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Travel behaviour of self-employed workers in the Netherlands: Differences in leisure travel and commutes

Master's Thesis

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Abstract

Over the past two decades, the proportion of self-employed workers within the working population has grown markedly in the Netherlands, as well as in many other European nations. Despite this shift, there has been limited research into the travel behaviors of the self-employed, particularly concerning leisure travel and transportation mode choice. This study addresses this gap by analyzing aggregated and trip-level data from the Netherlands Mobility Panel for the years 2017-2020. The posed research question is, "How do commute and leisure travel behaviors of self-employed workers in the Netherlands differ from those of employed workers?" The empirical findings not only corroborate existing literature on commute travel behavior but also reveal that self-employment is significantly associated with an increased preference for car usage, both for leisure and commuting. Furthermore and very interesting, they provide weak evidence suggesting that being self-employed results in more kilometres and time spent traveling by car for leisure.

Table of Contents

List of Tables

1. Introduction

Technological advancements and societal shifts are continuously changing the working world, allowing for new ways of working but also demanding an increased flexibility for fast adaption to new developments and events. The covid-19 epidemic from 2020 until 2022 has disruptively put another level of pressure on the adaptive capabilities in the work environment, where large part of the administrative working population in the Netherlands, but also in many other European countries and the USA, was recommended by the government to work at home when possible. In the Netherlands, this recommendation was extended by an obligation to work from home for couple of weeks in October 2020 (Bird & Bird LLP, 2021). While many individuals found working from home challenging, especially when lacking the necessary infrastructure or children in the household are not allowing for a focused environment, others appreciated the arrangement because of an increase in work autonomy, because it allowed for a more flexible integration of the workload into their daily life. Before the epidemic, literature suggested that in average the work autonomy was declining for employees in the European Union since 1995 (Lopes et. al., 2014). Contemporaneously, there is another trend which can be observed since 2000, the increasing share of self-employment in the working population. Self-employment is typically characterized by greater work-autonomy since business decision, regarding workload, timing, place of work and procedure are more influenced by the self-employed-workers themselves. Given the potential for a more diverse work-schedule and the consequently increased flexibility in leisure-time, differences in travel behavior between self-employed people and employees seem very likely, impacting both, the leisure and commute travel behavior. The relevance of these differences in travel behavior become clearer when looking at data from the European Commission. The data shows that self-employment in the European Union increased by 13.6 % from 2000 to 2017, outpacing the growth of overall employment, which rose by only 9.8% during the same period (European Commission, 2019). Similarly, in the Netherlands, the proportion of self-employed individuals within the working population has almost consistently increased, rising from 12.2% in 2003 to 16.4 % in 2020 (CBS Statline, n.d.). Apart from an increased work-autonomy, reduced effective travel costs by car are another factor of self-employment which may have an influence on the travel behavior. With the ability to declare travel costs by car, but also the initial purchase of a vehicle, as tax relevant expanses, self-employed people might face lower effective travel costs

by car for business related trips but also for leisure trips, due spillover effects, when the purchase of a car and the maintenances costs are declared as business expanses.

Considering the hypothesized features of self-employment and looking at the trend of a rising proportion of self-employed people in Europe, important questions for policymakers arise: How will the travel behavior patterns of citizens change in the future? Furthermore, how can effective policies be designed to address the spatial challenges in urban areas caused by motorized individual traffic? One approach to address these questions is to analyze the travel behavior of self-employed individuals, specifically differentiating between commute and leisure travel, unveiling informative patterns of travel behavior. Therefore, the aim of this study is to scrutinize associations of self-employment with travel behavior indicators and to provide answers to the main research question "How do commute and leisure travel behaviors of self-employed workers in the Netherlands differ from employed workers?

To the best of knowledge at the time of writing this thesis, the travel behavior of self-employed individuals, regarding both, leisure and commute travel, has only been examined in the literature by Shin (2019) through a case study in the USA. While differences in commuting have been theoretically and empirically discussed in other studies, such as by Van Ommeren & van Straaten, (2008), Giménez-Nadal (2020) and Albert et al. (2019), the general finding is that self-employed people tend to have in average shorter commutes.

The empirical analysis of this study employs the Netherlands Mobility Panel of the years 2017-2020 for its investigation on the research question. It explores the relationship between self-employment and the travel behavior for leisure and commute travel regarding the following indicators: average trip frequency, trip length, kilometer and time travelled. Given the importance of individual motorized travel in the research field of travel behavior and its relevance for policymakers, this study extends its analysis to the relationship of self-employment with the car-travel indicators kilometer and time travelled by car and transport mode choices for leisure and commute purposes. The analysis of car-travel in this work is suggesting some interesting evidence for a positive association of self-employment and the car-usage for leisure and commute travel. Although weak in significance, there's also evidence pointing to an increase in kilometers and time travelled by car for leisure among the self-employed. In this thesis, both results are hypothetical

explained by the reduced effective travel cost by car and increased work autonomy of self-employed people. However, evidence for causality is not provided.

The remainder of this paper is organized as follows: First, the theoretical framework of this study is described. It begins with a literature review on self-employment and travel behavior. This is followed by an explanation of the hypothesized factors of self-employment, work autonomy and reduced travel costs, which are suspected to impact the travel behavior. The expected relationship of the hypothesized factors and self-employment with the travel behavior indicators is discussed in that section. After that, a brief overview of the influence of the built environment and important socio-economic factors on travel behavior is provided. The next section describes the research design and the data utilized for the analysis. The main results are then shown in the part of the empirical analysis, which contains descriptive statistics and regression analysis of the travel behavior indicators. This part is followed by a chapter discussing the results and linking them to the expected relationship and hypothesized factors described in the theoretical framework. The next chapter then addresses the important limitations and is followed by an outlook on future research on this topic. After that, the conclusion is briefly summarizing the key findings of this study.

2. Theoretical Framework

Determines of travel behavior have been researched exhaustively in the last couple of decades to provide useful insides for urban planners and policy makers. The main factors can be divided into two major categories, the built environment, and the socio-economic factors. The built environment describes the infrastructure people are confronted with when they travel. This category contains mostly approximative variables which describe the connectivity and accessibility from start to end of the travel. The socio-economic factors on the other hand, contain the individual specific characteristics, like income, education or the age which have been evidently shown to be associated with travel behavior. In the latter, the employment status is an important factor for work and leisure travel behavior (Lucas et. al., 2016; Simma & Axhausen, 2003). In the main body of literature, the status usually only indicates different occupation status like employed, full-time, part-time, retirement, unemployment, housework, student. Instead of looking at difference in travel behavior across these statuses, this research is examining difference among the supposedly most substantial group – the active working population. In particular, the study focuses

on the two main types of employment in society, self-employment and employed by an employer, aiming to explore the travel behavior characteristics associated with self-employment.

The subsequent part begins with a brief definition of self-employment in the context of the research and continues with an overview of studies related to self-employment and travel behavior. After that, the hypothesized reasons for expected differences in travel behavior between self-employed people and employees are explained, representing the motivational foundation for this comparative analysis. This is followed by a literature review on other important determinates of travel behavior, grouped into the built environment and socio-economic setting.

Literature review self-employment and travel behavior

In this study, self-employment is categorized as a legal status, similar in most other European countries, which is different from salary dependent employment by the fact, that self-employed people work solely for themselves and have the responsibility to declare and pay taxes for the turnover of business or professional activities and to declare and pay income taxes by themselves.

Several studies focusing on Europe show, that the average commuting distance and duration is significantly shorter for self-employed people than for employees. Albert et al (2019) using a large Survey on Quality of Life at Work with N=30.900 show that the average length of commutes in Spain is in average 19% shorter when the person is self-employed. Giménez-Nadal (2020) find in their study using the European Working Conditions Survey from 2015 an average shorter commuting trip by 18.6 (male) and 24.7 (female) minutes associated with self-employment in Western Europe. Van Ommeren & van der Straaten (2008) find similar results for the Netherlands and further attribute the differences to search-imperfections for employment and for commercial space, where the latter is in average a less competitive market and easier to find close to home. Evidence that self-employment is also impacting travel for leisure can be conclude from Kuppam & Pendyala (2001), who conducted a case study among commuters in Washington DC (USA), showing the trade-off nature between time spent at work and commuting and other out-of-house activities. They also show the complementary nature of some activities which have the criteria for so called trip-chaining, for example making groceries on the way back home after work. Considering the difference in commuting behavior of self-employed people described before, self-employment is likely to affect leisure travel too. While the relationship with commuting and employment status has been researched to a certain extent, a comprehensive picture including the

effects on leisure travel has been scarcely provided by literature. At the time of writing this research only Shin (2019) was found to have researched leisure and work-related travel of self-employed people in a case study around Seattle (USA). For that study, the author utilized a travel diary survey made in 2014, collecting travel data of a 24h period (weekday) of the participants of the region. The author divides the sample into commuters and from-home workers. The results show, in line with the studies mentioned before, that the commuting distances are shorter for self-employed people than for employees. The picture for leisure travel patterns is more complex showing for non-commuters a shorter trip distance for self-employed people. The author also shows that the time-distribution (departure time) of the trips made during a day are different. Among commuters, employees made relatively more work-related trips during peak hours (6-9 and 16-19) than self-employed, while during the off-peak-hours self-employed people made relatively more trips. Self-employed commuters make more leisure trips in the morning peak-hours and during the day, whereas employees make more leisure trips during the evening-peak. Surprisingly this pattern doesn't hold for non-commuters, where the self-employment status doesn't show a clear association with the trip schedules. Overall, the expected increased flexibility of self-employed people leads to significant association between self-employment and travel times for a certain extent, in the case the person is not working from home. Regarding the travel mode choices, the study suggests a decreased likelihood for using public transport for commutes for self-employed people. A potential explanation by the author is the lack of commuter benefit programs for self-employed people in comparison to their employees, which give incentives to use alternative modes of transport. Apart from this study, there is no further study found exploring the transport mode choices for self-employed people for leisure and work-related travel found at the time of writing this thesis.

