypotheses not only by interpreting the data but also by means of statistical investigations. The sample consisted of 187 questionnaires, which were answered up to the last item. In addition, we recoded variables that have an ordinal data level, for example, as a result of underlying Likert scales, into metric variables for the calculation of new variables.

To investigate hypotheses 1 to 4, distribution differences had to be tested for statistical significance. For hypothesis 1, this applied to variables *A1* and *C3*. Due to the non-normal distribution of the data indicated by the Kolmogorov–Smirnov test, we used the sign test in order to examine the significance of the distribution differences [34]. Since for the investigation of hypothesis 2 only public transport was relevant from questions *A3* and *C4*, we firstly defined multiple response sets from these. However, we could not conduct a chi-square test for distributional differences due to the low use of public transport and, as a result, expected values lower than 5 [34]. Therefore, hypothesis 2 was tested by comparing the frequency of "bus" and "train" statements alone. In order to illustrate the data, we defined further multiple response sets using the items *A3*, *B4*, and *C4*, containing all response options, as well as an additional variable for mapping multimodality. We manually added values to this dichotomous variable when multiple modes of transportation were selected in a case. We took a similar approach regarding business trips but defined a further additional variable to represent multimodality including use of airplanes, since air travel always contains various modes of transport and, therefore, the share of air travel would not have been explicitly mapped. Since the items *A2*, *B3*, and *C3* each refer to periods of different lengths, we firstly adjusted them to a period of 12 months by using the equation $B3/15 \times 12$ to calculate the variable *B3_year*. For the calculation of *C3_year*, we used the equation $C3/4 \times 12$ for cases from the first survey wave, respectively, $C3/5 \times 12$ for those from the second one. We excluded individual cases that had consistently high values over all three survey periods (outliers), so that they would have biased the distribution of variable *C3_year*. In these cases, we assumed a misunderstanding of the questions. The data levels of items *A2*, *B3_year* and *C3_year* allow the use of the Wilcoxon test for connected samples to test the distributions for significant differences, as required to investigate hypotheses 3 and 4 [34]. To investigate hypothesis 5, we firstly calculated the variable *commuting_change* using the equation C2–A1, in order to describe the change in individual commuting frequency. Furthermore, the increase in individual *problem perception* of climate change was calculated using equation $E1_{SQ002}-E1_{SQ001}$. Since this increase represents the basic assumption for the investigation of hypothesis 5, we examined the distribution differences for significance. Due to the non-normal distribution of the data, we made use of a sign test, which resulted in a significant difference in *problem perception* of climate change ($z = -6.100$, $p < 0.001$, n = 187). To examine the statistical relationship between the new variables, we then calculated Spearman's rank correlation coefficient Rho based on the ordinal level of data [34]. In order to investigate hypothesis 6, we first ranked the five company departments according to their proportionate use of working from home as indicated by the collected data on a five-point ordinal scale. The scale measured the *affinity to work from home* of activities related to the specific case study. The variable *climate awareness* is based on a scale derived from the *problem perception* (variable *E1*) and the *risk assessment* (variable *E2*) of climate change. To calculate it, we used the equation $(E1_{SQ001} + E1_{SQ002} + E2_{SQ001} + E2_{SQ002} + E2_{SQ003} + E2_{SQ004} + E2_{SQ005} + E2_{SQ006}) \div 8$. The eight items showed excellent internal consistency (Cronbach's Alpha = 0.930) [35]. Afterwards, we could examine the new variables for statistical correlation using Spearman's Rho. To investigate hypothesis 7, we calculated a *work condition index* from the items of questions *D2* and *D3*. The associated variables *autonomy*, *quantitative overload*, and *calmness*, which are each operationalized by two items, were first tested for internal consistency. For the variable *autonomy*, we found acceptable to high internal consistencies, while for the variable *calmness*, internal consistency was acceptable in the scenario of usual mobility and low in the scenario of reduced mobility [35]. However, the internal consistency of

the variable *quantitative overload* in the scenario of reduced mobility was unacceptable (Cronbach's Alpha = 0.451), which is why we excluded the variable from the index calculation [35]. Due to the higher relevance of the variables for question *D3* for hypothesis testing, this limit seemed plausible. Accordingly, we took the variables *autonomy*, *calmness*, and *appreciation* into account, while excluding *quantitative overload*. We then formed the index additively. To calculate the variable *willingness to work from home*, we recoded the item *D4* using the formula 6 − *D4* and integrated it with variable *D5*. At this point, we considered their internal consistency of Cronbach's Alpha = 0.655 as sufficient. To investigate the hypothesis, we examined the variables *D3_working_conditions* and *willingness_to_work_from_home* for correlations using Spearman's Rho. Finally, as part of the examination of hypothesis 8, we again made use of Spearman's Rho to examine the variables *climate_awareness* and *willingness_to_work_from_home* for statistical correlations.

