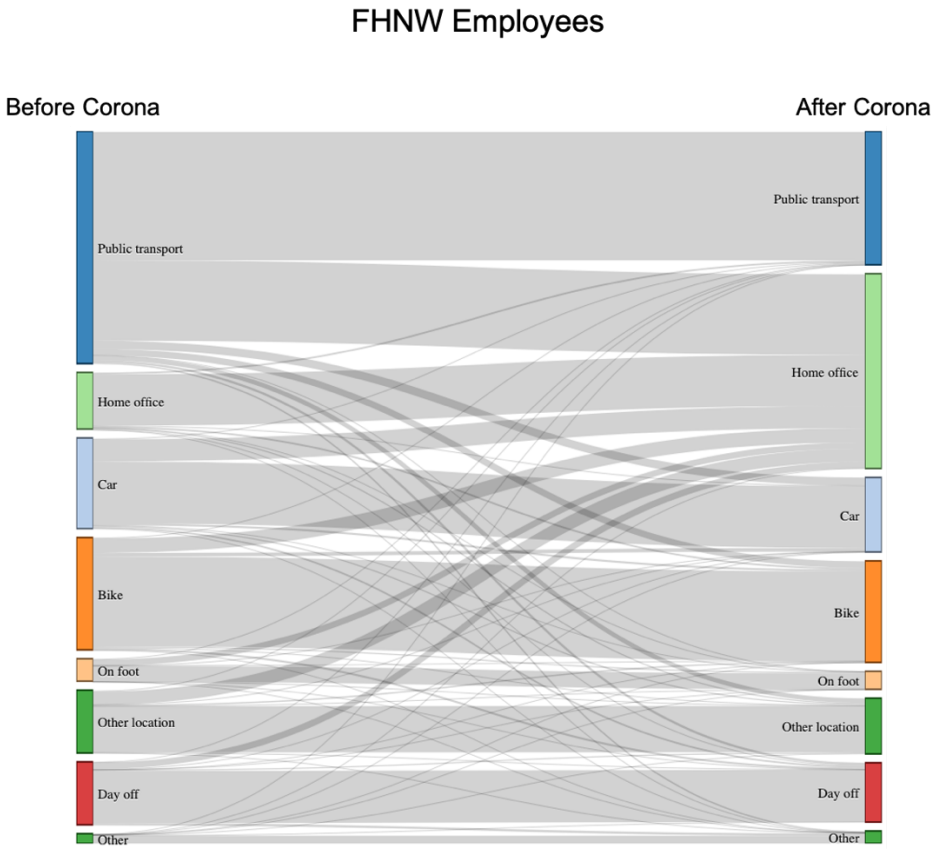

Long-term impact of COVID-19 on commuting patterns of employees

Evidence from surveys on intended behavior in two large organizations

Alexander Erath, FHNW
Raphael Mesaric, FHNW

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Alexander Erath
University of Applied Sciences and Arts Northwestern Switzerland
4132 Muttenz
T: +41 61 228 54 26
E: alexander.erath@fhnw.ch

Raphael Mesaric
University of Applied Sciences and Arts Northwestern Switzerland
4132 Muttenz
E: raphael.mesaric@fhnw.ch

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Abstract

This paper presents an analysis of potential long-term impacts of COVID-19 on commuting patterns of employees in Switzerland. Two surveys have been conducted in April and May among employees working at Roche Diagnostics International (RDI) in Rotkreuz and at the University of Applied Science of Northwestern Switzerland (FHNW) with with work locations at six different sites. The respondents were asked to indicate their typical commuting behavior for each day of the week before the pandemic and how they intend to adapt it once are all pandemic related restrictions will be lifted.

Every second employee of FHNW and of those RDI employees who work in an office environment intend to work at least once a week from home. As a result, the share of work from home days per week for these people would increase by about 30 percentage points. Among the RDI employees working in production, development or a laboratory environment at RDI every fourth intends to work from home after the pandemic. The number of days FHNW employees and RDI employees who work in an office environment intend to work from home follows a uniform distribution. However, when interpreting those findings, one needs to consider that ultimately the policies each organization will put in place might limit the actual number of days each employee will be able to work from home.

Beside the impact of the work environment, we identify that work from home is particularly popular on Friday and among people who commuted by public transport before the pandemic. Employees who commute by bike or on foot are less likely to work from home. Further factors that significantly impact the propensity to work from home at least in one dataset include travel duration between home and work by car and public transport, sex and household composition.

Given the importance of work from home arrangements in future, further research is needed to better understand how factors such as job profile, company culture, personal attitudes,

household composition and availability of space to work from home as well as distance and travel options between home and work impact the propensity of working from home. Based on the findings of such studies, travel demand models should be expanded to include the impact of work from home on destination, mode and time choice.

Keywords

Work from home, COVID-19, long term effects, modal split

1. Introduction

The COVID-19 pandemic led to a sudden increase of people working from home. According to the data collected for Mikrozensus Verkehr und Mobilität (Bundesamt für Statistik BFS & Bundesamt für Raumentwicklung ARE, 2017) in 2015, about 18% of Swiss employees worked partially and 6% intensively (i.e. at least 30% of the work time) from home (Ravalet & Rérat, 2019). The MOBIS-COVID data showed that during the pandemic, the share of people able or allowed to work from home rose from initially about 30% up to 60% in September 2020 (Molloy & Axhausen, 2021). After easing the containment measures, the share of people working from home continuously dropped in the aftermath of all three waves. However, the rate of people in the MOBIS-COVID sample able or allowed to work from home remained at about 50% in July 2021. At this time, the federal administration withdrew its recommendation to work from home, but many firms and institutions still required employees to wear masks at the workplace at least in certain situations.

The MOBIS-COVID data shows that a shift in mindset took place with regards to the feasibility and effectiveness of work from home (or anywhere) arrangements. In addition, companies have made considerable investments in IT infrastructure and software supporting remote collaboration. In addition, many employees have purchased new hardware (e.g. computer monitors) and office furniture to better facilitate working from home. Therefore, it is fair to expect that work from home (or anywhere) arrangements will remain popular once the pandemic is over and hence occur more frequently than before. At the same time, anecdotal evidence suggests that people miss certain aspects of their usual workplace such as personal meetings and chance encounters.

While there are currently plenty of (informed) speculations (McKinsey Global Institute, 2021; Robinson, 2021; Zurich, 2021) and concepts available concerning post-pandemic workplace policies and its related challenges (Chertkovskaya et al., 2020; Kane et al., 2021; Malhotra, 2021) as well as first estimates concerning the potential of work from home arrangements in Switzerland (Rutzer & Niggli, 2020), we did not find any study about how employees actually intend to balance their work time between location-based and remote work once pandemic restrictions will be lifted. In this context, we try to answer the following research questions:

- How do employees intend to combine work from home (and anywhere) and on site in the future?
- How do type of work and previous work from home policies impact employees' intention?
- How do distance, travel duration, quality of the transport connections and modal preference impact the willingness to work from home / anywhere?
- How do sociodemographic variables such as age, gender, household composition as well as the spatial characteristics of the home location impact employees' intention with regards to future work from home engagement?

To answer these research questions, we conducted surveys in two large organisations: the University of Applied Sciences of Northwestern Switzerland (FHNW) with sites in Basel, Muttenz, Olten, Solothurn and Brugg/Windisch and Roche Diagnostics International (RDI), which is located in Rotkreuz. RDI is one of the main sites of the Diagnostics Division of the Roche Group. The work force at RDI includes around 3500 employees. Our sample includes answers from about 2'911 employees (850 at FHNW and 2061 from the RDI) who are engaged in different work environments (office, lab, production, and field service). Since the validity of responses from about 1'250 students are dubious with regards the actual feasibility of study from home arrangements, we do not include analysis of those responses in this paper.