Hypothesized factors of self-employment

Work autonomy

With the obligation to be fully responsible for all business activity and taxes declaration comes along an in average increased work autonomy. An attempt to define work autonomy in the field of organization behavior and employees is made by Hackman & Oldham (1976) defining it as "The degree to which the job provides substantial freedom, independence, and discretion to the individual in scheduling the work and in determining the procedures to be used in carrying it out." Studies have shown, that increased control and autonomy is an important factor for people

becoming self-employed (Van Gelderen & Jansen, 2006; Feldman & Bolino, 2000) and are often, as revealed in panel surveys across several European countries, main reason for higher job-satisfaction (Lange, 2012; Benz & Frey, 2004 & 2008b). In a more fine-grinded analysis, comparing the relative share of satisfaction in specific job dimensions within the overall job satisfaction, Benz & Frey (2004) can show that in Western Europe the job dimension "Autonomy" is responsible for the largest share of the difference in satisfaction. The results are based on the analysis of the answers to the survey question "I can work independently". This is in line with the psychological perspective of Deci & Ryan (2000), who argue that the psychological needs for competence, autonomy, and relatedness are important factors for motivation, performance, and overall well-being. For the travel behavior mainly the increased freedom in scheduling of the work and in choosing the place of work is assumed to have an impact travel behavior. Especially avoiding rush-hours is suspected to deter the travel behavior regarding the travelling hours for commute trips as shown in the case study by Shin (2019). Trip frequencies for commutes and leisure is also suspected to be higher, since a "deblocking" of working hours allows to split up classical 8 hours of work in smaller time-units like four-times two hours. This possibility could lead self-employed people to a more time and cost - efficient combination of leisure and work activities. In line with Shin (2019) and Van Ommeren & van der Straaten (2008) the average trip length for commutes is expected to be shorter for self-employed people, because of the autonomy of choosing the place of work and the more favorable market-situation for commercial space compared to finding work close to one's home. For leisure trips, the increased freedom to schedule the work is expected to have a positive influence on the average length of leisure trips. By here called "blocking" of leisure time, for example taking off for a complete afternoon on one day and compensating it with longer working hours on other days, leisure activity further away become available for integration even during the week, which could lead self-employed to make in average longer leisure trips during the week. Consequently, the average time and kilometers travelled, which is the product of the average trip length and the average trip frequency, is expected to be higher for leisure travel, since both composing factors are expected to be positive correlated with self-employment. For commuting purposes, the expected direction of the average time and kilometers travelled associated with self-employment is not clear since the expected length of commute trips is shorter, but the frequency is expected to be higher. Since being self-employed is likely to come along with larger independence of scheduling, it is expected that the car as transport

mode has an increased attractivity for commute and leisure travel as modal choice since it enables to utilize and leverage this flexibility even more. This comes along with an expected increased kilometers/time travelled by car and likeliness for car-ownership.

Reduced travel costs by car

Another hypothesized impact on the travel behavior of self-employed people could be the reduced effective travel costs by car due to declaration of travel and business expenses in the tax declaration. Although the declaration of business expanses is officially only valid for work-related travel under Dutch tax-law, the tax-relevant fix and purchase costs of the vehicle do also decrease the effective cost per kilometer when the vehicle is used for leisure travel. This leads to a suspected increased car ownership and likeliness to use the car as transport mode, also for leisure travel. The hypothesis, that self-employed people have more kilometer and time travelled by car, especially for leisure purposes, has so far not been not scrutinized in literature as best of knowledge at the time of writing this thesis. The impact of reduced effective travel costs by car on the trip frequency, length and total kilometers/time travelled with all modes of transport seems to be more complex. Hypothesizing on these associations is suspected to contribute more to the question of how car-usage influences these travel pattern indicators, which is not part of this research and therefor left out. The following table 1 shows the expected impact of self-employment on travel behavior and the hypothesized factors.

Table 1: Hypothesized factors of self-employment and expected association with travel behavior

Hypothesized factors of self-employment	trip frequency		trip length		kilometers/time travelled		kilometers/time travelled by car		Modal Choice: Car		Car Owner-ship
	commute	leisure	commute	leisure	commute	leisure	commute	leisure	commute	leisure	
Increased work autonomy	+	+	-	+	?	+	+	+	+	+	+
Reduced effect. travel costs with car							+	+	+	+	+
Expected association with self-employment	+	+	-	+	?	+	+	+	+	+	+

Literature review of the built environment

The impact of the built environment on travel behavior on the contrast has been studied exhaustively. For the Netherlands Schwanen et al. (2004) evaluated the impact of the urban form on the Dutch travel behavior using the "Netherlands National Travel Survey" from 1998, looking at modal split, commuting distances, and travel for shopping. With a comparison of different urbanized cities and regions in the Netherland, they show that a higher urbanization is associated with a decreased commuting time, distance, a lower share of car commuters and an increased share of cycling and public transport for commutes and shopping travel. This is in line with the Meta-analyses on published studies about the associations of built environment and travel behavior provided by Leck (2006) and Ewing & Cervero (2010). The composing factors of the built environment are organized in an approach by Cervero & Kockelman (1997) into the three D's: density of population and employment, diversity of land-use and design of urban area (pedestrian friendliness). Based on travel trip surveys from the US, the authors find marginal, but significant negative associations of density, diversity and design with a households' miles travelled with a motorized vehicle (VMT), and positive ones with the probability of non-motorized travel mode choices. In a later study review of the same author, destination accessibility and distance to public transport are added as major factors to the organizational framework of influencing factors of travel behavior (Ewing & Cervero, 2010). This later review shows in line with the earlier work, that the built characteristics have significant but weak associations, in terms of magnitude, with the average vehicle miles travelled and the transport mode choices for walking and public transport, which is also found in a study by Ding et. al. (2017) using the 2001 National Household Travel Survey (NHTS) in the region of Baltimore. Nevertheless, the authors find the strongest association upon the examined factors for the accessibility of a destination and vehicle miles travelled, while walking as transport mode has the highest correlation with diversity of land-use and public transport the highest correlation with the proximity to transit. Furthermore, the review shows, that when for different built environment criteria controlled, the job density shows the weakest association with vehicle miles travelled and the transport choices walking and public transport. Ding et. al. (2017) furthermore finds a significant negative association of distance to transit and using public transport and walking. They also show that the street-network design, in terms of number of intersections per area, also has a significant positive association with the probability of non-motorized travel. These results are in line with the earlier meta-analyzes study of Ewing & Cervero (2010) who find a negative association of vehicle miles travelled with increased number

of intersection density in the analyzed studies. Summing up, the literature provides evidence that the vehicle miles travelled and transport mode choice are influenced by the built environment, which is a made up of different categories, each not strong in magnitude isolated but of increased importance in combination. Sun et. al. (1998) find in line with the other authors, a negative association of population density and vehicle miles travelled, but cannot find significant association of population density and land diversity with number of trips made. They suggest, based on their results, that land use policy is more likely to affect more the total vehicle miles travelled than the number of trips made.

Literature review on socio-economic factors

The patterns of socio-economic characteristics for travel behavior and have been also exhaustively researched. Literature shows almost uniformly that being female is negative associated with the average trip distance for commutes in Europe and the US (Turner & Niemeier (1997), White (1986), Sandow &Westin (2010), Schwanen et. al. (2004). Lu & Pas (1999) show additionally a positive association with trip frequency. Ng & Acker (2018), Sandow &Westin (2010) and Limtanakool et al. (2006) also show that the likeliness of using public transport is higher for woman. Income seems predominantly to be positive associated with commuting distance, especially for men, as Sandow & Westin (2010), Turner & Niemeier (1997) and White (1986) show in their case studies from Sweden and the USA. The car usage also seems to be positive associated with income as Dielemann et. al. (2002) show in a case study from the Netherlands. Theoretical explanations for the income effect on commute travel are manifold and scrutinized by urban economist. The most famous and simplest explanatory model is the standard monocentric city-model, in which utility rises with more consumed space for housing and decreases with commuting costs. The prices per sqm are assumed to be in average lower in less densely populated areas, away from the business district. Having a larger budget overall, high income people can effort higher commuting costs and contemporaneously utilize cheaper prices per square meter in the outskirts of the city, which enables them to maximize their utility by consuming more housing space while allowing for a certain increase in commuting costs. Nevertheless, this model is of course an extreme simplification and more complex models have emerged and discussed among urban economists (Gordon, Kumar, & Richardson, 1989). In literature from the Netherlands the impact of higher education (at least college degree) on travel behavior is a bit contrasting. Dieleman et al. (2002) find a positive association with the likeliness to use the car for commuting

and leisure trips, and a negative with the total distances travelled by car for leisure and work. On the contrast, in a more restricted binary choice model with only modes car and train, Limtanakool et al. (2006) find a different pattern. Here, higher education is positive associated with the probability to use train instead of car. In their work about impact of education on travel behavior in the Netherlands, Groot et al. (2012) find supporting results for Limtanakool et al. (2006), showing that education is positive associated with commuting time and distance and the propensity to use more public transport and bicycle. A provided explanation is, that higher educated people are likely to commute more into higher agglomerated areas, where accessibility by public transport is increased. Having children living in the household seems be strong and highly correlated with an increased use of car in the modal split, for leisure and commute (Dieleman et. al., 2002). A logical explanation offered by the authors for this observation, is the increased time pressure and stricter schedule for the workers to choose car over public transport and the effortful navigation with children for shopping and other leisure activity with other transport modes. The number of working hours per week and from home is also very likely to have an influence on the workers travel activity scope, since it directly impacts the time budget a person has available. The age is also very likely to have an influence because of the activity level correlated with the age of a person. By sharing housework duties like doing groceries, the number of people living in a household is also suspected to have an influence on travel behavior.

The examination of the difference in travel behavior of self-employed people can provide useful insights for policy makers to make effective policies for urban mobility, for example for the contribution to the goal of reducing motorized individual traffic. The self-employed people are a non-marginal share of the working population in the Netherlands and are easy to determine for the government, which makes them a relevant and suitable group of the population to address with policies. In this thesis, the differences in travel behavior are theoretically discussed by the hypothesized factors, work autonomy and reduced effective travel cost by car. Although the research method doesn't allow for any causality claims, the results may incentivize further research to pay attention on the influence of these factors.

3. Research Design and Data

Research Approach

The main objective of this thesis is to research the difference in travel behavior of self-employed individuals in the Netherlands. For this purpose, a comparative analysis of the travel behavior, based on average trip length, frequencies, kilometers and time travelled, kilometers and time travelled by car and transport mode choices by travel motives of self-employed individuals is conducted. Furthermore, the likeliness of car-ownership is examined. The empirical approach uses descriptive analysis, two-part models, including logit -regressions for the first part and ordinary least squares (OLS) -regressions for the second part, and a multi-nominal logistic regression for the transport mode choices. All models have controls for socio-economic factors and the built environment.

Database and Sample

The Netherlands Mobility Panel (MPN), which is employed for this work, is designed for studying trends in travel behavior of a fixed group of people over long time to provide insights for policy makers on effects of policy changes (Netherlands Institute for Transport Policy Analysis (KiM), n.d.). The datasets of the MPN are built upon yearly surveys gathering information about a person's and household's characteristics and a three consecutive day trip diary, in which participants record trip data on these days (24h) and further characteristics and events of the recorded days, for example weekend or weekday, illness, or other. Although the MPN is available for the years 2013 until 2020, only the years 2017 until 2020 are employed for this work, since before that, no information about a household's income were recorded. Before data cleaning for completeness, depending on necessary variables and further restrictions, 13,038 individuals are in the dataset.

For the exploration of the travel behavior, the trips recorded by the participants are grouped by two different travel-motives: travel for work and travel for not work-related purposes which will be referred to as leisure travel in the following. The work-related trips are further subdivided into commutes, which are defined as trips to or back from work, and work-related trips, which are exclusively trips made from work to work. Most trips are made for commute and leisure purposes, a lot smaller fraction for work-related trips. Assuming that work-related trips are less influenced by the built-environment and socio-economic factors but the job characteristics, the analysis focuses on commute and leisure trips only. The trips of the participants of the MPN data in this

analysis are restricted to workers over the age of 18. Consequently, volunteering, retired, unemployed and house working people are removed from the dataset. In addition, people who declared transportation as part of their occupation are furthermore removed, since their travel behavior is very different and hardly comparable. Trips with a negative trip length or a z-score, meaning the trip length subtracted by the sample mean and divided by the standard deviation in the sample, of above 10 are also removed (104 trips), since these trips are regarded as outliers. Furthermore are trips removed which have a negative or zero trip distance (10 trips) or trip duration (6 trips). The remaining observations only contain people who declared to be self-employed or employed. There are no people remaining in the dataset who declared to have more than one job and to be self-employed and employed at the same time. All analysis, apart from the multinominal logistic regression model for the transport mode choices, use aggregated data. To guarantee that all recorded days and years of the panel (one wave represents one year between 2017 and 2020) are equally weighted, the aggregation is performed by estimating daily averages, yearly averages, and averages by individual, in this explicit order. The aggregated sample then consists of 3380 observations, each representing one individual. In this sample, 245 people have stated to be self-employed in at least one year of the survey.