Building on the collection and analysis of the quantitative data, we conducted the qualitative survey. The aim was to supplement the data obtained from the quantitative survey with the company's perspective regarding the four guiding research questions. This is based on the fact that companies create the framework conditions and take mobility-related measures in response to the crisis that influence work-related mobility.

2.3. Qualitative Data Using an Expert Interview

A qualitative expert interview was a suitable way of gathering the company's perspective. In this way, the interviewee's position in the company, which allows him to help shape the aforementioned framework conditions, meant that we could assume the information gathered on the research topic to be as comprehensive as possible [36]. The semi-structured interview guideline aimed at structuring the topic field—also, with regard to the deductive categorization in the course of the analysis [36]. It was created according to the principle "[. . .] as open as possible and only as structuring as necessary [. . .]" [37] (p. 219). However, this still allowed for pre-formulated questions [36]. We created the interview guideline according to the sequence presented by Bogner et al. [36] (pp. 32–34). We conducted the expert interview on 15 March 2022, with one of the company's CEOs via Microsoft Teams. Afterwards, we transcribed the 50 min-long interview in accordance with the rules of content-semantic transcription [38]. For the evaluation of the qualitative material, we used the content-structuring qualitative content analysis method [39] with MAXQDA 2022 [40].

3. Results

3.1. Quantitative Results

The divisional distributions of the study population and the sample differed from each other. While around three quarters of all employees in the population were employed in the sales-related Wholesale and Retail departments, this proportion represented only 33.1% of the sample. In contrast, the areas of Administration, where 34.2% of participants were employed, as well as Field Service (14.4%) and Logistics (16.0%) were overrepresented in the sample compared to the population. Management comprised three cases in the population and one case in the sample and, therefore, was excluded from all procedures that differentiate by department.

The average age of the participants was 43.1 years, with the lowest average age of 35.6 years in Administration and the highest of 50.3 years in Field Service. Regarding the participants' gender, 60.4% were female and 38.0% were male. The remaining 1.6% did not answer the question.

3.1.1. Commuting

The participants were asked to estimate how often they commuted "before the crisis" (before March 2020), "during the crisis" (March 2020 until June 2021), and at the time the survey was conducted. We found that the proportion of daily commuters decreased by more than half with the onset of the crisis, so that a total of 29.9% now commuted

"never" or "weekly or more rarely" and another third "several times a week", while the remaining third of respondents continued to commute daily (see Figure 1). At the time of the survey, commuting frequencies had risen again, but the share of "daily" commuters remained about 12 percentage points below the pre-crisis level, while more than twice as many participants now stated that they commuted "several times a week". However, the proportion of "never" responses fell to 7.5%, below the pre-crisis level of 10.7%. We determined the significance of the distribution differences through a sign test (z = −3.280, *p* = 0.001, n = 176).
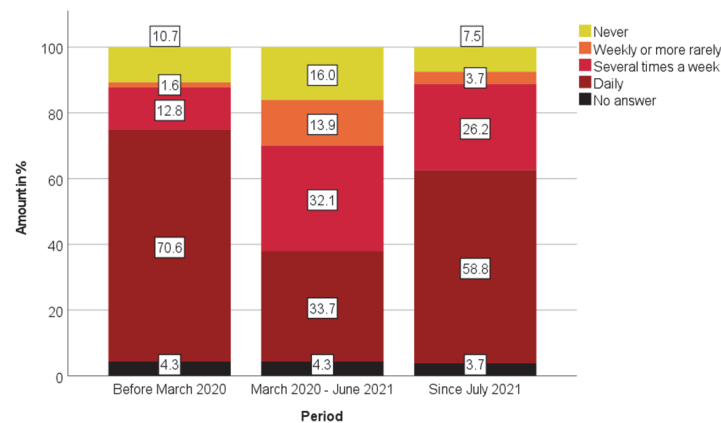

Figure 1. Perceived commuting frequencies before, during, and after the crisis.

