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We’re not there yet, are we? The influence of travel-based multitasking on the utility of travel time for Rotterdam’s public transport commuters

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Summary

It is often assumed that the demand for travel is derived; individuals do not derive utility from travel itself, but in partaking in activities at their desired destination. This assumption underpins travel demand forecasting models to transport infrastructure appraisal. In the past decades, however, scholars have noted that an intrinsic utility for travel does in fact exist, partially attributed to the activities conducted during travel time i.e. travel-based multitasking. Travel-based multitasking is more viable than ever due to the advancement of information and communication technologies which has improved the range of activities that can be conducted as well their effectiveness (Jain & Lyons, 2008; Mokhtarian & Salomon, 2001; Singleton, 2018).

In encouraging a modal shift towards public transport in Rotterdam, service providers have recognized the value of more productive and comfortable travel experiences in enhancing their service offering and accordingly the utility of travel time. For example, the RET has quoted the example of installing Wi-Fi connections as an innovative selling proposition to stimulate entertainment using ICTs and accordingly customer satisfaction (RET, n.d.c.). The effect of travel-based multitasking on the utility of travel time has also been proven in the context of Rotterdam in Rasouli & Timmermans' (2014) paper.

Despite the facilitation of travel-based multitasking by transport service providers, the potential benefits of travel time use remain widely disregarded. Subjective well-being-based measures of the utility of travel time have not been utilized, despite the potential long-term effects of travel time on life satisfaction and emotional well-being, especially in the case of commuting, one of the least appreciated moments of the day that is most widely and frequently taken (Ettema et al., 2012; Ettema & Verschuren, 2007; Kahneman et al., 2004a; Kouwenhoven & de Jong, 2018; Van der Waerden et al., 2009). This among other limitations shape the objective of this research: to establish the impact of travel-based multitasking on the utility of travel time for public transport commuters in Rotterdam.

The research strategy that has been used is that of a survey due to its large-scale approach, using both questionnaires and pilot questionnaires. Sampling procedures were a mix of cluster and convenience sampling, and the data analysis spanned both descriptive and inferential statistics. Numerical and graphical descriptive statistics were referred to, spanning histograms to Spearman's correlations, and a multiple linear regression used to infer causality.

The main finding is that the average public transport commuter in the sample experiences a positive utility of travel time, which is influenced moderately by travel-based multitasking as a function of both primary activity characteristics and secondary activities. The effect is specific to a total of five indicators: trip duration, trip crowdedness, and Wi-Fi connectivity, in addition to entertainment by reading and eating/drinking. Thus, travel time gains are not the main transport benefits, and intrinsic positive utility for travel does indeed exist (Annema et al., 2016; Jains & Lyons, 2008; Mokhtarian & Salomon, 2001; Singleton, 2018). Furthermore, Mokhtarian et al.'s (2001) claim that the intrinsic positive utility for travel partially arises due to gains in economic productivity does not go validated either which does not support arguments towards upgrading public transport vehicles to include, for example, laptop stations and work zones. However, it suggests that the benefits of travel-based multitasking may go beyond the trip – as claimed by Ettema et al. (2012), although it may not be immediately satisfying to be productive while travelling, the benefits may ripple through the participant's day, improving well-being overall.

The practical recommendations that can be given to the RET and NS, taking into account the limited generalizability of results given the sample size, is firstly to improve Wi-Fi connectivity. The second recommendation is to focus investments into optimizing public transport cabins for entertainment by reading. Recommendations that can be made for future research are studying the effect of travel-based multitasking on the utility of travel time using longitudinal data to allow for more reliable impact evaluation and investigating the decision utility involved in multitasking and how it differs from experienced utility – this is recommended in order to understand whether the productive benefits of travel-based multitasking extend past travel time into the improved day-to-day wellbeing of commuters.

Keywords

Travel time use, utility of travel time, travel-based multitasking, public transport, commuting

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Abbreviations

ICTs	Information and communication technologies
IHS	Institute for Housing and Urban Development Studies
MRDH	Metropolitan Region of Rotterdam – The Hague
NS	Nederlandse Spoorwegen
RET	Rotterdamse Elektrische Tram
STS	Satisfaction with Travel Scale

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1 Background

In the transportation field, it is often assumed that the demand for travel is derived; individuals do not derive utility from travel itself, but in partaking in activities at their desired destination. Essentially, travel, as a function of time and cost, is a disutility that must be minimized. This assumption underpins travel demand forecasting models, where activity-based approaches are common, and transport infrastructure appraisal (Jain & Lyons, 2008; Mokhtarian & Salomon, 2001; Singleton, 2018).

In the past decades, however, scholars have noted that an intrinsic utility for travel does in fact exist. Travel allows people to express independence and social status, expose themselves to their environments, and take the time to prepare for or reflect on a long day's work (Handy et al., 2005; Jain & Lyons, 2008; Mokhtarian & Salomon, 2001; Singleton, 2018; Steg, 2005). Accordingly, the utility of travel is "tripartite", attributed not just to the activities conducted at the destination, but to the travel experience itself in addition to the use of travel time to conduct activities i.e. to multitask (Mokhtarian & Salomon, 2001, p. 130; Singleton, 2020). Each of these elements can crucially impact the utility of travel time, and accordingly, travel preferences and behaviour, generating new trips, changing trip routes and destinations, and even impacting modal choice (Malokin et al., 2019; Mokhtarian & Salomon, 2001; Mokhtarian, 2007).

Travel-based multitasking as a potential determinant of travel utility is especially interesting to study since it is more viable than ever and is an avenue for productivity, not just enjoyment. This is due to the evolution of two socio-technical trends, the first of which being the advancement of information and communication technologies (ICTs) (Shaw et al., 2019). This trend has improved the feasibility for travel-based multitasking, expanding the range of activities that individuals can conduct during their travel, as well as the effectiveness in which they are carried out. It has also enabled public transportation providers to create new products and services such as the provision of on-board Wi-Fi (Mokhtarian, 2018; Pawlak, 2020). The second trend is the "passengerization of travel" which has improved the opportunity for travel-based multitasking (Mokhtarian, 2018, p. 2; Shaw et al., 2019). This is illustrated by the rise of on-demand services as ride-hailing and, most critically, the promise of vehicle automation which is expected to transform the nature of travel so that it is no longer experienced as a primary activity – according to Malokin et al. (2019, p.2), "travel will dissolve into more permeable channels permitting overlapping continuity of activities" (Shaw et al., 2019).

1.2 Problem statement

With approximately 650,000 inhabitants, Rotterdam ranks as the second largest city of the Netherlands. Its transport sector poses a serious threat to the environment and climate, estimated to contribute to a third and a quarter of the city's carbon emissions and air pollution, of which passenger transport is a significant determinant (City of Rotterdam, 2019). With an expected demand for an additional 50,000 homes, decoupling the environmental effects of passenger transport has become more relevant than ever (City of Rotterdam & MRDH, 2017). Public transport has been widely acknowledged to have a key role in the city's path towards sustainable mobility. However, it only makes up 22% of Rotterdam's total passenger-kilometres, indicating room for improvement (Government of the Netherlands, 2019; Voerknecht & van Bokhorst, 2018).

In encouraging a modal shift towards public transport, service providers have recognized the value of travel-based multitasking in the form of more productive and comfortable travel experiences in enhancing their service offering and accordingly the utility of travel time. The public transport operators active in Rotterdam have begun to invest in this area, as the following local evidence shows. For example, to improve the convenience of travel, Rotterdamse Elektrische Tram (RET) was the first European public transport service provider to offer free Wi-Fi across its entire fleet in 2015, spanning buses, metros, trams, and even the ferry (RET, n.d.a.). More recently, it has upgraded part of its bus fleet to add USB charging points (RET, n.d.b.). In their 2016 annual report, they quoted the example of installing Wi-Fi connections as an innovative selling proposition to stimulate entertainment using ICTs and accordingly customer satisfaction (RET, n.d.c.). Although these changes are not limited to transport flows in Rotterdam alone, Nederlandse Spoorwegen (NS) has, too, acknowledged changing expectations regarding the quality and comfort of service, upgrading their intercity trains with recharging facilities and vocalizing their intention to section trains into meet and great as well as work and rest zones, on top of already existing quiet zones (NS, n.d.a.; NS, n.d.b.). In their 2018 annual report, they have, too, acknowledged the "socioeconomic impact" of more comfortable and useful travel time (NS, n.d.c., p.127). In addition, in the 2019 annual report, they state their management approach to traveller satisfaction involves giving customers the opportunity to spend their time meaningfully, offering them free time and the ability to make the most out of it by, say, working/studying or entertainment by reading through the facilities at offer (NS, n.d.d.). More broadly, Dutch politicians have also implied the importance of facilitating travel-based multitasking in encouraging higher utilities of travel time, and accordingly a modal shift – quoting Stieneke van der Graaf of the Christian Democratic Appeal, "We want NS to invest in more innovations […]. If we want people to prefer the train to the car, then we must also ensure that the internet in the train is good, fast and reliable" (Trainreiziger, 2019).

Local academic evidence of the effect of travel-based multitasking on the utility of travel time in Rotterdam is from Rasouli & Timmermans (2014), who formulated and analyzed a random effects model to aid the design of more comprehensive activity-based travel demand models. Aligning with this thesis, the authors studied the effect of both sub-variables of travel-based multitasking on the utility of travel time: primary activity characteristics, defined as trip attributes, as well as secondary activities, known as the activities conducted alongside travel. The utility of travel time was derived from just one cognitive judgment of travel time, whereas this study combines both affective and cognitive evaluations of the utility of travel time for a comprehensive measure of an individual's mental state while travelling and their rational judgments of the trip experience. All in all, the results show that differences in primary activity characteristics affect the utility of travel time. In terms of public transport mode, utility of travel time is highest on trains, followed by bus and tram. The metro was outside the scope of the research. The study also showed that travelling without a companion, as well as longer trip durations, decreased the utility of travel time. As for secondary activities, all activity categories show positive results – significantly, entertainment in the form of reading followed by working/studying using ICTs, and non-significantly, working/studying, communication with other passengers, and eating/drinking (Rasouli & Timmermans, 2014). The primary activity characteristics that went unstudied are that of trip crowdedness and Wi-Fi connectivity, whereas the secondary activities that were not discussed are entertainment using ICTs, relaxation and communication using ICTs.

Despite the facilitation of travel-based multitasking by transport service providers, the potential benefits of travel time use still remain widely disregarded, in the appraisal of large-scale infrastructural projects as well as in academia. In cost-benefit analyses of transport projects, the main transport benefits are attributed to travel time gains, excluding the effects of more productive or comfortable travel experiences (Annema et al., 2016; Kouwenhoven et al., 2014; Mouter et al., 2019). Since the value of travel time gains are not differentiated across regions, such an assumption impacts the cost-benefit analyses of transport projects across the entire nation, including Rotterdam (Mouter, 2016). Furthermore, although such an assumption has been tested in academic literature over the years (Malokin et al., 2019), this is not the case in the Netherlands where research examining the impact of travel-based multitasking on the utility of travel time is stagnant. In fact, Keseru & Macharis (2017) have noted only five published academic articles in their global review of empirical evidence. The majority of these studies are either descriptive, narrowing down the nature and frequency of multitasking, or take a monetary approach to valuing travel time, calculating it based on stated preference experiments of route choice which differ in the ability to conduct secondary activities, trip duration, and costs (Ettema & Verschuren, 2007; Kouwenhoven & de Jong, 2018; Van der Waerden et al., 2009).

All in all, there exists a large research gap in Rotterdam. Subjective well-being-based measures of the utility of travel time making use of affective and cognitive evaluations have not been utilized, despite the potential long-term effects of travel time on life satisfaction and emotional well-being, especially in the case of commuting, one of the least appreciated moments of the day that is most widely and frequently taken (Ettema et al., 2012; Ettema & Verschuren, 2007; Kahneman et al., 2004a; Kouwenhoven & de Jong, 2018; Van der Waerden et al., 2009). Furthermore, not all potentially significant dimensions of primary activity characteristics have been discussed, starting with public transport modes; although a relatively wide range of modes have been studied, the differentiation between public transport modes has excluded the metro, limiting the understanding of how the primary activity characteristic impacts the utility of travel time. Furthermore, primary activity characteristics related to the travel space and infrastructure have not been considered, indicated by Wi-Fi connectivity and trip crowdedness. These shortcomings of previous research in Rotterdam severely limit the recommendations that can be made to public transport providers (Keseru & Macharis, 2017).

1.3 Research objective, question, and sub-questions

The objective of this research is therefore to establish the impact of travel-based multitasking on the utility of travel time for public transport commuters. Accordingly, the research questions are:

- To what extent does travel-based multitasking influence the utility of travel time for Rotterdam's public transport commuters?
    - What are the affective and cognitive evaluations of the utility of travel time?
    - To what extent do primary activity characteristics influence the utility of travel time?
    - To what extent do secondary activities influence the utility of travel time?

Travel-based multitasking is the independent variable which consists of sub-variables: primary activity characteristics and secondary activities. The utility of travel time is the dependent variable which consists of sub-variables: affective and cognitive evaluations of utility of travel time.

1.4 Significance of the research

The academic relevance of this research paper stems primarily from the fact that it attempts to fill a large research gap, as explained above, in the Dutch literature. Determining whether and to what extent travel-based multitasking influences commuters' utility of travel is necessary since it provides a basis for research on the monetary valuation of travel time and the determinants of travel preferences and behaviour, questioning the accuracy of the value of travel time savings as an indicator of transport benefits.

Socially, this thesis is relevant since it helps understand travel time use patterns of commuters, and to what extent travel-based multitasking enables a higher utility of travel time. Doing so would provide a clearer picture of what commuters prefer, and consequently, would help transport providers align their products and services to fit demand, further promoting sustainable modes of transport. Due to the repeated nature of commuting, changes could significantly impact life satisfaction and well-being, on the long run (Ettema et al., 2012).

1.5 Scope and limitations

The scope of the research is limited to commuters based in Rotterdam due to limited resources for data collection. However, their movements across the entirety of the Metropolitan Region of Rotterdam-The Hague (MRDH) will be studied. Firstly, the region is polycentric and has experienced increasing commuting flows over the past decade, and secondly, such a decision will allow for not only for travel-based multitasking across buses, trams and metros to be compared, but for trains too (OECD, 2016). In addition, the scope is limited to the effect of each sub-variable of travel-based multitasking on the utility of travel time independently and does not delve into the relationship between them although causality has been theoretically and empirically proven. Such a decision has been made for a more focused research scope, which aligns with standard practice in the literature.

The limitations of this thesis include that it makes use of cross-sectional as opposed to longitudinal data, which may have provided further insight into the effect of travel-based multitasking on the base level of the utility of travel time across trips (Ettema et al., 2012), and have allowed stronger and more flexible impact evaluation techniques to be utilized. It also does not study interactions between the two sub-variables of primary activity characteristics and secondary activities, limiting the understanding of what conditions facilitate higher utility.

Chapter 2: Literature review/theory

2.1 Introduction

In this chapter existing theories and empirical evidence will be discussed in relation to the variables of the research question: the utility of travel time, which is the dependent variable, and travel-based multitasking, the independent variable. The variables will be defined and conceptualized into sub-variables and indicators, and the theoretical and empirical relationships between them outlined. They will be summarized into a conceptual framework which will guide the study further.

2.2 Utility of travel time

2.2.1 Defining utility

Prior to discussing utility under the context of travel, it is necessary to define what utility refers to in the first place. The concept is underpinned by the theory of hedonism, dating back to Plato, which states that well-being exists in a mental state of pleasure or happiness (Reiss, 2013). The moral philosopher Bentham (1996) accordingly described utility to be the balance of pleasure over pain resulting from the outcome of a decision (Reiss, 2013). Since the contemporary field of economics is built on the assumption of rational consumer behaviour, which stipulates that individuals make decisions to maximize their ordinal utility functions based on consistent and transitive preferences, utility is mostly inferred from observed choices that take into account alternatives (De Vos et al., 2016; Ettema et al., 2010; Kahneman et al., 1997). Such an approach measures what is called the decision utility, and is quite common in utility-based studies concerning travel behaviour despite the fact that it is quite distinguishable from what Bentham was originally referring to – the experience of utility in itself (De Vos et al., 2016; Ettema et al., 2010).

Experienced utility can be categorized into instant and remembered utility, the former measured in real time and the latter in retrospect. It has been shown that, on average, individuals choose activities that maximize their remembered utility, which in turn influences decision utility (Kahneman et al., 1997; Kahneman & Krueger, 2006). Although reports of remembered utility are sentimentally in line with reports of instant utility, Kahneman & Krueger (2006) found that they are largely influenced by systematic biases. In their evaluations, individuals weighed momentary utilities unequally, emphasizing the peak and end experiences. Furthermore, the duration of their experiences was left completely neglected (De Vos et al., 2016; Kahneman et al., 1993).

Largely synonymous to experienced utility is the concept of subjective well-being, albeit its development from the field of psychology (De Vos et al., 2016). The concept is often utilized to measure remembered utility and consists of two affective and cognitive dimensions (Ettema et al., 2012; Diener, 2009). Affective well-being captures one's emotional state while conducting an activity – specifically, the strength, incidence, and longevity of positive and negative feelings. It is estimated by using scales with opposing adjectives or asking individuals for the frequency of certain emotions, given a time frame. On the other hand, cognitive well-being is one's judgment of satisfaction within the activity or timespan. Overall, the dimensions are indicated by Diener et al.'s (1985) Satisfaction with Life Scale (De Vos et al., 2016). To approximate the experienced utility of travel, subjective well-being scales are often adjusted and used (De Vos et al., 2016).

2.2.2 Negative utility of travel time

The first formalized theory tackling how the scarce resource of time is allocated and valued can be traced back to Becker (1965) (Athira et al., 2016; Lugano & Cornet, 2018). Under the assumption that an individual can allocate their time freely between labour and leisure, and given standard utility maximization theory, potential savings in travel time can be utilized for a rise in income (Becker; 1965; Small, 2012). This trade-off implies that travel time is unproductive time (Ettema & Verschuren, 2007; Small, 2012), and that its implicit value, which is the monetary valuation of travel time, is simply a function of the sensitivity to changes travel time and cost. This is derived from (hypothetical) decisions in choice models (Lugano & Cornet, 2018). Thus, travel time is treated as a disutility, valued negatively (Ettema & Verschuren, 2007).

This negative conceptualization of travel time has underpinned the transportation field for decades, guiding not only travel demand models, but transport policies and project appraisals (Jain & Lyons, 2008; Mokhtarian & Salomon, 2001; Singleton, 2018). Heterogenous individuals are often summed into a utility-maximizing aggregate that values travel time savings above all, incentivizing the creation of new transport policies and infrastructure that estimate millions in economic savings from even the smallest of reductions in travel time (Lyons & Urry, 2005; Watts & Urry, 2008). Although such an approach remains standard in most countries, more holistic views that are representative to the traveller's experience have gained momentum, especially in the beginning of the 21st century (Jain & Lyons, 2008; Kouwenhoven & de Jong, 2018; Mokhtarian & Salomon, 2001; Singleton, 2018).

2.2.3 Positive utility of travel time

Mokhtarian & Salomon (2001) first introduced the theory of the positive utility of travel time and it has since been researched from perspectives of decision utility, experienced utility, and subjective well-being.

Mokhtarian & Salomon (2001) proposed that an intrinsic utility for travel does exist, stipulating that the overall positive utility of travel stems from three components. Adhering to the traditional approach, the utility of travel is firstly derived from the activities conducted at the traveler's destination – if individuals could remove travel as a component of accessing and partaking in opportunities, they would (Lyons & Urry, 2005). The second element can be attributed to the intrinsic characteristics of travel – Mokhtarian & Salomon (2001, p.703) note "the sensation of speed, movement through and exposure to the environment, the scenic beauty or other attraction of route". It is here that travel is to some extent regarded as the end, as opposed to the means to an end (Reichman, 1976 as cited in Mokhtarian & Salomon, 2001). Finally, a positive utility of travel time is also derived from the activities done on the move; travellers are able to be productive by working/studying, which, as explained by Lyons et al. (2007), leads to trips being regarded as more worthwhile and useful, creating a positive utility of travel time (Ettema et al., 2012; Mokhtarian et al., 2001). Another cause, albeit less economical, is the enjoyment derived from anti-activities such as relaxation, which provide an avenue for travellers to prepare for a destination's activities and their roles (Mokhtarian & Salomon, 2001).