4. Empirical Analysis and Results

Descriptive Analysis

The following table 2 provides an overview of the differences in characteristics of self-employed people in the sample regarding the socio-economic factors and the built environment. A more detailed description of the explanatory variables can be found in the table A1 in the appendix.

Table 2: Descriptive statistics of socio-economic factors and built environment

	self-employed	**employed**	**differences**
Explanatory Variables			
Children in household	0.31	0.24	-0.07**
Female	0.46	0.52	0.05
Academic (at least academic degree)	0.51	0.43	-0.08**
Young (18-29)	0.11	0.18	0.07***
Adult (30-59)	0.73	0.73	0.01
Old (60-79)	0.16	0.08	-0.08***
Household Income - low	0.15	0.14	-0.02
Household income - average	0.51	0.61	0.09***
Household income - high	0.33	0.26	-0.08**
Number of people in household	3.02	2.80	-0.22**
Working hours	35.73	33.85	-1.88*

Working hours from home	13.79	3.70	-10.09***
Distance to next public transport	3.80	3.55	-0.25
Population density - low	0.30	0.29	-0.00
Population density - moderate	0.18	0.17	-0.00
Population density - high	0.53	0.54	0.01
Driving license (car)	0.96	0.95	-0.01
Vehicle (car or van)	0.89	0.87	-0.03
Motorized (car/van and motorbike)	0.89	0.88	-0,02
Observations (individuals)	220	3135	3355

Note:*, ** and *** denote statistical significance at the 10%, 5%, and 1% levels respectively of the conducted t-test. 25 People who have switched their employment status between 2017 and 2020 are excluded from the descriptive statistics but retained in the data for the regression analysis in the following part. The total number of individuals in the data set used for the regression analysis are 3380 people.

Regarding the socio-economic factors, the share of self-employed people in this sample living together with at least one child in the household is significantly higher than among employed people. The share of people with an academic degree is also increased among self-employed people. The age structure shows also significant differences, where the share of young people among the self-employed is smaller, but larger of older people. The income structure is also significantly different, showing that the share of high household income is larger among the self-employed people, whereas the share of average household income is smaller. Furthermore, self-employed people tend to live in average with significantly more people in one household and work significantly more hours from home than employees. On the other hand, there are no significant differences in the built environment between the two groups regarding the distance to the nearest public transport station and the population density in the residential areas. Other explanatory variables like the possession of a vehicle (car &van), being motorized (car, van and motorbike) or having a driving license show no significant differences between the two groups.

The conditional descriptive statistics for leisure and commute travel behavior is shown in table 3. A commute is defined as a trip to or from work, where as a leisure trip is regarded as every other trip apart from commutes and trips made from work to work. To be a commuter in this sample, a person must have recorded at least one commute trip, whereas a person must have recorded at least one leisure trip to have leisure, accordingly. In the sample, commuters are significantly less common among self-employed people (59 %) than among employees (87%). Having leisure shows no significant difference between the two employment types. All descriptive statistics in the table on commute and leisure travel are conditional on being a commuter or having a recorded at least

one leisure trip, respectively. The descriptive statistics about trips by car are accordingly conditional on that at least one trip was made by car for the according travel purpose.

The trip frequencies of commutes of self-employed people, among commuters, is significantly fewer than among employed commuters. For the trip length, self-employed people do commute significantly shorter per trip in terms of time. On weekends self-employed people travel longer per trip in terms of time and distances for leisure purposes, but the difference is only significant at the 10% level. The kilometers and time travelled, which is calculated by a multiplication of the daily averages of trip frequencies and distances/times, show, that self-employed people travel in average significantly less time in total and for commute compared with employees. The indicators of kilometers and time travelled by car also show bigger differences. Here self-employed people travel significantly more distance and time by car in total combined regardless the purposes, although the difference in kilometers is only significant at the 10 % level. Furthermore, do they travel significantly more kilometers and time by car for leisure purposes overall and on weekends, although the overall kilometers travelled by car regardless the purpose and the time for leisure travel on weekends are only significant at the 10 % level. Concluding the most important findings from this descriptive statistics analysis, self-employed people in the sample travel less often and shorter for commutes. Leisure travel shows more significant differences on weekends and also for kilometers and time travelled by car.

Table 3: Conditional descriptive statistics of travel behavior indicators

	self-employed	**employed**	**differences**
Dependent variables (as daily averages per person; trips in frequencies; distances in kilometers; time in minutes)			
commuters (at least one commuting trip recorded)	0.59	0.87	0.28***
commuters - car (car used at least once for commutes among commuters)	0.82	0.73	-0.09**
leisure (at least one leisure trip recorded)	0.95	0.93	-0.02
Leisure (car used at least once used for leisure trip among leisure)	0.87	0.86	-0.01
weekdays (share of recorded weekdays)	0.72	0.74	0.02
frequencies			
trips	3.56	3.64	0.08
trips - commute	2.12	2.33	0.21**
trips - leisure	3.21	3.21	-0.00
trips - weekday	3.68	3.77	0.08
trips - weekend	3.21	3.41	0.20
trips - weekday - commute	2.17	2.35	0.17
trips - weekend - commute	1.82	2.02	0.21

trips - weekday -leisure	3.18	3.20	0.02
trips - weekend - leisure	3.21	3.36	0.15
lengths			
Distance	17.59	17.61	0.02
Time	28.69	27.58	-1.11
Distance - commute	19.94	22.24	2.30
Time - commute	26.04	30.70	4.65**
Distance - leisure	15.14	13.56	-1.58
Time - leisure	26.62	24.12	-2.51
distance - commuting - weekday	20.22	22.54	2.32
time - commuting - weekday	26.24	31.04	4.80**
distance - commuting - weekend	12.00	16.43	4.43
time - commuting - weekend	16.62	24.09	7.48**
distance - leisure - weekday	11.57	11.67	0.10
time - leisure - weekday	23.16	22.07	-1.09
distance - leisure - weekend	21.35	16.99	-4.36*
time - leisure - weekend	32.65	27.89	-4.76*
kilometers/time travelled (= length * frequency)			
kilometers travelled	55.25	63.04	7.79
time travelled	87.43	100.20	12.76**
kilometers travelled - commute	45.85	59.49	13.63
Time travelled - commute	58.35	85.77	27.43***
kilometers travelled – leisure	43.16	41.89	-1.27
Time travelled - leisure	73.78	72.77	-1.01
kilometers travelled – commute - weekday	47.60	60.82	13.21
kilometers travelled - commute - weekend	19.73	35.00	15.27**
time travelled - commute - weekday	60.10	87.62	27.51***
time travelled - commute - weekend	27.56	53.16	25.60***
kilometers travelled - leisure - weekday	31.78	36.66	4.88
kilometers travelled - leisure - weekend	60.80	53.20	-7.60
time travelled – leisure - weekday	63.45	67.66	4.21
time travelled – leisure - weekend	91.40	85.36	-6.04
kilometers/time travelled by car/van			
kilometers travelled – car	63.59	56.33	-7.27*
time travelled – car	77.98	68.49	-9.49**
kilometers travelled – commute – car	45.48	47.06	1.58
Time travelled – commute – car	54.62	55.47	0.84
kilometers travelled – leisure – car	53.95	45.85	-8.11**
Time travelled – leisure – car	66.03	57.53	-8.50**
Kilometers travelled - weekday – commute – car	47.62	47.70	0.08
Kilometers travelled - weekend – commute – car	22.70	34.89	12.19*
Kilometers travelled - weekday – leisure – car	37.60	39.65	2.05
Kilometers travelled - weekend – leisure – car	74.82	57.54	-17.29**
Time travelled - weekday – commute – car	56.54	56.16	- 0.38
Time travelled - weekend – commute – car	29.57	42.30	12.73**
Time travelled - weekday – leisure – car	51.24	52.97	1.74
Time travelled - weekend – leisure – car	81.07	66.92	-14.16*
Observations (individuals)	220	3135	3355

Note:*, ** and *** denote statistical significance at the 10%, 5%, and 1% levels respectively of the conducted t-test. The depending variables are conditional, meaning for commutes and leisure travel only individuals with at least one trip in the respective category were considered. For kilometres/time travelled by car, additionally only individuals were considered who have at least one trip with car in the respective travel purpose category. An example for illustration: The unconditional amount of people travelled with car for leisure in the dataset is the number of self-employed individuals (220) x the share of individuals with at least 1 leisure trip (0.95) x the share of people with at least one car trip for leisure purposes among the people with leisure trips recorded (0.87) = 182 individuals. Not considering the 25 people who switched their status.

Table 4 shows the descriptive statistics of the transport modes used for travel of the two groups. Noticeable hereby is a strong discrepancy between the two working types in the relative share of car as transport modes for commuting trips. Self-employed people use the car for commuting relatively more often with 65.23 % of all commuting trips, whereas employed people only have a relative share of 51.43 %. The difference in the usage of public transport is accordingly similar big, but the other way round, where the share for commute trips is 19.06 percentage points lower among self-employed people than among employees. Less of a difference can be found in the share of commuting trips by bikes, where self-employed people have 4.88 percentage points less than the employees. The discrepancy in walking is quite large, where the "walking share" of the commute trips is with 12.31 almost 10 percentage points higher among self-employed. This observed pattern could be supported by the theory of Van Ommeren & van der Straaten (2008), which suggests an easier search for commercial space than for work, which makes the distance of the working place and home smaller for self-employed people since they can choose the workplace (or commercial space) more freely closer to their home. For leisure trips the statistical differences are a lot smaller, where the leisure trips by car with a share of 54.82 % among self-employed and 51.86 % among employed people have the biggest difference.

Table 4: Descriptive statistics of travel by transport modes

Transport mode by purpose	**self-employed**	**employed**	**sample**
commute trips in %			
Car	65.23	51.43	52.06
Public transport	5.25	24.31	23.44
Bikes	16.87	21.75	21.53
Walking	12.31	2.35	2.81
Other	0.34	0.15	0.16
Observations (trips)	**1,162**	**24,078**	**25,240**
leisure trips in %			
Car	54.82	51.89	52.09
Public transport	5.47	6.82	6.73
Bikes	20.65	21.52	21.46
Walking	18.80	19.44	19.40
Other	0.26	0.33	0.32
Observations (trips)	**3,526**	**49,472**	**52,998**

Note: The transport modes are grouped as the following: car = car/van/motorbike; public transport = bus, tram, train; bikes = bicycle, e-bike, moped (max 45 km/h), scooter (max 45 km/h), pedelec (max 45 km/h); walking = walking; other = taxi, boat, agriculture vehicle. The sample's total number of trips is 78,238.