2. Objectives

The results of the MOBIS-COVID survey (Molloy & Axhausen, 2021) and the Intervista Mobility Monitoring (Intervista AG, 2021) show that the COVID-19 pandemic led to a significant reduction in commuting travel distances which in most cases can be related to an increase of work from home activities. According to the Intervista Mobility Monitoring, the share of people that commute to either a fixed work or study location dropped during the first lockdown from about 50% to only about 22%. The value increased again in September 2020 to about 47% but until July 2021 never reach that level again but was at around 40% in July 2021 when the study ended. This substantial increase of about 20% of the work force with originally fixed work locations now engaging in work from home activities on a given day has not only an impact on the organization of work activities (layout of offices, real estate demand etc.) but also on transport. The change of commuting patterns has not only a direct impact on travel demand during the peak hours but also raises new issues ranging from a new demand for more flexible public transport subscription models to changing requirement with regards to the

parking offering at the work place. The objective of this work is to identify to which extent people plan to adapt their commuting behavior based on the experiences made during the pandemic. In particular, we attempt to identify the main drivers for people to shift towards more work from home and for other significant mode changes (e.g., from public transport to car or private motorised transport (PrT) in general).

To achieve this objective, two surveys were conducted within major companies, the University of Applied Sciences and Arts Northwestern Switzerland (FHNW) and RDI. These surveys did not directly address the aforementioned issue, but rather assess the life cycle and potential measures for mobility management, respectively. As this requires knowledge about the presumed long-term effect of the COVID-19 pandemic on the commuting behavior, the surveys do also gather information about how people plan to adapt their behavior in the long run based on their experiences during the pandemic (especially work from home, WFH).

To answer our research questions, we show visualization of the mode choices over the course of the week to give a first indication of the relative changes in mode choice before and after the pandemic. Sankey diagrams illustrating the flow from the pre-pandemic modes to the post-pandemic modes allow to identify the main absolute changes, i.e., which pre-pandemic modes are most inclined to be switched and which modes benefit the most from the pandemic and are chosen more often in the “new normal”.

While such descriptive analysis is helpful to illustrate the significance of the different changes in commuting patterns, they are not well suited to identify individual characteristics, that explain to which extent different person groups intend to engage in work from home activities. To this end, we develop and estimate choice models to provide insights how different characteristics impact the intended behavior and hence can be identified as main drivers of pandemic-related mode switches.

Considering the limitations of the employed sample, we derive conclusions focusing on the impact on travel demand and provide recommendations how the transport sector should react and take advantage of the expected changes.

3. Data

The main source of data for this research are two web-based surveys, which have both been conducted in April and May 2021. One survey has been conducted among all employees and students of the University of Applied Sciences and Arts Northwestern Switzerland (FHNW). The second survey addressed around 3500 people working at Roche Diagnostics International (RDI) in Rotkreuz.

The University of Applied Sciences in Switzerland has eight different sites and in total 9 schools, each consisting of various institutes. In total, the FHNW employs more than 2'200 people and teaches more than 13'000 BSc- and MSc-students plus roughly 3'000 students in further education. The survey has been conducted as part of a life cycle assessment study to quantify the environmental impact of the FHNW, with a special focus on food, infrastructure and transport. During the survey period, severe restrictions were in place at all facilities of the FHNW. Employees were requested to work from home if possible and apart from a few exceptions, in-person instruction on the campus was not possible, subsequently putting the campus life on hold for the most part. The switch to online teaching came along with profound changes in the mobility patterns. To gauge the long-term impact of the pandemic on travel behavior and hence changes to the environmental footprint, the survey included questions about the commuting behavior during a typical week before the pandemic (the baseline was a week in September 2019), but also the expected weekly routines after the end of the policy measures to contain the pandemic.

RDI is located about 800m away from the railway station which offers direct and frequent train connections to Zug, Zurich and Lucerne and is also served by S-trains. Frequent bus services exist between the site and this train station. The survey was conducted in the process of developing a new mobility strategy for the company at this site. During the survey period, multiple pandemic measures were in place at the site. Most people who had the option to work from home did work from home (e.g., office jobs). At the same time, the previously active mobility strategy was suspended (discounts for public transport as well as parking restrictions on the site).

Figure 1 shows how we collected information about the weekly commuting behavior before and after the pandemic. We chose a weekly raster format to collect data on mobility behavior

as this approach corresponds to the usually weekly recurring commuting patterns of people who work part time. In addition, the response burden is comparably low. While respondents were asked to indicate their usual weekly commuting pattern before the pandemic (revealed preference), the question concerning the post-pandemic pattern is hypothethical (stated preference) and will obviously depend on company policy with regards to work from home and other factors. By asking specifically for the "planned behavior", we aimed to collect information on the personally intended behavior.

Figure 1: Question about the intended weekly commuting pattern after the pandemic

Post-Corona: Please indicate your commute to Campus in Muttenz in a typical week (without holidays or business trips) with **moderate weather conditions** (e.g. September or April). Please indicate your planned behavior **after the normalization of the corona situation**.

Please select an option for each day of the week, according to your regular weekly pattern. In case you don't follow a weekly pattern, please indicate your general travel behaviour using the provided matrix (independent of the weekdays).

	Public transport (incl. Park+Ride and Bike+Ride)	Own car	On foot	Bicycle	E-Bike / S-Pedelec	Motorcycle	Carpooling	Work from home: no trip	Work at different location: no trip to the site	Day off: no trip	Other means of transport
Monday	○	○	○	○	○	○	○	○	○	○	○
Tuesday	○	○	○	○	○	○	○	○	○	○	○
Wednesday	○	○	○	○	○	○	○	○	○	○	○
Thursday	○	○	○	○	○	○	○	○	○	○	○
Friday	○	○	○	○	○	○	○	○	○	○	○
Saturday	○	○	○	○	○	○	○	○	○	○	○
Sunday	○	○	○	○	○	○	○	○	○	○	○

The simplicity of the chosen question format does also have its drawbacks. To filter out erroneous or invalid data, multiple validity checks have been performed, e.g. to exclude observations from people who indicated to drive but neither hold a driver's license nor have a car available. Obviously, the stated intention with regards to the post-pandemic weekly commuting pattern is subject to various sources of uncertainty, e.g. changing companys policies, coordination within in the household and changes in home location or work arrangments. However, to account for the scale of such potential uncertainties, the respondents were asked to indicate how confident they are concerning the indicated post-corona commuting

pattern on a scale with seven levels ranging from “not sure at all” to “very sure”. In any of the analysis presented in this paper, we only use observations from people who indicated to be “sure” or “very sure” about the indicated their post-pandemic mobility behavior. In this way, the presented results we can minimized potential distortions by people who are not yet sure about their future mobility patterns and therefore more likely end up with different mode choices.

The two surveys were also very similar with regards further questions such as the availability of mobility tools, household composition and includes also attitudinal variables. However, attitudinal variables are not employed in the analysis presented in this paper but can be subject for further research.

The response rate for the FHNW survey was in average 25% for employees and 10% for the students (without further education). Comparison with official statistics from the FHNW shown that the survey sample includes an adequate number of responses from all schools (Table 1) and mostly as well for the students. However, lacking access to a database with email adresses for the students in further education, we could not address this group systematically. As a result, answers from only 2.5% of all students in further education could be collected. Since their courses also do not follow a weekly recuring pattern we decided to omit any data from students in further education from further analysis. We also decided to exclude the responses from Bsc- and MSc-students as they generally do not have a choice regarding their mobility behavior but are dependent on the format and the scheduling of the lectures.