In a survey spanning 1900 respondents from San Francisco, it was confirmed that travellers may indeed derive a positive utility from travel intrinsically – using an experienced utility approach, it was found that almost half of the respondents did not agree that travel time is wasted time, more than a third viewed their commute trip as a productive transition, and more than two-thirds agreed that arriving at their destination was not the only "good thing about travelling" (Mokhtarian & Salomon, 2001, p. 709).

Jain & Lyons (2008), too, have backed the theory of the positive utility of travel time - that a positive utility of travel exists beyond partaking in activities at the destination - albeit from a sociological, network perspective of participation. They state that travel time can be conceptualized as a reward that not only has the potential to benefit the traveller but those within their network too. Based on the analysis of focus group discussions, the authors found that benefits can be derived from transition time, where the traveller experiences distance and adjusts between the demands of the origin and destination, and time out, where the co-presence or fixed space of travel enables the individual to retreat from their responsibilities and be by themselves or conduct an activity. These two benefits in experienced utility are crucially enabled by the travel space and its infrastructure, in addition to the objects that the traveller bring along to their journey, which vitally includes ICT devices (Jain & Lyons, 2008).

Conceptualizations of travel time in an economic context have, too, evolved to consider the direct utility that can be derived from travel (Kouwenhoven & de Jong, 2018). Jara-Diaz (2008), among others (DeSerpa, 1971; Evans, 1972; McFadden, 1981), formulate its value monetarily so that it is the deviation between two monetary factors: the utility that could have been obtained if the travel time was allocated elsewhere, or, in other words, its opportunity cost, and the value of the utility created while travelling. Accordingly, the model theorizes that the monetary value of travel time declines if journeys become more comfortable and productive. Although it still assumes that, at its core, travel time is a disutility due to its opportunity cost, exemplified by the competitive uses of time across a variety of purposes and locations, the approach challenges the notion that the demand for travel is only derived and, in doing so, allows for a more accurate estimation of the transport benefits resulting from travel time savings (Kouwenhoven & de Jong, 2018).

Empirical evidence pointing towards a positive utility of travel time from a monetary lens of decision utility includes findings from a series of Dutch research papers which examined developments in the monetary value of travel time across a decade. In these studies, it was shown that the strength of the increase in the monetary value of travel time was not as predicted, after adjusting for income changes, due to improvements in ICTs which changed the productivity and comfort of travel time. This was especially the case for users of public transport (Kouwenhoven & de Jong, 2018; Kouwenhoven et al., 2014).

In recent years, conceptual approaches to the positive utility of travel time have evolved to approximate the utility of travel time from an approach of subjective well-being. As has been discussed in section 2.2.1, the approach is largely synonymous to experienced utility in that it, too, acknowledges the discrepancies between predicted and experienced outcomes of decisions (Ettema et al., 2010). However, its development from the field of psychology allows for impacts to be studied more comprehensively, taking into account not only cognitive evaluations of the utility of travel time but affective components too. The most renowned measure is the Satisfaction with Travel Scale (STS) (Ettema et al., 2011). It considers the affective evaluation of travel based on six scales of valence and activation, “three which distinguish between positive deactivation (eg: relaxed) and negative activation (eg: hurried) and three which distinguish between positive activation (eg: alert) and negative deactivation (eg: tired)” (Ettema et al., 2012, p.216-7). The cognitive evaluation of the utility of travel time is indicated by rating the quality of the transport service and its efficiency across three scales. Overall, ratings can be summed or kept separate. The day-reconstruction method is regularly used to approximate the STS, despite potential biases introduced by their retrospective nature, due to its convenience and cost-effectiveness compared to in-travel experience sampling (Ettema et al., 2012; Kahneman et al., 2004b; Mokhtarian & Pendyala, 2016; Shwarz et al., 2009).

Empirical evidence of a positive utility of travel time from such a perspective of subjective well-being is emerging, the most notable article being Ettema et al.’s (2012) which showed that the average utility of travel time was indeed positive for Swedish public transport commuters.

2.3 Travel-based multitasking

2.3.1 Definition and conceptualization

Although a universal definition is difficult to pinpoint due to the different contexts it may occur in, as well as the emerging nature of the field, the act of multitasking is widely referred to as the participation in multiple activities at once (Circella et al., 2012; Kenyon, 2010; Keseru & Macharis, 2017). In the context of transport, travel is one of these concurrent activities (Circella et al., 2012; Jain & Lyons, 2008; Keseru & Macharis, 2017). It is important to further state that multitasking refers to the behaviour of conducting activities simultaneously as opposed to the degree of preference for those activities i.e. polychronicity (Circella et al., 2012; Shaw et al., 2019).

Activities conducted during travel can be classified into primary activities and secondary activities. According to Circella et al. (2012), primary activities are ones that the individual will conduct regardless, whereas secondary activities are simply incidental to primary activities, and may even demand the most resources in comparison. When travel is a means to transition to a target activity at a destination, as is the case with commuting, it is regarded as the primary activity, and any overlaid activities are considered as secondary. However, when travel is done for itself, it can be primary or secondary. Travel-based multitasking can therefore be referred to as the participation in primary and secondary activities at once (Circella et al., 2012).

These activities are further conceptualized into active and passive activities; the distinction is made between the two categories by recognizing whether the traveller is deliberately using their physical and/or mental resources with respect to the primary and secondary activities they engage in. Consequently, active activities are those that require effort from the traveller, whereas passive activities occur without the traveller's input (Circella et al., 2012; Keseru & Macharis, 2017).

The primary activity of travel differs in passivity and activity according to the mode of travel used. For example, in the case of public transport, travelling is largely a passive activity; only for a minimal fraction of the journey does the traveller need to be present – when boarding a vehicle or making a transfer. Driving a car, however, requires active physical and/or mental resources from the traveller (Circella et al., 2012; Keseru & Macharis, 2017). Crucially, this effects the degree and nature of which secondary activities are undertaken. Public transport passengers are not only more likely to conduct activities secondary to travel because they do not have to focus on the road, but also have the liberty to partake in more active activities, especially given ICT developments. Driving a car on the other hand entails active attention which accordingly limits secondary activities to ones that are passive, such as listening to music, as opposed to studying or working (Circella et al., 2012; Kenyon, 2010; Keseru & Macharis, 2017).

2.3.2. Defining primary activities

As seen in the above section, travel is considered to be one of the simultaneous activities that form travel-based multitasking, referred to as a primary activity when the trip purpose is attributed to a destination. It is in practice characterized by trip attributes, which are indicated by several aspects, proven to be significant in past literature, namely: public transport mode, trip duration, presence of a companion, trip crowdedness, and Wi-Fi connectivity (Keseru & Macharis, 2017). These can be measured subjectively, from the traveller's point of view.

Empirically, the most common travel modes studied relate to public transport, specifically in trains. Evidence from urban public transport modes like metros, trams and buses remains limited (Keseru & Macharis, 2017). Car travel has not been studied extensively due to its limitations on secondary activities, although the study of shared services like ridehailing has been on the rise, with authors as Gao et al. (2019) and Malokin et al. (2019) using their results to inform autonomous vehicle scenarios. Non-motorized, active modes of travel like walking and cycling have also rarely been studied (Singleton, 2019), in addition to air travel, in which contributions have only been made by Schwieterman & Battaglia (2014) across the years, according to Keseru & Macharis' review of the empirical evidence of travel-based multitasking (2017).

Other primary activity characteristics include the trip duration, which is how long it takes for a traveller to get from station to station in one public transport vehicle. It has been operationalized continuously (Singleton, 2019) or split into multiple categories as has been done by Ettema et al. (2012). With all modes excluding that of air travel, the scope is usually split into within or above two hours, with the former categorized further into 10, 15 or 20 minute intervals (Ettema et al., 2012; Ettema & Verschuren, 2007; Malokin et al., 2019). In taking into account whether there is a travel companion, little attention is paid to how many companions the individual traveller has and it is therefore operationalized as a dummy variable (Wang & Loo, 2018), although Timmermans & Van der Waerden (2008) distinguish between couples and groups. Trip crowdedness can be subjectively measured as the ability for the traveller to find a seat (Kroes et al., 2013). Wi-Fi connectivity is often characterized into two dimensions in the context of public transport: that of the reliability and speed. The reliability of Wi-Fi is defined as the ability to connect to the service without disruptions, whereas the speed of Wi-Fi is how fast the connection is in use (Ettema et al., 2012; Keseru & Macharis, 2017; Pawlak, 2020).

2.3.3 Defining secondary activities

The secondary activities overlaid over the primary activity can be reported in various ways, the first of which being the measurement of its absolute occurrence (Keseru & Macharis, 2017). This was the case in Bjørner's (2016) study, where the author measured the occurrence of different secondary activities, no matter the duration. On the other hand, some authors as Susilo et al. (2012) only take note of the secondary activities that travellers spend the most time on, and therefore do not account for shifts between them. The final approach is to investigate the duration of all secondary activities (Keseru & Macharis, 2017; Ohmori & Harata, 2008).

Pawlak (2020) has split secondary activities into two broad typologies: hardware-centric secondary activities, and function-centric ones, based on a literature review. A hardware-centric operationalization of secondary activities focuses on the specific devices or items used to conduct activities, such as specific ICTs or a book, and is most often witnessed in observation-based studies. A major drawback is that it overlooks the multifunctionality of devices given ICT developments. The function-centric typology of secondary activities captures the purpose of conducting activities, for example, for communication or entertainment purposes, and is therefore more insightful to understanding traveller behaviour. Since these two typologies are not mutually exclusive, the majority of studies mix the two conventions, which allows for the use and purpose of digital activities to be gauged in comparison to non-digital ones. Accordingly, in questionnaire-based surveys, secondary activities are roughly split into eight categories: working/studying using ICTs, working/studying, entertainment by reading, entertainment using ICTs, communication using ICTs, communication with other passengers, relaxation, and eating/drinking (Wang & Loo, 2018).

It is vital to take note however that the categorization of secondary activities is not standard across the literature, which complicates across-study comparisons (Keseru & Macharis, 2017). The potential overlap between categories makes it difficult to come to a consensus, and the fast-paced nature of ICTs development warrants the addition, as well as removal, of categories (Keseru & Macharis, 2017; Lyons et al., 2016).

2.4 The effect of travel-based multitasking on the utility of travel time for commuters on public transport

This section outlines the empirical evidence pointing towards the influence of travel-based multitasking on the utility of travel time. It is specific to the scope that has been chosen for this research – commuting as a trip purpose, and public transport as the travel mode. Therefore, the empirical literature discussed below is specific to that scope; all articles include commuters who use public transport in their sample, although they may have been part of a larger discussion involving non-transit modes and trip purposes as leisure and business.

2.4.1 The effect of primary activity characteristics on utility of travel time

Empirically, it has been shown that the primary activity characteristics introduced above impact the utility of travel time. These are: public transport mode, trip duration, presence of a companion, trip crowdedness, and Wi-Fi connectivity.

According to Rasouli & Timmermans (2014), the utility of travel time, operationalized by one summary judgment of trip satisfaction, differs significantly across modes, with the utility of travel time being higher than average on trains and lower than average for buses, and especially trams. The finding that travelling by train has a larger utility of travel time compared to the bus is in line with Abrantes & Wardman's (2011) research on the differences in monetary valuations of travel time. In Ettema et al.'s (2012) paper studying the impact of primary and secondary activities on the satisfaction with travel scale, however, the authors find that the overall utility of travel time is significantly lower across train and bus trips when compared to the tram and metro, despite similar affective evaluations. The authors note that such a finding highlights the "discrepancies between actual and experienced affect and remembered and socially constructed opinions about services and travel modes" (Ettema et al., 2012, p.219). In other words, although travelling on trains and buses may not result in negative feelings, they may still be judged cognitively as a negative experience. All in all, there is little consensus regarding which modes produce a higher utility of travel time in themselves, perhaps due to differing contexts.

As for the duration of travel, it has largely been alluded to in the literature that it affects the utility of travel time negatively, which is in line with standard microeconomic theory that underpins monetary valuations of travel time, as seen in section 2.2.2 of this literature review (Ettema et al., 2012; Stutzer & Frey, 2008). Wang & Loo (2018) expand on this finding by showing that a positive quadratic effect of travel time exists, meaning that the strength of this negative relation decreases for longer trips, perhaps due to the compensating effect of secondary activities as ICTs over time (Gamberini et al., 2013; Ohmori & Harata, 2008). Such a relationship has been confirmed by Ettema et al. (2012).

The presence of a trip companion has also been tied to changes in the utility of travel time. Wang & Loo (2018) have found that those travelling alone have lower subjective utility of travel time levels; this has also been confirmed by Rasouli & Timmermans (2014) who, too, saw a significant effect.

As for the link between Wi-Fi connectivity and the utility of travel time, it has been shown that an improvement in connectivity in terms of speed and reliability leads to higher utility (SDG, 2016). Bounie et al. (2019) demonstrated the link, showing that the monetary valuation of travel time savings would decline by 12% from optimal connectivity. Taking a subjective approach, it was found that passengers became more frustrated with their travels due to "the prolonged inability of the train operator to provide sufficient connectivity” (Bjørner, 2016; Keseru & Macharis, 2017, p.12).

The last indicator of primary activity characteristics that is said to influence the utility of travel time is trip crowdedness. According to Batarce et al. (2016), the denser the public transport vehicle, the lower the monetary valuation of travel time; the marginal disutility of travel time was found to be more than double relative to empty vehicles. Lyons et al. (2016) found a similar effect when examining the experienced utility of travel time between 2004 and 2014. Wardman (2014) attributes this to the high discomfort associated with not finding a seat. In addition, the author ascribed the negative relationship of trip crowdedness on the utility of travel time to its implication on more frequent and longer stops, which make trips longer. Furthermore, trip crowdedness tends to inhibit the freedom to conduct secondary activities, therefore affecting the utility of travel time (Wardman, 2014), as will be explained in section 2.4.3. In contrast, Ettema et al. (2012) found a positive impact of crowdedness on both cognitive and affective evaluations of utility, indicating that lower levels of crowdedness make commuters uncomfortable and bored.

2.4.2 The effect of secondary activities on utility of travel time

Although it has been established in section 2.2.3 that the extent and nature of secondary activities can lead to a positive utility of travel time, it is imperative to present the empirical findings across categories of working/studying using ICTs, working/studying, entertainment by reading, entertainment using ICTs, communication using ICTs, communication with other passengers, relaxation, and eating/drinking.

The first secondary activity is working/studying using ICTs. In their 2014 study, Rasouli & Timmermans found a positive and significant causal relationship between the secondary activity and the utility of travel time, which was operationalized based on a cognitive trip judgment. Wang & Loo (2018) also found a positive and significant effect when studying its influence on high-speed rail passengers, as did Malokin et al. (2015) based on a survey in California, showing that productivity did indeed improve the utility of travel time.

Working/studying without ICTs has been said to be a positive determinant of the utility of travel time as stated by Mokhtarian et al. (2001). This is supported by Lyons et al.’s (2007) study which showed that train passengers who mostly worked/studied regarded their travel time to be productive which improved their satisfaction. However, it has been found to have an insignificant influence on the utility of travel time by both Rasouli & Timmermans (2014) and Ettema et al. (2012), the latter article having operationalized the utility of travel time according to the STS scale.

Entertainment by reading has been reported to have a significant, positive effect on the utility of travel time according to Rasouli & Timmermans (2014). It also had the highest effect among other secondary activities in the article. Wang & Loo’s (2018) results also backed this finding, albeit having the lowest effect among other secondary activities studied.

Travellers who partake in entertainment using ICTs or communication using ICTs have been found to have no discrepancies in the utility of travel time according to Wang & Loo (2018). In Ettema et al.’s (2012) study, however, the use of ICTs had been linked to lower levels of positive activation, meaning that ICT users show less feelings of enthusiasm during their commute, perhaps representing unsuccessful efforts to avoid boredom.

Communication with other passengers has been found to be an insignificant determinant of the utility of travel time according to Wang & Loo (2018). However, Ettema et al. (2012) found that it leads to positive affective and cognitive evaluations of the utility of travel time which indicates positive feelings of relaxation and enthusiasm.

Relaxation has been found to indicate boredom or stress according to Ettema et al. (2012). The authors found it had a negative effect on the utility of travel time. According to Wang & Loo (2018), it showed no significant impact.

The last secondary activity is eating/drinking, which has been shown to have a positive effect on the utility of travel time according to Singleton (2020). According to Rasouli & Timmermans (2014), however, it was insignificant despite its large positive coefficient due to large variations between individuals.

2.4.3 The effect of primary activity characteristics on secondary activities

The two sub-variables of travel-based multitasking, primary activity characteristics and secondary activities, are related in that primary activity characteristics affect the nature and extent of secondary activities. Such a relation has been extensively analysed and empirically proven in travel-based multitasking literature and is therefore discussed below, although it is beyond the scope of this research.

The first indicator of primary activity characteristics that will be discussed is travel mode. In the above section, it has been alluded to that the passive or active nature of the mode chosen by the traveller can affect the nature and extent of secondary activities, exacerbated by legal and technical constraints. This is especially apparent when comparing secondary activities on public transport with cars. However, differences in secondary activities between public transport modes also exist, in spite of the common passive nature (Keseru & Macharis, 2017; Ohmori & Harata, 2008). In Zhang & Timmermans' 2010 study determining the likelihood of secondary activity participation based on primary activity characteristics, it was found that passengers travelling on rail, including commuters, were less likely to relax, compared to those travelling on other public transport modes, favouring active secondary activities such as working/studying. This finding was supported by Patriarche & Huynen (2014) who noted a significantly higher incidence of working/studying on trains. When examining the differences between the nature of secondary activities on buses and trains, Russell et al. (2011) discovered through structured observations that bus passengers mostly relaxed, whereas train passengers partook in more active secondary occupations, studying/working with and without the use of ICTs notably more often. This finding is confirmed by Ettema et al. (2012) and applies to trams as well. The passive nature of secondary activities on buses and trams can accordingly be attributed to their instability, simple interiors, and large number of stops due to congestion or arrivals. Guo et al. (2015) notes that this may also contribute to a higher frequency of entertainment and communication using ICTs. Metros, on the other hand, seem to facilitate more active secondary activities than buses and trams, seeing more studying/working in addition to the use of ICT devices, although unclear for what purpose (Ettema et al., 2012; Keseru & Macharis, 2017). It must be noted however that the longer nature of train journeys in comparison to other modes may explain the nature and extent of secondary activities.

The second indicator is that of trip duration. Naturally, longer trips imply not only higher durations of secondary activities but also more active categories of secondary activities such as reading (Keseru & Macharis, 2017). According to Ohmori & Harata (2008), travellers decide secondary activity categories and duration based on what they deem to be an appropriate duration for the activity related to their total journey time, taking into account the ease of using equipment on different travel modes. On train journeys exceeding 30 minutes, it has been found that commuters are more likely to work/study; however, according to Gamberini et al. (2013), trip durations as low as 12 minutes can facilitate active secondary occupations too, as seen in the London Underground where, on average, travellers begin to work/study and communicate on their hand-held ICT devices just two stops after they board (Frei et al., 2015; Keseru & Macharis, 2017).

Travelling with a companion in the fourth indicator. It affects secondary activities in that the presence of a companion deters travellers from relaxing (Zhang & Timmermans, 2010) in favour of communication with other passengers for longer periods of time (Keseru & Macharis, 2017; Timmermans & Van der Waerden, 2008; Van der Waerden et al., 2009).