Regarding the modal split, we could not observe a clear loss of importance of public transport as it was of low importance already in the baseline scenario. Before the crisis, a total of 3.7% employees used buses or trains and another 12.3% commuted multimodally. At the time of the survey, a total of 3.8% claimed to commute by public transport and 11.8% multimodally.

To explain the changes in the participants' commuting behavior, it is worth looking at the changes in their occupational situation during the crisis. Figure 2a indicates that mobile working options were predominantly used in the administrative sector. Here, almost half of the employees stated that they had worked from home during the crisis, although continuous working from home was rare across departments. Nevertheless, working from home was present in all departments, at least to some extent. Working short hours also occurred in all departments, though it was most prevalent in Retail, where nearly two-thirds of participants were affected. In the Wholesale and Field Service departments, almost half of the participating employees also worked short hours in each case during the crisis. The fewest changes took place in the Logistics department, where around two-thirds of participants reported no change. Regarding the transition out of the crisis (b), it can be seen that some employees continued to work from home, particularly in the Administration and Wholesale areas. In the latter, working from home even exceeded the crisis level. In the Field Sales department, an increase in continuous working from home could still be observed. Participants rarely stated that they had been working short hours during this period. The vast majority of respondents in most departments stated that there had been no change. Only in Wholesale (34.8%) and Administration (45.6%) we recorded lower percentages.

3.1.2. Business Trips

Looking at the average number of business trips taken per employee per year, the emergence of the crisis has led to a significant drop from 25.0 to 9.07 average business trips. For the period since July 2021, the average business trip frequency rose again from 9.07 to 19.06. Therefore, there have been 23.8% fewer business trips per year since June 2021 than before the crisis, according to employees' estimates.
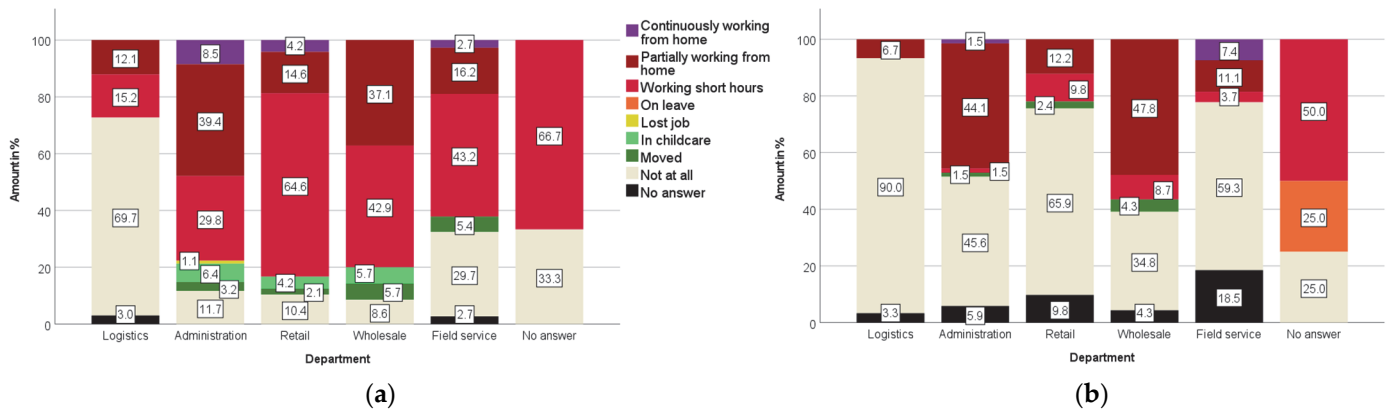
Figure 2. (**a**) Changes in the professional situation compared to the pre-crisis period; (**b**) changes in the professional situation compared to the crisis period.

In order to investigate hypotheses 3 and 4, we tested the distribution differences for statistical significance using a Wilcoxon test. According to the result, the frequencies are significantly lower during the crisis ($z = -7.687$, $p < 0.001$, n = 170, r = 0.59), as well as afterwards ($z = 3.532$, $p < 0.001$, n = 163, r = 0.28), than before.