Table 1: Response rate of FHNW employees by different schools

School	Response rate
Architecture, Civil Engineering and Geomatics	14.2%
Applied Psychology	33.9%
Art and Design	21.5%
Life Sciences	19.0%
Social Work	33.6%
Music	18.1%
Education	25.0%
Engineering	33.0%
Business	31.0%

Table 2 shows the distributions of various variables in the full survey sample collected at FHNW. The final sample used in the model includes 3'163 observations from 700 employees. Here, one observation corresponds to the indicated mobility choices from one participant on a given workday (i.e., there are usually five observations from one participant). With regards to gender, the number of observations is quite balanced (48 % female, 52% male). In addition, the survey included questions to collect basic sociodemographic information both on the individual and household level as well as the availability of different mobility tools and questions to describe attitudes with regards to different mobility management measures as well as motives behind the indicated pre-pandemic mobility choices. In addition, we also generated generic information on the spatial characteristics of the home location such as population density in a radius of 400m and the agglomeration types (Switzerland's areas with urban character 2012) as defined by the Swiss Federal Statistics Office. Almost every second employee lives in a core city. The average travel distance between home and the work location of 27.6 km is much higher as the Swiss average which amounted to 14.6 km in 2019 (Bundesamt für Statistik, 2020).

Table 2: Distribution of selected variables in the full FHNW survey (only employees)

Variable	**Attribute**	**Share of the survey sample**
Gender	Male	48.4%
	Female	51.6%
Driver's License	Yes	91.1%
	No	8.9%
Average travel distance between home and work		27.6 km
Agglomeration type (residence)	Rural / outside agglomerations	7.8**%**
	Agglomeration (border)	18.0%
	Agglomeration (main core)	26.7%
	Agglomeration (core city)	47.5%

The response rate of the survey conducted among the employees of RDI was 57%. Comparison with data from human resources has shown that the sample is representative for the entire workforce. The sample also includes a relevant number of responses for the various type of workplaces. Table 3 shows the distributions of various further variables. The final sample used for further analysis consists of 7'553 observations from 1'630 people. Again, a single observation constitutes to the indication of pre- and post-pandemic commuting choice on a workday in a generic week. External employees indicated substantial higher rates of uncertainty with regards to their post-pandemic travel behavior as most of them are employed with temporary contracts. Therefore, they are underrepresented in the final sample. One third of valid

responses origin from women and two third from men which resembles well the work force at this companys on this regard. The average travel distance between the home and work location of 17.8 km is also substantially higher as the Swiss average but to a lesser extent than in the case of FHNW.

Table 3: Distribution of selected variables in the RDI survey

Variable	Attribute	Share of the survey sample
Gender	Male	65.9%
	Female	34.1%
Driver's License	Yes	94.5%
	No	5.5%
Average travel distance between home and work		17.8 km
Spatial type of residence	Rural / outside agglomerations	14.3%
	Agglomeration (border)	30.3%
	Agglomeration (main core)	29.1%
	Agglomeration (core city)	26.3%
Type of workplace	Office	65.7%
	Development	15.4%
	Production	8.9%
	Laboratory	5.2%
	Other	4.8%

4. Descriptive analysis

The descriptive analysis focuses on the presentation of intended, long-term changes in commuting behavior with regards to the following dimensions

- Weekly commuting pattern,
- Mode switching,
- Impact of commuting distance on the intention to work from home more often,
- The number of days each respondent intends to work from home during a typical week.

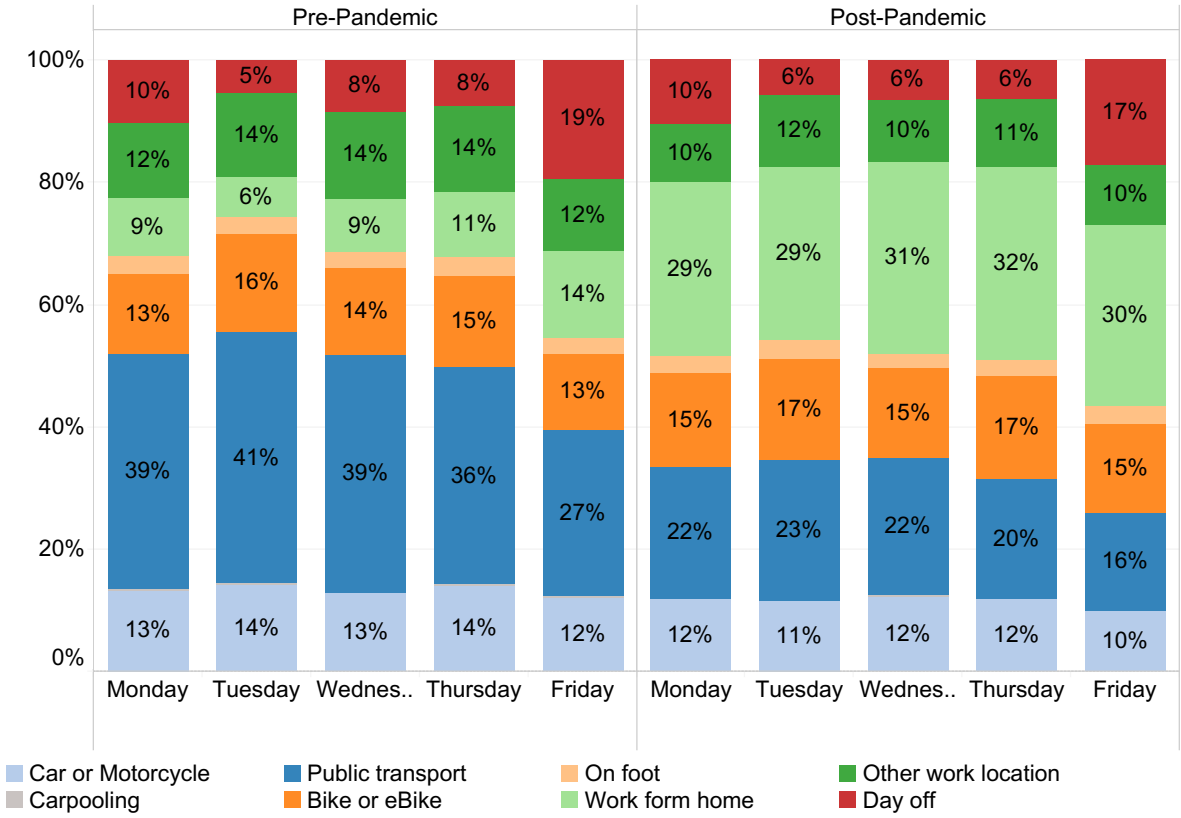
By comparing the results of the surveys conducted in the two organization, first insights with regards the generalizability of the findings will be derived.

4.1 Weekly commuting pattern before and after the pandemic

Figure 2 illustrates the weekly commuting patterns before and after the pandemic at FHNW. According to the responses of the FHNW employees, a threefold increase of the work from home share from 10% before the pandemic to 30% after the pandemic is expected. Most

employees are working in an office environment with flexible schedules in an academic environment. Given that Rutzer & Niggli (2020) indicate the suitability of job profiles between 0.79 (agricultural scientist) and 1 (lecturer, professor) on a scale between 0 and 1, it is interesting to see that the share of work days FHNW employees intend to spend at home or another work location only accounts to 45% (excluding days off).