The fifth indicator is Wi-Fi connectivity, specifically speed and reliability. According to Bjørner (2016), travellers indicated that the reliability of Wi-Fi connections negatively affects the use of ICTs. This finding was supported Gripsrud & Hjorthol (2012). Furthermore, in SDG's (2016) study examining the value of mobile connectivity on trains, a portion of travellers indicated that they would spend more time using ICTs in light of faster connections (Keseru & Macharis, 2017; Pawlak, 2020).

The final indicator of primary activity characteristics is trip crowdedness. Higher levels of crowdedness decrease the frequency of communication with other passengers and the use of ICTs across purposes (Gamberini et al., 2013; Guo et al., 2015; Timmermans & Van der Waerden, 2008).

2.5 Conceptual framework

The conceptual framework that this thesis will follow is shown below in Figure 1. The theory of the positive utility of travel time stipulates that travel-based multitasking affects the utility of travel time and has therefore been selected to guide the research. As discussed previously, it was introduced formally by Mokhtarian & Salomon in 2001 in response to the negative conceptualization of the utility of travel time which states that there is only a disutility to travel time due to its costs and time. The theory has been chosen since it has been backed by various authors across sociological and economic fields, having been studied from decision utility, experienced utility and subjective-wellbeing perspectives, specifying that, overall, travel-based multitasking improves the utility of travel time by making trips more useful and enjoyable (Ettema et al., 2012; Jain & Lyons, 2008; Jara-Diaz, 2008; Mokhtarian et al., 2001). Therefore, travel-based multitasking is the independent variable which affects the dependent variable the utility of travel time. Travel-based multitasking consists of two sub-variables, namely primary activity characteristics and secondary activities (Circella et al., 2012). The sub-variables are linked to each other in that the former affects the latter, but this effect goes beyond the scope of the thesis. The utility of travel time, conceptualized from a perspective of subjective well-being, also consists of two-sub-variables, namely affective and cognitive evaluation (Ettema et al., 2011; Ettema et al., 2012). There is no relation stipulated between the two sub-variables.

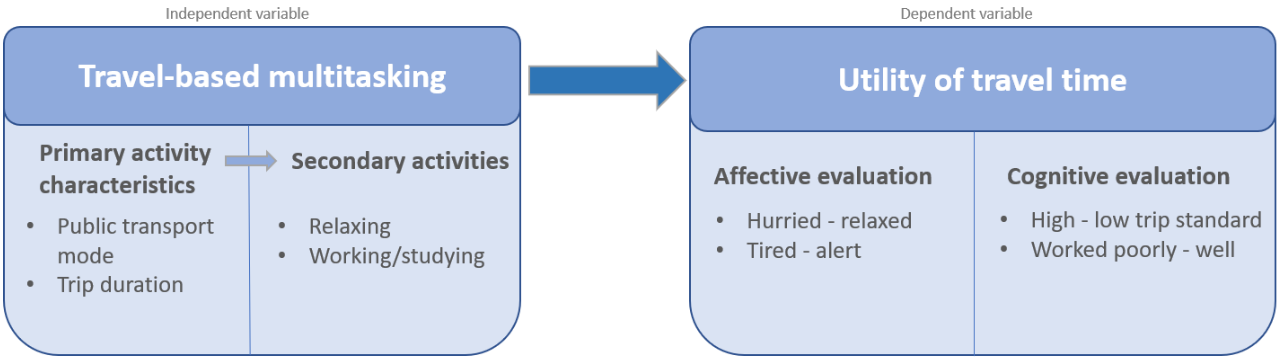

Figure 1: conceptual framework showing the effect of travel-based multitasking on the utility of travel time, including sub-variables and examples of indicators

Chapter 3: Research design, methods and limitations

3.1 Introduction

In Chapter 3, the research design, data collection instruments, sampling methods and size, and data analysis methods of this study will be introduced and described. The validity and reliability of the research strategy will also be discussed, and finally, the theory of the positive utility of travel will be operationalized into variables, sub-variables and indicators on the basis of Chapter 2.

3.2 Description of the research design and methods

3.2.2 Research type

The type of this research is explanatory as it applies developed theories in the search for a causal relationship between travel-based multitasking and the utility of travel for public transport commuters. It is deductive as opposed to inductive since the aim is not to develop new theories to diagnose the empirical world, but to construct a model based on existing theories (van Theil, 2014).

3.2.3 Research strategy

In conducting research, it is crucial to narrow down a suitable strategy. According to van Theil (2014), research strategies may span surveys, case studies, desk research, and experiments. In this thesis, a survey has been chosen.

The research strategy of a survey is characterized by a "large-scale approach" and is most suitable for deductive research that aims to generalize findings to a large population (van Theil, 2014, p. 74). Thus, the main data collection instrument is that of a questionnaire in which many variables are measured in a standardized manner using, for example, scales and categories. This is to ensure that data is easily retrievable from a large number of respondents, whose participation stems from a sampling procedure (van Theil, 2014). All in all, a survey has been deemed most suitable for this research since it allows conclusions to be generalized externally to a large population – in this case, public transport commuters of Rotterdam.

3.2.4 Data collection instrument

Now that it is established that the research strategy is a survey, the data collection instruments chosen can be discussed. They are that of a questionnaire and pilot questionnaire.

As has been established in the previous section, the strength of surveys largely stems from the use of questionnaires, which facilitate generalizability. The most used form is the written questionnaire consisting of closed-ended questions, although questionnaires are also used in telephone surveys and structured interviews (van Theil, 2014). This research makes use of a written questionnaire displayed online, via the Qualtrics software. It includes static content in the form of descriptive texts to introduce the purpose of the research and provide context to certain questions that need elaboration to ensure they are fully understood, as well as standard questions in multiple choice, Likert scale, and open-ended, single-line text entry formats.

To improve the reliability of results, a pilot was conducted prior to the questionnaire. Pilot questionnaires allow researchers to refine their measurement instruments and achieve a wider grasp of the practicalities of research, and are usually conducted with few individuals of the target population (Gudmundsdottir & Brock-Utne, 2010; Malmqvist et al., 2019; van Teijlingen & Hundley, 2002; van Theil, 2014). Doing the pilot questionnaire involves administering online questionnaires, cognitive interviews where respondents narrate their thought processes while filling out the questionnaire, and retrospective individual debriefings (Ruel et al., 2016). All in all, it loosely follows the format of a brief semi-structured interview. Such an instrument has been chosen over open and structured interviews to balance flexibility with replicability. According to Ruel et al. (2016, p. 106), the following elements are necessary to be considered when gathering reactions: “question wording and language”, “comprehensive measurement”, “mutually exclusive measurement”, and “additional comments”, and have accordingly been noted.

3.2.5 Sampling design

3.2.5.1 Population

The population of this research is public transport commuters based in Rotterdam travelling within the MRDH, with the sampling unit being at an individual level. Such a population can be estimated on the basis of the working and student population of Rotterdam as reported by the Municipality of Rotterdam. According to the latest figures, the population consists of 443,707 people (Municipality of Rotterdam, 2020).

3.2.5.2 Sample size

A minimum sample size must be reached to not only ensure the generalizability of results, but to also ensure accuracy in analyses (van Theil, 2014). In statistical analyses, for example, coefficients and their significance levels have proven to be largely inaccurate with low sample sizes (Goodhue et al., 2006).

In the case of a questionnaire, the equation shown below can be utilized for sample size calculation, given a large population. Given a confidence level of 95%, a consequent Z score of 1.96, a standard deviation of 0.5 and a margin of error of +/-5%, the number of respondents needed is 385 (Smith, n.d.).

$$Sample\ size = \frac{Z\ score^2 * standard\ deviation * (1 - standard\ deviation)}{margin\ of\ error^2}$$

As for the sample size necessary to conduct the pilot questionnaires, van Belle (2002) suggests a minimum of 12 respondents (Johanson & Brooks, 2009). Therefore, the aim for questionnaire recruitment was 385 respondents, and 12 respondents for the pilot questionnaires.

3.2.5.3 Sampling procedures

Sample approaches can be sorted into two: probability and non-probability sampling. The former entails the selection of the sample from chance and is based on the principle of random sampling, whereas the latter is purposive in nature (Richardson et al., 1995; van Theil, 2014).

For survey inference, probability sampling is considered the standard due to its ability to minimize both known and unknown biases in the selection of respondents, improving sample representativeness and generalizability (Richardson et al., 1995; van Theil, 2014; White, 2016). However, since the retrieval of a sampling frame which identifies every unit in a base list was unlikely in the case of this thesis, and due to the difficulty of conducting on-board intercept surveys during the COVID-19 pandemic, the methods of simple, stratified, and variable fraction stratified random sampling were not able to be conducted. Therefore, cluster sampling, where the population is split into geographical segments before drawing a random sample, is one of the chosen sampling procedures (Richardson et al., 1995). It has been conducted by sending mail to random addresses within each of Rotterdam’s 76 unique postcode regions, stating the link at which the online questionnaire can be reached. Ten addresses per region were chosen, drawn randomly based on public postcode data, making a total of 760 questionnaire invitations (Postcodebijadres, n.d.). To make up for low response rates usually associated with probability sampling, as well as the lack of considerable resources, it has been supplemented with non-probability, convenience sampling in the form of online, self-selected questionnaires. Such an integrated approach can improve the estimation of model parameters, although it is important to note that online surveys are usually prone to selection, size, and nonresponse biases, reducing external validity (Fricker, 2008; Richardson et al., 1995; Wisniowksi et al., 2020).

The sampling procedures chosen to recruit participants for the pilot questionnaires is that of convenience sampling where it is up to the individual to choose to participate. Respondents were recruited from the researcher's network. Such an approach has been chosen over random sampling due to a lack of resources, especially amidst the COVID-19 pandemic, and because no statistical inferences will be made on the basis of this data (Fricker, 2008).

3.2.6 Validity and reliability

3.2.6.1 Validity

The validity of a research paper is assessed based on its internal and external validity. According to van Theil (2014), when a study is of high internal validity it means that the researcher has measured the effect intended. Accordingly, it is determined by whether or not variables have been operationalized accurately, and whether the effect being measured has been proven to exist. To ensure internal validity, the operationalization of variables was based on an extensive literature review, and the formulation of items conducted carefully to guarantee that they do not invite multiple interpretations and are not leading. In addition, answer categories were designed to be as consistent, comprehensive, distinct and as mutually exclusive as possible. Furthermore, since respondents sometimes adapt their answers according to the research situation, the final questionnaire was never filled out with the researcher's presence to avoid social desirability bias (van Theil, 2014).

As for external validity, it refers to the ability to generalize results of the sample studied to a broader population (van Theil, 2014). In order to produce generalizable findings, the sampling size criterion outlined previously must be met. This did not occur, with 69% of the sample size being achieved, due to limitations in time allocated towards data collection. However, another method to improve external validity is that of a probability sampling method to ensure randomization. As mentioned in the previous sub-section, the probability sampling method of cluster sampling, based geographically, has been used, albeit in combination with non-probability, convenience sampling. The combination was necessary to ensure at least an adequate sample size for inferential statistics.

3.2.6.2 Reliability

Improving the reliability of a study involves working on two dimensions: the accuracy and the consistency of variable measurement. Doing so ensures that the researcher reaches true findings and that their research is repeatable (van Theil, 2014). The operationalization of variables according to previous practice in the literature was therefore done. In addition, the measurement instrument of the questionnaire was authenticated through pilot questionnaires, through which changes to wording of items were made, and the suitability of the multiple linear regression analysis validated through a series of diagnostic tests. Lastly, the Cronbach's alpha was used to measure internal consistency when combining indicators into multidimensional constructs.

3.2.7 Data analysis

The questionnaire data was analysed using descriptive and inferential statistics on the software Stata.

Descriptive statistics allow the basic features of the sample and variables to be explored and summarized in terms of numerical measures as means, standard deviations, Cronbach's Alphas, and correlations, as well as graphical indicators as frequency charts and histograms (van Theil, 2014).

The numerical descriptive statistics of means and standard deviations are used in the case of continuous data such as the primary activity characteristic of trip duration and secondary activities. Means are useful as a statistical feature in that they summarize data into one central value, whereas the standard deviation describes the spread of the data and its variability from the mean (Boslaugh, 2012; van Theil, 2014).

In the case of latent constructs which are not directly measured but instead inferred from the combination of indicators into a scale, the descriptive statistic of the Cronbach's Alpha is used; this is the case of affective and cognitive evaluations of the utility of travel time and the primary activity characteristic of Wi-Fi connectivity. Tavakol & Dennick (2011, p.1) state that Cronbach's alpha measures the internal consistency, or reliability, of a scale; it "describes the extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of the items within the test". Coefficients above 0.70 are deemed acceptable, and the higher the score, the more reliability ensured (Santos, 1999).

According to van Theil (2014), measuring the correlation between variables is a relevant descriptive technique used to establish whether a relationship exists, its direction, and how strong it is. It is necessary to note that it does not validate causality as a multiple linear regression does; however, it is a useful tool to be conducted beforehand. Therefore, it is used prior to making causal inferences – in the second and third sub-research questions. Two common methods of measurement are Pearson's and Spearman's correlations; the latter is chosen since it allows for the use of both continuous and categorical data and does not assume normality (Laerd Statistics, n.d.; Weaver at al., 2017). The correlation coefficients can take values between and including -1 and 1, where -1 indicates a perfect, negative linear association, 0 the lack of a relationship, and 1 a perfect, positive linear association. The rule of thumb is that absolute values between 0 and 0.3 are considered weak, 0.3 and 0.7 moderate, and 0.7 to 1 strong (Ratner, 2009). A confidence level of 95% will be used where values below 0.05 are considered significant.

Descriptive statistics can also be displayed graphically (Boslaugh, 2012). In the case of categorical data, or continuous data that can be easily split into categories, frequency charts in the form of pie or bar charts are used showing the distribution of categories in sample percentages. Histograms are similar to frequency charts in that they show the frequency of data within intervals or bins. The difference is that these bins are more frequent and not easily comparable; histograms display the distribution of continuous, ordinal data that cannot clearly be divided into meaningful categories (Boslaugh, 2012). Therefore, it is used only in the case of the utility of travel time and its sub-variables.

On the other hand, inferential statistics determine whether the relationships between the variables outlined in the conceptual framework are systematic, the chosen method of this thesis being the multiple linear regression (van Theil, 2014). A multiple linear regression is estimated by ordinary least squares and models and accounts for potential, observable differences between the utility of travel time, as a continuous variable, according to changes in primary activity characteristics and secondary activities. The six assumptions of the multiple linear regression will be checked prior to analysis to ensure its suitability and determine whether minor changes to models need to be made (Stock & Watson, 2011). In analysis, coefficients are analysed using a confidence level of 95%. The R-squared of each model will also be reported to indicate explanatory power.

3.3 Operationalization

3.3.1 Definition of theories, variables, and indicators

The theory underpinning the thesis is the theory of a positive utility of travel time, which according to Mokhtarian & Salomon (2001) is tripartite, partially determined by travel-based multitasking. Accordingly, the dependent variable of this thesis is the utility of travel time. In this thesis it is defined as the experienced utility of travel time from a subjective well-being approach, which can be operationalized by two sub-variables measuring affective and cognitive evaluations of travel time – in other words, commuters' feelings and judgments. For the affective component, six indicators are used to evaluate, among others, relaxation and alertness, whereas the cognitive component consists of three indicators evaluating the quality of service and efficiency of public transport. Indicators here include, for example, whether the trip was of a very high or low standard. This operationalization follows the STS developed by Ettema et al. (2010).

As for the independent variable, travel-based multitasking, it is defined as the participation in primary and secondary activities at once. It is measured by two sub-variables: primary activity characteristics, indicated by public transport mode and trip duration among others, as well as secondary activities, indicated by the duration spent by the commuter on secondary activity categories as entertainment and ICTs (Ettema et al., 2012; Ettema et al., 2010; Krueger et al., 2019).

3.3.2 Operationalization table

The operationalization table is shown below in Table 1. It excludes control variables as socio-demographics and other trip-related indicators.

Theory	Variable	Sub-variable	Indicators	Indicator sources
The positive utility of travel time	Travel-based multitasking	Primary activity characteristics	- Public transport mode o Bus o Tram o Metro o Train - Trip duration (in minutes) - Presence of a companion o Yes o No - Trip crowdedness based on ability to find a seat on a 5-point Likert scale from "very easy" to "very difficult" - Wi-FI connectivity o Perceived reliability of on-board Wi-Fi on a 5-point Likert scale of "far below average" to "far above average" in addition to "I don't know" o Perceived speed of on-board Wi-Fi on a 5-point Likert scale of "far below average" to "far above average", in addition to "I don't know"	(Ettema et al., 2012; Pawlak, 2020; Rasouli & Timmermans, 2014; SDG, 2016; Singleton, 2019; Wang & Loo, 2018)
		Secondary activities	Maximum 3 categories time has been spent on, measured in terms of percentage of travel time spent on each - Working/studying using ICTs - Working/studying - Entertainment by reading - Entertainment using ICTs (listening to audio/watching videos/gaming/browsing/social media use) - Communication using ICTs (personal messaging/calling) - Communication with other passengers - Relaxation (window gazing/people watching/doing nothing) - Eating/drinking	(Ettema et al., 2012; Krueger at al., 2019)
	Utility of travel time	Affective evaluation	The intensity and incidence of positive and/or negative feelings during the trip on a 7-point Likert scale - Very tired - very alert - Very bored - very enthusiastic - Very fed up - very engaged - Very hurried - very relaxed - Very worried- very confident - Very stressed - very calm	(Ettema et al., 2012; Ettema et al., 2010)
		Cognitive evaluation	Judgment of satisfaction with trip on a 7-point Likert scale - Worst I can think of - best I can think of - Very low standard - very high standard - Worked very poorly - worked very well	(Ettema et al., 2012; Ettema et al., 2010)

Table 3: conceptual framework showing the effect of travel-based multitasking on the utility of travel time, including sub-variables and examples of indicators

Chapter 4: Presentation of data and analysis

4.1 Introduction

Below, the survey data that has been collected will be described and analyzed to come to findings for this research. Chapter 4 begins with a description of the survey and sample, followed by the presentation of descriptive statistics and statistical analysis according to each sub-question. Results will be discussed under the context of the literature review and conceptual framework.

4.2 Description of survey

The public transport commuter living in Rotterdam and travelling within the MRDH is the unit of analysis of this thesis. A public transport commuter is considered to be an individual travelling to or from their place of work or study using either a bus, tram, or metro operating within the RET's concession area, or an NS train.

The questionnaire was piloted among 12 respondents and, accordingly, adjustments made to the wording and order of questions. The final questionnaire was published in both English and Dutch and available for participation on desktop and mobile platforms.

Although asking respondents to base their answers on the trip they took on the same day is the standard among the literature to avoid large discrepancies between instant and remembered utility (De Vos et al., 2016; Ettema et al., 2012), doing so during the COVID-19 pandemic would likely bias the sample towards people who cannot or choose not to work remotely, such as essential workers. Furthermore, due to the in-vehicle public transport regulations put in place by the national government, mandating the use of face masks among other guidelines, this practice would introduce biases in the measurement of utility of travel time, secondary activities like socializing, and primary activity characteristics such as the crowdedness of vehicles. Therefore, respondents were asked to base their answers on their average, non-eventful, pre-COVID19 commute trip.

The survey can be found in Annex 1.

4.3 Description of sample

The sample consists of respondents who were targeted firstly based on the cluster sampling of the 76 unique postcode regions, with ten survey invitations sent out randomly per postcode. This was supplemented with non-probability convenience sampling in the form of self-selected questionnaires distributed on social media platforms, namely Facebook, Reddit, and LinkedIn. Overall, 661 responses were achieved but were cut down according to the criteria for analysis: age between 18 and 65, living in Rotterdam, travelling by public transport within the Metropolitan Region of Rotterdam – The Hague, working more than 12 hours a week or studying, and complete responses. Respondents from the area of Rozenburg were also filtered out since the town does not lie within RET's concession area (MRDH, n.d.), altogether leaving a final sample size of 264 respondents, attaining 69% of the sample size necessary to ensure external validity.

