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**The introduction of home-office during the pandemic: influences on mobility decisions and potential long-term effects**

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Table of contents

[1 Introduction 2](#_Toc103857042)

[Background 4](#_Toc103857043)

[2 Methods 4](#_Toc103857044)

[2.1 Tools 4](#_Toc103857045)

[2.2 Statistical Analysis Methods 6](#_Toc103857046)

[2.2.1 Linear Regression 6](#_Toc103857047)

[2.2.1.1 Simple Linear Regression 6](#_Toc103857048)

[2.2.1.2 Multiple Linear Regression 6](#_Toc103857049)

[2.2.2 Null-hypothesis Significance Testing 6](#_Toc103857050)

[2.2.2.1 P-value 6](#_Toc103857051)

[2.2.2.2 F-test 6](#_Toc103857052)

[2.3 Data Collection 6](#_Toc103857053)

[2.3.1 COVID-19 Community Mobility Reports 6](#_Toc103857054)

[2.3.2 Infas360 Corona Datenplattform 6](#_Toc103857055)

[2.3.2.1 Corona-Strength-Index 6](#_Toc103857056)

[3 Data Analysis 6](#_Toc103857057)

[3.1 Defining appropriate time periods 6](#_Toc103857058)

[3.2 Workplace change from the baseline over time for every state 6](#_Toc103857059)

[3.3 Home office restrictions imposed by the government for every state 6](#_Toc103857060)

[3.4 The correlation of workplace change with the change of visit and length of stay for various places compared to a baseline 6](#_Toc103857061)

[3.4.1 Comparing the correlations for specific time periods for specific states 7](#_Toc103857062)

[3.5 Analysing the relation between the strength of the correlation and population density for every state 7](#_Toc103857063)

[3.6 The correlation of the Corona-Strength-Index with the change of visit and length of stay for various places compared to a baseline. 7](#_Toc103857064)

[3.6.1 Comparing the correlations for specific time periods for specific states 7](#_Toc103857065)

[3.7 Comparing the influence of workplace change and the influence of the Corona-Strengh-Index with on the change of visit and length of stay for various places 7](#_Toc103857066)

[3.8 Using multiple regression analysis to predict the change of visit and length of stay for various places compared to a baseline 7](#_Toc103857067)

[3.8.1 Using workplace change and residential change to predict certain variables 7](#_Toc103857068)

[3.8.2 Using workplace change and the Corona-Strength-Index to predict certain variables 7](#_Toc103857069)

[3.8.3 Comparison 8](#_Toc103857070)

[4 Results 8](#_Toc103857071)

[5 Conclusion 8](#_Toc103857072)

[Table of figures 9](#_Toc103857073)

[List of tables 10](#_Toc103857074)

[List of abbreviations 11](#_Toc103857075)

[List of literature 13](#_Toc103857076)

# Introduction

The COVID-19 pandemic has had a substantial influence on how we structure our everyday life. Schools got closed, stores got closed, even workplaces had to be shut down amongst other measures in order to slow the spread of the contagious virus. Obviously, this had and still has a huge impact on our mobility choices. Several studies suggest that (Przybylowski, Stelmak, and Suchanek 2021; Borkowski, Jażdżewska-Gutta, and Szmelter-Jarosz 2021). In 2021, on January 19th, the federal government of Germany decided to impose a home office mandate, which states that employers are obligated to offer their employees the option to work from home. On April 21st 2021, the mandate got embedded in the German Infection Protection Act (IfSG) and in addition to that, requires employees to make use of the option to work from home if there is no reasons against it (Alipour et al. 2021, 4). There’s a broad consensus that after the pandemic there will be a hybrid world of work (Economist 2021; Alipour et al. 2021, 16). Still, the pandemic has led us to let the ongoing and ever progressing issue of global warming fade into the background. A study from 2021 analyzing the mitigation potentials of end-use sectors shows, that the transport sector, amongst the industry and building sector, contributes most to the mitigation of the climate change. This study estimated a total mitigation potential of 62 % for the transport sector, resulting in the reduction of a carbon dioxide equivalent of 5.8 Gigatons (Creutzig et al. 2021, 4).

Thus, of particular interest in this thesis are changes in mobility behavior in Germany, triggered by the pandemic especially associated with the introduction of home office in companies. In a future hybrid world of work with more and more people partly working from home, the conclusions for future mobility behavior and as a consequence thereof, reductions of emissions, could prove beneficial for slowing down the rate of global warming.

The main goal of this thesis is the identification of the various factors contributing to changes in mobility behavior resulting of working from home. The various factors I identified during the process of my research should be set into context of the “PDMD-Framework”, a framework, which presents a summary of factors contributing to travel decisions, and therefore helps to categorize the factors once they have been identified (Rojas López and Wong 2019).