An advantage of the extensive MPN survey is that also it asks the participants for several events which happened in the person's life in the year of the survey, for example the loss of household member, the birth of a child or a change of employment. For this work, the answers to the event "I have started my own business" including several subsequent questions on the experienced effect on their travel behavior, were analyzed. Since only the answers to these specific survey questions are the necessary criteria to be considered for this analysis and a completeness of the explanatory variables is not necessary, more waves of the MPN can be used (2014-2020). The following table 5 summarizes the responses of individuals having answered the question "I have started my own business" with "yes" (N=419) and have additionally answered the statements in the table below with either "yes" or "no" (N=311 & 171). Any other observations with answer-categories like "event did not occur" "unknown" "not asked" "not completed" are not considered. If a person has answered the questions multiple times with "yes" in several waves, only the answers of the first wave are considered.

Table 5: Survey questions responses

Statement in Survey (transl. from Dutch)	No	Yes	N	%-Yes
My travel behavior has changed	128	183	311	58.84
I started making more trips	212	99	311	31.83
I started making fewer trips	269	42	311	13.50
I started traveling on other days	250	61	311	19.61
I started visiting other locations	216	95	311	30.55
I started traveling at different times	230	81	311	26.05
I started covering more kilometers	223	88	311	28.30
I have started to cover fewer kilometers	271	40	311	12.86
I started traveling with a different means of transport	284	27	311	8.68
I became the owner of another means of transport	292	19	311	6.11
I have taken out or changed a transport subscription	301	10	311	3.22
I cancelled my transport contract	165	6	171	3.51
I got rid of my car	306	5	311	1.61

As expected from the literature review, the survey shows, that a change of the employment type has an impact on the travel behavior for most (58.84%) of the respondents. Regarding the provided categories of impact on travel behavior, the largest differences in behavior were recorded for the number of trips, where 31.82% of the participants stated, that they make more trips. The second most often recorded change is about the locations people are visiting after becoming self-employed, which have changed for about 30.55%. This doesn't surprise since a change of work itself is likely to come along with a change of working place but is not necessarily a character of being self-employment. 28.30% of the participants who became self-employed stated, that they cover more kilometers. This characteristic cannot be found in the pattern of the descriptive statistics. One reason for that could be that the question was predominantly understood as kilometers travelled by car which is supported by findings in the descriptive statistics. Another reason for this behavior could also be found in the job-specific characteristics of the newly self-employed persons, which then is likely to have more impact on work-to-work related trips, which are not part of this analysis. Furthermore, the change of employment type had for many people a larger impact on the time (26.05%) and the days (19.61%) of travelling, which was also found by Shin (2019).

Regression Analysis

While the descriptive statistics provides an overview on the indicators of travel behavior of the two groups, it cannot show which role self-employment status plays in explaining these differences. To explain the association of self-employment with travel behavior in respect to trip length, frequency, kilometers and time travelled and kilometers and time travelled by car a two-part model is employed, which uses a logistic regression for the first part and an ordinary least squares (OLS) regression model for the second part. A further explanation of the two-part model and a discussion about the OLS-assumptions can be found later in this chapter. For examining car-ownership a logit-regression model is applied.

Ordinary least squares assumptions

For the ordinary least squares (OLS) method to be the best linear unbiased estimator (BLUE) the model has to hold for the five Gauss-Markov assumptions which are in brief: (I)linearity of the parameters, (II) random sampling of the population, (III) non-collinearity of the regressors, (IV)

exogeneity – no correlation of the regressors with the error term and (V) homoscedasticity – the error of the variance remains constant independent of the regressors value (Lee, 2017).

The linearity of the parameters (I) is a strong assumption which is unlikely to hold for all controlled variables in the models of the study. This is because individuals might weigh the impact of explanatory variables differently, suggesting that their effects might not be linear or constant across the population. To mitigate potential non-linearities and to make the models more robust, the dependent variables are transformed using the natural logarithm. The assumption (II) of random sampling is also very strong, it does not hold completely for the dataset. The categorization by employment type is not random by definition and is therefore prone to selection bias, when looking for causal relationship, due to unobserved and uncontrolled characteristics common for one group, for example the propensity to be socially active or strive for independenc or come from a wealthy family. A more advanced method instead of OLS, like the fixed-effect method, could account for these time-invariant unobserved characteristics and examine a more causal relationship. Since the variables of interest, especially self-employment, are for most participants in the panel dataset time-invariant, it is not suitable for this analysis, because the within-estimation would eliminate time-invariant variables. Nevertheless, for the purpose of investigating the research question, associations with self-employment and travel behavior without causal claims are considered as sufficient. The third assumption (III) of non-collinearity of the regressors was tested with a pairwise correlation matrix of the explanatory variables. While almost all variable pairs have a rather low correlation coefficient, the highest correlation in the matrix was found between the variable “number of people in the household” and “children” (0.5071) and “having a driving license for car” and “motorized” (0.5373), the latter pair is not used simultaneously as predictor in any model. This assumption is therefor considered to hold sufficiently. The (IV) assumption of exogeneity in OLS is a crucial concern. By having added many control variables, which have been scrutinize and established by literature to have an association or impact on travel behavior, the risk of having serious omitted variables bias, which is one condition which would violate the exogeneity assumption, is reduced and kept as low as possible. Regarding the homoscedasticity assumption (V), the potential impact of heteroscedasticity on the efficiency of the models is mitigated by applying robust standard errors in the regression models.

For the hypothesizes testing in this study, here mainly the significance of associations of self-employment with travel behavior indicators, the additional assumption (VI), the normality of errors, has to hold at least satisfactory to expect more reliable results. This assumption is violated when running the OLS models without ln-transformation of the dependent variables, while after the transformation, the residuals follow sufficiently an approximate normal distribution. An exemplary graphical comparison of the distributions of the residuals for model I, the average commuting distance, can be seen in figure B1 in the appendix.

The assumptions discussed above are considered to hold sufficiently or if not, the implication of the violation is taken into account in the analysis. Overall is the OLS regarded to be a suitable estimation method for this analysis. Nevertheless, the downside of the ln-transformation of the dependent variables is, that observations with the value of 0 for the dependent variables cannot be considered in the OLS regression since the natural logarithm of 0 is undefined. All ln-transformed OLS regression models, for leisure and commutes, are thereby conditioned on having non-zero values, and are therefore only applied to a subsample in which the individuals have in average at least one leisure trip (3156 individuals) or one commuting trip made (2890 individuals). The implication of this conditional sampling is discussed in the chapter limitations.

Furthermore, to test for specification issues of the conducted OLS models, the Ramsey Reset test was applied for all OLS-models. The Ramsey Reset test shows the significance of non-linear combinations of the independent variables when they are added to the linear regression model. After being added to the equation, a joint significance F-test is conducted to scrutinize if the non-linear combinations can explain a significant part of the overall variability of the model. A significant Ramsey-Reset p-value in the OLS-result-tables can indicate a potential misspecification of the model. The outcome of the Ramsey-reset tests are discussed collectively in chapter 6 “Limitations”.

Two-part model

For data samples with zero-inflated observations for the dependent variables, like in this study, a two-part model can be applied. The first part predicts with a probability regression model the probability for the individuals to have non-zero number of commutes or leisure trips, respectively, and the second part estimates the actual associations of the variable of interest and the travel indicator employing an OLS-regression in the conditional subsample. For the first part, a binary

logit-regression model is conducted, where the dependent variables are binary and have the value of 1 if the individual has a non-zero number of trips made for commuting, or leisure purposes respectively, and 0 otherwise. The average marginal effects of the probability logit-models of the first part are shown in table 6. The results show, that being self-employed significantly decreases the probability to have recorded at least one commute by 8.4 percentage points, keeping all other factors constant. For having leisure travel, the employment status shows no significant association.

Table 6: Logit-regression results for probability for commute and leisure travel

Model	**(I)**	**(II)**
Dependent variable	**commuter**	**leisure**
Regression	logit	logit
Transformation (output)	average marginal effects	average marginal effects
self-employed	-0.0844*** (0.0179)	-0.00129 (0.0194)
Children	0.0178 (0.0159)	0.0457*** (0.0132)
Female	0.00831 (0.0126)	0.00528 (0.00986)
Academic	0.0345** (0.0120)	0.00916 (0.00938)
Distance to public transport	0.00181 (0.00166)	-0.000704 (0.00106)
Working hours	0.00656*** (0.000672)	-0.00251*** (0.000560)
Working hours form home	-0.00949*** (0.000618)	0.00370** (0.00115)
Number of people in household	-0.0119* (0.00502)	-0.0174*** (0.00334)
Household Income low	-0.0212 (0.0179)	-0.0189 (0.0124)
Household Income high	-0.0217 (0.0132)	0.00987 (0.0108)
Population density high	-0.0199 (0.0156)	0.00773 (0.0116)
Population density low	-0.0329 (0.0178)	0.0115 (0.0127)
young	-0.0121 (0.0160)	-0.0287** (0.0104)
old	-0.0418* (0.02)	0.0130 (0.0188)
motorized	-0.00404 (0.0191)	0.0154 (0.0130)
weekday	0.194*** (0.0186)	-0.214*** (0.0341)
Observations	3380	3380
Pseudo R-squared	0.1899	0.1598

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

Trip length, trip frequencies and average kilometers & time travelled

The conditional results of the OLS-Model, part two of the two-part model, for average trip lengths are shown in the table 7 below. Among commuters, self-employment shows a significant negative association with the average trip distance and duration for commutes, when controlled for the

socio-economic factors and built environment. Self-employment significantly decreases the commuting trip length by 58.0 % and the trip duration by 42.8 %, keeping all other factors constant. For leisure trips, among the people with a positive number of recorded leisure trips, no significant association with self-employment can be found.

Table 7: OLS-regression results trip length

Model	**(III)**	**(IV)**	**(V)**	**(VI)**
Dependent variable	**trip distance commute (daily average)**	**trip time commute (daily average)**	**trip distance leisure (daily average)**	**trip time leisure (daily average)**
Regression	OLS	OLS	OLS	OLS
Transformation dependent variable	Natural logarithm	Natural logarithm	Natural logarithm	Natural logarithm
self-employed	-0.580*** (0.124)	-0.428*** (0.0739)	0.00982 (0.0574)	0.108 (0.0892)
children	-0.00696 (0.0602)	-0.0504 (0.0361)	-0.248*** (0.0333)	-0.249*** (0.0550)
female	-0.364*** (0.0507)	-0.173*** (0.0292)	-0.0188 (0.0272)	-0.0546 (0.0447)
academic	0.212*** (0.0480)	0.155*** (0.0277)	0.0599* (0.0254)	0.0879* (0.0412)
Distance to public transport	0.0153* (0.00619)	0.00973** (0.00357)	-0.00226 (0.00334)	-0.00708 (0.00597)
Working hours	0.0204*** (0.00325)	0.00900*** (0.00186)	-0.000140 (0.00151)	0.00551* (0.00244)
Working hours form home	0.0160** (0.00556)	0.0136*** (0.00303)	0.00129 (0.00175)	-0.00437 (0.00295)
HH: Number of people	-0.0377 (0.0197)	-0.0106 (0.0115)	-0.0335** (0.0110)	-0.0594** (0.0181)
HH: Income low	-0.0627 (0.0728)	-0.0284 (0.0408)	-0.0762 (0.0398)	-0.232*** (0.0667)
HH: Income high	0.124* (0.0519)	0.100** (0.0306)	0.0654* (0.0286)	0.0789 (0.0461)
Population density high	-0.00343 (0.0584)	0.0649 (0.0339)	0.0280 (0.0337)	0.0803 (0.0531)
Population density low	0.141* (0.0675)	0.0270 (0.0391)	0.0128 (0.0378)	0.225*** (0.0592)
young	0.149* (0.0622)	0.0725* (0.0367)	0.0495 (0.0364)	0.120* (0.0602)
old	-0.381*** (0.100)	-0.115* (0.0476)	-0.0956* (0.0471)	-0.253*** (0.0743)
motorized	0.479*** (0.0785)	-0.0853 (0.0456)	-0.0112 (0.0455)	0.394*** (0.0762)
weekday	0.217** (0.0808)	0.167*** (0.0464)	-0.262*** (0.0419)	-0.571*** (0.0697)
_constant	1.282*** (0.174)	2.762*** (0.101)	3.272*** (0.0929)	2.074*** (0.155)
Observations	2890	2890	3156	3156
R-squared	0.14	0.12	0.06	0.07
Ramsey-Reset (Prob >F)	0.00	0.03	0.04	0.24

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The individuals considered in the model are conditional on having at least one commuting trip or leisure trip respectively, recorded.