Prior to understanding the data related to each sub-question and analyzing it, it is necessary to first attain a firm understanding of the composition of the sample itself. This is in regards to indicators concerning the geographical scope of the research, and secondly in terms of trip-related and sociodemographic indicators that go beyond the scope of the conceptual framework but are still necessary to control for in statistical analysis according to the literature.

The geographical information of respondents can be split into their area of residence as well as the region of their commute destination. Firstly, it can be said that the sample covers roughly

72% of Rotterdam's residential areas. This is based on an optional request to state the first four letters of respondents' postcodes. The highest postcode frequency corresponds to the area of Kralingen-Crooswijk, at 20% of the sample, followed by Rotterdam Centrum at 14%. These regions are only the 6th and 9th most populated areas in Rotterdam, indicating that the sample is not fully representative of the whole of Rotterdam (Municipality of Rotterdam, 2020). As for the region of commute, most of the sample travels within the area of Rotterdam, as can be seen in Figure 2 (Annex 2), with 29% going beyond the city and into other regions of the MRDH.

The sociodemographic attributes of the sample are age, educational attainment, gender, living situation, and annual income.

Age has been measured continuously as opposed to categorically, where the mean age is 30 years and the standard deviation, or the spread of the data, is at 12 years. To visualize the data and obtain a better understanding of its composition, categories have been created. As seen in Figure 3 (Annex 2), the sample largely consists of a younger population, followed by those between the age of 26 and 50, and finally, at just 9%, those between the age of 51 and 65. Roughly, there is a 30% overrepresentation of the younger population in comparison to official statistics, with the remaining age groups underrepresented (Municipality of Rotterdam, 2020).

In terms of educational attainment, as shown in Figure 4 (Annex 2), the sample consists mostly of undergraduate degree holders, followed by high school graduates and those with postgraduate degrees. It is unclear what the split truly is in Rotterdam.

As for the gender split of the sample, it consists mostly of those who identify as males, seen in Figure 5 (Annex 2). Here, the male population is overrepresented compared to that of Rotterdam, by about 14 percentage points (Municipality of Rotterdam, 2020).

The majority of the sample are cohabiting, living with other people, whereas just 24% reside by themselves, as seen in Figure 6 (Annex 2). It is unclear what the split truly is in Rotterdam.

In terms of annual income level, the sample majority is considered to have a middle income, between 13,401 and 69,700 euros, at 41%. The following subgroup is that of low income – those who earn less than 13,400 euros a year. High income respondents were rare, at 2%, whereas 20% of the sample decided to leave their income level undisclosed, as seen in Figure 7 (Annex 2). Official data regarding Rotterdam's income is unclear; however, high income respondents are underrepresented (Municipality of Rotterdam, n.d.).

The trip-related attributes of the sample that will be used as controls are commute frequency, commute purpose and trip direction. They differ from primary activity characteristics in that there is little theoretical backing to their links to the utility of travel time. It must be noted that there is no relevant population data to crosscheck under- or over-representation of the sample, unlike the case of several sociodemographic indicators.

In Figure 8 (Annex 2) it can be seen that the commute frequency of the majority of the sample is 5 days a week, attributed to 44%. It is closely followed by that of 3-4 days a week, at 42%. Those who travel to work 1-2 days a week are next at 10%, and, finally, those travelling 6-7 days a week.

The purpose of the sample's commute is split into those travelling to work and those travelling to their place of study, the former holding the majority at 56%, seen in Figure 9 (Annex 2). As for the direction of travel, 52% of the respondents referred to their commute towards their place of work or study (refer to Figure 10 in Annex 2). This was assigned randomly in the questionnaire.

4.4 Presentation and analysis of data related to sub-questions

In Chapter 4, for each sub-question, data concerning the variables in question and their indicators will be presented in the form of numerical and graphical descriptive statistics. Prior to the statistical analysis required for the second and third sub-questions, the assumptions of the chosen inferential method, the multiple linear regression, will be tested and the final models derived. The regression results will then be presented. Overall, where possible, comparisons will be made to findings from the literature.

4.4.1 What are the affective and cognitive evaluations of the utility of travel time?

The first sub-research question is descriptive in nature, aiming to outline the levels of affective and cognitive evaluations of the utility of travel time among the sample. Thus, it will be analysed with descriptive statistics alone. These will include the numerical descriptive statistics of means, standard deviations and Cronbach's Alpha, and graphical descriptive statistics of frequency charts and histograms. Correlation analysis will not be utilized since a relationship between the affective and cognitive evaluations of utility of travel time have not been stipulated or discussed by the literature, is not in the conceptual framework, and is therefore beyond the scope of this explanatory research.

4.4.1.1 Descriptive statistics

Based on the Satisfaction with Travel Scale developed by Ettema et al. (2011), the variable the utility of travel time consists of two sub-variables or dimensions, namely: the affective evaluation of the utility of travel time, and the cognitive evaluation of the utility of travel time.

As described in Chapter 2, the affective evaluation of the utility of travel time refers to the individual's emotional state while travelling (Ettema et al., 2012). It can be measured by utilizing six items on a seven-point scale of opposing adjectives, an example of which spans a statement of being "very hurried" to "very relaxed". The frequencies of each of the seven points can be found for each item in Figures 11 to 16 of Annex 2. The distributions display an identification of confidence during travel time as opposed to worry, followed closely by calmness versus stress. Feelings of relaxation also scored higher than that of hurry, with a larger variation of data. The sample also, although minimally, identified with statements related to engagement over feeling "fed up". However, respondents displayed elements of boredom compared to enthusiasm while travelling, albeit quite marginally and not by many points in comparison to feelings of tiredness over alertness.

After testing for Cronbach's alpha and finding the combination of the six items into one scale to be reliable at a coefficient of 0.81, seen in Table 2 (Annex), the sub-variable of the affective utility of travel time was created as an average. Figure 17 below displays a histogram of the frequency density of the affective utility of travel time, the graphical descriptive method chosen due to the continuous and ordinal nature of the sub-variable, from which it can be inferred that it leans to a more positive evaluation. The average score is in fact positive at 0.28, with the minimum evaluation recorded at -2.30 and the maximum, although rarely logged, at 3, which indicates that a small portion of the respondents resonated with affective utility statements at the maximum for each indicator, but not vice versa. In addition, the data showed a standard deviation of 1.03 points around the mean.

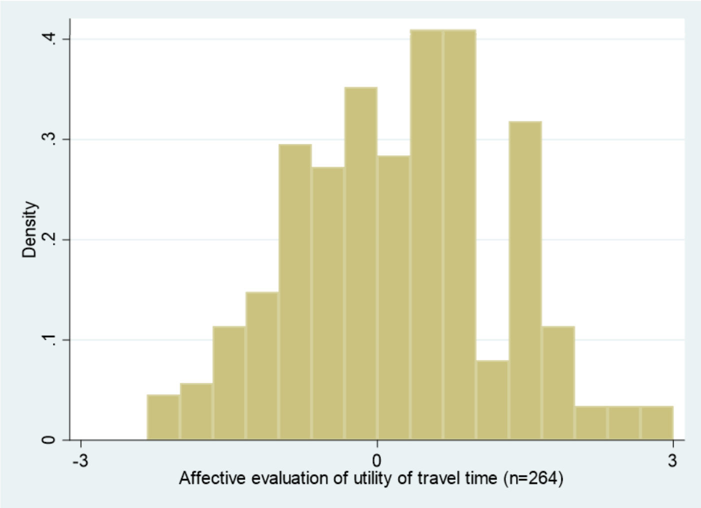

Figure 17: histogram of affective evaluation of utility of travel time

The cognitive evaluation of the utility of travel time will now be discussed. It refers to the individual's judgment of satisfaction while travelling and can be measured by utilizing three items on a seven-point scale (Ettema et al., 2012). Respondents were, for example, asked to rate their trip from being of "very low standard" to "very high standard". The frequencies of each of the seven points can be found for each cognitive item in Figures 18, 19 and 20 of Annex 2. The distributions show that respondents' evaluations of the trip in regard to whether it was the "worst" or "best" leaned towards a more positive evaluation, with just one single respondent recording it as "worst", although neutral responses were most common. The variance of responses regarding the standard of the trip was slightly higher with 1% of the sample indicating that the trip was of a "very low standard", although positive responses were slightly more frequent in comparison to the previous item, with less respondents opting to vote for the neutral option. When it comes to whether the trip "worked poorly" or "well", results are overwhelmingly positive relative to other items, indicating that respondents were satisfied with the functioning of the trip.

The Cronbach's alpha of combining the three cognitive items into one scale is found to be reliable at 0.73, as shown in Table 3 (Annex). Therefore, the cognitive utility of travel time was created from the average. The histogram of its frequency density in Figure 21 shows that the evaluation of travel time is skewed towards the left, with a longer tail in the positive section of the number line. In contrast to the affective utility of travel time, on average, higher scores are reached; respondents were found to have reached the maximum and minimum attainable scores, 3 and -3, more frequently and the average was found to be at 0.76 points. Furthermore, the spread of the sub-variable was slightly lower at 0.91 points around the mean.

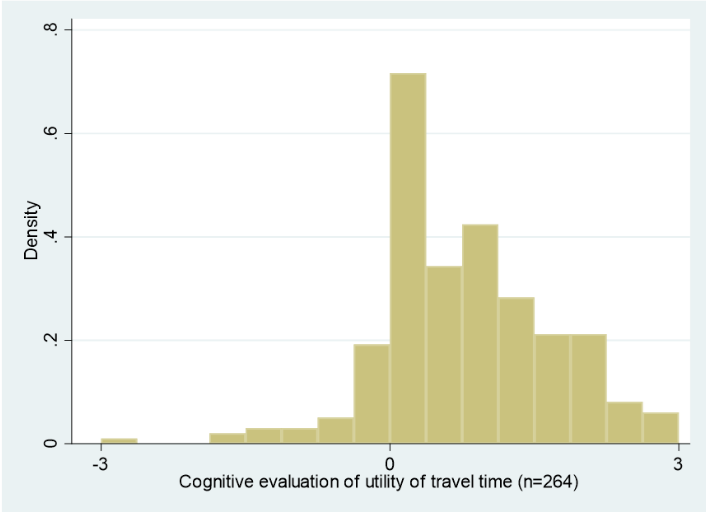

Figure 21: histogram of cognitive evaluation of utility of travel time

4.4.1.2 Overview

Relating the descriptive statistics to the literature, it has been found that the affective and cognitive evaluations of the utility of travel time are positive, at an average of 0.28 and 0.76 respectively, from a scale of -3 to 3. The average of the cognitive evaluation of the utility of travel time is more than double than that of the affective evaluation of the utility of travel time, indicating that respondents have less positive emotional states than rational judgments of trip satisfaction – their moods during travel are slightly worse than their experiences of the efficiency and quality of their trip, on average. In addition, the affective evaluation showed more variability around the mean than the cognitive evaluation, showing slightly more irregularity in responses. Ettema et al. (2012) found a similar finding in their research on the effect of travel-based multitasking on the utility of travel time, albeit smaller differences. An explanation to this trend could be that travellers' affective utility of travel time may be influenced by factors that go beyond their trip, more so than they affect the cognitive evaluation, where travellers are likely to give a more objective evaluation. Singleton (2020) cites personality differences and overall satisfaction with life across home and work domains as possible determinants that may affect the affective evaluation of travel.

The positive affective and cognitive evaluations of the utility of travel additionally point towards respondents valuing their travel time beyond its opportunity costs; travel time is not necessarily experienced as a disutility. This aligns with the positive conceptualization of the utility of travel time that has seen growth in the literature, from both economic- and well-being-based approaches, refuting the inference of the utility of travel time based on standard microeconomic theory, which entails choice experiments that vary only in time and costs (Ettema et al., 2012; Jain & Lyons, 2008; Kouwenhoven & de Jong, 2018; Mokhtarian & Salomon, 2001).

4.4.2 To what extent do primary activity characteristics influence the utility of travel time?

Answering the above sub-question will be done with a multiple linear regression. Before such an analysis, descriptive statistics will be presented, specifically means, standard deviations, correlations, Cronbach's Alphas, frequency charts, and histograms. The regression model's assumptions will then be checked. Primary activity characteristics is the first sub-variable of travel-based multitasking, indicated by: public transport mode, trip duration, presence of a companion, trip crowdedness, and Wi-Fi connectivity. The dependent variable, the utility of travel time, is indicated through the summation of affective and cognitive evaluations.

4.4.2.1 Descriptive statistics

The most common public transport mode referred to by the sample was that of the metro, at 34%, followed by the tram, train, and bus, as is shown in Figure 22 below. This does not reflect the most frequently *used* public transport mode of the sample since those who chose several modes were randomly allocated one part of their journey to base their answers on.

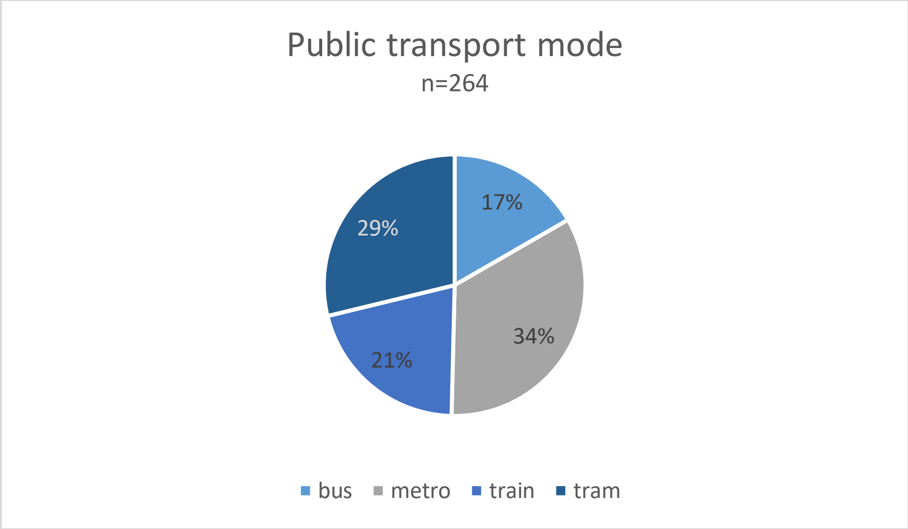

Figure 22: bar chart of frequency distribution according to public transport mode

As for the trip duration, it was measured continuously, where the minimum trip length noted was that of 2 minutes, and the maximum 120 minutes. The average trip duration was 24 minutes, and the standard deviation, or spread of the data, 18 minutes. To gain a better understanding of its composition, categories have been created and frequencies visualized below in Figure 23. The most common trip duration category was between 11 and 20 minutes at almost 35% of observations. Short trips taking 10 minutes or less were next, and the least frequent trip length was between an hour and two, at less than 5%. Such results are fitting with the fact that most of the respondents travelled within the area of Rotterdam.

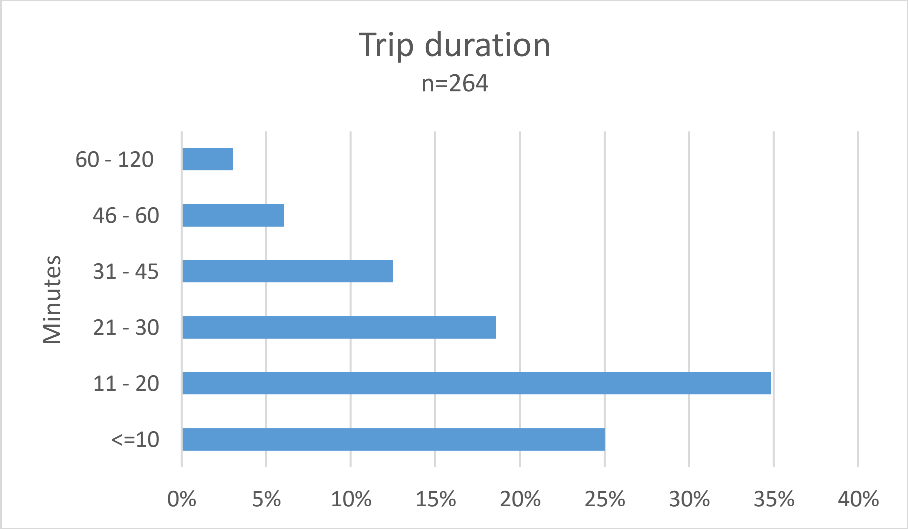

Figure 23: bar chart of frequency distribution according to trip duration

Most respondents reported travelling by themselves, without a companion, as seen in Figure 24 (Annex 2).

Trip crowdedness was operationalized by the ability to find a seat, ranked via a five-point Likert scale. Around 35% of the sample found it easy to find a seat, followed closely by those who found it neither easy nor difficult, shown in Figure 25 below. Overall, trips were reported to be slightly or very crowded much less often than the opposite, which points to a regular public transport service frequency in Rotterdam.

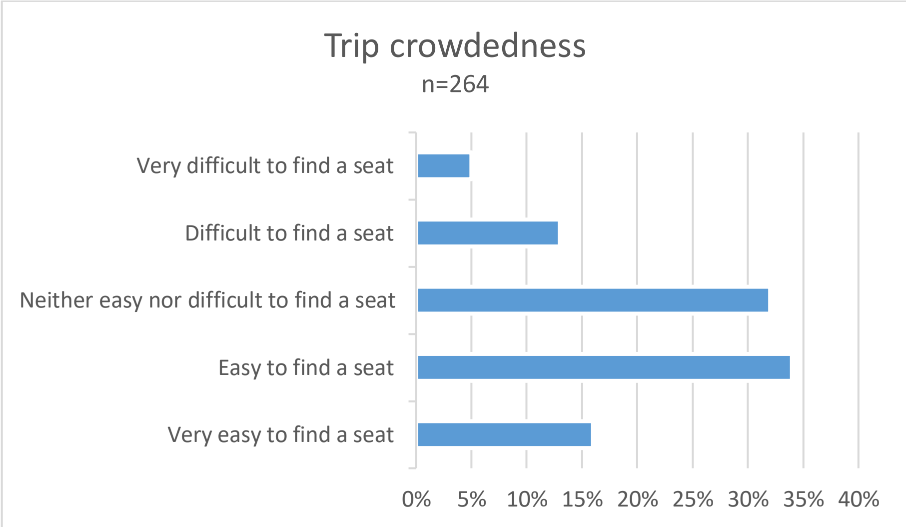

Figure 25: bar chart of frequency distribution according to trip crowdedness, determined by difficulty to find a seat

The connectivity of on-board Wi-Fi consists of two elements: the speed and reliability of Wi-Fi, as perceived by public transport users, shown in Figure 26 and 27 (Annex 2) respectively. The trend of the data is quite similar for both indicators, with the majority of the sample scoring the Wi-Fi speed and reliability to be far below average, followed by average, and somewhat below average. Overall, respondents scored the Wi-Fi speed and reliability to be somewhat or far below average much more often than vice versa, indicating that there is perhaps a degree of dissatisfaction regarding the service. It is crucial to report that 30% of the sample were not aware of the speed or reliability of the on-board Wi-Fi and have accordingly been recorded as missing values.

Since the connectivity of on-board Wi-Fi is a latent construct, not directly measured, its Cronbach's alpha is calculated prior to the aggregation of the two indicators into a scale. In the case of Wi-Fi connectivity, Table 4 displays a coefficient of 0.86, which is above the benchmark of 0.70, indicating that the scale is reliable to be used for further analysis. The average response for the final variable is that the Wi-Fi connectivity is somewhat below average, with the standard deviation being 1.10 points on the five-point Likert scale.

Cronbach's alpha: Wi-Fi connectivity	
Number of items in the scale	2
Scale reliability coefficient	0.86

Table 4: Cronbach's alpha associated with combining Wi-Fi speed and reliability to measure Wi-Fi connectivity

Since the utility of travel time will be analysed as a whole in relation to primary activity characteristics, taking into account both affective and cognitive components, it is necessary to combine the two scales discussed in section 4.4.1 into one. As shown below in Table 5, the Cronbach's alpha is satisfactory at 0.72, indicating that the two scales are indeed dimensions of the one latent construct of the utility of travel time.