The secondary goal is to draw conclusions from those factors contributing to mobility changes during the pandemic and transfer them to a future, non-pandemic world, as the concept of working from home is likely to stay in one way or another after the pandemic.

The research questions are therefore as follows:

* How did the introduction of home-office in Germany during the pandemic affect mobility decisions of individuals and what were the determining factors?
* What are potential long-term effects of mobility decisions made by individuals working from home in Germany in a future world without the pandemic?

In order to provide sufficient answers to those research questions, extensive data analysis has been the core of the thesis. In chapter 3.3, the origin of the data and the determinative variables are described and why the data proved useful for the thesis. In chapter 4, all data analysis is conducted. First, appropriate time periods for the main analysis will be introduced to prevent distortion in the later stages of the analysis. Next, the variable workplace change - a variable which indicates how often people traveled to their workplace compared to before the pandemic - is analyzed over time for the defined time periods in the years 2020, 2021 and 2022 to illustrate the increase of home office for several states in Germany. In addition to that, the strength of specific home office regulations imposed by the government over time will be shown. After the preliminary analysis, the first part of the main analysis is conducted, where workplace change is correlated with other mobility variables through means of simple linear regression for every state. Afterwards, the strength of the correlations for all variables will be compared for every time period between states to provide insights into how different states with different population densities reacted to the introduction of home office. Since the population density of a state is also an interesting factor to take into consideration, the influence of the population density of a state on changes in mobility decisions associated with workplace change are examined.

In the second part of the main analysis, the correlation of the Corona-Strength-Index – an index which indicates the strength of a measure imposed by the government - with other other mobility variables is examined again through means of simple linear correlation to gain insights into how the strength of various measures imposed by the state may affect mobility decisions. In the last part of the main analysis, multiple correlation analysis is performed to complement and broaden the insights gained in the previous analysis steps. Finally, in chapters 5 and 6, conclusions from the main analysis are drawn and set into context of the research questions. Also, possible implications of the conclusions for the future are provided.

# Background

Extensive research has been conducted on mobility behavior during the COVID-19 pandemic. One study conducted in 2020 in the polish city Gdansk shows, that the COVID-19 pandemic indeed had a significant impact on the traffic and modal split. According to this study, the use of sustainable traffic forms like public transport and shared mobility services have declined, whereas the use of private vehicles such as cars and bicycles and walking has increased (Przybylowski, Stelmak, and Suchanek 2021, 8). Another study conducted in England during the spring 2020 lockdown shows by analyzing mobile phone data, that a correlation between socioeconomic status and mobility reduction exists (Lee, Qian, and Schwanen 2021, 12). In 2021, the German research institutes ifo and infas released a paper in which research has been made on the use of home office during the COVID-19 pandemic in Germany. The study shows amongs others a survey conducted in the months January 2021 until June 2021, which identifies the rate of people working from home for each month. The study shows a particular high increase of people working from home since the start of the COVID-19 pandemic in Germany (Alipour et al. 2021, 4–8). However, no particular research has been made yet on examining the changes in mobility behavior of individuals working from home during the pandemic, especially compared with the mobility behaviors of those individuals before working from home.

# Methods

## Tools

The most important tool used for all data analysis in this thesis is R, which is a free software environment for statistical computing and graphics. R is a Free Software under the terms of the Free Software Foundations’ GNU General Public License and runs on a variety of platforms such as Windows or MacOS (R roundation n.d.). As for the IDE (Integrated Development Environment), RStudio has been chosen. RStudio includes a console, syntax-highlighting and an editor which supports direct code execution (RStudio 2022). It simplifies the development of R-scripts and displays important parameters right away. As shown in Figure 1, the main view is divided into four sections: A code section, a console section, an environment section and a plot section. This makes it possible to get feedback immediately when performing data analysis and therefore speeds up the process significantly. R proved especially useful for automating correlation analysis with different parameters and the subsequent visualization of the results, making it more flexible when changing those parameters. R also comes with a variety of packages which significantly reduce the workload when implementing complex scripts. The most frequently used R-packages used for this thesis were dplyr and ggplot2, which are all part of tidyverse, which in turn is a large collection of R packages. The package dplyr is an important library for data transformation, which was essential to get the data in the right form in order to visualize the data and draw conclusions from it. The package ggplot2 is a powerful library which enables the creation of a variety of graphs, including time series, scatter plots and linear trend lines.

Another tool used for analyzing purposes was Microsoft Excel in order to quickly verify data from tables generated with R scripts and draw conclusions before further processing and visualizing them back in R. Excel provides some handy features such as conditional formatting and advanced filtering, which makes it possible to swiftly change the perspective on the datasets without the need to implement complex R scripts on the first hand.