Figure 2: Commuting behavior before and after the pandemic for FHNW employees

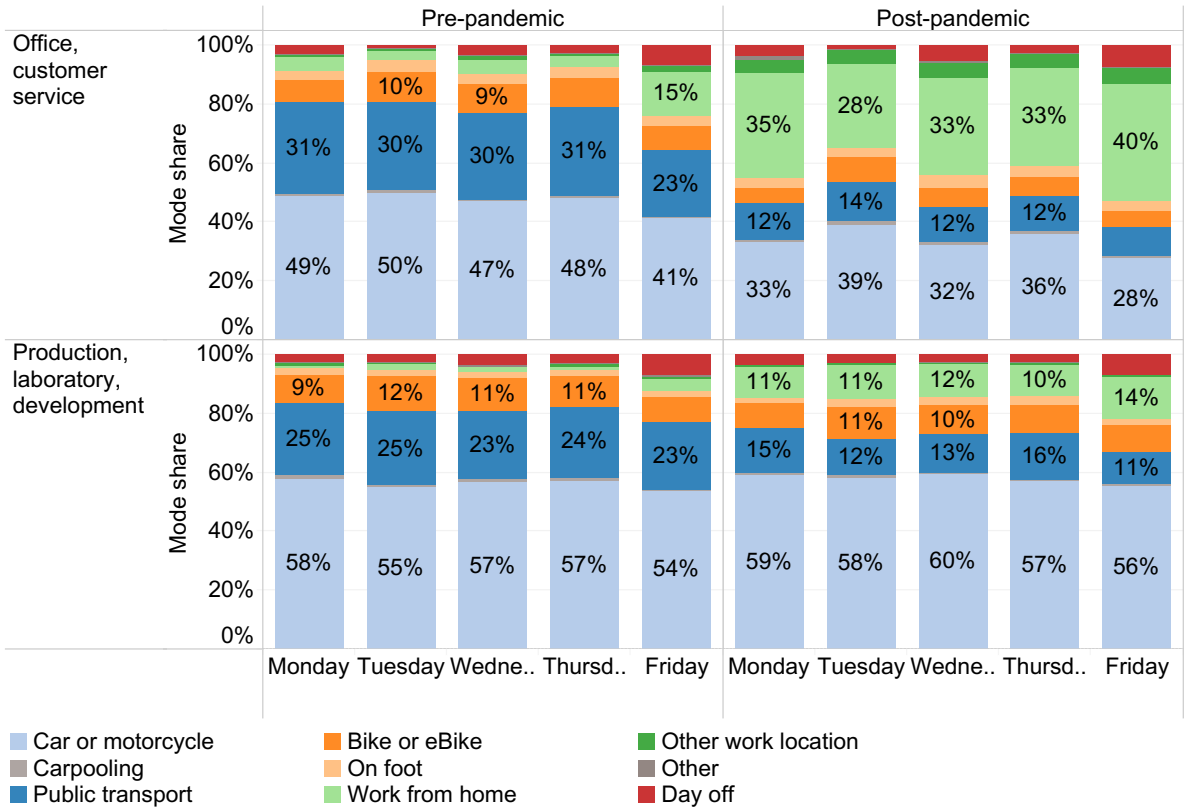


With regards to the distribution of work from home as well as days off, it is noted the demand patterns with lower commuting travel demand on Monday and Friday will persist. However, while the difference between the two weekdays with highest (Tuesday) and lowest (Friday) share of employees on site amounted to 20 percentage points (74% on Tuesdays, 54% on Fridays), this value is expected to reduce to 10 percentage points (54% on Tuesdays, 43% on Fridays). Or in other words: the average office occupancy at the busiest day of the week in future will be on par with the occupancy on a Friday before the pandemic.

Two third of employees at RDI are working in job functions that are conducted in an office environment. According to the responses of the RDI employees illustrated in Figure 3, the share

of work activities conducted at home increases from 6% before the pandemic to 35% after the pandemic (excluding days off). The other third either works in laboratory environment, production or customer service. For such job profiles Rutzer & Niggli (2020) indicate the suitability of job profiles between 0.5 (pharmaceutical production). Here, an increase from 2% to 11% of work activities conducted at home is expected.

Figure 3: Commuting behavior before and after the pandemic for RDI employees



Based on the collected responses, it is expected that Tuesday and Friday continue to be the busiest and quietest days of the workweek in the offices at RDI. However, different to FHNW a similar drop of employees on site is expected both for Tuesday (from 95% to 65%) and Friday (75% to 47%). Therefore, existing imbalances with regards to the office occupancy across the week will only slightly reduce. The number of employees on site in production, laboratory and development will continue to remain much more constant across the different workdays as compared to office jobs.

Based on the illustrated examples, we can conclude that the work from home propensity as indicated by Rutzer & Niggli (2020) describe upper limits of the share of work from home for

different job profiles. Many employees still plan to regularly work on site despite their job profile would allow to conduct most of the tasks from a flexible location.

4.2 Mode switching

To identify whether and how the employees intend to switch travel modes, we plotted Sankey diagrams in which the width of the connectors between the indicated mode shares before and after the pandemic is proportional to the number of observations, which in our case are individual workdays. Figure 4 shows the diagram that has been plotted based on the data collected from all FHNW employees that worked at FHNW already prior to the pandemic and indicated to be “sure” or “very sure” with regards to their stated mobility behavior once all pandemic-related restriction will be lifted.

We observe that in employees who used to commute by public transport intend to switch to work from home in 35% of the cases (workdays) while in 55% of the cases the intention is to continue to travel by public transport. Given the importance of commuting travel for public transport, the expected drop is public transport ridership is substantial. Switching to other modes of transport is of limited relevance with a share of 4% to private motorized transport (PrT) and 3% to bicycle.

The relative share of car trips that are planned to become obsolete due to more work from home activities amounts to 25% which is substantially lower than in the case of public transport. In addition, only few people intend to replace car trips by other modes of transport. Interestingly, with 20%, a rather high share of all work activities that were originally performed at other locations are planned to be conducted from home in a post-pandemic future. Finally, among all bike and foot trips, only 13% and 10% are planned to be substituted through work from home activities.