Cronbach's Alpha: utility of travel time	
Number of items in the scale	2
Scale reliability coefficient	0.72

Table 5: Cronbach's alpha associated with combining affective and cognitive evaluations to measure overall utility of travel time

Figure 28 below shows the frequency distribution of the final variable: the utility of travel time, where the maximum value is 6 and the minimum at -4.33. It roughly follows a normal distribution where there is symmetry around the mean, which in itself is 1.05, indicating that the average utility of travel time for respondents is positive. This follows naturally from the positive trends of affective and cognitive evaluations. The standard deviation, or spread of the data, is 1.71 points.

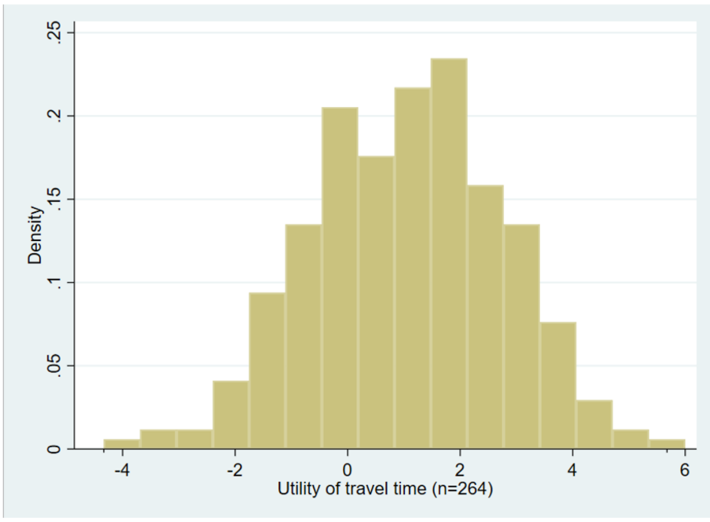

Figure 28: histogram of utility of travel time

Table 6 displays correlations between primary activity characteristics and the utility of travel time. Relationships that are considered significant under a 95% confidence interval are trip crowdedness and Wi-Fi connectivity. Trip crowdedness displays a negative correlation to the utility of travel time, whereas Wi-Fi connectivity relates to it positively. Both relationships are weak since they are below a benchmark of 0.3. These findings align with Batarce et al. (2016) who has stated that more crowded public transport vehicles are associated with less utility due to feelings of discomfort with proximity, and Bjørner (2016) who has shown passengers' frustrations with insufficient connectivity due to their reduced ability to participate in secondary activities.

Primary activity characteristics		Correlation in relation to the utility of travel time
Public transport mode	Bus	-0.12
	Tram	0.03
	Metro	0.10
	Train	-0.05
Trip duration		-0.10
Presence of a companion		0.00
Trip crowdedness		**-0.19**
Wi-Fi connectivity		**0.20**

Table 6: Spearman's rank-order correlation between utility of travel time and primary activity characteristics, where bolded figures are significant

4.4.2.2 Regression diagnostics

The sub-research question will be analyzed by utilizing the multiple linear regression, as explained in Chapter 3. It is necessary to validate its six assumptions before conducting analysis in case any transformations must be made for a better fit between the data and analysis, or in case another inferential method is better suited to the data at hand.

The first assumption is the unlikelihood of large outliers. It can be accounted for through the correction of data entry errors or their removal (Stock & Watson, 2011). Typing errors were indeed found in several observations prior to running descriptive statistics, where indicators as age and trip duration were abnormally large. Accordingly, they were excluded from the data set, validating the assumption.

The second assumption is the independence and identical distribution of variables across all observations i.e. that the sample mean is not biased, therefore allowing for inferences to be made to the wider population (Stock & Watson, 2011). This assumption applies to questionnaire data gathered through cluster sampling due its element of randomization. Sampling had to some extent been done randomly, following a geographic clustering method, although it was supplemented occasionally with non-probability, online sampling. Since the data set is cross-sectional and observations do not refer to the same respondents over time, the assumption is to some extent validated (Stock & Watson, 2011).

No multicollinearity between independent variables is the third assumption. Perfect linear relationships between independent variables can result in inaccurate standard errors (Stock & Watson, 2011). To test this assumption, the variance inflation factor can be calculated on the basis of a preliminary regression. It is necessary to note that values beyond the threshold of 2.5 that correspond to dummy indicators representing three or more categories can go disregarded (Allison, 2012; Chen et al., 2003). As seen in Table 7 in Annex 2, the variance inflation factors for necessary variables are significantly below 2.5. The assumption holds.

The fourth assumption entails constant, or homoscedastic, variance of residuals – that there exists no pattern between residuals, which are the vertical distance between observations and the values they have been predicted to be based on the regression (Chen at al., 2003). Violation leads to inaccurate standard errors and p-value estimates, especially when dealing with small sample sizes (Yobero, 2016). The White test can be referred to after running a preliminary regression (Chen et al., 2003). As seen in Table 8 (Annex 2), the null hypothesis of homoscedastic variance of residuals is not rejected due to the large p-value, validating the assumption. To further ensure accurate standard errors, regressions will be run subject to robust standard errors.

The fifth assumption is that residuals are distributed normally, required to ensure valid hypothesis testing. To check this assumption, preliminary regressions must be run to estimate residuals, and the Shapiro-Wilk W test conducted (Chen at al., 2003). Table 9 (Annex 2) shows that the normality of residuals cannot be rejected, indicating that the assumption holds.

The final and most crucial assumption is linearity between dependent and independent variables. Violating the assumption leads to incorrect and unreliable results (Stock & Watson, 2011). With two values, dummy variables satisfy this assumption. Otherwise, it is diagnosed through augmented partial residual plots of each independent variable following a preliminary regression, which can be found in Figures 29 to 40 in Annex 2 (Chen et al., 2003). Four variables stand out as non-linear, namely: trip crowdedness, where there are three significant deviations from linearity, working/studying using ICTs and communication with other passengers, where there are two significant deviations respectively, and eating/drinking where there is one. Since transforming these variables into logarithms does not correct for such non-linearity and transforming them into quadratic variables does not abide by the theory, these variables have been converted into dummies. Trip crowdedness will hold a value of one if the respondent has indicated slight or extreme difficulty in finding a seat; otherwise, it will hold a value of zero. The secondary activities mentioned above will take a value of one if the respondent has indicated spending more than zero percent of their travel time on them, and a value of zero otherwise. Although converting variables into categorical dummies loses information, doing so is preferred since linearity is crucial to running multiple linear regressions.

Therefore, the assumptions of the multiple linear regression hold, and the following models will be run to answer the sub-research question:

$$(1)\ \textit{Utility of travel time} = \beta 0 + \beta 1 * \textit{working/studying using ICTs} + \beta 2 * \textit{working/studying} + \beta 3 * \textit{entertainment by reading} + \beta 4 * \textit{entertainment using ICTs} + \beta 5 * \textit{communication using ICTs} + \beta 6 * \textit{communication with other passengers} + \beta 7 * \textit{relaxation} + \beta 8 * \textit{eating} + \beta 9 * \textit{public transport mode} + \beta 10 * \textit{trip duration} + \beta 11 * \textit{presence of a companion} + \beta 12 * \textit{trip crowdedness} + \beta 13 * \textit{age} + \beta 14 * \textit{educational attainment} + \beta 15 * \textit{gender} + \beta 16 * \textit{living situation} + \beta 17 * \textit{income} + \beta 18 * \textit{commute frequency} + \beta 19 * \textit{commute purpose} + \beta 20 * \textit{trip direction} + \mathcal{E}$$

$$(2)\ \textit{Utility of travel time} = \beta 0 + \beta 1 * \textit{working/studying using ICTs} + \beta 2 * \textit{working/studying} + \beta 3 * \textit{entertainment by reading} + \beta 4 * \textit{entertainment using ICTs} + \beta 5 * \textit{communication using ICTs} + \beta 6 * \textit{communication with other passengers} + \beta 7 * \textit{relaxation} + \beta 8 * \textit{eating} + \beta 9 * \textit{public transport mode} + \beta 10 * \textit{trip duration} + \beta 11 * \textit{presence of a companion} + \beta 12 * \textit{trip crowdedness} + \beta 13 * \textit{age} + \beta 14 * \textit{educational attainment} + \beta 15 * \textit{gender} + \beta 16 * \textit{living situation} + \beta 17 * \textit{income} + \beta 18 * \textit{commute frequency} + \beta 19 * \textit{commute purpose} + \beta 20 * \textit{trip direction} + \beta 21 * \textit{Wi-Fi connectivity} + \mathcal{E}$$

Not only are primary activity characteristics regressed to the utility of travel time, but so are secondary activities and other socio-demographic and trip-related control variables; such an approach has been decided upon to avoid the violation of the conditional independence assumption, which requires that determinants of the dependent variable which vary with independent variables be included in inferring causality. Omitted variable bias would arise otherwise, risking the violation of the second regression assumption (Hank et al., 2020; Stock

& Watson, 2011). The models are identical aside from the addition of Wi-Fi connectivity in the second. The reason such an approach has been chosen is because Wi-Fi connectivity has only been collected from 70% of respondents, with 30% of the sample observations being treated as missing; running a regression on only 70% of the sample would introduce bias and skew results in favor to those who are prone to use Wi-Fi. Since Wi-Fi connectivity is seen as a key indicator of primary activity characteristics with an effect on utility, it was not omitted.

4.4.2.3 Regression results

The results of the multiple linear regression are shown below in Table 10. It is found that the only three significant effects of primary activity characteristics are that of trip duration, trip crowdedness, and Wi-Fi connectivity.

Primary activity characteristics		Model 1 R-squared=20%		Model 2 R-Squared=31%	
		Coefficient	P-value	Coefficient	P-value
Public transport mode (reference=train)	Bus	-0.60	0.10	-0.82	0.09
	Tram	-0.12	0.73	-0.41	0.32
	Metro	0.07	0.83	0.01	0.98
Trip duration (continuous)		-0.01	**0.05**	-0.01	**0.05**
Presence of a companion		-0.21	0.61	-0.06	0.90
Trip crowdedness		-1.10	**0.00**	-1.10	**0.00**
Constant		-0.05	0.95	-0.32	0.74
Wi-Fi connectivity (continuous)		-	-	0.28	**0.01**

Table 10: regression results of model 1 and 2 with a focus on primary activity characteristics

When accounting for secondary activities and socio-demographic and trip-related control variables, trip duration has a negative causal effect on the utility of travel time. This aligns with standard microeconomic utility maximization theory underpinning travel demand models and infrastructure appraisals. It implies that longer commutes reduce the utility of travel time due to the opportunity cost involved; individuals would perhaps rather allocate their time towards other activities such as labor or leisure (Becker; 1965; Small, 2012). The finding is also backed empirically; Ettema et al. (2012) attributed longer trips to lower evaluations of the utility of travel time, both affectively and cognitively. Therefore, it holds that, on average, the commuters that have been studied do indeed benefit from shorter trips. Although it is difficult to interpret the coefficient clearly due to the ordinal dependent variable, the effect is relatively small at an 0.01 change in utility of travel time for each additional minute, bearing in mind that the utility of travel time spans a 10 point scale, roughly. This effect is robust across both models.

The second significant effect is trip crowdedness, which has a negative causal influence on the utility of travel time. This aligns by Batarce et al. (2016) and Wardman's (2014) findings which imply that higher levels of crowding negatively affects the utility of travel time due to increased discomfort associated with not finding a seat, the potential effects of crowding on longer trip durations, and its impedance on secondary activities that can be carried out. For example, it may not be as comfortable for passengers to communicate with each other, as noted by Timmermans & Van der Waerden (2008). However, such a finding conflicts with research by Ettema et al. (2012) who explain that commuters have higher affective and cognitive evaluations of their trip the more crowded it is since it creates a safer and more active environment. It seems that in the case of the sample, however, this is not the case; commuters see less utility the more crowded it is, perhaps because safety and activity in the carriage is less of a concern compared to physical discomfort and the ability to freely conduct secondary activities. Trip crowdedness also reduces the utility of travel time relatively more than trip duration does, with a one-point difference, indicating that it is perhaps a stronger room for investment. This effect remains the same across both models.

As for Wi-Fi connectivity, which is included only in the second model, it has a positive impact on the utility of travel time. It also accounts for a large increase in the R-squared, or the explanatory power, of the model from 20% to 31%. Commuters in the sample that perceive a higher level of Wi-Fi connectivity, on average, enjoy their trips more, which has been suggested by Bounie et al. (2019) among other authors (Bjørner, 2016; SDG, 2016) since it can improve the efficiency and ability to undertake secondary activities that require the use of web-enabled ICTs (Shaw et al., 2019). It also validates Jain & Lyons' (2008) hypothesis that the benefits of travel time are enabled by elements of the travel space and its infrastructure, which includes the provision of Wi-Fi. In terms of its coefficient, Wi-Fi connectivity does not have as high of implications as trip crowdedness does but is a stronger determinant of utility of travel time than trip duration, taking into account the range of values it can hold. The effect of Wi-Fi connectivity is especially striking given its low average score, implying that there is room for improvement in Wi-Fi reliability and speed which could bring about more satisfactory travel times.

Public transport modes of the bus, tram, metro in comparison to the train have no significant impacts on the utility of travel time according to both models. These findings differ starkly from the literature which has largely shown that the utility of travel time for buses, trams and metros do differ in comparison to trains, which are largely regarded as the most comfortable and productive public transport vehicle (Abrantes & Wardman, 2011; Rasouli & Timmermans, 2014). This implies that, for the sample, the utility of travel time does not differ across the RET and NS; the (dis)satisfaction derived from their services are, on average, similar, despite Rasouli & Timmerman's (2014) findings specific to Rotterdam.

The presence of a companion, too, does not have significant consequences on the utility of travel time. This does not align with Rasouli & Timmermans' (2014) findings showing that travelling alone reduces the utility of travel time significantly in Rotterdam.

4.4.2.4 Overview

Bringing together descriptive statistics and statistical results, significant causal relationship between primary activity characteristics of trip duration, trip crowdedness, and Wi-Fi connectivity to the utility of travel time is revealed. Starting with the dependent variable, the utility of travel time is slightly positive at a mean value of 1.05 from a potential range of -6 to 6. In terms of the independent variable of trip crowdedness, which was most commonly reported as low due to the ease of finding a seat, it was found to have the strongest significant effect on the utility of travel time. The direction of the relationship was negative, as has been alluded to through the significance of Spearman's correlation, aligning with Batarce et al.'s (2016) results; travelers in the sample may find the difficulty of finding a seat to be discomforting. Wi-Fi connectivity is the second strongest determinant of the utility of travel time, first showing a significant and positive correlation to the variable followed by its causal inference through the regression, which has been backed by Bounie et al. (2019) among other authors; better Wi-Fi connectivity may improve the efficiency and ability to conduct ICT-based secondary activities. On average, however, the sub-variable was reported to be somewhat below average, indicating a room for improvement. The weakest significant determinant was trip duration. The trip duration of the sample was most frequently between 11 and 20 minutes, and the sub-variable was reported to have a negative effect on the utility of travel time, despite the lack of a significant correlation. Controlling for other variables therefore proved to be useful, and the findings coincide with previous literature stemming back to negative conceptualizations of travel time grounded in standard microeconomic theory, although, on the contrary, the effect of more subjective and less traditional primary activity characteristics were more noteworthy.

4.4.3 To what extent do secondary activities influence the utility of travel time?

Answering the above sub-question will be done with a multiple linear regression. Before the regression analysis, descriptive statistics will be presented, specifically means, standard deviations, correlations, and frequency charts, and the regression diagnostics briefly described. Secondary activities is the second sub-variable of travel-based multitasking, indicated by: working/studying using ICTs, working/studying, entertainment by reading, entertainment using ICTs, communication using ICTs, communication with other passengers, relaxation, and eating/drinking. The dependent variable, the utility of travel time, is indicated by the summation of affective and cognitive evaluations.

4.4.3.1 Descriptive statistics

The descriptive statistics of secondary activities are outlined in this section according to the order set out in the operationalization table in Chapter 3. Since the utility of travel time has already been described previously, it will not be discussed again.

Table 11 below displays the percentage of respondents who indicate participating in each secondary activity category, where participation is a duration above zero minutes, ranked from highest to lowest. It can be seen that an overwhelming share of respondents, specifically 86% of them, reported using ICT devices as a form of entertainment, whether that be by browsing, listening to music, watching videos, or gaming, indicating a high penetration of devices in respondents' travels, as has been noted by authors as Guo et al. (2015) and Gamberini et al. (2013). Relaxation in the form of people watching, window gazing, and doing nothing is second most frequent at 62%, suggesting that passive activities which do not require many physical/mental resources are common. Communication using ICTs, whether it be through messaging or calling, is also frequent at 43%, which, too, supports the high use of ICT devices. Other secondary activity categories that are not so frequent but are still notable is entertainment by reading, which 19% of the sample partakes in, and working/studying using ICTs, which 15% of the sample conducts. Only 2% of respondents respectively work/study without the use of ICTs and talk to other passengers, whereas 1% dedicate a portion of their travel time to eating/drinking.

Secondary activities	Percentage of travellers who indicate participation in a secondary activity
Entertainment using ICTs	86%
Relaxation	62%
Communication using ICTs	43%
Entertainment by reading	19%
Working/studying using ICTs	15%
Working/studying	2%
Communication with other passengers	2%
Eating/drinking	1%

Table 11: percentage of travellers who have indicated participating in each secondary activity

The first indicator of secondary activities that will be discussed is working/studying using ICTs. A bar chart is shown in Figure 41 (Annex 2). It displays frequencies of the percentage of travel time spent on working/studying using ICTs. The majority of respondents spend between 1 and 20 percent of their travel time working/studying using ICTs with a minority spending their whole trip on this one activity. For those participating in the activity, the average percentage of travel time spent is 33, and the variability 20 percentage points.

The second indicator is working/studying, without the use of ICTs. As has been mentioned above, only 2% of respondents reported doing so. Accordingly, the bar chart in Figure 42 (Annex 2) shows that working/studying is mainly done between 1 to 20% of the travel time. Respondents have never reported conducting the activity throughout 80 to 100% of their trip. The average percentage of travel time spent on the activity is 32, and the standard deviation is 24 percentage points, indicating a higher variability around the mean compared to working/studying with ICTs.

As for entertainment by reading, the majority of those who do participate in the activity spend between 21 and 40% of their travel time on it, found from referring to Figure 43. As was the case with working/studying, it has never been reported to be done alone, with the maximum achieved percentage being 80%. The average percentage of travel time spent reading is 35%, with the spread of the data at 18 percentage points.

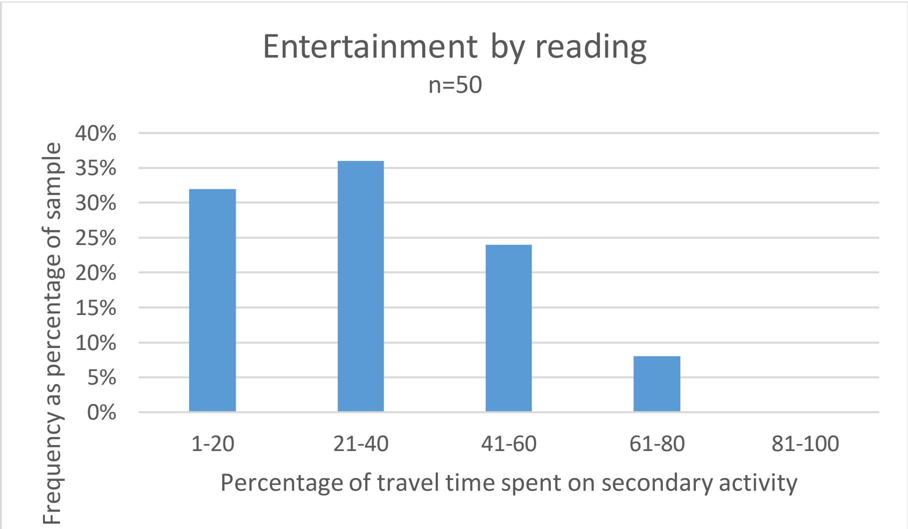

Figure 43: bar chart of frequency distribution of entertainment by reading

Entertainment using ICTs is an intensive activity in terms of duration spent, shown below in Figure 44. The majority of those who participated spent between 81 to 100% of their time on their ICT devices, either browsing, listening to music, gaming, or watching videos. Such a finding has brought the average percentage of travel time spent on the activity up to 75%. The minimum time spent was between 1 to 20% of the trip which happens to be the least frequent occurrence, and there is a high amount of variation around the mean, at 39%.