The conditional OLS-regression results for the trip frequencies of the two groups are shown in table 6. Among commuters, the self-employment status has a significant negative association with the trip frequency of commutes. Self-employed individuals make in average 10.8 % fewer commuting trips than employees, keeping all other factors constant. The overall and leisure trip frequency show no significant association with self-employment.

Table 8 OLS-regression results trip frequency

Model	**(VII)**	**(VIII)**	**(IX)**
Dependent variable	**trip frequency (daily average)**	**trip frequency commute (daily average)**	**trip frequency leisure (daily average)**
Regression	OLS	OLS	OLS
Transformation dependent variable	Natural logarithm	Natural logarithm	Natural logarithm
self-employed	-0.0369 (0.0316)	-0.108** (0.0366)	-0.0184 (0.0324)
children	0.181*** (0.0199)	-0.0590** (0.0220)	0.198*** (0.0212)
female	0.0658*** (0.0167)	-0.0593** (0.0193)	0.0882*** (0.0183)
academic	0.107*** (0.0154)	0.0856*** (0.0174)	0.0655*** (0.0164)
Dist. to public trans.	-0.00394 (0.00208)	-0.00141 (0.00206)	-0.00454* (0.00222)
Working hours	-0.00128 (0.000945)	-0.000476 (0.00110)	-0.00261** (0.001000)
Working hours (from home)	-0.000473 (0.00116)	0.00850*** (0.00190)	-0.000229 (0.00114)
HH: number of people	-0.0332*** (0.00667)	0.0205** (0.00725)	-0.000122496
HH: income low	-0.0612** (0.0231)	-0.0470 (0.0253)	-0.0201 (0.0250)
HH: income high	0.00784 (0.0177)	-0.0157 (0.0201)	0.00267 (0.0187)
Population density high	0.0148 (0.0209)	0.00464 (0.0225)	0.0349 (0.0227)
Population density low	0.0151 (0.0226)	-0.00112575	0.0363 (0.0250)
young	-0.0769*** (0.0211)	-0.0175 (0.0237)	-0.0939*** (0.0238)
old	0.0152 (0.0273)	0.00446 (0.0271)	0.0380 (0.0295)
motorized	-0.187*** (0.0272)	-0.322*** (0.0346)	-0.0956*** (0.0289)
weekday	-0.00711 (0.0262)	0.0374 (0.0297)	-0.179*** (0.0279)
_cons	1.408*** (0.0564)	0.953*** (0.0660)	1.301*** (0.0602)
Observations	3380	2890	3156
R-squared	0.08	0.09	0.20
Ramsey-Reset (Prob >F)	0.14	0.00	0.00

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The individuals considered in the model are conditional on having at least one commuting trip or leisure trip respectively, recorded.

Table 7 shows the results of the models analyzing the average daily kilometers and time travelled, again conditional on the individual having at least one trip made for commutes, or leisure respectively. Since the average daily kilometers and time travelled are calculated by a multiplication of the averages of daily trip frequency and the daily trip length, it is not surprising that only for commutes are significant differences in the regression results. Being self-employed is associated with traveling in average 68.8 % fewer kilometers and 53.9 % fewer minutes than

employees, keeping all other factors constant. For leisure travel no significant association with self-employment can be found.

Table 9 OLS-regression results kilometers and time travelled

Model	**(X)**	**(XI)**	**(XII)**	**(XIII)**
Dependent variable	**kilometers travelled – commutes** (average daily)	**Time travelled – commutes** (average daily)	**Kilometers travelled – leisure** (average daily)	**Time travelled – leisure** (average daily)
Regression	OLS	OLS	OLS	OLS
Transformation dependent variable	Natural logarithm	Natural logarithm	Natural logarithm	Natural logarithm
self-employed	-0.688*** (0.133)	-0.539*** (0.0864)	0.1000 (0.0925)	0.00470 (0.0586)
children	-0.0641 (0.0666)	-0.108* (0.0468)	-0.0792 (0.0582)	-0.0517 (0.0362)
female	-0.425*** (0.0588)	-0.233*** (0.0406)	0.0323 (0.0489)	0.0720* (0.0314)
academic	0.309*** (0.0542)	0.251*** (0.0370)	0.169*** (0.0443)	0.130*** (0.0284)
Dist. to public trans.	0.0137* (0.00679)	0.00853 (0.00459)	-0.0111 (0.00644)	-0.00696 (0.00372)
Working hours	0.0196*** (0.00362)	0.00833*** (0.00238)	0.00405 (0.00267)	-0.00154 (0.00175)
Working hours (from home)	0.0249*** (0.00657)	0.0222*** (0.00424)	-0.00499 (0.00324)	-0.000168 (0.00187)
HH: number of people	-0.0178 (0.0222)	0.00840 (0.0151)	-0.0818*** (0.0195)	-0.0543*** (0.0120)
HH: income low	-0.111 (0.0817)	-0.0796 (0.0537)	-0.247*** (0.0735)	-0.0887 (0.0456)
HH: income high	0.109 (0.0596)	0.0853* (0.0420)	0.0780 (0.0500)	0.0663* (0.0318)
Population density high	0.00409 (0.0667)	0.0754 (0.0461)	0.129* (0.0576)	0.0871* (0.0372)
Population density low	0.0985 (0.0751)	-0.0157 (0.0510)	0.274*** (0.0635)	0.0602 (0.0414)
young	0.134 (0.0721)	0.0567 (0.0498)	0.0183 (0.0673)	-0.0367 (0.0425)
old	-0.383*** (0.105)	-0.118* (0.0585)	-0.209** (0.0787)	-0.0639 (0.0519)
motorized	0.145 (0.101)	-0.422*** (0.0715)	0.221* (0.0906)	-0.165** (0.0583)
weekday	0.257** (0.0912)	0.213*** (0.0617)	-0.715*** (0.0766)	-0.407*** (0.0483)
_cons	2.254*** (0.202)	3.734*** (0.139)	3.385*** (0.173)	4.525*** (0.112)
Observations	2890	2890	3156	3156
R-squared	0.13	0.13	0.06	0.06
Ramsey-Reset (Prob >F)	0.00	0.64	0.00	0.61

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The individuals considered in the model are conditional on having at least one commuting trip or leisure trip respectively, recorded.

Transport mode choice

The second part of the regression analysis of this study focuses on the transport modes. Therefor a multinominal logistic regression model (MNL) is used to determine the association with different modal choices. In contrast to the two-part OLS regression before, the MNL does not use aggregated data, but the long dataset where each observation represents one trip. The MNL is

frequently used in the research field of transport economics and provides relative probabilities of the different modes of transport relative to a base category. One key assumption is the independence of Irrelevant Alternatives (IIA), which means in the context of this analysis, that the features of a specific transport mode do not influence the relative likelihoods of selecting other options. A potential violation of this assumption could be that using a car as driver presupposes a driving license, while the other modes of transport don't require larger pre-conditions and could thereby drive people to use other modes of transport instead. To keep the model as precise as possible, the possession of a car-driving license is introduced as control in the model and replaces the possession of a motorized vehicle. Furthermore, the possession of a motorized vehicle in the transport mode choice model is suspected to suffer from unclear and maybe reverse causality. Since the data is from an unbalanced panel dataset, where individuals have a different number of trips depending on their travel behavior and number of years they are participating in the survey, the average daily number of commute and leisure trips and the number of observations per individual are also added as controls.

Table 10 and table 11 show the average marginal effect of the MNL regression model for commute and leisure travel, for the mutually exclusive transportation modes car, public-transport and the short distance modes walking & bikes combined. Trips made by other modes of transport like boats and taxis, were excluded. The reference category of this model is the transport mode "car", which means that the average marginal effects of public transport and non-motorized transport are relative to using the car as transport mode. On the other hand, the average marginal effects of the reference category "car" are relative to the probability of not using a car, but public transport or non-motorized transport. The results in table 10 show, that being self-employed is significant associated with all transport mode choices for commutes. Keeping all other factors constant, self-employment increases in average the probability to use the car for commutes rather than using public transport or walking & bikes as modes of transport by 29.9 percentage points. Adequately, the probability is decreased for using public transport by 25.8 percentage points in average, relative to using the car, keeping all other factors constant. Using slower and short distance mode of transport walking & bikes is also less likely for self-employed people with a decreased probability compared to using the car of 4.1 percentage points in average.

Table 10 MNL- regression results for transport mode choice for commutes

Model	**XIV**		
Dependent variable	**Transport mode - commute**		
Regression	multinomial logistic regression		
Transformation (output)	average marginal effects		
	car	public transport	Walking & Bikes (non-motor & motor with max 45 km/h)
self-employed	0.299*** (0.023)	-0.258*** (0.025)	-0.041*** (0.011)
children	0.019** (0.007)	0.017*** (0.004)	-0.036*** (0.006)
female	0.015** (0.006)	0.017*** (0.004)	-0.031*** (0.005)
academic	-0.067*** (0.005)	0.023*** (0.003)	0.045*** (0.005)
Dist. to public trans.	0.002* (0.001)	-0.001*** (0.000)	-0.000 (0.001)
Working hours	0.000 (0.000)	0.000 (0.000)	-0.001** (0.000)
Working hours (from home)	-0.002*** (0.000)	-0.000 (0.000)	0.002*** (0.000)
HH: number of people	0.007** (0.002)	-0.012*** (0.001)	0.004* (0.002)
HH: income low	0.008 (0.008)	-0.004 (0.005)	-0.004 (0.006)
HH: income high	0.000 (0.006)	0.001 (0.003)	-0.001 (0.005)
Population density high	-0.049*** (0.006)	0.029*** (0.004)	0.020*** (0.006)
Population density low	-0.012 (0.007)	0.009 (0.005)	0.003 (0.007)
young	0.009 (0.007)	0.014*** (0.004)	-0.022*** (0.006)
old	-0.014 (0.008)	0.005 (0.006)	0.010 (0.007)
weekday	-0.058*** (0.011)	0.022** (0.008)	0.037*** (0.009)
Driving license	0.395*** (0.019)	-0.120*** (0.007)	-0.275*** (0.014)
Distance of the trip	0.018*** (0.000)	0.003*** (0.000)	-0.021*** (0.000)
Number of observations	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
Ave. number of trips for leisure	-0.092*** (0.003)	0.076*** (0.001)	0.016*** (0.003)
Ave. number of trips for commute	-0.012*** (0.002)	0.013*** (0.001)	-0.001 (0.002)
Observations (trips)	23,489		
Pseudo R-squared	0.5434		

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 5%, 1%, and 0,1% levels, respectively. The individuals considered in the model are conditional on having at least one commuting trip or leisure trip respectively, recorded.