Figure 4: Mode switching for FHNW employees

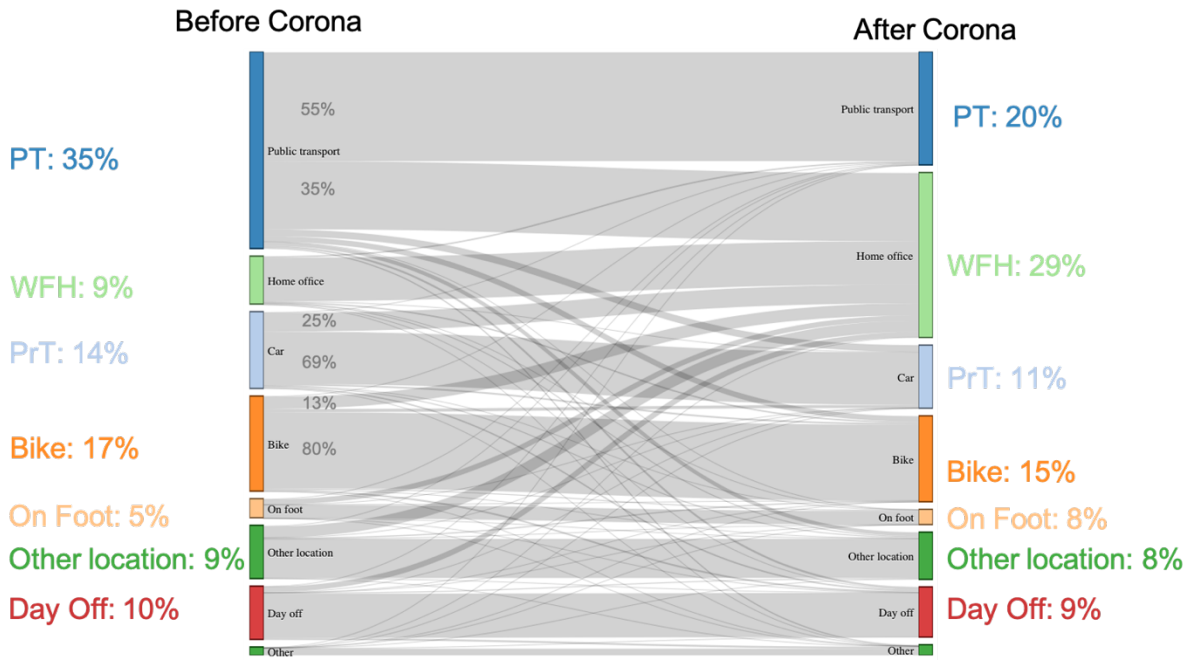
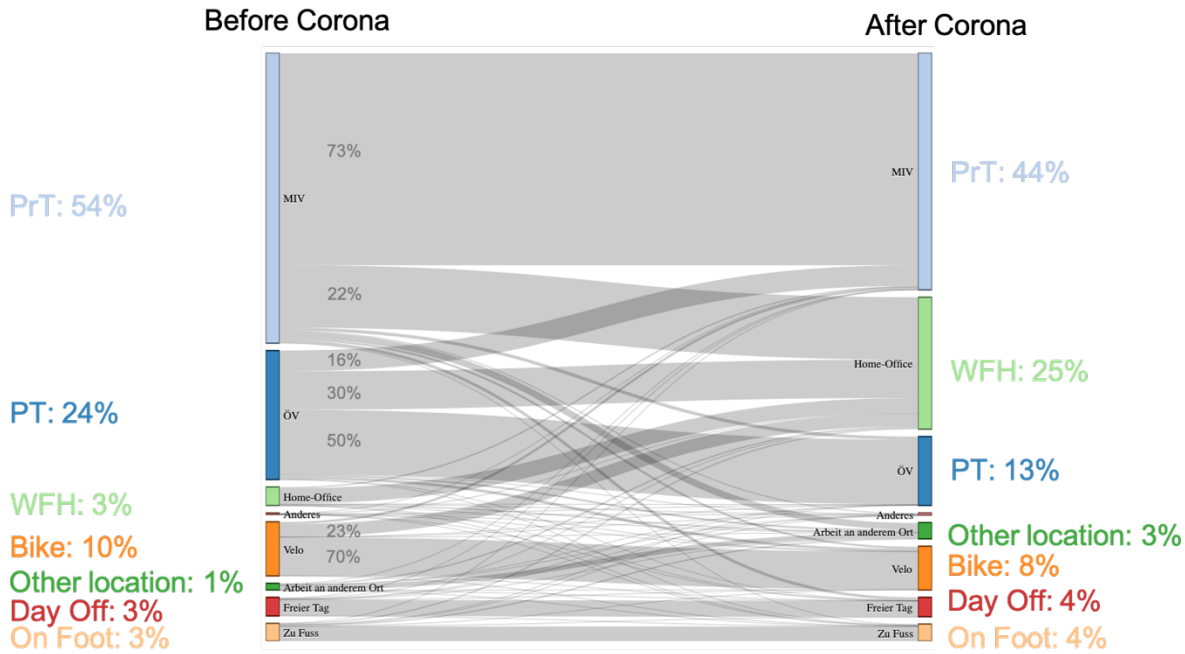


Figure 5 shows the intend mode switching patterns as indicated by the responding RDI employees. Every second trip that was originally conducted by public transport is slated to be replaced by other modes of transport or substitute by work from home. Interestingly, the relative replacement rate of trips by public transport through PrT is more popular than at FHNW (16% vs. 4%). We also observe a higher relative substitution rate through work from home activities for trips by public transport (30%) as compared to bicycle (23%), PrT (22%), and foot (6%). Those values are quite like those observed for the FHNW employees, except for a higher relative substitution rate for bike trips.

In summary, we observe that a substantial number of trips are substituted by work from home. The substitution rate is substantially different for the various modes of transport and the biggest demand drops are expected for public transport. Switching behavior between the different other modes of transport is observed as well, but generally of minor importance with the exception that a relevant share of public transport trips is supposed to be replaces by PrT.

Figure 5: Mode switching for RDI employees



4.3 Commuting distance and intention to work from home

Based on an analysis of Swiss travel diary dating back to 2010 and 2015, Ravalet & Rérat (2019) showed that the distance between home and work is significantly longer for people who telecommute. While this finding can be caused by various reasons, it is obvious that the time gains by replacing commuting trips with work from home activities are higher for longer distance between home and work. Therefore, one would expect that people with longer commutes intend to work from home more often.

Figure 6 shows the mode shares by driving distance between home and work as indicated for a post-pandemic situation by the FHNW employees. The share of work from home ranges between 21% and 33% across all distance bins with an only a slight trend of increasing work from home shared with increasing distance.

Figure 6: Post-pandemic mode shares by driving distance, FHNW (distances above 120km omitted due to limited case observations)

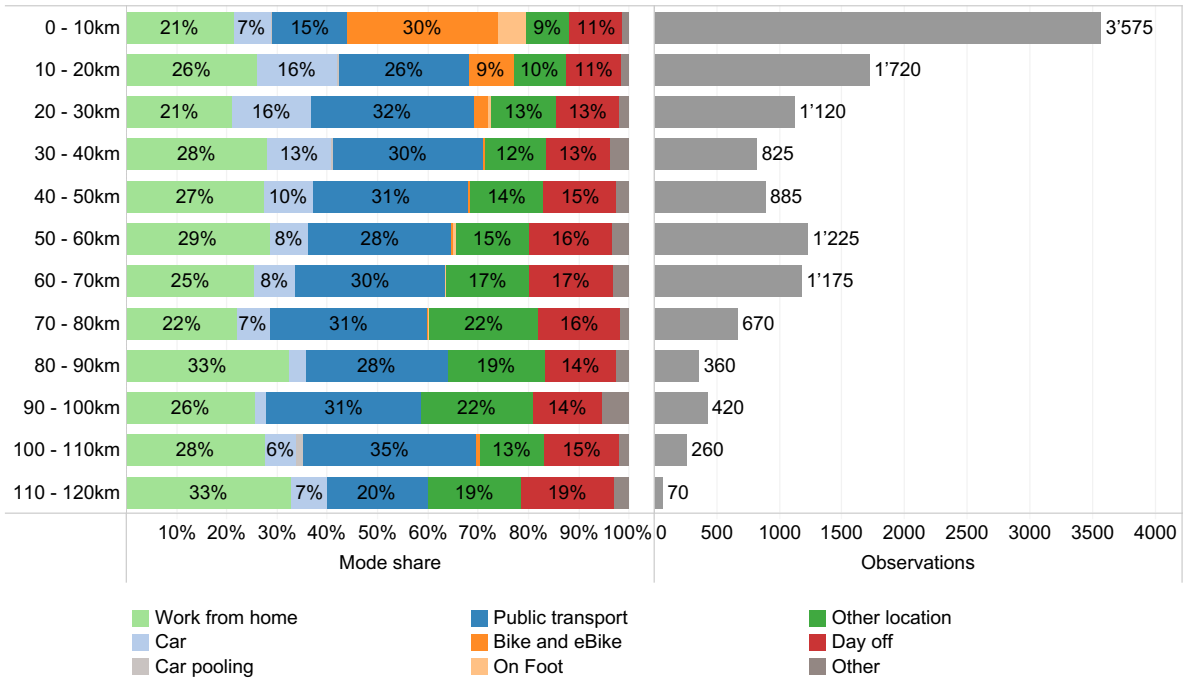
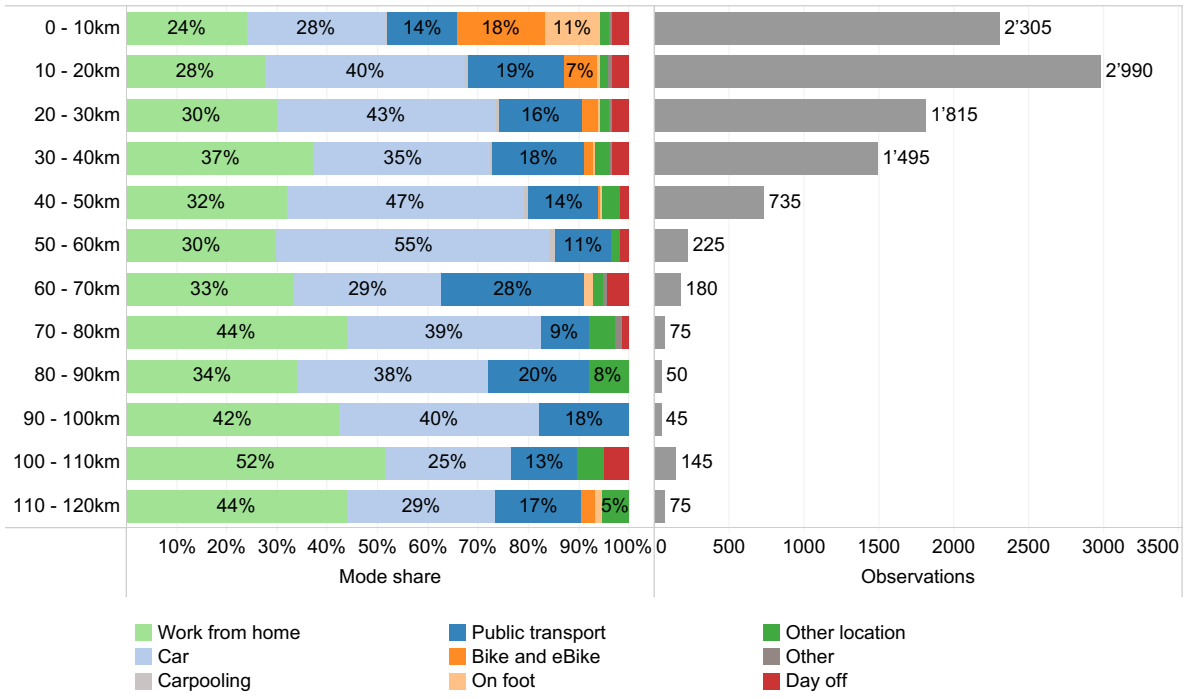