3.1.3. Climate Awareness

Regarding the *problem perception* of climate change, we observed an increase (see Figure 3). While 67.4% of respondents considered climate change to be a serious problem before the crisis, this figure had risen to 80.7% by the time of the survey.
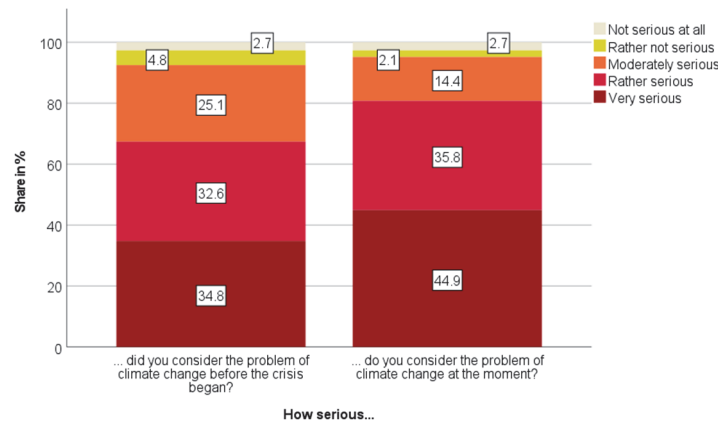

Figure 3. Problem perception of climate change before the crisis (retrospective) and at the time of survey.

After calculating the new variables *commuting_change* and *E1_change*, we carried out a correlation analysis using Spearman's Rho, but there was no significant correlation ($r_s = 0.051$, $p = 0.489$, n = 176).

Having calculated the new variables *affinity to work from home* and *climate awareness*, we could then perform a correlation analysis between these variables, again making use of Spearman's Rho. We found a moderate significant correlation of both variables ($r_s = 0.001$, $p = 0.259$, n = 154).

Overall, a higher degree of climate awareness was observed in departments with a higher affinity to work from home. However, the long-term changes in employee behavior did not play a role with regard to the increase in the problem perception of climate change.

3.1.4. Willingness to Work from Home

In order to examine if better working conditions contribute to a higher willingness to work from home, we calculated the *work condition index* using the variables *autonomy*, *calmness*, and *appreciation*. With a mean value of 9.85, working conditions were rated slightly better for the reduced mobility scenario than for high mobility (9.51) (see Figure 4). The most significant difference was in the variable *calmness*, but *autonomy* was also rated better in the case of reduced mobility. The assessment of *appreciation*, on the other hand, was lower in relation to reduced mobility.
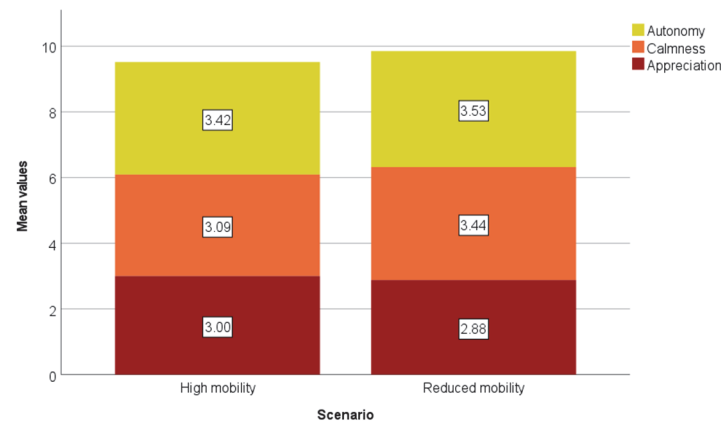

Figure 4. Assessment of working conditions with high and reduced mobility.

In order to investigate hypothesis 7, we performed a correlation analysis between the new variable *willingness to work from home* and the *work condition index* in the reduced mobility scenario using Spearman's Rho. We found a moderate significant correlation between the two variables (r_s = 0.269, p = 0.039, n = 59). Ultimately, we examined hypothesis 8 of a correlation between the *willingness to work from home* and the degree of *climate awareness* using Spearman's Rho. No correlation between the variables was found (r_s = 0.555, p = 0.069, n = 80). These results indicate that the willingness to work from home is not driven by the employees' climate awareness, but rather by the work conditions that can be found at home.