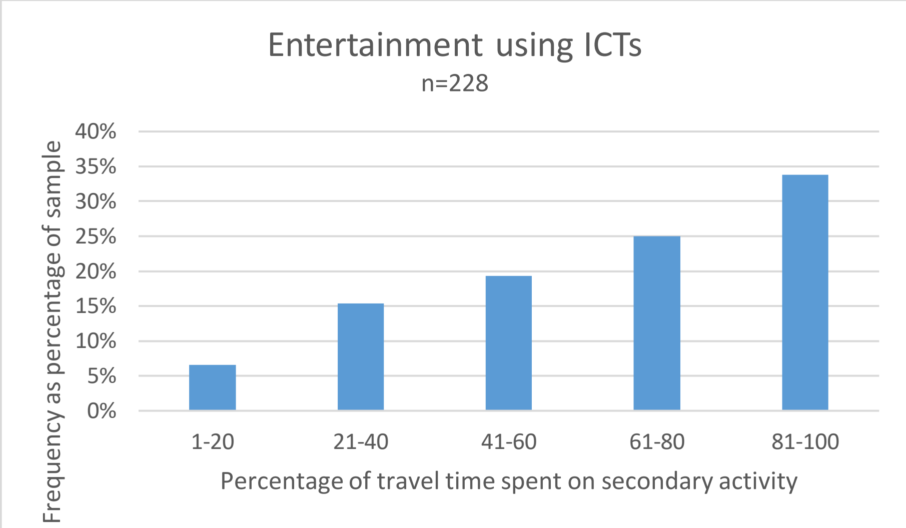

Figure 44: bar chart of frequency distribution entertainment using ICTs

The fifth secondary activity category is communication using ICTs. The majority of the sample who participate in the activity allocate between 1-20% of their travel time on it, seen in Figure 45 (Annex 2), indicating that it is an activity that is not necessarily prioritized. Furthermore, the mean time spent on the activity is 27 percent of travel time, and the standard deviation only at 20%. From there, the general trend is a drop in frequency as more time is spent on the activity.

Communication with other passengers is done extremely rarely; only 2% of the sample has indicated participation. Out of these 5 observations, the majority spent between 1 to 40% of their time engaging in the activity, seen in Figure 46 (Annex 2), with the maximum reported duration spent being 90%. The average amount of time spent on the activity is 37% of travel time, and the variability around the mean moderate at 30%.

Relaxation is most frequently done around between 1-20% of the sample's travel time, according to Figure 47 (Annex 2). The trend is downward sloping with peaks, and the mean at 41 percent of travel time. The standard deviation is moderate, specifically around 27%.

As for eating/drinking, it is the least frequent activity, recorded for only 1% of the sample. Figure 48 (Annex 2) shows that the overwhelming majority of the sample eats/drinks between 1 to 20% of the travel time. The maximum time spent is 90%, bringing up the mean to 34% of travel time spent on the activity. The standard deviation is highest of all secondary activities at 49%, meaning that answers are rarely standard across the sample.

As shown in Table 12, a Spearman's correlation (Laerd Statistics, n.d.; Weaver at al., 2017) was run between all secondary activities and the utility of travel time to determine whether a relationship exists in addition to its direction and strength. Based on the correlation matrix alone it can be said that there is no significant relationship between secondary activities and the utility of travel time; none of the coefficients were significant. Such a finding alludes to the fact that although respondents may choose to engage in secondary activities for a variety of reasons, in an attempt to pass time or improve comfort and productivity (Shaw et al., 2019; Singleton, 2018), it does not necessarily increase or reduce their satisfaction – the effect is indifferent. It is important to note that such a finding does not prove that the utility of travel time is negative in itself – it may in fact be positive due to other reasons mentioned by Mokhtarian & Salomon (2001) such as the value associated with reaching the trip destination and the intrinsic value of travel such as the sensation of speed. The regression analysis done further into the chapter will highlight whether these results hold causally and when controlling for other indicators.

Secondary activities	Correlation in relation to the utility of travel time
Working/studying using ICTs	-0.08
Working/studying	-0.06
Entertainment by reading	0.09
Entertainment using ICTs	0.00
Communication using ICTs	0.02
Communication with other passengers	0.01
Relaxation	0.02
Eating/drinking	0.04

Table 12: Spearman's rank-order correlation between utility of travel time and secondary activities, where bolded figures are significant

4.4.3.2 Regression diagnostics

The sub-research question will be tackled through the use of a multiple linear regression, as was the case with the second sub-research question. In section 4.4.2.2, it was decided that answering the second sub-research question would involve the inclusion of primary activity characteristics, secondary activities, and control variables into the final models to avoid omitted variable bias. This must also be ensured for the third sub-research question; therefore, the models are identical across these sub-research questions and the regression assumptions continue to hold and do not have to be tested again.

4.4.3.3 Regression results

The multiple linear regression results are displayed in Table 13 below. The only secondary activity that is significant across both models is that of entertainment by reading. Eating/drinking is significant only in the first model.

Secondary activities	Model 1 R-squared=20%		Model 2 R-Squared=31%	
	Coefficient	P-value	Coefficient	P-value
Working/studying using ICTs	-0.19	0.52	0.15	0.70
Working/studying (duration, continuous)	0.00	0.90	-0.02	0.18
Entertainment by reading (duration, continuous)	0.02	**0.03**	0.02	**0.05**
Entertainment using ICTs (duration, continuous)	0.00	0.39	0.00	0.28
Communication using ICTs (duration, continuous)	0.01	0.14	0.00	0.55
Communication with other passengers	0.20	0.81	-0.26	0.77
Relaxation (duration, continuous)	0.00	0.45	0.00	0.68
Eating/drinking	0.02	**0.05**	0.01	0.15
Constant	-0.05	0.95	-0.32	0.74

Table 13: regression results of model 1 and 2 with a focus on secondary activities

In accounting for secondary activities and socio-demographic and trip-related control variables, entertainment by reading has a positive causal impact on the utility of travel time. Such a finding proves that, for the commuting sample, a positive utility of travel time can be driven through conducting active secondary activities that may make a trip more pleasurable, not in an economic sense of productivity but from a standpoint of subjective well-being. Although the implication is only applicable to reading for leisure, it still displays the fundamental existence of an intrinsic utility for travel beyond accessing opportunities at a final destination, contrary to the assumptions of travel demand models and infrastructure appraisals (Lyons & Urry, 2005; Mokhtarian & Salomon, 2001). More empirically, the finding aligns with research previously conducted in Rotterdam; Rasouli & Timmermans (2014) indicated that the utility of travel time saw the largest significant increase from entertainment by reading compared to other significant secondary activities. Although it is unclear exactly why this is the case, even upon referring to literature, it can be speculated that perhaps entertainment by reading, as a more traditional alternative compared to, say, entertainment using ICTs, is more valued due to its simplicity and less repetitive nature. Furthermore, since it requires more active attention, it is perhaps more rewarding in consequence. Its coefficient, which is stable across models, is moderate overall when compared to the values that the utility of travel time can take on, but is high relative to primary activity characteristics; in the case that a commuter spends 100% of their travel time reading for leisure, a 2-point increase in the utility of travel time would be achieved on average, compared to a commuter who spends only 1% of their travel time reading for leisure, who only gains the baseline improvement of 0.02.

As for eating/drinking, which is only significant in the first model, it is shown that it affects the utility of travel time positively. Since the activity is prohibited in many locations where studies have been conducted, the Rasouli & Timmermans (2014) study can be referred to for comparison, which has, too, been done in Rotterdam, where eating/drinking is allowed across all vehicles (RET, n.d.d.). In their study, eating/drinking is insignificant, yet has the highest correspondent effect on the utility of travel time. Singleton (2020) also found a positive influence of eating/drinking on the utility of travel time, and it was significant. The author has speculated that eating/drinking may be rewarding as a traditional activity since it satisfies a human need in a manner that compensates for pressured time schedules outside of travel. In terms of its coefficient, it is the same as the baseline effect of participating in entertainment by reading, but unlike entertainment by reading, is stable no matter the duration spent on the task. This is due to the fact that eating/drinking was operationalized as a dummy variable to fit the multiple linear regression assumptions. Accordingly, the effect is quite low in comparison to primary activity characteristics. It must be noted however that this analysis must be taken lightly due to the activity's sudden insignificance in the second model, which happens to provide higher explanatory power.

The other six secondary activities show no significant effects on the utility of travel time. Main takeaways are that, firstly, the use of ICTs for entertainment and communication are not determining factors of the utility of travel time. Although public transport service providers have been increasingly investing in facilities that improve their use, and rightfully so due to the demonstrated influence of Wi-Fi connectivity on the utility of travel time, conducting these ICT-based activities have no significant effect on commuter satisfaction in the sample. This is backed by sources in the literature as Wang & Loo (2018).

Secondly, working/studying, whether or not ICTs are used, is insignificant as well. Incompatibilities with the literature exists in regard to working/studying using ICTs; for example, a Rotterdam-based study found a positive and significant effect (Rasouli & Timmermans, 2014; Wang & Loo, 2018). The insignificance of working/studying without the use of ICTs, on the other hand, is in alignment with the empirical evidence from and beyond Rotterdam (Ettema et al., 2012; Rasouli & Timmermans, 2014). Although it has been alluded to by Mokhtarian et al. (2001) that working/studying in either cases should be a positive determinant of the utility of travel time due to improvements in economic productivity, they do not necessarily make travel time more worthwhile subjectively. However, it is important to note that despite insignificant effects, the advantages of working/studying may go beyond travel time to affect utility in other domains of the commuter's day – it may not be pleasurable to work/study on public transport with or without ICTs, but the benefits of getting it out of the way may later improve well-being.

Other findings are that communication with other passengers as an insignificant determinant of utility of travel time aligns with Wang & Loo's (2018) research, although according to Ettema et al. (2012), leads to positive affective and cognitive evaluations of the utility of travel time. The last indicator of secondary activities is relaxation; its insignificance, too, aligns with Wang & Loo's (2018) research but differs in Ettema et al. (2012)'s study, which showed that relaxing decreases the utility of travel time and can indicate boredom or stress.

4.4.3.4 Overview

To briefly sum up the results of descriptive statistics and the regression analysis, it has been found that the secondary activities of entertainment by reading and eating/drinking have a positive, significant influence on the utility of travel time, although the latter is only significant in one model. Entertainment by reading is not the most common secondary activity among the sample, with only 19% participating compared to 96% involved in entertainment using ICTs. Furthermore, it is not a time-intensive activity, with the average respondent spending around 35% of their travel time dedicated to it, choosing to complement their travel time with other secondary activities too, unlike the case of entertainment using ICTs which takes up around 75% of respondents' time on public transport. However, it has a positive impact on the utility of travel time, which aligns with Rasouli & Timmermans' (2014) finding; conducting the active secondary activity makes the trip more pleasurable as a leisure activity which is not productive in an economic sense. As for eating/drinking, it is the least common secondary activity, with only 1% of the sample noting it. The average time spent on the activity was around 34%, similar to entertainment by reading. It has a weaker, positive influence on the utility of travel time that is not robust across models in comparison. The direction of effect aligns with Singleton's (2020) findings, a possible explanation being that it is valued as a traditional activity that compensates for packed time schedules outside of travel. Both entertainment by reading and eating/drinking showed no significant relationship with the utility of travel time in terms of correlations, indicating that controlling for other variables was indeed useful in clarifying the relationship.

Chapter 5: Conclusions

5.1 Introduction

The goal of Chapter 5 is to summarize the main research findings outlined in the previous chapter. The sub-research questions and main research question will be answered, followed by a summary of the limitations of this study. Considering these limitations, practical recommendations will then be given, in addition to recommendations for further research and the author's outlook.

5.2 Main findings

5.2.1 What are the affective and cognitive evaluations of the utility of travel time?

The first sub-research question was answered through the use of descriptive statistics, both numerically and graphically, in order to find the affective and cognitive evaluations of the utility of travel time of the sample.

Upon combining the six indicators of the affective evaluation of the utility of travel time, which is the respondent's individual mental state during their time on Rotterdam's public transport, it was found that it leaned towards a positive value. Specifically, the average was found to be at 0.28, which is only slightly positive relative to the maximum attainable scale of -3 to 3. The minimum recorded evaluation was at -2.30, meaning that not a single respondent gave all indicators the lowest possible score, yet the opposite was true for the maximum. As for the cognitive evaluation of the utility of travel time, also known as the respondent's judgment of the efficiency and quality of their experience on Rotterdam's public transport, it scored higher than double that of the affective evaluation, at a mean value of 0.76, with the maximum possible scores achieved on both ends: 3 and -3. The positivity of these sub-variables as well as the finding that the cognitive evaluation is higher than the affective evaluation of travel time shows that respondents, on average, find their trip to be satisfactory in terms of quality and efficiency more so than their moods and emotional states throughout time on public transport. Ettema et al. (2012)'s research showed similar results. A possible explanation is that the affective utility of travel time is more likely influenced by exogenous, psychological factors such as respondents' personalities or their overall satisfaction and outlook of life; cognitive evaluations of the utility of travel time possibly require the respondent to step aside from their moods and evaluate the items from a more rational perspective (Singleton, 2020).

All in all, these findings show that the affective and cognitive evaluations of the utility of travel time in the sample are usually positive, and that travel time not necessarily experienced as a disutility. Mokhtarian & Salomon's (2001) proposal that there is a positive utility of travel time can accordingly be validated, specifically for the sample due to low external validity stemming from the lack of full randomization and a low sample size, although what they are determined by when put together into a single variable is a question further answered under the following sub-research questions.

5.2.2 To what extent do primary activity characteristics influence the utility of travel time?

This sub-research question was analyzed through the use of a multiple linear regression, based on questionnaire data. Descriptive statistics, visual and numerical, were run prior. Findings from each method are synthesized below.

The utility of travel time, as the dependent variable which has been calculated on the basis of summing the affective and cognitive utility of travel time into one figure, is slightly positive averaging at 1.05. The attained range is from around -4 to 6, although it theoretically could have spanned values from -6 to 6 had there been more adverse responses. The most notable primary activity characteristics among the sample are those that are significant in their effect on the utility of travel time, namely trip duration, trip crowdedness and Wi-Fi connectivity.

The primary activity characteristic with the strongest effect on the utility of travel time is that of trip crowdedness, which has been found to have a negative influence shown from its regression coefficient of -1.10. Based on the literature, such a direction of influence can be attributed to a certain level of discomfort associated with the difficulty of finding a seat, perhaps because it forces the passenger to check multiple carriages or stand for a portion of their journey time (Batarce et al., 2016; Wardman, 2014). Furthermore, trip crowdedness implies the limitation of secondary activities that commuters can freely carry out. The level of trip crowdedness reported as a descriptive statistic was, on average, low; respondents were able to find seats easily, and so the occurrence of respondents having a lower utility of travel time for this reason was low in the sample.

Wi-Fi connectivity is the second strongest determinant of the utility of travel time; commuters with higher evaluations of Wi-Fi connectivity in terms of its reliability and speed, on average, have higher levels of utility of travel time. This has been deduced from its regression coefficient which is 0.28. Furthermore, the indicator's addition into the regression in model 2 brought about an 11% increase in the R-squared of the model, hinting that it is of high explanatory power. The positive influence of the indicator can be attributed to its role as an element of travel infrastructure that provides an improved efficiency and ability to conduct secondary activities that require Wi-Fi access through the use of ICTs (Bounie et al., 2019; Bjørner, 2016; Jains & Lyons, 2008; SDG, 2016; Shaw et al., 2019). It is necessary to note one descriptive statistic here: the majority of the sample found the Wi-Fi connectivity to be below average, meaning that the benefits of higher Wi-Fi connectivity have not been reaped in the sample.

As for trip duration, it is the weakest determinant of the utility of travel time, and was only found to have a relationship with the utility of travel time when controlling for other variables; unlike the two indicators discussed above, no significant correlation had been alluded to. Based on the multiple linear regression, the causal relationship is negative in that commuters with longer trips have been found to, on average, have lower levels of utility of travel time; the regression coefficient of -0.01 implies an 0.01 decrease in the utility of travel time for every additional minute spent in a transport vehicle. It is important to bear in mind, however, that most of the sample partook in trips below 20 minutes; for the majority, trip duration did have a negative, significant effect on the utility of travel time, but definitely a minimal one. The direction of the relationship aligns with traditional microeconomic utility maximization theory stipulating that the opportunity cost of travel increases with the length of commute; other activities such as labor or leisure are more rewarding in comparison (Backer, 1965; Ettema et al., 2012; Small, 2012). However, the strength of the causality is overstated in the literature, with other subjective indicators carrying more weight.

Therefore, it can be said that primary activity characteristics as a sub-variable of travel-based multitasking does indeed influence the utility of travel time. The strength of such an influence is moderate, given that the significant coefficients of trip duration, trip crowdedness and Wi-Fi connectivity trigger no more than a 1-unit change in the utility of travel time, considering its numerical range. Although it was presupposed that the presence of a companion and the public transport mode reported would also affect the utility of travel time, they proved to induce no significant effect on the dependent variable. These findings must be taken with precaution, however, given characteristics of the sample; full randomization was not achieved, and the sample size was 69% of that required. This could have potential consequences on the interpretation of statistical results; for example, the overrepresentation of younger populations in the sample could partially explain the effect of Wi-Fi connectivity on the utility of travel time, although this possibility is reduced due to the use of age as a sociodemographic control indicator.

5.2.3 To what extent do secondary activities influence the utility of travel time?

As is the case with the previous sub-research question, the third sub-research question was analyzed through the use of a multiple linear regression, based on questionnaire data, after outlining descriptive statistics. Findings from each method are brought together below.

Based on the sample, the most secondary activities that do affect the utility of travel time are those were significant in either model: entertainment by reading and eating/drinking, although neither secondary activity proved to have a significant correlation to the utility of travel time, not to mention the other categories.

The two secondary activities have the same direction of effect on the utility of travel time. However, entertainment by reading was significant in both models, unlike eating/drinking, and is the most notable secondary activity since it has a stronger influence on the dependent variable when taking into account longer durations spent on the activity as a proportion of travel time. In section 4.4.3.3 it appeared that commuters who partake in entertainment by reading score, on average, higher levels of utility of travel time, deduced from the regression coefficient of 0.02 which indicates an 0.02 increase in the utility of travel time for every extra minute spent on the activity as a fraction of travel time. These findings align with research previously conducted in Rotterdam which found it attributed to the most significant, highest effect compared to other secondary activities (Rasouli & Timmermans, 2014). The reason as to why this secondary activity is significant over others is unclear, but a partial explanation can be that benefits are derived from its active, traditionally simplistic nature. In the sample, the activity was conducted among only 19% of respondents, with those respondents spending, on average, 35% of their travel time on the activity. Accordingly, it appears that there is room for the secondary activity to grow in use, in both occurrence and duration.

As for eating/drinking, it, too, has been shown to induce a higher level of utility of travel, albeit only in the first model where Wi-Fi connectivity is excluded; in the first model, the regression coefficient is 0.02 showing that, as a dummy indicator, participation in the activity improves the utility of travel time by that baseline value. Based on Singleton's (2020) study, the secondary activity may be considered as rewarding since it directly gives commuters the opportunity to satisfy a basic need which is a matter of maintenance, by directly compensating for their busy schedules. However, it has been reported among only 1% of the sample, among which there is the highest variability in the percentage duration spent on a secondary activity around the mean, which is 34%.