Figure 7 shows the mode shares by driving distance between home and work as indicated for a post-pandemic situation by the RDI employees. The share of work from home ranges between 24% and 52% across all distance bins. Different to FHNW, a linear trend of increasing shared of work from home with increasing distances is observed. However, given the difference in the distribution of distances between home and work between the companies, the RDI sample includes substantially fewer observations in the bins with higher distances.

Figure 7: Post-pandemic mode shares by driving distance, RDI (observations with distances above 120km omitted)



4.4 Number of days per week working from home

FHNW employees who hold a public transport subscription (excluding half fare card) account for 67% of all commuting trips conducted by public transport before the pandemic. For RDI employees, this value even amounts to 82%. As a rule of thumb, holding a public transport subscription makes financially sense if one uses it for commuting at least three times per week. However, this obviously also depends on the travel distance between home and work as well as the frequency and distance of other trips conducted by public transport. At the same time, public transport subscriptions make a big share of the total revenue in public transport and commuters hold a substantial share of all sold subscriptions. Therefore, it is particularly interesting to look at the distribution of the number of days per week each respondent plans to work from home after any pandemic related restrictions will be lifted.

Figure 8 shows the frequency distribution of workdays with planned work from home activity per week for FHNW employees. Before the pandemic, 73% of the employees worked did not regularly work from home. This share is expected to drop to 48% once all pandemic-related

restrictions are lifted. Interestingly, the distribution of the number of days working from home follows almost a uniform distribution with values ranging between 13% of employees working one day and 7% four days per week from home. It was also tested whether this distribution would be different for people holding a public transport subscription. However, no relevant difference could be identified.

Figure 8: Frequency distribution of workdays with work from home activity per week for FHNW employees

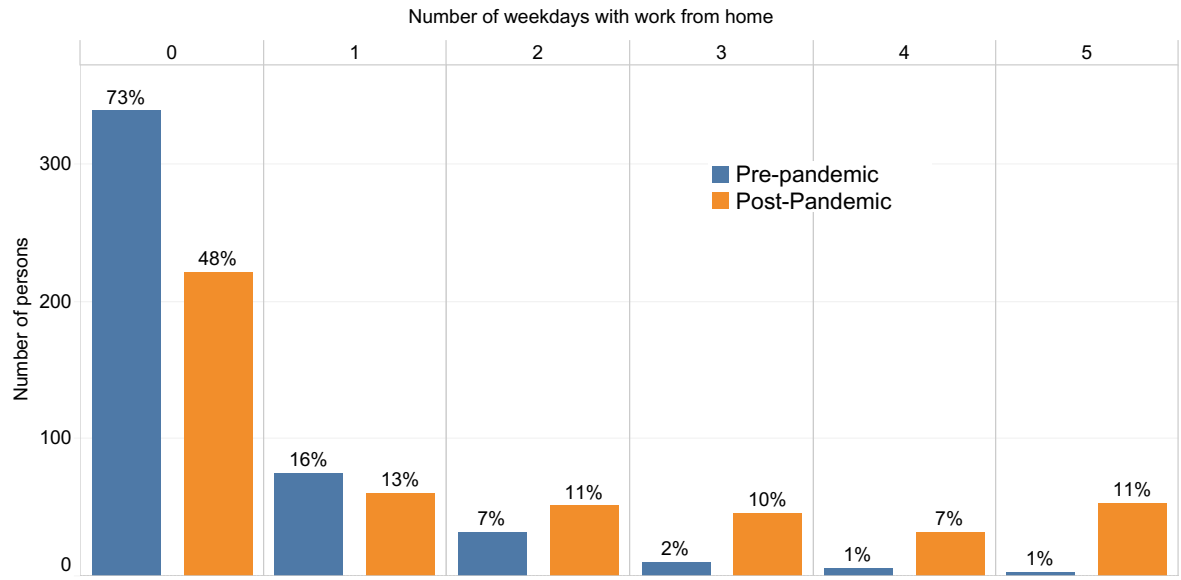
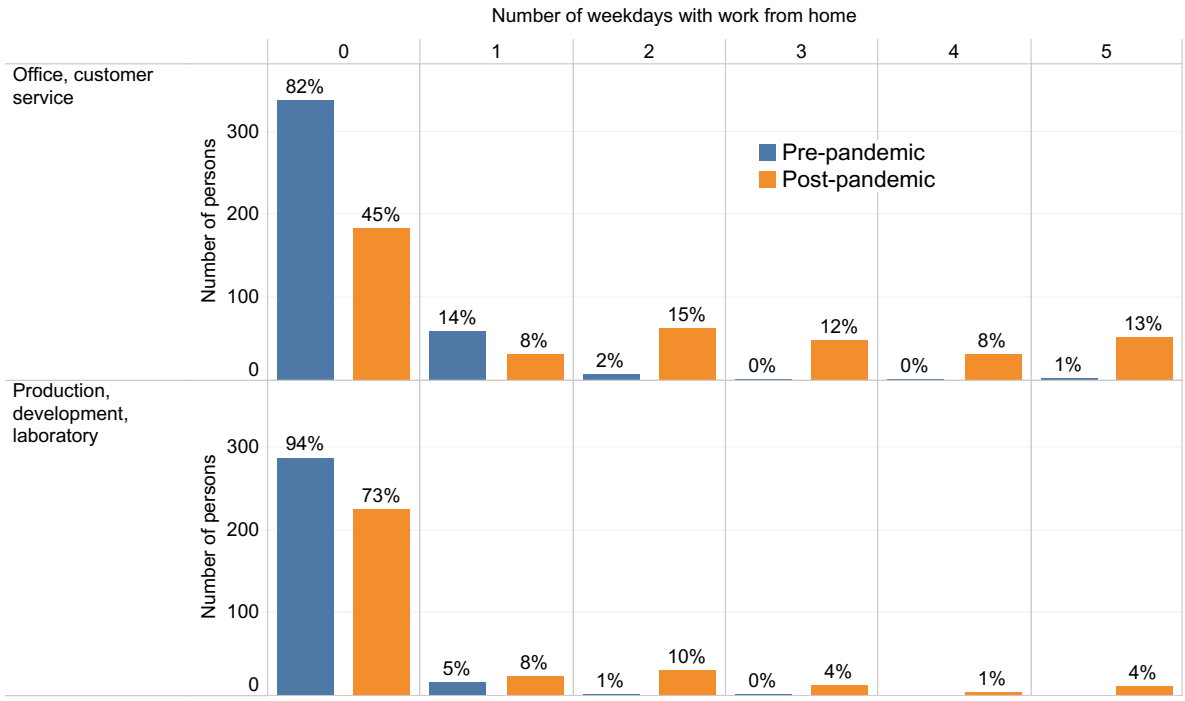


Figure 9 shows the frequency distribution of workdays with planned work from home activity per week for RDI employees. The upper graph shows the responses from employees either working in an office environment or in customer service, the lower graph for employees in production, development or a laboratory environment.