3.2. Qualitative Results

3.2.1. Commuting and Working from Home

In this case study, the expert explained that working from home was non-existent in the traditionally shaped company before the COVID-19 crisis. However, corresponding opportunities were established and expanded in the course of the pandemic. At the beginning of the crisis, especially during lockdown, an estimated 50–60% of employees were solely working from home. Additionally, 40% of employees from departments with significantly reduced workloads such as Retail and Wholesale were only working short hours. However, during the course of the pandemic the working conditions returned step-by-step to the usual forms of work. Nevertheless, up to 50% of the work in the administrative area could be completed from home according to the expert. The expert also explained that it is desirable for the company to have employees working mainly in-office, which many employees are satisfied with.

Although the sales representatives rely on regular business trips, they could also work in-office. This has already been the case in the past and is still welcomed by the company. Additionally, the expert expects a shift to more online trading in the future, which would also have an impact on downstream processes and work conditions. As a result of increasing digitization, other activities within the company could become more home-office-oriented.

The expert mentioned a lasting effect, which can be seen in the possibility of continuing to work from home for 20% of the weekly working time where applicable. Repeatedly, he mentioned the freedom of choice for employees on deciding where to work from.

"I would tend to think that it should be up to the employees themselves to decide where they work. And then a healthy mixture will automatically result, because every person is different." (interview lines 328–330)

However, even though the possibility to work from home exists, the expert said that this has not resulted in any obvious change in commuting behavior. Nevertheless, this shift in work places offers potential for reducing emissions, especially in more rural regions, where the lack of sufficient public transportation infrastructure, long distances, and the associated use of cars by employees for commuting is predominant. Also, the advancement of digitization is seen as a prerequisite for working from home to the full extent of its capabilities.

3.2.2. Business Trips

In the course of the crisis, there was a significant decrease in the frequency of business trips. On the one hand, this has external reasons, such as the legally required closure of stores. On the other hand, partners such as agencies or suppliers have asked for meetings to be moved to the digital space. High incidence figures continued to represent a crisis-related external reason for reduced business trips at the time of the survey.

In general, the expert estimated business trip frequency to be 40% lower at the time of the survey compared to the baseline year of 2019. This has led to the realization that many matters, such as shorter coordination appointments with agencies or annual meetings, can be conducted more easily via video conference.

When analyzing the data, we noticed that ecological reasons for questioning or foregoing business trips were always mentioned in connection with monetary aspects. This led to the assumption that the incentive for environmental action consists primarily of cost advantages.

A certain competitive pressure also played a role in the decision to go on business trips. For example, it is disadvantageous not to be represented at trade fairs. Social aspects in the form of personal meetings with other representatives of the industry are also important. However, product aspects such as haptics, which cannot be perceived digitally, also play key roles.

Although the expert considered the reduced business trip volume "[. . .] okay for now [. . .]" (interview line 479), an increase is to be expected. In his estimate, the need for business trips will be more strongly questioned in the future, so that business trip frequencies will not return to pre-pandemic levels.

3.2.3. Ecology and Sustainability

As was already apparent regarding business trips, the incentives for the company to act in an ecological manner were primarily cost benefits: "[. . .] sustainability is not only an end in itself, but sustainability always has something to do with cost benefits, which is a positive thing [. . .]" (interview lines 224–226). In total, the expert mentioned ecological aspects five times in connection with cost benefits in the interview. Defining itself as a discounter chain, costs play a special role for the company. The importance of cost advantages for ecological action was legitimized by "[. . .] a quote from a CEO of a discount store: 'The awareness of sustainability stops with the German consumer at the checkout' [. . .]" (interview lines 578–579). Accordingly, the monetary incentive for ecological action is decisive for the company, because, according to the interviewee, it is also decisive for environmentally friendly behavior on the part of consumers.

Furthermore, the unsuitability of some more sustainable means of transport for business trips, as well as product-related aspects limit the company's potential to act ecologically, according to the expert.

3.2.4. Willingness to Work from Home

In the perception of the expert, for the employees the new situation was new and unfamiliar and the initial response to the legally binding expansion of working from home was mixed. In particular, the individual suitability of working from home depends not only on the activity, but above all on the situation of the employees. For example, the technical

equipment must be available at home. The expert also noted the advantage of having a well-equipped workplace, since a poor posture can otherwise negatively affect health in the long term. The simultaneous work at home of two or more employees in the household can also be difficult if the equipment is inadequate.

According to the expert, employees perceived the work–life balance predominantly as advantageous. Childcare and work can be combined, but the former can also be a hindrance when working from home. The right to work from home on a pro rata basis also allows private appointments to be combined with work.