The last tools used for this bachelor thesis are Git and GitHub. While Git is a software used for tracking chances in for example software code, GitHub is a provider of internet hosting for services using Git. GitHub was used to safely store the R scripts and the data created from those scripts and to provide a platform for the submission of all R scripts created in the course of this thesis. A public git repository named aleksmaksimovic/bachelor\_thesis has been created for that purpose[[1]](#footnote-2).

Graphical user interface, application

Description automatically generated

Figure 1: RStudio IDE

Source: Author’s screenshot

## Statistical Analysis Methods

### Linear Regression

#### Simple Linear Regression

#### Multiple Linear Regression

### Null-hypothesis Significance Testing

#### P-value

#### F-test

## Data Collection

### COVID-19 Community Mobility Reports

### Infas360 Corona Datenplattform

#### Corona-Strength-Index

# Data Analysis

## Defining appropriate time periods

## Workplace change from the baseline over time for every state

*Hier würde ich mit Zeitreihen beschreiben bzw. visualisieren, wie sich in den Bundesländern verglichen zum Basiszeitraum die (physischen) Arbeitsplatzbesuche über die Zeit geändert haben.*

## Home office restrictions imposed by the government for every state

*Hier würde ich für ein paar Bundestaaten die Homeoffice-Restriktionen, welche von der Regierung beschlossen wurden, für die Jahre 2020, 2021 und 2022 visualisieren.*

## The correlation of workplace change with the change of visit and length of stay for various places compared to a baseline

*Hier definiere ich die Zeiträume und begründe, weshalb ich diese Zeiträume für meine Analysen als sinnvoll empfinde.*

### Comparing the correlations for specific time periods for specific states

*Hier zeige ich die Ergebnisse meiner Korrelationsanalysen the Variable workplace\_change mit den anderen Variablen und zeige Auffälligkeiten.*

## Analysing the relation between the strength of the correlation and population density for every state

*Hier möchte ich zeigen, wie sich die Korrelationen der einzelnen Variablen in Abhängigkeit der Bevölkerungsdichte des Bundeslandes verhalten und Auffälligkeiten aufzeigen.*

## The correlation of the Corona-Strength-Index with the change of visit and length of stay for various places compared to a baseline.

*HIer möchte ich nun den Corona-Strenge-Index korrelieren mit den jeweiligen Variablen.*

### Comparing the correlations for specific time periods for specific states

*Ich werde hier die Zeiträume wieder für die Korrelationen miteinander vergleichen und Auffälligkeiten aufzeigen.*

## Comparing the influence of workplace change and the influence of the Corona-Strengh-Index with on the change of visit and length of stay for various places

*Hier möchte ich demonstrieren, dass die Variable workplace change viel stärker korelliert mit den jeweiligen Variablen als der Corona-Strenge-Index, was auch mit dem „new normal“ zusammenhängt.*

## Using multiple regression analysis to predict the change of visit and length of stay for various places compared to a baseline

*Hier würde ich es nochmal mit multipler Regression versuchen um zu schauen, wie sich die Korrelationen verhalten wenn ich mehr als eine Variable verwende, um den Einfluss auf eine andere Variable zu erklären. Den Abschnitt 4.7 würde ich aber eher kurz halten, möchte damit aber nochmal interessante Sachzusammenhänge aufzeigen.*

### Using workplace change and residential change to predict certain variables

### Using workplace change and the Corona-Strength-Index to predict certain variables

### Comparison

*Hier würde ich nochmal meine multiplen Korrelationsanalysen grob miteinander vergleichen und beurteilen.*

# Results

*Hier kommt die Interpretation meiner Ergebnisse.*

# Conclusion

*Hier habe ich vor, meine Ergebnisse nochmal kompakt zusammenzufassen und vor allem verstärkt mit meinen Forschungsfragen in Zusammenhang zu bringen. Ich hier nochmal verstärkt auf meine letzte Forschungsfrage eingehen „potential long term effects on mobility decisions“.* *Bei meinen Datenanalysen sind mir einige Trends aufgefallen, und die möchte ich hier nochmal kurz erläutern, da diese eventuell Aufschluss geben können über zukünftige Entwicklungen und eventuell einen Outlook geben.*

# Table of figures

[Figure 1: RStudio IDE 5](#_Toc103701169)

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# List of tables

[Tabelle 1: Beispieltabelle 2](#_Toc449012846)

# List of abbreviations

(Abkürzungen in alphabetischer Reihenfolge einfügen)

Abk. Abkürzung

…

# List of literature

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1. https://github.com/aleksmaksimovic/bachelor\_thesis [↑](#footnote-ref-2)