Therefore, all in all, secondary activities as a sub-variable of travel-based multitasking does indeed have an influence on the utility of travel time – a positive impact, partially validating Mokhtarian & Salomon's (2001) hypothesis that the utility of travel time is tripartite. The strength of the effect is moderate since it would, at most, result in only a 2-point increase in the utility of travel time, taking the dependent variable's roughly 10-point numerical range into account. Although the other six secondary activities were stipulated to have an effect on the utility of travel time, they lead to no significant effect. This contrasts with the rise of ICTs among other investments in travel space infrastructure such as meet and great zones, as well as their use, and displays that the gains of conducting secondary activities is not limited to secondary activities that improve economic productivity (Mokhtarian et al., 2001; Shaw et al., 2019). These findings are limited to the sample, however, due to the small sample size and improper randomization.

5.2.4 To what extent does travel-based multitasking influence the utility of travel time for Rotterdam's public transport commuters?

Taking the main findings of the sub-research questions into account, it can be said firstly that the utility of travel time is, on average, positive for the sample, indicated by the summation of both affective and cognitive evaluation sub-variables which were positive, too, at values 0.28 and 0.76 respectively from a scale of -3 to 3. This indicates that travelers' moods were more than twice as worse off than their rational evaluations of their time on public transport in terms of service quality and efficiency, from which it can be stipulated that perhaps personality differences among other psychological factors come into play, and that the average respondent experiences a positive utility of travel time overall. Answering the question directly, travel-based multitasking as a function of both primary activity characteristics and secondary activities does significantly influence the utility of travel time for the public transport commuters in Rotterdam, the Netherlands that have been studied. As shown above, the effect is specific to a total of five indicators: trip duration, trip crowdedness, and Wi-Fi connectivity, in addition to entertainment by reading and eating/drinking, which, alongside control variables, have an explanatory power of 31% as inferred by the R-squared of the second model. As deduced from the coefficients of each, it can be said that the effect of travel-based multitasking on the utility of travel time is moderate overall and is stronger for secondary activities.

Taking into account the limited external validity of this research due to the small sample size and underrepresentation of certain populations, the assumption underpinning travel demand forecasting models and transport infrastructure appraisal is falsified; travel time gains are not the main transport benefits, and intrinsic positive utility for travel does indeed exist, attributed to other elements of travel-based multitasking (Annema et al., 2016; Jains & Lyons, 2008; Mokhtarian & Salomon, 2001; Singleton, 2018). Accordingly, such a finding can have potential implications on travel preferences and behavior, as found by Malokin et al. (2019) among others (Mokhtarian & Salomon, 2001; Mokhtarian, 2007). Furthermore, Mokhtarian et al.'s (2001) claim that the intrinsic positive utility for travel partially arises due to gains in economic productivity does not go validated either, as explained above, which does not support arguments towards upgrading public transport vehicles to include, for example, laptop stations and work zones; investing in comfort and leisure alone would be more rewarding for the traveler. However, such a finding suggests that the benefits of travel-based multitasking may go beyond the trip – although it may not be immediately satisfying to be productive while travelling, the gains may ripple through the participant's day, improving well-being overall (Ettema et al., 2012).

5.3 Limitations

There are various limitations to this study that undermine its validity and reliability, starting with the data. The first issue is that the sample size necessary to ensure external validity was not achieved. Thus, inferences were not able to be generalized to the public transport commuting population of Rotterdam and are limited to the sample. Secondly, as seen in the description of the sample in Chapter 4, the sample was not strongly randomized, seeing over- and under-representations of certain population segments – for example, in terms of gender and locations of residence. This issue undermines internal validity due to the weakening of the second regression assumption which stipulates the independence and identical distribution of variables across observations, and accordingly has implications on external validity. Had the COVID-19 pandemic not been ongoing, more accurate methods of cluster sampling could have been utilized on the basis of public transport stations, ensuring higher randomization with respect to the target population of public transport commuters, as opposed to the general living population of Rotterdam which was sampled; it was unclear whether those invited to the questionnaire were public transport users in the first place. This was also a drawback when it came to achieving the necessary number of respondents. The last limitation concerning data is a question of the reliability of questionnaire responses. Respondents were asked, and reminded throughout the survey, to respond to questions with their average, non-eventful, pre-COVID19 commute in mind, as explained in Chapter 4. This poses a threat to reliability in that the discrepancies between instant and remembered utility are likely to be higher due to a large elapsed time between the trip and their time of response, and would have also affected the reliability of independent variables (Ayhan & Isiksal, 2005). It also limits the sample to those who state that they usually travel by public transport, as opposed to those who may not use it often but happen to do so on the day of questionnaire recruitment.

Methodological limitations are also present. The method of the multiple linear regression attempts to account for observable differences in estimating the effect of travel-based multitasking on the utility of travel time. For a reliable causal interpretation, omitted variables should not exist. Although control variables were used to reduce the bias, it is almost always present in cross-sectional studies due to their inherent inability to account for non-observable differences between individuals that go beyond the scope of study – for example, personality differences. The appropriate approach to ensure the reliability of results would have been to use longitudinal data following the same individuals over a number of trips over time. Finally, the last limitation is that the models used did not account for interactions between primary activity characteristics and secondary activities and their effects on the utility of travel time, undermining the understanding of the interlinkages between the two sub-variables. Although it had been stated that examining the effect of primary activity characteristics on secondary activities was beyond the scope of this research, studying how their co-occurrences affect the utility of travel time could have provided insight into, for example, whether the effect of entertainment for reading on the utility of travel time differs across varying trip durations, allowing for more specific recommendations to be made.

5.4 Recommendations

5.4.1 Practical recommendations

The practical recommendations that can be given to the RET and NS on the basis of this conclusion, taking into account the limited generalizability of results given the sample size, is firstly to improve Wi-Fi connectivity. Commuters value higher levels of Wi-Fi connectivity; its effect on the utility of travel time has been shown to be significantly positive. However, on average, it has been shown they are scored somewhat below average. Accordingly, it is recommended that the RET and NS invest in improving their Wi-Fi services so that it they are more reliable and faster, taking into account the capacity of their public transport vehicles. The second recommendation is to focus investments into optimizing public transport cabins for entertainment by reading. This is more straightforwardly done in trains due to the existence of quiet zones that fulfil such a purpose but can be trickier for other transport modes – in this case, the demand for facilities that encourage reading should be adequately studied.

5.4.2 Recommendations for future research

Recommendations that can be made for future research are firstly, studying the effect of travel-based multitasking on the utility of travel time using longitudinal data to allow for more reliable impact evaluation that controls for non-observable, potential determinants as personality differences, and incorporating interaction effects between sub-variables to understand under what conditions the utility of travel time is maximized. The final recommendation would be to investigate the decision utility involved in travel-based multitasking and how it differs from experienced utility – this is recommended in order to understand whether the productive benefits of travel-based multitasking extend past travel time into the improved day-to-day wellbeing of commuters.

5.5 Author's outlook

Positioning the results of this research within a broader discussion of travel time use and the effect of travel-based multitasking on the utility of travel time, as well as its progression over time, it can be said firstly that the results indicate the need for cost-benefit analyses and models used to estimate travel demand to progress beyond objective, directly measurable factors such as trip duration to better reflect the more complex reality of transport today through the subjective lens of the traveller. This would allow potential utility improvements from travel-based multitasking to be accounted for. As the facilities and services offered by public transport providers improve alongside technological developments to keep up with competition and cement urban and regional sustainable passenger transport, the potential of travel time to become more transparent and freer for overlaying with secondary activities grows, stretching and blurring the boundaries of activities and availability, making it ever so crucial to have this phenomenon reflected in modelling and decision-making (Mokhtarian, 2018). This raises another point that public transport providers must bear in mind – whether improvements in the utility of travel time stemming from travel-based multitasking truly translate into informing travel mode choice. A positive utility of travel time may reduce incentives to switch from public transport to, say, the use of automobiles, but is it enough to go beyond and stimulate changes in modal preferences and behaviour (Mokhtarian, 2018; Singleton, 2020)? Such a question also poses implications on the discussion of autonomous vehicles and the wide belief that they will transform how travellers perceive their travel time since transit-based studies have been used to inform such scenarios (see Malokin et al., 2019).

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Annex 1: Questionnaire

Introduction:

Welcome!

My name is Maryam. I am conducting this survey for my master's thesis at Erasmus University Rotterdam. I am specifically interested in how you use your travel time and how it affects your satisfaction with Rotterdam's public transport. Your participation should allow me to provide recommendations to the RET and NS to improve your travel experience.

By participating you have the chance to win a **20-euro** gift voucher at bol.com!

The survey should take no more than 10 minutes to complete. Your answers will be anonymous and will be deleted right after analysis.

Questions:

1. How old are you? ____

2. Do you live in the Municipality of Rotterdam?

○ Yes

○ No

The COVID-19 pandemic has naturally changed many areas of our life, including our travel patterns and experiences.

Therefore, I ask you to base all of your answers on what your situation was before the introduction of lockdown measures in March 2020.

3. Choose which statement applies to you

○ I am a student

○ I have a job where I work more than 12 hours a week

○ I am a student and have a job where I work more than 12 hours a week

○ None of the above

[If respondent is both a student and employee]

4. You have indicated that you study and have a job. Did you usually travel more frequently to your place of work or place of study?

○ Place of work

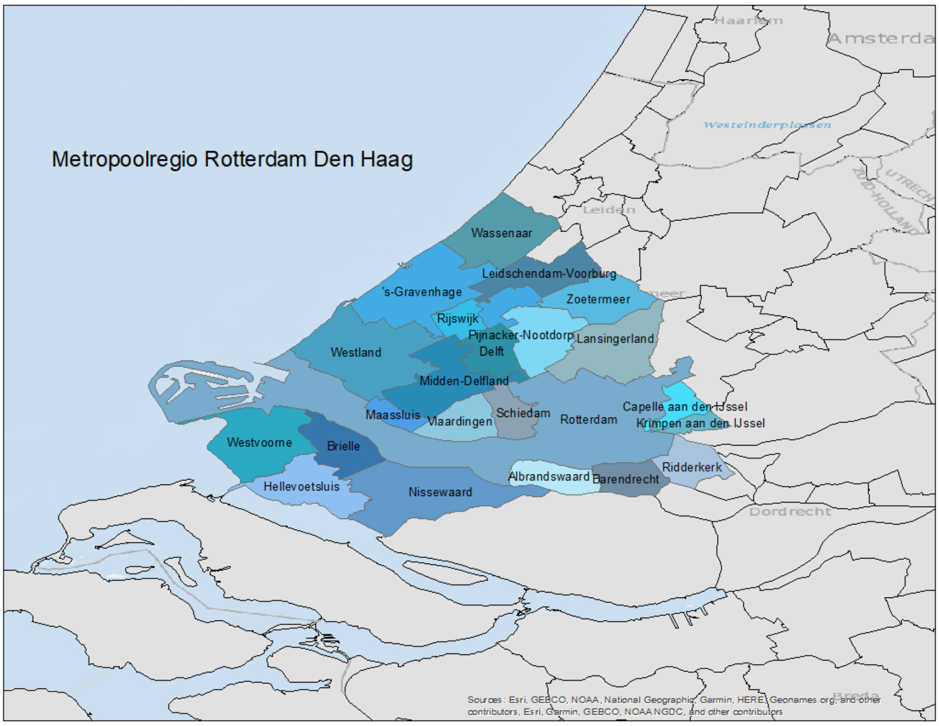
○ Place of study

5. Before the COVID-19 lockdown measures were introduced, how often did you travel to your place of study/work per week?

- ◯ 1-2 days a week
- ◯ 3-4 days a week
- ◯ 5 days a week
- ◯ 6-7 days a week
- ◯ I did not travel to my place of study even before COVID-19

6. Is your place of study/work within the region shown below?

- ◯ Yes, and it is in Rotterdam
- ◯ Yes, and it is not in Rotterdam
- ◯ No



7. When you travel to your place of study/work, do you often use public transport?

○ Yes

○ No

[If randomized direction is to place of work/study]

You will be asked below to indicate what modes of public transport you usually use on the way to your place of study/work. Please consider only the modes you enter while you are in the area of Rotterdam, **not** the ones you take from other areas.

Example scenario:
Your commute to your place of study/work involves **3** modes. You take the bus from your home to Rotterdam Centraal, where you take a train to Den Haag Centraal, and then step on a tram to your place of study/work. In the question below, you would only select **2** modes: the bus and train since you entered them while you were in the area of Rotterdam.

[If randomized direction is from place of work/study]

You will be asked below to indicate what modes of public transport you usually use on the way from your place of study/work. Please consider only the modes where your destination is in the area of Rotterdam, **not** the ones you use to travel within other areas.

Example scenario:

Your commute from your place of study/work involves **3** modes. You take the tram from your place of study/work to Den Haag Centraal, where you take a train to Rotterdam Centraal, and then step on a bus to go home. In the question below, you would only select **2** modes: the the train and the bus, since those are the modes that take you somewhere in the area of Rotterdam.

8. What mode(s) of public transport do you usually use on the way **[randomized: <u>to/from</u>]** your place of study/work?

☐ bus

☐ tram

☐ metro

☐ train

For the purpose of this survey, please think only of an average, uneventful, pre-COVID19 trip given:

- Direction: from home [predetermined by randomization: to/from] your place of study/work
- Mode: [mode chosen/randomized mode if more than 1 chosen]

9. From station to station, how long is your trip in minutes? _____

10. Do you travel with a companion? This could be anyone you know, from a family member to a colleague.

◯ Yes

◯ No

11. How would you rate the ability to find a seat?

◯ Very easy

◯ Easy

◯ Neither easy nor difficult

◯ Difficult

◯ Very difficult

12. How would you rate the connection reliability of the on-board WiFi?

◯ Far above average

◯ Somewhat above average

◯ Average

◯ Somewhat below average

◯ Far below average

◯ I don't know

13. How would you rate the speed of the on-board WiFi?

◯ Far above average

○ Somewhat above average

○ Average

○ Somewhat below average

○ Far below average

○ I don't know

For the purpose of this survey, please think only of an average, uneventful, pre-COVID19 trip given:

- Direction: from home [predetermined by randomization: to/from] your place of study/work
- Mode: [mode chosen/randomized mode if more than 1 chosen]

14. Below are categories indicating how people spend their travel time. Please indicate what you usually do - you can choose from 1 to 3 categories provided you usually do them **all** during **one** trip.

☐ Working/studying using electronic devices

☐ Working/studying without electronic devices

☐ Doing nothing/resting/sleeping

☐ Reading for leisure

☐ Listening to audio (music, podcasts, etc.)

☐ Watching videos

☐ Gaming

☐ Browsing/social media use

☐ Personal messaging/calling

☐ Talking to other passengers

- [ ] Window gazing/people watching
- [ ] Eating/drinking

15. Below are the activities you conduct. Please indicate how much percent of the time you spend on each.

Activity	Percent
[Activity chosen]	__
[Activity chosen]	__
[Activity chosen]	__

Below are 9 statements to complete, each with a pair of opposite adjectives. For each statement, please check the option that best corresponds to your average commute experience, from -3 to 3.

For example, if you usually feel very hurried during your commute, check -3, whereas if you usually feel very relaxed, check 3. If you usually feel neither hurried nor relaxed check 0. If you usually feel only a little bit hurried or relaxed, check any of the numbers in between that best fits your experience. If you are not sure, click "I don't know".

16.

	Very hurried -3	-2	-1	0	1	2	**Very relaxed** 3	I don't know
During my average commute I feel	○	○	○	○	○	○	○	○

17.

	Very worried -3	-2	-1	0	1	2	**Very confident** 3	I don't know
During my average commute I feel	○	○	○	○	○	○	○	○

18.

	Very stressed -3	-2	-1	0	1	2	**Very calm** 3	I don't know
During my average commute I feel	○	○	○	○	○	○	○	○

19.

	Very tired -3	-2	-1	0	1	2	**Very alert** 3	I don't know
During my average commute I feel	○	○	○	○	○	○	○	○

20.

	Very bored -3	-2	-1	0	1	2	**Very enthusiastic** 3	I don't know
During my average commute I feel	○	○	○	○	○	○	○	○

21.

	Very fed up -3	-2	-1	0	1	2	**Very engaged** 3	I don't know
During my average commute I feel	○	○	○	○	○	○	○	○

22.

	The worst trip I can think of -3	-2	-1	0	1	2	**The best trip I can think of** 3	I don't know
My average commute is	○	○	○	○	○	○	○	○

23.

	Very low standard -3	-2	-1	0	1	2	**Very high standard** 3	I don't know
My average commute is	○	○	○	○	○	○	○	○

24.

	Very poorly -3	-2	-1	0	1	2	**Very well** 3	I don't know
My average commute trip works	○	○	○	○	○	○	○	○

25. What is your highest completed level of education?

○ High school

○ Undergraduate degree (HBO/WO Bachelor)

○ Postgraduate degree (HBO/WO Master, PhD)

26. What is your yearly income after tax?

- ◯ 13,401-28,000 euros
- ◯ 28,001-41,600 euros
- ◯ 41,601-69,700 euros
- ◯ 69,701-83,000 euros
- ◯ >83,001 euros
- ◯ Prefer not to say

27. What is your gender?

- ◯ Male
- ◯ Female
- ◯ Other

28. What is your living situation?

- ◯ Living alone
- ◯ Living with others

29. What is the postcode of your current residence? Please indicate only the first four numbers. ____

30. Please enter your email below to qualify for the bol.com gift voucher ___

Annex 2: Descriptive statistics and regression diagnostics

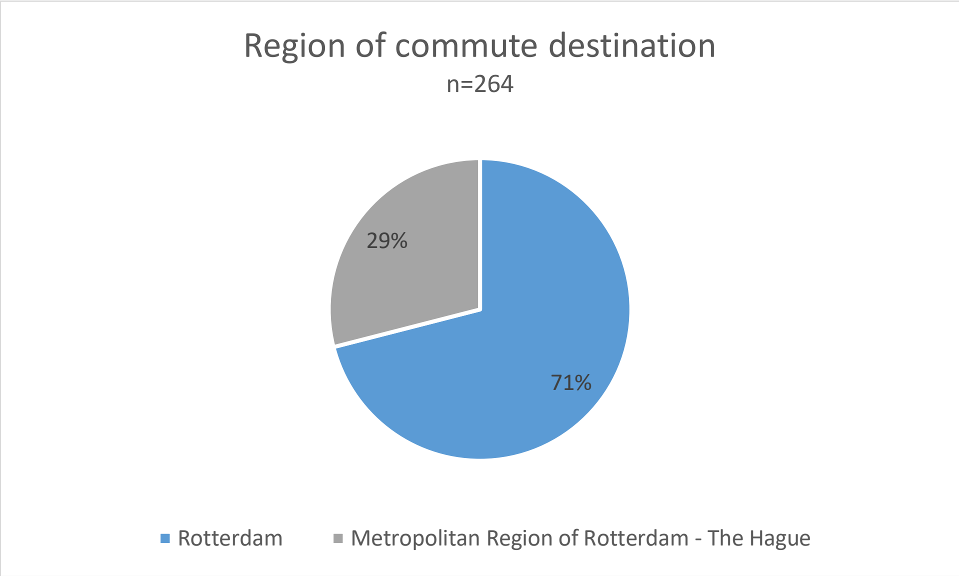


Figure 2: pie chart of frequency distribution according to region of commute destination