Although the expert considered the quality and quantity of working from home to be positive overall, concerns arose on both sides, the company's and employee's, regarding the frequency of working from home. For example, the workplace is not only useful for carrying out work processes, but also as a space for social encounters. A healthier approach is to give employees freedom of choice whether to work from home or in-office, which was again emphasized in this context, according to the expert.

4. Discussion

4.1. Commuting and Working from Home

Finally, we can answer the first subordinate research question "How did the pandemic affect work-related commuting?" on the basis of the empirical results. On the one hand, there was a significant reduction in commuting frequency during the crisis and beyond, which can be explained on the basis of internal company measures. While these measures were originally introduced at the beginning of the crisis in accordance with legislation, the possibility of working from home for 20% of the weekly working time remains in place even beyond the crisis in departments with an affinity to work from home. However, this figure is still a long way from the estimated potential of 53% attested to the retail sector [41]. Compared to another forecast, according to which 8% of German employees will work exclusively from home after the pandemic and a further 27% will work from home partially [42], this value is lower than previously assumed, particularly because of its reference to a small proportion of the company. Pütz also assumed an average presence time at the place of work of 50% for homeworkers [11], which we could not observe in this case study. Although the value of one possible day for working from home per employee is also below the value of 2.7 days [10], in this case study, we observed an increase above average compared to the forecast average increase of 0.2 days [10]. The option of working from home on a pro rata basis, which the investigated company introduced, only offers the potential for reducing emissions if the 20% are not distributed over all five working days, so that commuting frequencies could be reduced by one day. In the long term, our expert assumed that up to 50% of the workload in the administrative sector can be performed from home, but the resulting "healthy mixture" could also lead to an increase in total greenhouse gas emissions due to the need to supply energy to both the home and office locations [10]. Since commuting in the case study and the surrounding rural area is emission-intensive due to the poor public transport infrastructure and the consequently large proportion of car drivers, there is considerable potential for reducing emissions in such rural areas through increased use of working from home options. Accessibility is a key factor to provide for low-carbon mobility options [43]. In this use case, the semi-rural infrastructure did not allow for changes in transportation mode.

In general, changes in the use of transport could also lead to an emission reduction in the area of work-related mobility. The loss of importance of public transport for commuting, which was frequently identified [8,15–18,20,26], could not be observed in this case study because public transport was almost insignificant at baseline anyway.

4.2. Business Trips

The frequency of business trips decreased significantly with the emergence of the pandemic. However, at 63.8%, the decrease was lower than the 83.3% recorded by the VDR [21]. Business closures, preferences of business partners and the general infection

situations played a major role here. In the long term, we observed a decrease in the frequency of business trips of 23.8–40%, whereby sustainable behavioral changes in the form of increased use of video conferencing as well as the increasing questioning of the necessity of business trips partly resulted from the crisis [44,45]. However, it has also become clear that face-to-face meetings cannot always be replaced by digital ones [21]. Competitive pressure [46] plays a role here, particularly for company representatives at trade fairs, because "[. . .] ultimately the industry meets there, and then it is always bad if you stay out of it [. . .]" (interview lines 478–479). The expected increase in the frequency of business trips without reaching pre-crisis levels is in line with the forecasts [46,47].

4.3. Climate Awareness, Ecology, and Sustainability

According to our findings, we can answer the third research question "How do the observed changes in work-related mobility affect individual climate awareness?" In our case study, changes in commuting behavior are not related to the problem perception of climate change. The increase in problem perception could rather be due to a general increase in climate awareness of the German population [48]. The change in the problem perception of climate change found in this study must be viewed critically, since the corresponding item is subject to the retrospective view of the respondents. Furthermore, we found a significant correlation between the affinity to work from home and climate awareness of the participants. This could be due to an increased concern with and the associated greater importance of ecological aspects in the departments with high affinity to work from home, which as an occupational group-specific value could ultimately also affect behavior [12]. However, other reasons, such as socio-economic or demographic differences such as age or education level, could also be decisive for differences in climate awareness between departments. Company environmental attitudes follow rational choice due to the major role of the cost factor [12].