The following table 11 shows the average marginal effects of the transport mode choices for leisure trips. Here the difference between self-employed and employed regarding their probabilities of the transport mode choices are smaller in magnitude, but also significant. Keeping all other factors constant, the probability for self-employed people to use the car as transport mode for a trip is in average 3.3 percentage points higher than the probability of using public transport or walking & bikes, keeping all other factors constant. The probability for choosing public transport is in average

1.8 percentage points and walking & bikes is 1.4 percentage points lower than choosing the car. All three associations are significant.

Table 11 MNL- regression results for transport mode choice for leisure travel

Model	**XV**		
Dependent variable	**Transport mode - leisure**		
Regression	multinomial logistic regression		
Transformation (output)	leisure		
Variables	car	public transport	Walking & Bikes (non-motor & motor with max 45 km/h)
self-employed	0.033*** (0.010)	-0.014* (0.006)	-0.018* (0.009)
children	0.073*** (0.006)	-0.011** (0.004)	-0.062*** (0.005)
female	-0.001 (0.005)	0.000 (0.002)	0.001 (0.005)
academic	-0.069*** (0.005)	0.017*** (0.002)	0.053*** (0.004)
Dist. to public trans.	0.004*** (0.001)	-0.001* (0)	-0.003*** (0.001)
Working hours	0.002*** (0.000)	0.001*** (0.000)	-0.003*** (0.000)
Working hours (from home)	-0.000 (0.000)	-0.001*** (0.000)	0.001*** (0.000)
HH: number of people	0.014*** (0.002)	-0.011*** (0.001)	-0.003 (0.002)
HH: income low	-0.044*** (0.007)	0.006* (0.003)	0.038*** (0.006)
HH: income high	-0.008 (0.005)	0.004 (0.003)	0.003 (0.005)
Population density high	-0.049*** (0.006)	0.025*** (0.003)	0.024*** (0.005)
Population density low	-0.011 (0.007)	-0.017*** (0.004)	0.028*** (0.006)
young	-0.014* (0.006)	0.019*** (0.003)	-0.005 (0.006)
old	-0.012 (0.008)	-0.003 (0.004)	0.014* (0.007)
weekday	-0.053*** (0.004)	0.030*** (0.002)	0.023*** (0.004)
Driving license	0.340*** (0.015)	-0.080*** (0.004)	-0.260*** (0.014)
Distance of the trip	0.041*** (0.001)	0.005*** (0.000)	-0.046*** (0.001)
Number of observations	-0.001*** (0.000)	-0.000 (0.000)	0.001*** (0.000)
Ave. number of trips for leisure	-0.033*** (0.002)	0.014*** (0.001)	0.019*** (0.002)
Ave. number of trips for commute	-0.011*** (0.002)	0.023*** (0.001)	-0.012*** (0.002)
Observations (trips)	45,898		
Pseudo R-squared	0.2796		

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively. The individuals considered in the model are conditional on having at least one commuting trip or leisure trip respectively, recorded.

Vehicle kilometers & time travelled and Car-Ownership

For determining the association of self-employment with kilometers and time travelled by car the two-part regression model on the aggregated data by individual is employed. The first part is the

probability of having at least one commuting trip made and having travelled at least one commute by car. The probability of the first condition, being a "commuter" or "having leisure travel" is already provided in table 5 using a logit-model. The probability of the second condition among the commuters or leisure traveler respectively of having at least one commuting or leisure trip by car is likewise estimated using a logit-model. The results are shown in table 11. Among commuters, being self-employed significantly increases the probability to use the car at least for one time for commute by 8.9 percentage points, keeping all other factors constant. The probability of having at least one leisure trip by car shows no significant association with self-employment.

Table 12 Logit-regression results for probability to travel by car for commute travel

Model	**(XVI)**	**(XVII)**
Dependent variable	**commuter**	**leisure**
Regression	logit	logit
Transformation (output)	average marginal effects	average marginal effects
self-employed	0.0890* (0.0450)	0.0116 (0.0256)
children	0.0753** (0.0229)	0.0655*** (0.0186)
female	-0.0141 (0.0186)	0.0167 (0.0133)
academic	-0.0842*** (0.0171)	-0.0499*** (0.0124)
Dist. to public trans.	0.00942** (0.00293)	0.00213 (0.00211)
Working hours	0.00440*** (0.00113)	-0.000236 (0.000761)
Working hours (from home)	-0.00421** (0.00144)	-0.0000527 (0.000890)
HH: number of people	-0.0126 (0.00704)	0.000630 (0.00552)
HH: income low	-0.0433 (0.0237)	-0.0792*** (0.0167)
HH: income high	0.0441* (0.0200)	0.00127 (0.0150)
Population density high	-0.0649** (0.0215)	0.00368 (0.0163)
Population density low	0.0461 (0.0263)	0.0389* (0.0197)
Driving license	0.422*** (0.0360)	0.208*** (0.0189)
young	0.00423 (0.0219)	-0.0174 (0.0158)
old	0.00610 (0.0331)	0.00797 (0.0233)
weekday	0.0252 (0.0289)	-0.133*** (0.0239)
Observations	2890	3156
Pseudo R-squared	0.1044	0.1007

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

The results of the OLS-regression with the dependent variables kilometers or time travelled by car, conditional on the subsample of people who have at least one trip recorded for commuting or respectively leisure travel, are shown in table 13. Self-employed commuters having at least one trip by car, travel in average 39.6 % less kilometers and 25.8 % less minutes by car than their employed counterparts, keeping all other factors constant. The associations are significant at 5% and 1% level. For leisure travel, being self-employed increases the time travelled by car in average by 11.4 %, keeping all other factors constant. This association is significant at the 10 % level. The likeliness of car-ownership is examined with a logit-model, also using the aggregated data of the individuals. Being self-employed shows no significant association with the likeliness of having a car or van, keeping all other factors constant. The results are also shown in table 13.

Table 13 OLS-regression results for kilometers and time travelled by car and logit-regression results for probability of car- ownership

Model	**(XVIII)**	**(XIX)**	**(XX)**	**(XXI)**	**(XXII)**
Dependent variable	**kilometers travelled – commutes - by car** (average daily)	**time travelled – commutes - by car** (average daily)	**Kilometers travelled – leisure - by car** average daily)	**Time travelled – leisure - by car** (average daily)	**Vehicle**
Regression	OLS	OLS	OLS	OLS	Logit
Transformation dependent variable	Natural logarithm	Natural logarithm	Natural logarithm	Natural logarithm	Output: Average marginal effects
self-employed	-0.396*** (0.118)	-0.258** (0.0828)	0.166 (0.0847)	0.114* (0.0568)	-0.0176 (0.0197)
children	-0.147* (0.0623)	-0.156*** (0.0427)	-0.180** (0.0588)	-0.101** (0.0379)	0.0664*** (0.0171)
female	-0.315*** (0.0526)	-0.160*** (0.0368)	-0.0125 (0.0476)	0.0359 (0.0309)	0.00863 (0.0102)
academic	0.241*** (0.0489)	0.174*** (0.0337)	0.168*** (0.0433)	0.0824** (0.0280)	-0.0278** (0.00969)
Dist. to public trans.	0.0143* (0.00614)	0.0112* (0.00443)	-0.00273 (0.00580)	-0.000618 (0.00371)	0.00500** (0.00179)
Working hours	0.0149*** (0.00325)	0.00811*** (0.00228)	0.00247 (0.00259)	0.000569 (0.00174)	0.000178 (0.000594)
Working hours (from home)	0.0153** (0.00496)	0.0124*** (0.00355)	-0.00303 (0.00305)	-0.00166 (0.00194)	0.000106 (0.000665)
HH: number of people	-0.00185 (0.0204)	0.0224 (0.0133)	-0.0737*** (0.0184)	-0.0330** (0.0119)	0.0118** (0.00452)
HH: income low	-0.0196 (0.0752)	-0.0149 (0.0532)	-0.154* (0.0686)	-0.0502 (0.0439)	-0.0440*** (0.0112)
HH: income high	0.0271 (0.0548)	0.0291 (0.0378)	0.0421 (0.0497)	0.0373 (0.0321)	0.0408** (0.0139)
Population density high	0.0751 (0.0603)	0.102* (0.0426)	0.111* (0.0555)	0.145*** (0.0363)	-0.0161 (0.0127)
Population density low	0.151* (0.0664)	0.0278 (0.0469)	0.268*** (0.0608)	0.123** (0.0401)	0.0167 (0.0161)
motorized	0.287* (0.125)	0.185* (0.0925)	0.0960 (0.102)	0.0529 (0.0670)	
young	0.0864 (0.0655)	0.0780 (0.0452)	-0.0133 (0.0642)	-0.0140 (0.0424)	-0.0702*** (0.0106)
old	-0.151 (0.0951)	-0.0344 (0.0615)	-0.0489 (0.0739)	0.00385 (0.0502)	0.0552* (0.0231)
weekday	0.207* (0.0826)	0.195*** (0.0565)	-0.626*** (0.0715)	-0.365*** (0.0470)	-0.0188 (0.0155)
license					0.273*** (0.0139)
_cons	2.347*** (0.207)	2.999*** (0.149)	3.698*** (0.170)	3.981*** (0.113)	
Observations	2119	2119	2725	2725	3380
R-squared	0.11	0.09	0.06	0.05	--
Pseudo R-squared	--	--	--	--	0.3418
Ramsey-Reset (Prob >F)	0.00	0.00	0.10	0.24	--

Note: Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The individuals considered in model are conditional on having at least one commuting trip or leisure trip respectively, recorded. For Logit (model XXII), Robust standard errors in parenthesis. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

5. Discussion

The empirical analysis provides mixed support for the hypothesized association of self-employment and travel behavior. The following table 14 gives an overview of the determined direction of relationship of self-employment and the travel behavior indicators and the hypothesized direction of relationship from the theoretical framework.

Table 14 Overview expected relationship vs empirical analysis

	trip frequency		trip length		kilometers/time travelled		kilometers/time travelled by car		Modal Choice: Car		Car Owner-ship
	commute	leisure	commute	leisure	commute	leisure	commute	leisure	commute	leisure	
Expected association with self-employment	+	+	-	+	0	+	+	+	+	+	+
Results: Associations of self-employment in the sample	-	0	-	0	-	0	+	0/+	+	+	0

Commute travel

The associations between commute travel and self-employment predominantly align with the expected relationship. Among commuters, the most pronounced association relates to average daily kilometers and time traveled. Specifically, self-employed individuals are associated with 68.8% fewer kilometers and 53.9% fewer minutes traveled for commuting, keeping all other factors constant. Both the average trip frequency and average trip length for commuting are significantly and negatively associated with being self-employed; however, the association with trip length is noticeably stronger. These findings are in line with existing literature on the commuting patterns of self-employed individuals. The proposed influence of the increased work

autonomy among self-employed individuals, especially in the context of choosing their place of work, may account for the reduced commute length. The ability to freely select a workplace location, potentially closer to one's residence, can decrease commute distances. This observation aligns with the findings of Van Ommeren & van der Straaten (2008). They argued that the increased availability of commercial spaces due to a more favorable market environment, in contrast to traditional job market conditions, is responsible for this observed pattern. The decreased likelihood of self-employed individuals being commuters in this study corresponds with the before mentioned increased autonomy in workplace choice, increasing the chances of them choosing to work from home instead of commuting.