The share of people who have not regularly worked from home before the pandemic but plan to do so in future is somewhat higher for RDI employees who work in an office environment or customer service. This can be explained by the less restrictive work from home policy at FHNW before the pandemic. However, the share of employees that plan to not regularly work from home in future (45%) is about the same as observed for FHNW (48%). Interestingly, for RDI employees who work in an office or customer service environment the distribution follows again a uniform pattern as already identified for FHNW employees whose majority also works in an office environment.

Given the experience of working from home in the pandemic, we the share of employees who work in a production, development or laboratory environment and intend to work from home at least once a week increases by 19%. Most of those employees plan to work from home one or two days per week.

Figure 9: Frequency distribution of workdays with work from home activity per week for RDI employees



5. Modelling

To achieve the purpose of this project, two multinomial logit (MNL) models are estimated, one for each survey. These models describe the change of travel mode (including work from home, but excluding observations for work at other locations and day off) on the level of individual weekdays based on the choice observed for a typical, pre-pandemic week and feature the following alternatives:

- Change from any mode to work from home (change_to_wfh)
- Change from public transport to PrT (change_pt_to_mt)
- Change from public transport to bike or ebike (change_pt_to_bike)
- Public transport before and after (stay_pt)
- PrT before and after (stay_mt)

- Bike or ebike before and after (stay_bike)
- On foot before and after (stay_foot)
- Change from public transport to any other, except PrT, work from home or bike/ebike (change_pt_other)
- Change from PrT to any other mode, except work from home (change_mt_other)
- Change from bike or ebike to any other mode, except work from home (change_ebike_other)
- Change from foot to any other mode, except work from home (change_foot_other)
- Change from work from home to any other mode (change_wfh_other)

The availability of the "stay" and "change_x_other" alternatives in the choice set is dependent on the selected mode for a given weekday under pre-pandemic conditions. The availability of the alternatives "change_pt_to_mt" and "change_pt_to_bike" is dependent on the availability of a driving license and a car or motorcycle, or a bicycle, respectively.

For the "stay" and "change_x_other" alternatives, the utility functions only include alternative specific constants. The alternatives "change_x_to_y" do not include any alternative specific constants, but combinations of mode or person specific variables. In this way, the alternative specific constants of the "stay" alternatives can be interpreted as lag variables that capture the inertia of not changing the mode of travel for a given workday. Similarly, the alternative specific constants of the "change_x_to_other" alternatives can only be interpreted as a generic utility offset in comparsion to the "change_x_to_y".

The utility function of the "change_x_y" includes dummy variables to account for the mode selected on a given day before the pandemic. In this way, we can test whether employees who used to travel with a certain mode x are more likely to switch to a new mode y. In addition, the function includes include various socio-demographic variables (e.g., gender, employment status, type of work) as well as spatial (neighborhood type, density), transport supply variables (travel time) and day of the week. This allows to test whether certain types of employees are more likely to switch to work from home or whether travel duration between home and work impacts such a change of commuting patterns.

To determine the travel durations for the different modes, we used the GoogleMaps routing API. If the API did not return any suitable public transport connection from the place of residence to the workplace, the alternative public transport was tagged as "not available" and

trips from the respective locations by public transport were not considered in the final choice model.

Table 4 lists the parameters of the model we developed to describe the observed mode switching behavior of FHNW employees. Trips that were conducted by bike or PrT are least likely to be substituted by other modes of transport or work from home. Switching to any other modes of transport, except from PT to PrT or bike, is significantly less likely than substituting a trip by work from home.

Women significantly prefer to substitute work from home for commuting trips. However, employees who live as a family with children are less likely to replace commuting trips with work from home. The absolute value of the estimated parameter for the dummy variable "family" amounts to about half of the dummy variable "female". Hence, a working mother is still more likely to work from home than a single man.

A significant preference for work from home on Fridays, but not any other day of the week has been identified.

Employees who commuted by public transport or PrT are substantially more likely to work from home than their peers who commute by bike or on foot. However, given the high, but statistically insignificant parameter values, we expect substantial preference heterogeneity which provides motivation for further analysis. But generally, it can be stated that commuting by bike or on foot is perceived less of a burden and hence the gains of working from home are less valued by people wo commute by bike or on foot.

Longer travel duration by public transport does not significantly impact the likelihood of work from home. However, longer travel duration for employees who commute by car or motorcycle reduce the likelihood of work from home which seems counterintuitive. However, the low number of observations and low significance of the parameter estimate suggest to not derive any definite conclusions here.

People living in the agglomeration core and core cities are less likely to work from home. This might be due to limited space at home as rents tend to be higher an apartments smaller in this agglomerations types as compare to more rural areas.

Table 4: Results of the model to describe mode switching behavior of FHNW employees

Pre-pandemic	Pre-pandemic	Variable	Estimate	Sign.: **>0.95, *>0.9*
PT	PT	Constant	0.653	**
PrT	PrT	Constant	0.958	**
Bike	Bike	Constant	1.148	**
Foot	Foot	Constant	0.535	**
WFH	WFH	Constant	12.353	**
PT	Other	Constant	-4.547	**
PrT	Other	Constant	-1.520	**
Bike	Other	Constant	-1.479	**
Foot	Other	Constant	-1.506	**
WFH	Other	Constant	9.719	**
Any mode	WFH	Female	0.412	**
Any mode	WFH	Family	-0.205	-
Any mode	WFH	Monday	0.053	-
Any mode	WFH	Friday	0.277	**
PT	WFH	Constant	0.335	-
PT	WFH	Travel time pt (min)	-0.001	-
PrT	WFH	Constant	0.562	-
PrT	WFH	Travel time mt (min)	-0.019	*
Any mode	WFH	Core city	-0.250	-
Any mode	WFH	City	-0.748	**
PT	PrT	TT_PT	0.363	**
PT	Bike	TT_PT	-0.050	-
Key Figures				
Number of observations			3’163	
Number of individuals			701	
Rho-Square			0.45	
Log-Likelihood (0)			-3870	
Log-Likelihood (final)			-2124	

Table 5 lists the parameters of the model we developed to describe the observed mode switching behavior of RDI employees. Similar than in the case of FHNW, trips that were conducted by bike, foot or PrT are least likely to be substituted by other modes of transport or work from home. Switching to from PrT or bike to other modes of transport, except from PT to PrT is significantly less likely than substituting a trip by work from home.

Different to FHNW, female RDI employees do not significantly prefer to substitute work from home for former commuting trips. However, RDI employees who live as a family with children are also less likely to replace commuting trips with work from home. However, the strongest effect to predict likelihood of work from home is identified for employees working in an office environment. A strong preference to work from home is also identified for Fridays and to a lesser extent for Mondays.