4.4. Willingness to Work from Home

Ultimately, we can answer the fourth research question "Which aspects are important for the willingness to keep up working from home after the pandemic?". Better working conditions ensure greater acceptance of working from home, although the general response from employees was mixed. The availability of necessary technical equipment at home is important for health reasons as well as for trouble-free working. Therefore, companies are recommended to support their employees by providing hardware [28], which was also undertaken in this case study. Whether working from home becomes a burden or an enrichment is "[. . .] ultimately always dependent on the individual situation of the employee, whether he can work well or less well at home [. . .]" (interview lines 118–120).

In general, the improved work–life balance is an advantage both in the case study and according to literature [42]. Although the performance of small activities outside working hours, such as sending e-mails, leads to a positive increase in quantitative working time from a company's perspective, it also poses a risk to blur the boundaries between an employee's private and working life [49]. In this context, employee representatives should lobby for appropriate regulations to prevent the downsides of working from home [28].

On the other hand, the climate awareness of the respondents did not result in any behavioral effectiveness with regard to the willingness to work from home. This could be an indication that the slight adoption of climate-friendly behavior observed in the form of a reduction in commuting frequency was not the product of a conscious examination of everyday behavior but was subject to the framework conditions created by the company and German legislation. Accordingly, Tirachini and Cats point out that it is the governments' responsibility to strengthen the support in the case of public transportation [50]. Accessibility planning could help shape transport and land-use systems, providing low-emission mobility options [6]. At this point, it becomes apparent that the environmental behavior of the employees in the case study was not guided by environmental motives but were rather a result of expanded options to work from home.

4.5. Methodological Discussion

First of all, we can state that the mixed-method approach compared to conducting a purely quantitative study had the advantage that the quantitatively collected data could be classified, explained, and supplemented on the basis of the qualitative material, so that we could map the social reality of work-related mobility and record forecasts regarding the future development of work-related mobility.

Quantitative research is generally evaluated using the quality criteria of objectivity, reliability, and validity [51]. The former was given by the data collection via an online survey [52]. However, this approach also has disadvantages. Especially, answering online surveys can be disturbed by parallel activities and distractions. In addition, online surveys that have been started can easily be canceled, which can lead to an increase in the dropout rate [53]. As the research context of the COVID-19 pandemic is characterized by a particularly fast pace and frequent changes, a low reliability of the survey was to be assumed in principle.

The division of the study period into two waves offered the possibility of reviewing reliability by examining the variables grouped according to the two waves for distributional differences. However, this is not a test–retest reliability test because it was not conducted with the same subjects [51]. In the course of the Mann–Whitney tests carried out on all variables, we found distribution differences dependent on the survey wave for a total of 7 out of 130 items, 6 of which were used for the hypothesis investigation, which generally speaks for a high reliability of the survey.

Since most of the questions were taken from previous studies, a high degree of validity is assumable, although changes to the questions had a negative impact on validity in some cases. For example, an ordinal question construct would have been advantageous for questions *A2*, *B3*, and *C3*, which record the frequency of business trips. Firstly, the extrapolation to the measurement period of 12 months would not have been necessary in this case. Secondly, the comprehensibility of the questions is impaired due to the different lengths of the reference periods. Since values (outliers) had to be excluded if a misunderstanding could be assumed, the differences in business trip frequencies must be assessed critically. Furthermore, question *C1* lacks an answer option that records whether the respondent is again working entirely in the office or not. This was partially indicated under the answer option "Other" but was not taken into account in the statistical evaluation.

The qualitative interview can be criticized as too rigid following the interview guideline. At some points, specific topics named by the interviewee could have been discussed in more detail. In addition, the expert interview did not provide any insights into climate awareness, making it difficult to integrate the quantitative results with the company's perspective to answer the third research question. It should also be noted critically that addressing aspects of ecology and sustainability in particular can elicit biased responses due to social desirability [54]. Therefore, no critical statements could be expected towards the own company. Furthermore, an existing set of rules was used to transcribe the interview. The content-semantic transcription [38] ensures an easy comprehensibility of the transcript. A content-structuring qualitative content analysis was used to evaluate the material. Since the single expert interview did not consist of multiple cases, some forms of evaluation were not possible in the process.

Regarding generalizability it should be mentioned that all insights gained are specific to the case study. To enable readers to draw their own conclusions about the generalizability of the present study to other contexts, the research process was described in as much detail as possible and related to the theory and previous studies used [55].