The observed decreased frequency of commutes among the self-employed is surprising. Given a shorter distance to work, one might expect more frequent commutes, leveraging the flexibility of scheduling and avoiding peak hours when not working from home. A potential explanation for this negative association could be that commuting, even over shorter distances, remains predominantly a cost-factor in terms of time and money. With the enhanced autonomy that comes with self-employment, such commutes may still be minimized or altogether avoided.

The positive association of self-employment and the increased preferences for car as transport mode for commuting is an interesting finding of this work. Among commuters, being self-employed shows a strong, in terms of magnitude and significance, increased probability to travel by car for commuting instead of other modes of transport while the likeliness to use public transport and walking & biking are reduced in comparison to car. When considering that self-employed individuals, on average, have shorter commutes and assuming that cars are more favorable for medium to long-range distances, the results provide supporting evidence for the potential influence of other factors for the modal choice, which are in this work hypothesized, as the reduced effective travel costs by car and the increased leverage of the work-flexibility when using car as transport mode. Both factors might increase the likeliness tendency to choose car for commuting.

Leisure travel

Unlike commute travel, leisure travel mainly doesn’t show significant associations with self-employment, among people with recorded leisure trips. This holds true for the travel indicators trip frequency, trip length and kilometers and time travelled. This is in line with the patterns

observed in the descriptive statistics, where self-employed people do show a slightly longer distance and duration for trip length and kilometers and time travelled for leisure purpose, but the differences to employees are not significant. Consequently, the theorized influence of the work autonomy of self-employed people on leisure travel doesn't find supporting evidence here.

A possible theoretical explanation is, that the mechanism through which work autonomy might influence the travel behavior of self-employed people are either not strong enough or simply uncommon. The first mechanism, the reduced travel-time cost when avoiding peak-hours might be too weak. The second, the potential to schedule work to allow for longer leisure trips during the week, might be not a common behavior. Both mechanisms could also be outweighed by the fact, that travelling is a cost (time and money). Thus, travel might still be avoided when possible, even if the costs are lower or a more flexible scheduling is possible.

The picture is different for the modal choice and the kilometers and time travelled with car for leisure purposes. Among those who used the car for leisure travel, being self-employed increases the likelihood of car use, though the magnitude of the association is rather small compared to commute travel. The likeliness to walk or take the bike for leisure trips is decreased when being self-employed compared to using the car. Here the magnitude of the association is stronger than for commuting trips. This is in line with the anticipated correlation between self-employment and a preference for cars on leisure trips, which preference is theoretically reasoned in this study by the reduced effective travel cost by car and the leverage of work-flexibility which is further enhanced by the flexibility cars offer as transport mode.

Concerning the average kilometers and time travelled by car, the descriptive statistics show a significant difference of the average kilometers and time travelled by car between self-employed people and employees, where the self-employed people travel have higher averages of these indicators. Among those who have made leisure trips, the share of people who have at least one leisure-trip made by car is also significantly greater for the self-employed. The OLS-regression indicates only a weakly significant positive association at the 10 % significance level between self-employment and average kilometers and time travelled by car. Even though the evidence is weak, the results should be handled with care.

The OLS regression model for kilometers and time traveled by car is conditioned on individuals having traveled for leisure and having made at least one leisure trip by car. These preconditions

reduce the sample to 87% of the total sample-size. This reduction in sample size is likely to increase the standard errors and subsequently making it less probable for an association to be significant, keeping all other factors constant. Considering this and the significant differences from the descriptive statistics in the same direction, the findings provide weak evidence for hypothesized positive association of self-employment and kilometers and time travelled with car for leisure purpose. Nonetheless, these results underline a need for further research on this association, ideally using a larger dataset.

Car-ownership and survey answers

Of the 3,380 participants in the sample, 87.00% owned a van or car in at least one year of the survey. The descriptive statistics show no significant differences in car ownership between self-employed individuals and employees. The logit model results regarding the probability of car ownership do not indicate any significant association with self-employment, contrary to the hypothesized positive relationship of self-employment and car-ownership. Given the high rate of car ownership in the sample, it's possible that any differences are too slight to detect in this sample size and therefor the analysis doesn't provide any evidence for an increased probability for car-ownership among self-employed people. One possible theoretical explanation is, that car-ownership is influenced more by other socio-economic factors and the built environment, and the reduced effective travel costs by car and increased work-autonomy combined don't have a measurable influence on the car-ownership.

In table 5, the survey responses to the question regarding the impact on travel-behavior due to the event "I have started my own business" within the year of the particular survey wave are displayed. For the statements quantifiable by this analysis, the predominant statement, that "the travel behavior has changed" is in line with the findings of the analysis. More than half of the respondents answered with yes to this statement. The statement "I started travelling with another means of transport" corresponds with the results from the modal choice analysis, even though only 8.68 % of the affected newly self-employed respondents answered with yes. Interestingly, while 31.83 % and 28.30 % of the respondents stated that "I started making more trips" and "I started to cover more kilometers", respectively, these statements are not supported by the analysis. Table 8's data on overall trip frequency and table 9's data on kilometers traveled both suggest a significant negative association with these indicators.

One potential reason the analysis diverges from the subjective statements is that the affected individuals might have considered only trips made by car, as well as work-to-work trips. However, the average kilometers and time traveled by car—irrespective of whether for leisure or commute but conditional on recording at least one trip by car—is presented in table A3 in the appendix. In this context, self-employment doesn't support the statements and displays no significant associations with these indicators, even though they have a positive value. The analysis does not consider work-to-work trips. Moreover, since the events in the questions refer to the year of the of the survey, perhaps the adjustment to self-employment involves at the beginning certain "conversion-costs" in travel behavior in terms of time/kilometers and frequency until a more efficient travel behavior is adopted. The actual reason for the discrepancy between the subjectively stated increase in kilometers traveled after becoming self-employed and the analysis results remains unclear.

COVID-19 Measurements in 2020

To avoid doubts that the public measurements in response to the COVID-19 Pandemic in 2020 have affected self-employed people and employees in 2020 in this sample differently, although the likeliness that the recorded days of self-employed people and employees are significantly different in terms of public relevant measurements is low, considering that only three days of travel are recorded. Nevertheless, to make sure there that this holds true, the complete analysis was additionally run only considering the waves of the years 2017-2019. The estimated results are all in the same direction, have a similar magnitude and the same significance, except for the probability to travel by car for commute travel (table 12), which loses the significance in the restricted dataset (2017-2019) and for the association between self-employment and time travelled by car for leisure purposes, which also loses its significance at the 10% level, while the kilometers travelled by car for leisure becomes significant at the 10% level.

6. Limitations

In this chapter, the impact of the major limitations of the research approach and the choice of models for the analysis on the validity of the observed results is discussed.

Restricted validity because of conditional probabilities

In this work, the associations of self-employment with trip frequency, trip length, kilometers and time travelled, and kilometers and time travelled by car for both commute and leisure purposes are

estimated conditionally on an individual having a non-zero value for the dependent variable due to the ln-transformation of these variables. This conditional probability narrows the set of observations (individuals) to an even smaller number. This is particularly important because the proportion of self-employed people in the sample is with 245 individuals already small. As a result, the risk of committing a type II error —failing to reject a false null hypothesis — increases. This makes the study more likely to overlook significant associations that might exist in the broader, unrestricted sample population. Additionally, due to this conditional restriction, the models might not capture differences in travel behavior among individuals who make fewer trips per week, whether for leisure, commute, or by car. Even if the few trips made differ significantly between self-employed and employed individuals in terms of average trip length. This concern gains relevance when considering that only 3 days of travel are recorded per wave. If there are only few leisure, commute or and car trips per week, the chance of recording one of these rare trips could be relatively low. Such restriction can influence the estimated magnitude and, in extreme cases, even the direction of the relationship. The risk of reduced validity in the associations rises with the number of conditions and the degree of reduction in sample size. Therefore, the models of this study most susceptible to this distortion are concering commute and leisure travel by car.

Limited external validity because of job-heterogeneity

The share of self-employed individuals in the sample is relatively small, at approximately 7%. This makes the results prone to the influence of unobserved heterogeneity based on the type of occupation and industry the individuals are engaged in. For example, if the self-employed individuals in the sample predominantly work in industries that generally commute less and rely more on cars due to job-related reasons, the associations observed in the analysis could be primarily driven by the nature of the job itself, especially in the context of commute travel. In terms of leisure travel, unobserved personal characteristics, such as a preference for transport flexibility, might correlate with being self-employed. Furthermore, does the sample exclude people working in the transport sector, which is a not a niche and relevant in size. These above-mentioned factors are limiting the external validity of the findings in this work.

Models' misspecification concerns

The joint significance F-test p-values from the Ramsey test for the conducted regressions suggest that several models are likely to be misspecified. This is true for models concerning trip length (table 7), trip frequencies (table 8), kilometers and time traveled (table 9), and kilometers and time

traveled by car (table 13). Conversely, models that don't have a significant p-value from the F-test of the Ramsey test include average trip time for leisure purposes (table 7), overall average trip frequency (table 8), time traveled for commutes and leisure trips (table 9), and kilometers and time traveled for leisure purposes by car (table 13). The indication from the Ramsey test that some models might be misspecified is understandable. This is because explanatory variables might influence travel behavior differently for leisure and commute trips and may also be influenced by other unobserved factors, such as hobbies. This means that achieving an accurate specification of travel behavior indicators in relation to the explanatory variables is challenging. Even if accomplished, the model would likely suffer from overfitting to the sample. Although attempts were made to address potential misspecifications, such as adding quadratic terms for metric-scaled explanatory variables and including suspected interaction terms, none of these adjustments improved the issues indicated by the Ramsey test. While this limitation is significant, it's not expected to restrict the validity of the affected models to the extent that they lose all evidential power in associating self-employment with travel behavior indicators. Thus, further adjustments were regarded as overly complex and were not conducted. Notably, one of the primary findings – the significant positive association of leisure travel with time traveled by car - wasn't indicated as misspecified by the Ramsey test.

7. Future Research

This thesis provides valuable insights into the travel behavior of workers in the Netherlands, highlighting the increased propensity of self-employed individuals to use cars for both commute and leisure purposes. These findings can be useful for policymakers aiming to create strategies to reduce individual motorized traffic in urban areas. However, the future research required on this topic is twofold. First, conditional sampling and weak evidence for leisure travel by car, in terms of the kilometers and time travelled by car requires further evidence which could be scrutinized by using a larger sample and longer observation period. For instants, analyzing a larger cross-sectional dataset with aggregated travel data based on trips made in a longer period, for example a month or year, could effectively mitigate concerns about the validity of the results due to the conditional sampling in this work. Even if a potential ln-transformation of the dependent variables may be necessary and would still restrict the sample to people with a non-zero number of trips made by car, the results would be still more representative since a broader spectrum of people with

different trip frequencies (especially at the lower end) are considered. Moreover, the external validity of the results could be tested and potentially improved, by adding controls for the distribution of industries and occupation types of the self-employed people and employees. This could significantly enhance the ability to draw comprehensive conclusions about self-employment and its association with travel behavior across the entire working population in the Netherlands.