Employees who commuted by public transport are generally less likely to switch to work from home than their peers who commute by bike or on foot. However, longer travel times by public transport increase the likelihood of replacing commuting trips with work from home. This also holds for PrT trip duration. Given the high, but statistically insignificant parameter value for the constant describing the general substitution of PrT trips with work from home, we expect substantial preference heterogeneity was also the case in the FHNW model.

Different to the results of the model developed for FHNW data, no systematic impact of the agglomeration type on likelihood to work from home could been identified for RDI employees.

Table 5: Results of the model to describe mode switching behavior of RDI employees

Pre-pandemic	Pre-pandemic	Variable	Estimate	Sign.: **>0.95, *>0.9*
PT	PT	Constant	0.777	**
PrT	PrT	Constant	1.706	-
Bike	Bike	Constant	1.872	**
Foot	Foot	Constant	2.512	**
WFH	WFH	Constant	17.008	**
PT	Other	Constant	-1.950	**
PrT	Other	Constant	-1.337	-
Bike	Other	Constant	-0.232	-
Foot	Other	Constant	0.141	-
WFH	Other	Constant	15.349	**
Any mode	WFH	Office	0.867	**
Any mode	WFH	Female	0.047	-
Any mode	WFH	Family	0.271	**
Any mode	WFH	Monday	0.253	**
Any mode	WFH	Friday	0.753	**
PT	WFH	Constant	-1.192	**
PT	WFH	Travel time pt (min)	0.012	**
PrT	WFH	Constant	-0.369	-
PrT	WFH	Travel time mt (min)	0.013	**
Any mode	WFH	City	0.087	-
Any mode	WFH	City	-0.010	-
PT	PrT	TT_PT	0.001	-
PT	PrT	Family	-0.395	*
Key Figures				
Number of observations			7’611	
Number of individuals			1638	
Rho-Square			0.32	
Log-Likelihood (0)			-8770	
Log-Likelihood (final)			-5974	

Comparing the results of the two models, we identify the following factors statistically to increase the likelihood of the intention to work from home more frequently in both organizations:

- Working in an office environment
- Friday

Statistically significant impact of the following factors on the likelihood to switch to work from home could only be identify for one of the two organizations.

- Commuting by public transport (FHNW)
- Increasing likelihood to switch to WFH for longer travel duration by public transport or PrT turned out to be a significant factor only for RDI employees.
- A higher propensity of women to work from home only was identified for FHNW employees.
- A tendency to work from home more often on Mondays as compared to Tuesday, Wednesday and Friday was only identified for RDI employees.
- A lower propensity to work from home for people living in cities or the urban core could only be determined for FHNW employees.
- RDI employees living in family households and who used to commute by public transport have a higher propensity to switch to PrT.

Diverging findings were identified for the following factors:

- While RDI employees living in family households have a higher propensity to work from home, the opposite holds for FHNW employees.

There are several potential reasons for the observed differences. First, work from home was more common at FHNW before the pandemic. Therefore, FHNW employees who benefit more from work from home, e.g., due to a long commute might have worked from home already before the pandemic and are therefore less likely to substitute trips for more work from home. However, according to the collected data, FHNW employees with longer commutes have only slightly more frequently worked from home than their peers who live close to the workplace. Given the higher share of FHNW employees living in the urban core with more frequent and direct public transport connections to the workplace, restricting the potential travel related gains of working from home to only travel time might be too simplistic and a generalized travel cost approach more appropriate.

Similarly, the lower propensity to replace commuting trips with work from home identified for FHNW employees living in a family household might be partially caused by the fact that they were already slightly more likely to work from home before the pandemic.

The data collected at FHNW does not include specific information on the work environment. Depending on the school and job function, the share of employees working in an office environment is expected to differ substantially. In this context, the preference of women to

work from home might at least partially caused not be related to gender but a higher share of women working work in an office environment or jobs that are better suited to work from home.

6. Conclusion and further work

The data collected from both employees working at the University of Applied Sciences of Northwestern Switzerland and at the RDI main site in Rotkreuz suggests that the share of work for office workers will increase from about 5-10% before the pandemic to 30-40% after all restrictions will be lifted. We observe that in both organization about 50% of all employees working in an office environment plan to work from home at least once a week. Interestingly, the number of days per week each of those employees intends to work from home follows a uniform distribution. Whether this preference will be realized will obviously depend on the work from policies that the organizations will implement in future. Given the ever-improving software tools to facilitate remote work, the positive experiences many companies have made with work from home during the pandemic and the interest of employees to continue at least partially to work from home, it is fair expect that work from home will remain popular beyond the pandemic. Such change of travel demand has direct implications with regards to existing transport offers, in particular public transport.

First, most public transport commuters used flat fare season cards before the pandemic. Depending on the number of days each employee will work from home, the marginal cost paid for each commuting trip will increase and therefore make other modes comparatively more attractive. Commuting by public transport is more prevalent for office workers whose jobs tend to be in locations well served by public transport but offer only limited parking availability. Public transport operators have therefore started testing new subscriptions model that offer discounts when buying travel credits in advance, include price caps or allow to choose on which days the subscription is valid (Hoffmeyer, 2021). Given the limited validity of those new subscription offers, consequential effects must be expected with regards to mode and destination choice for non-work-related trips and should be studied by further research.

Second, companies might reduce parking restrictions as fewer people will commute to work but the number of available parking lot remains constant. In addition, congestion levels might remain at levels below the pandemic and hence make commuting by car more attractive.

Therefore, we expect a shift in modal split towards car while commuting traffic volume in general will drop in the short run.

Third, the new flexibility and reduced need to commute is expected to lead to rebound effects. There is plenty of evidence demonstrating that constant travel time budgets remained fairly constant both with respect daily and weekly travel over the last decades despite increasing travel speed and comfort levels (Metz, 2008; Stopher et al., 2017; Zahavi & Talvitie, 1974), although also significant variability in the travel-time budgets exist in different cities and among different person groups (Gallotti et al., 2015). Therefore, we expect people with the ability to work from home to adapt to the new normal by accepting work locations that are further away from home and a lower importance of accessibility in residential location choice. Furthermore, the attractiveness of second homes will increase as the working population will be able to spend more time there. The increased popularity of single family homes in agglomerations and apartments in touristic areas in Switzerland supports this argument (Handelszeitung, 2021). As a result, traffic demand will shift towards longer, less frequent trips. In total, this might lead to an increase in travel demand in the long run. This expectation is supported by an analysis of the Swiss Mobility and Transport Microcensus (MTMC) which showed that the mean distances travelled per week are 16% higher for Swiss full-time employees who telecommute (Ravalet & Rérat, 2019). However, given the decreasing demand for office space and increasing demand in the residential market might motivate real estate companies to retrofit office buildings into residential apartments. As those locations are often served well by public transport, this will result in more living space in environments with low car dependence which offers new opportunities for public transport and shared mobility providers.

The propensity to work from home is subject to a series factors including the job profile, company culture, personal attitudes, household composition, apartment layout. Travel duration by different modes of transport is therefore to be considered as just one of several aspects which influence whether and how many days per week people work from home. The data employed for the presented analysis was collected primarily to assess the environmental impact of commuting trips (FHNW) and the further develop mobility management measures (RDI), respectively. The analysis is therefore limited with regards to the factors that influence the propensity to work from home. Future research should include the full range of factors that

impact the decision to work from home and include questions concerning the availability of coworking spaces and other flexible work locations.

To capture work from home activities in travel demand models, further research is needed to identify model formulations that allow predictions based on variables that are already available in such models. Alternatively, one might need to add further variables and expand the functionality of those models to capture the most relevant effects such as different perception of distance in destination choice models and season card ownership. While we modelled how employees intend to switch of travel modes at the level of specific weekdays, other modelling approaches that employ the number of days people intend to work from home per week as dependent variable like the unimodal ordered probit model are potentially be better suited to explain the observed preference heterogenity.

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