5. Conclusions

In conclusion, the potential to reduce emissions regarding work-related commuting exists, but only if opportunities to work from home remain beyond the immediate COVID-19 crisis.

In this case study no change to lower-emission modes of transport in the modal split could be found, because the company was situated in a rural area with poor availability

of public transport infrastructure and, therefore, employees use mainly their own cars for commuting. However, a reduction in commuting behavior was observed, which could be explained by the company offering employees to work from home, which is still effective for 20% of the weekly working time. From the company's perspective of this case study, the tendency is to give employees greater freedom of choice regarding their place of work in the future; this may create opportunities for further emissions savings. However, when an inefficient use of home and office workplaces in terms of energy consumption is combined with a transport system that is not adapted to the changing demand for mobility, such a proportion of working from home can even lead to an increase in greenhouse gas emissions.

Regarding the employees' willingness to work from home, this case study revealed a nuanced picture: in line with the mixed responses regarding the changed situation due to COVID-19, the working conditions at home were rated slightly better than those in the office. Interestingly, the individual assessment of working conditions at home were directly related to the individual willingness to work from home. Therefore, improving the conditions for working remotely could help in activating a greater potential. In contrast to that, an individual's climate awareness could not be identified as a reason for a higher willingness to work from home. This shows that the adoption of climate-friendly behaviors in the form of reducing commuting is not a product of the individual decision based on climate awareness but is subject to externally created framework conditions. Accordingly, no correlation was found between changes in commuting frequency and an increase in problem perception of climate change.

Additionally, replacing business trips with video conferences has another considerable potential for reducing emissions. According to the expert, the decreasing frequency of business trips, which was observed in the course of the crisis, probably led to behavioral changes. Video conferences will be used more often for smaller meetings, leading to a lower business trip frequency in the long term compared to the pre-crisis level.

As the mobility-reducing effect of the crisis was bigger in other countries, such as Italy (54%) and the UK (51%), than in Germany (18%) [14] a bigger reduction in work-related mobility can also be assumed in those countries. Further research could focus on the long-term effect of the crisis on work-related mobility, comparing different countries.

Additionally, this case study showed a connection between the working-from-home-affinity of a person's work and their climate awareness with no obvious causality. Further research should focus on revealing the underlying connection. Additionally, comparing two companies, one from a sector with high potential and one for a sector with low potential for working from home, could help in tailoring beneficial framework conditions for emission-reducing work-related mobility.

Ultimately, the results of this case study emphasized that climate-friendly behavior in the context of work-related mobility is essentially not the result of individual motivation to act in a climate-conscious manner. Rather, it is subject to the framework conditions created by employers for the adoption of climate-friendly behaviors. The results of this work could be used by companies and policymakers to create such favorable framework conditions. They could also prompt employees to reflect on and adapt their commuting and business travel behavior.

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Appendix A

Table A1. Schematic overview of the quantitative survey structure including questions asked (own translation).

Section	Question Code	Question
A	A1	How often did you commute for work before the crisis?
	A2	How many business trips did you take each year before the crisis began?
	A3	Which mode of transportation did you usually use before the crisis began?
B	B1	To what extent has your professional situation changed compared to the time before the crisis?
	B2	How often did you commute for work during the crisis?
	B3	How many business trips did you take during the crisis?
	B4	Which mode of transportation did you usually use during the crisis?
	B5	How much did you limit your social contacts during the crisis?
C	C1	To what extent has your professional situation changed compared to the time before the crisis?
	C2	How often do you currently commute for work?
	C3	How many business trips have you taken since the end of the crisis?
	C4	Which mode of transportation do you usually use at the moment?
D	D1	When you think about all your commutes and occupationally mobile assignments ...
	D2	If I am regularly on the road on a work-related basis ...
	D3	If I am less on the road on a work-related basis ...
	D4	If you could choose, what would your ideal ratio of working from home to working in the office look like in the long run?
	D5	With what frequency would you have preferred to work from home if there had been no COVID-19 measures?
E	E1	How serious ...
	E2	How dangerous is climate change for ...
	E3	How much do you think keeping the home office can help reduce greenhouse gas emissions?
F	F1	Please enter your age.
	F2	Please indicate your gender.
	F3	Please enter your postal code.
	F4	Please indicate in which area you work within your company.
	F6	If you own a car yourself, how is it powered?
	F7	Approximately how far is your commute?

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