Secondly, for making policy implications, a more causal examination of the relationship between the reduced effective travel costs on the self-employed travel behavior would be beneficial, although this examination might be unlike harder to conduct, since tax-laws are applied nationwide which makes it hard to find an appropriate control group. Nevertheless, a policy change in tax-law which affects the travel costs by car for self-employed people or employees significantly could be used to examine this association further.

The rise in the share of self-employment in the Netherlands from 2003 until 2020 and the hypothesized differences in work-autonomy (expected to be increased) and effective travel costs by car (expected to be decreased) served as the primary motivation for this comparative examination of travel behavior of self-employed people in this work. Especially the exploration of the relationship between travel behavior for leisure purpose and self-employment is a major contribution of this work, a topic that has been hardly researched before. To examine the associations between travel behavior indicators and self-employment, the MPN panel datasets of the years 2017- 2020 were employed.

The most important contribution of this thesis is the evidence it provides for a significant, positive, and quantitatively relevant association between self-employment and the likeliness to use the car as transport mode for leisure and commute travel. Additionally, the results suggest weak evidence for a positive and quantitatively relevant association between self-employment and kilometers and time travelled by car for leisure purpose. These findings support the impact of theoretical perspectives of self-employment regarding travel behavior, namely the reduced effective travel costs by car and increased work autonomy. Nevertheless, it is important to mention that the influence of these factors remain theoretical. Providing stronger evidence for the relationship between self-employment and these travel-behavior indicator is crucial, especially considering the relatively small sample size, conditional subsampling on non-zero values for travel indicators in the analysis and the potential influence of job-related heterogeneities between self-employed and

employed group in the sample. A more causal examination is still needed and remains part of future research.

Further results regarding the commute travel behavior of self-employed individuals largely support evidence from existing literature. Specifically, the findings of this study can show a significant negative association of self-employment with average trip length, trip frequency, kilometers and time travelled, and kilometers and time travelled by car for commuting purposes among commuters. Notably, this is consistent with the findings and theoretical explanation provided by Van Ommeren & Van der Straaten (2008) who explain shorter commutes of self-employed individuals by the eased search for commercial space compared to an employment close the home. Regarding leisure travel, the indicators average trip length, trip frequency, kilometers and time travelled show no significant association with self-employment among those who have recorded at least one leisure trip in the dataset. Consequently, the hypothesized influence of work-autonomy on these indicators finds little to no support from this analysis.

Urban planning and mobility related policymakers would benefit from a deeper examination of these findings in future research, particularly in exploring the causal relationship between reduced effective travel costs by car and the travel behavior of self-employed individuals. This is especially important to understand the implications for the tax-policy effects on individual motorized traffic, given potential perverse incentives in tax laws favoring car travel for self-employed people, even for leisure travel as indicated in this study.

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Appendix

Table A1: Description of explanatory variables

Explanatory Variable	Description	Scale before aggregation of the panel waves by individuals	Interpretation of estimates	Mean (SD) after aggregating of panel waves by individuals (3380 Individuals)
Self-employed	Individual is self-employed	Binary	Dummy	0.069 (0.249)
Children in household	Children living in the household	Binary	Dummy	0.246 (0.418)
Female	Person being female	Binary	Dummy	0.514 (0.500)
Academic	Having an academic degree (at least bachelor)	Binary	Dummy	0.437 (0.494)
Young	Being between 18 and 29 years old	Binary	Categorial: relative to base category "adult"	0.177 (0.371)
Adult	Being between 30 and 59 years old	Binary	Base category for age	0.735 (0.423)
Old	Being between 60 and 79 years old	Binary	Categorial: relative to base category "adult"	0.089 (0.270)
Household Income - low	Year 2017: < 27,000 € yearly aggregated gross household income Year 2018 & 2019: < 28,600 € yearly aggregated gross household income Year 2020: < 29,500 € yearly aggregated gross household income	Binary	Categorial: relative to base category "Household income - average"	0.138 (0.337)
Household income - average	Year 2017: between 27,000 – 67,000 € yearly aggregated gross household income Year 2018 & 2019: between 28,600 – 71,000 € yearly aggregated gross household income Year 2020: between 29,500 € – 73,000 € yearly aggregated gross household income	Binary	Base category for Household income	0.599 (0.476)
Household income - high	Year 2017: > 67,000 € yearly aggregated gross household income Year 2018 & 2019: > 71.000 € yearly aggregated gross household income Year 2020: > 73,000 € yearly aggregated gross household income	Binary	Categorial: relative to base category "Household income - average"	0.262 (0.431)
Number of people in household	Number of people living in the same household	Metric	Continuous	2.814 (1.369)
Working hours	Number of working hours per week in week of survey	Metric	Continuous	33.967 (9.583)
Working hours from home	Number of working hours from home per week in week of survey	Metric	Continuous	4.378 (7.578)
Distance to public transport	Distance to next public transport station in kilometers	Metric	Continuous	3.559 (3.763)
Population density - low	Population density in municipality is < 1000 individuals / sqkm	Binary	Categorial: relative to base category "Population density – moderate"	0.291 (0.447)
Population density - moderate	Population density in municipality is between 1000 - 1500 inhabitants/sqkm	Binary	Base category for "Population density"	0.172 (0.372)

Population density - high	Population density in municipality is >1500 inhabitants/sqkm	Binary	Categorial: relative to base category "Population density – moderate"	0.537 (0.493)
Driving license (car)	Person has driving license for car	Binary	Dummy	0.947 (0.221)
vehicle (car or van)	Person has a car or van	Binary	Dummy	0.870 (0.322)
motorized	Person has a car, van or motorbike	Binary	Dummy	0.877 (0.314)
weekday	Day of record is a weekday	Binary	Dummy	0.739 (0.288)

Table A2: OLS-regression results overall trip length

Model	**(XXIII)**	**(XXIV)**
Dependent variable	**trip distance (daily average)**	**trip time (daily average)**
Regression	OLS	OLS
Transformation dependent variable	Natural logarithm	Natural logarithm
self-employed	-0.181* (0.0858)	-0.136** (0.0520)
children	-0.0389 (0.0503)	-0.0199 (0.0329)
female	-0.171*** (0.0433)	-0.0331 (0.0289)
academic	0.297*** (0.0391)	0.232*** (0.0262)
Dist. to public trans.	0.00163 (0.00543)	0.00170 (0.00351)
Working hours	0.0128*** (0.00257)	0.00441** (0.00167)
Working hours (from home)	-0.00166 (0.00337)	0.00128 (0.00200)
HH: number of people	-0.0780*** (0.0177)	-0.0522*** (0.0115)
HH: income low	-0.192** (0.0626)	-0.106** (0.0404)
HH: income high	0.114** (0.0439)	0.0905** (0.0292)
Population density high	0.0557 (0.0501)	0.0796* (0.0342)
Population density low	0.206*** (0.0544)	0.0415 (0.0374)
young	0.0786 (0.0561)	0.00376 (0.0373)
old	-0.262*** (0.0693)	-0.097* (0.0452)
motorized	0.112 (0.0794)	-0.333*** (0.0521)
weekday	0.0378 (0.0683)	0.0779 (0.0446)
_cons	3.175*** (0.154)	4.414*** (0.102)
Observations	3380	3380
R-squared	0.08	0.09
Ramsey-Reset (Prob >F)	0.09	0.00

Table A3: OLS-regression results overall trip length by car

Model	**(XXV)**	**(XXVI)**
Dependent variable	**trip distance – by car (daily average)**	**trip time – by car (daily average)**
Regression	OLS	OLS
Transformation dependent variable	Natural logarithm	Natural logarithm
self-employed	0.0879 (0.0714)	0.0915 (0.0481)
children	-0.0839 (0.0476)	-0.0332 (0.0305)
female	-0.125** (0.0406)	-0.0291 (0.0264)
academic	0.199*** (0.0372)	0.131*** (0.0241)
Dist. to public trans.	0.00717 (0.00504)	0.00697* (0.00334)
Working hours	0.0107*** (0.00238)	0.00620*** (0.00158)
Working hours (from home)	-0.00319 (0.00291)	-0.00206 (0.00189)
HH: number of people	-0.0580*** (0.0154)	-0.000244269
HH: income low	-0.0561 (0.0536)	-0.0130 (0.0353)
HH: income high	0.0837* (0.0417)	0.0653* (0.0272)
Population density high	0.0638 (0.0450)	0.102*** (0.0297)
Population density low	0.225*** (0.0493)	0.0907** (0.0331)
young	0.0754 (0.0505)	0.0579 (0.0339)
old	-0.0796 (0.0641)	-0.0105 (0.0435)
motorized	0.339*** (0.0876)	0.229*** (0.0583)
weekday	-0.0848 (0.0601)	0.0266 (0.0398)
_cons	3.078*** (0.147)	3.531*** (0.0977)
Observations	3003	3003
R-squared	0.07	0.05
Ramsey-Reset (Prob >F)	0.14	0.08

Figure B1: Distribution of residuals of model I (dependent variable: trip distance of commutes)

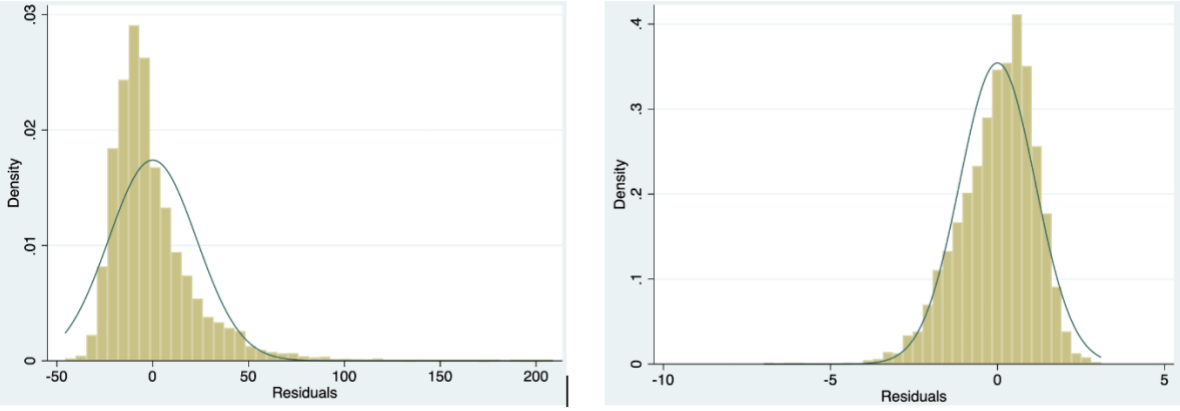

Figure B1 above shows the distribution of the residuals of the regression model I (table 6) with the average commuting trip distance as dependent variable. Left graph shows the distribution of the residuals without ln-transformation of the dependent variable and the right with the ln-transformation. The added bell curve lines show a normal distribution.