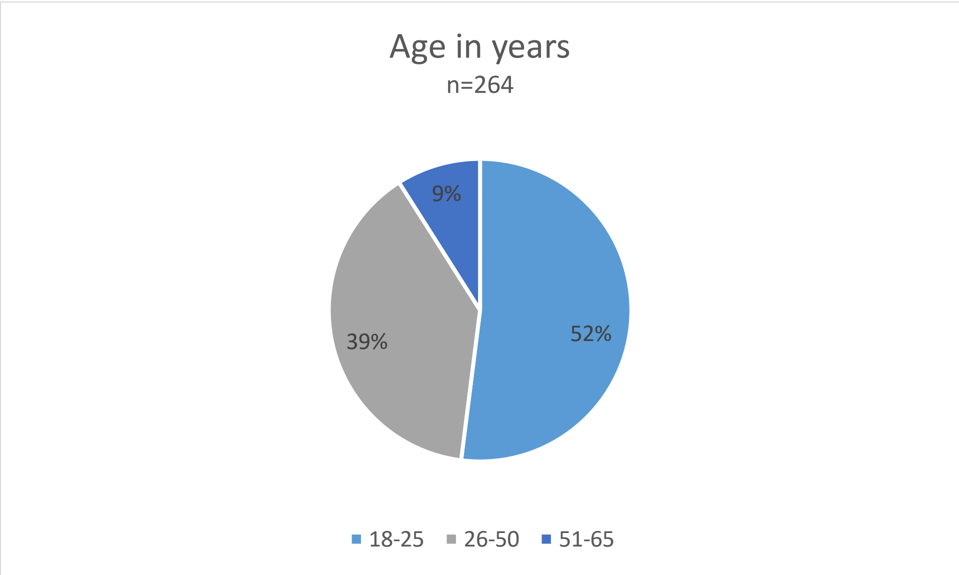


Figure 3: pie chart of frequency distribution according to age

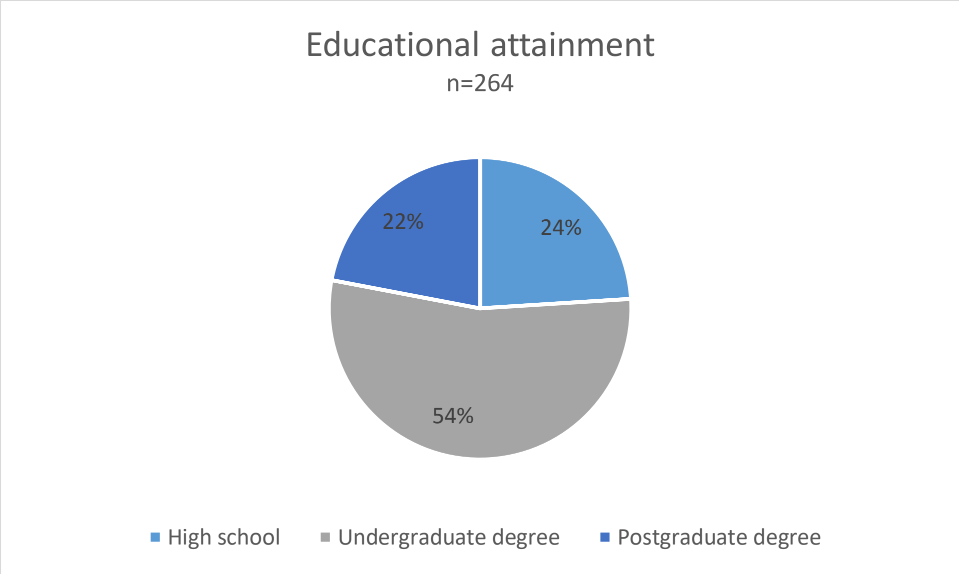


Figure 4: pie chart of frequency distribution according to educational attainment

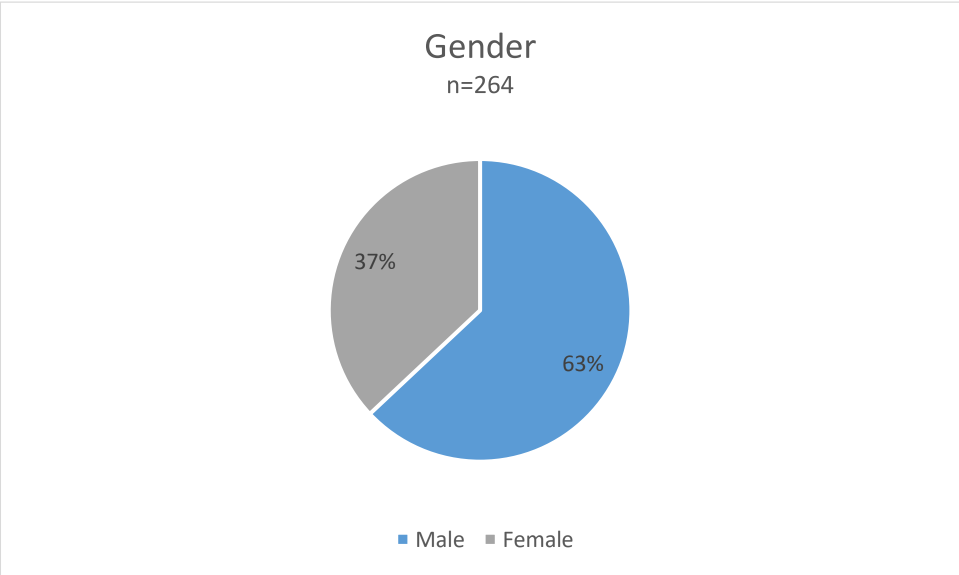


Figure 5: pie chart of frequency distribution according to gender

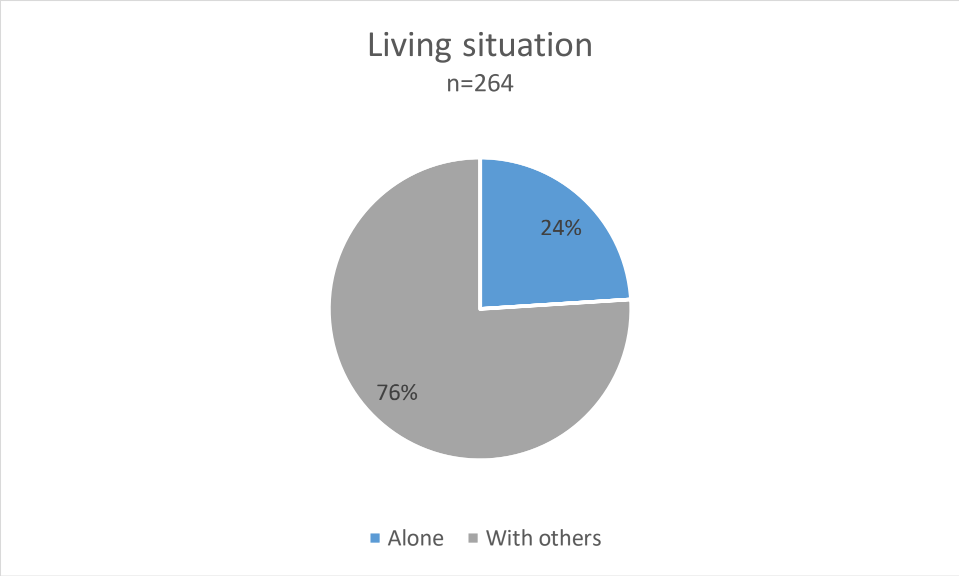


Figure 6: pie chart of frequency distribution according to living situation

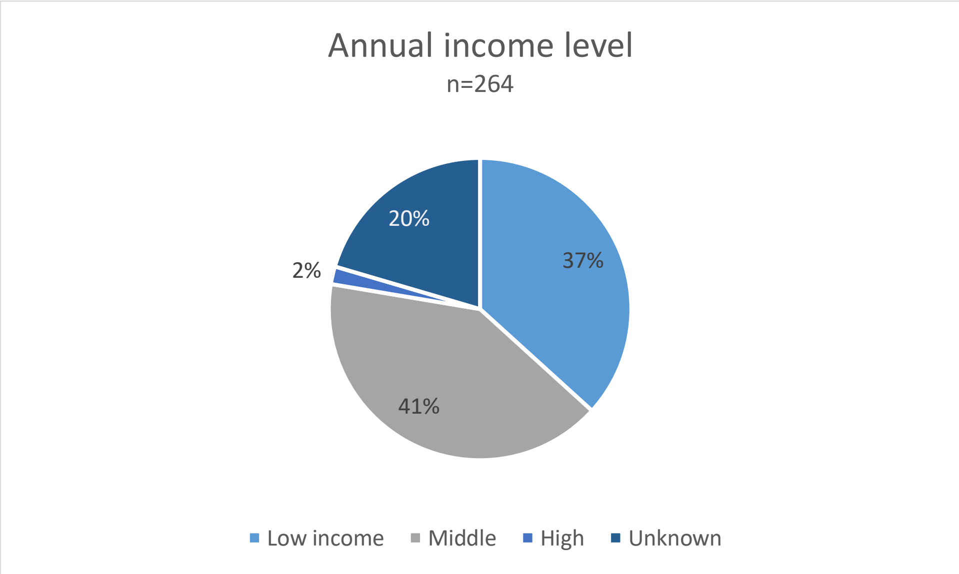


Figure 7: pie chart of frequency distribution according to annual income level

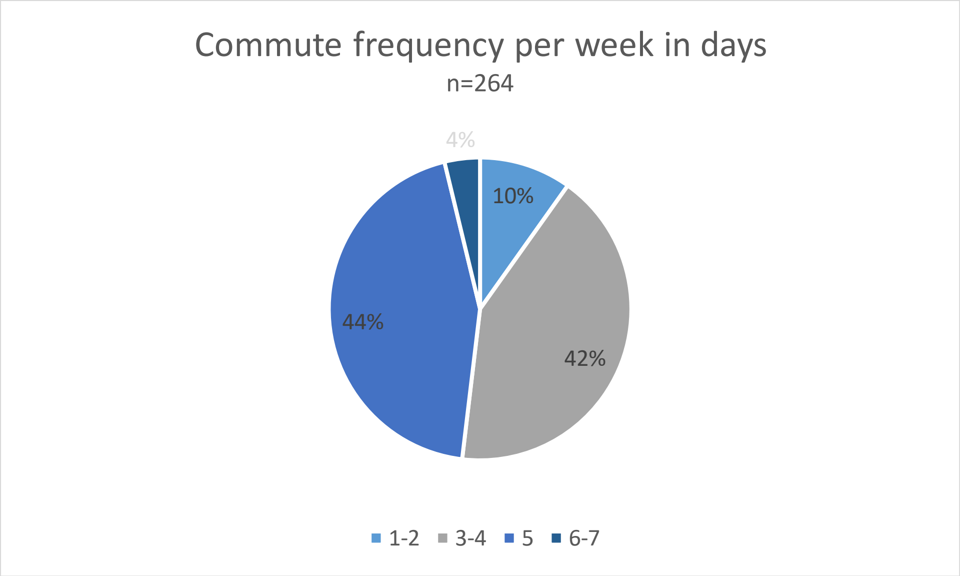


Figure 8: pie chart of frequency distribution according to commute frequency

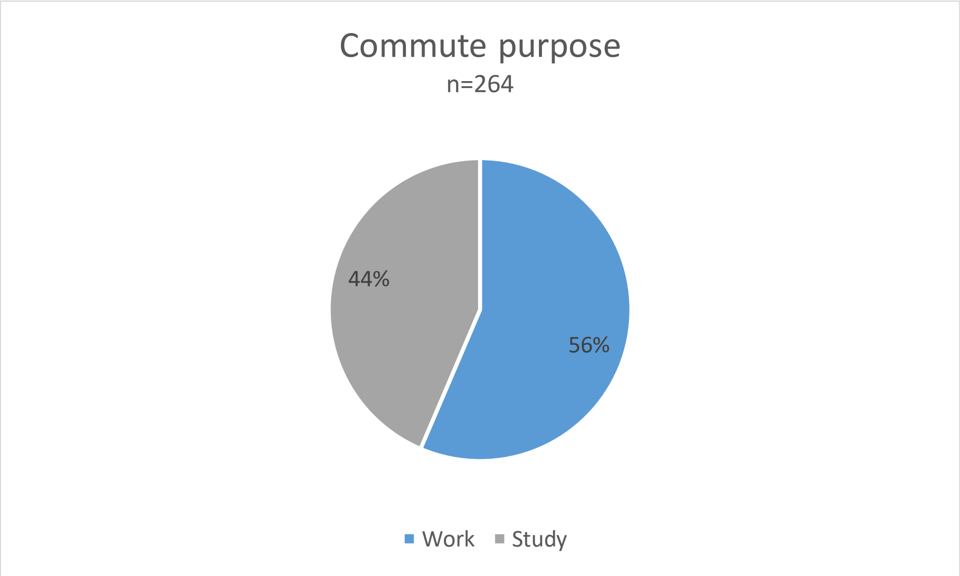


Figure 9: pie chart of frequency distribution according to commute purpose

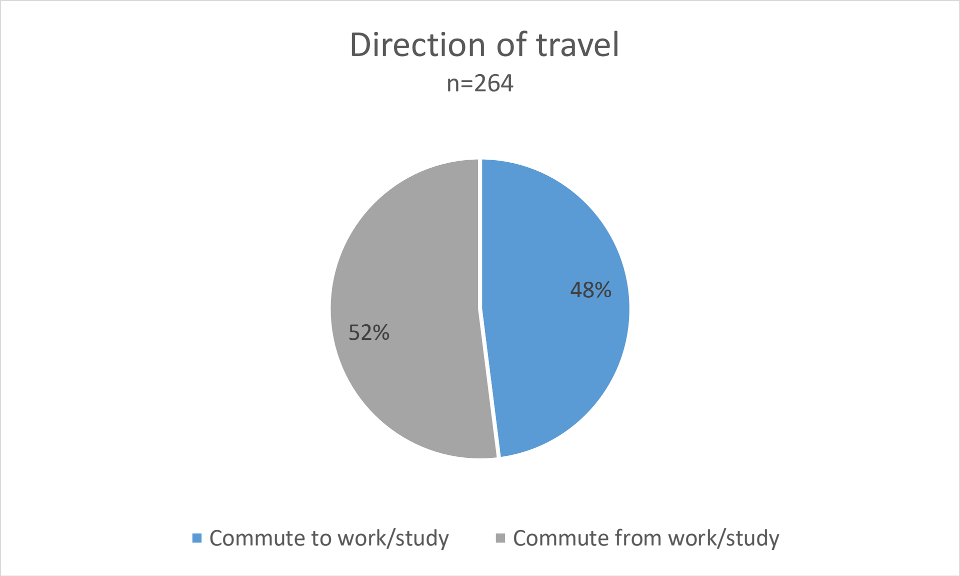


Figure 10: pie chart of frequency distribution according to direction of travel

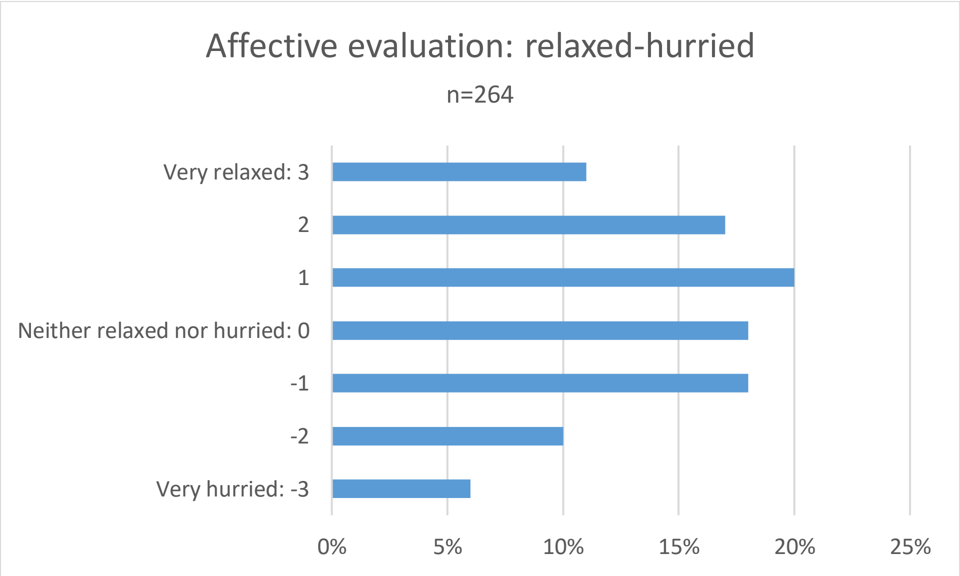


Figure 11: bar chart of frequency distribution according to affective evaluation statements from very relaxed to very hurried

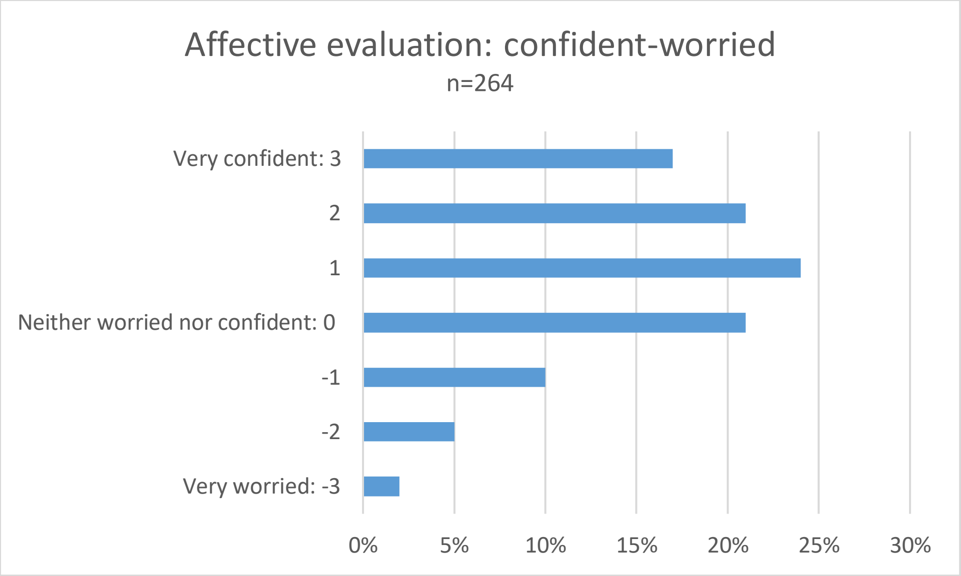


Figure 12: bar chart of frequency distribution according to affective evaluation statements from very confident to very worried

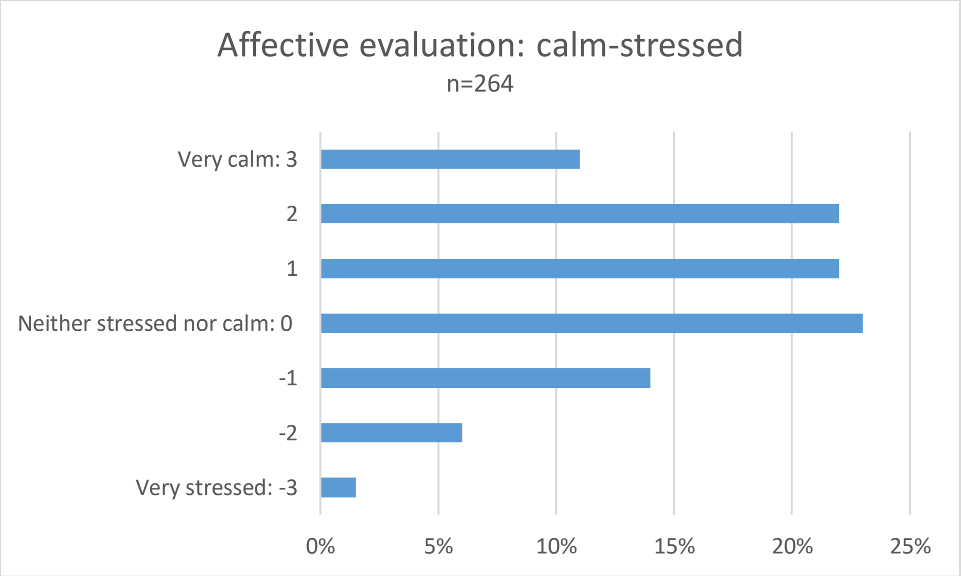


Figure 13: bar chart of frequency distribution according to affective evaluation statements from very calm to very stressed

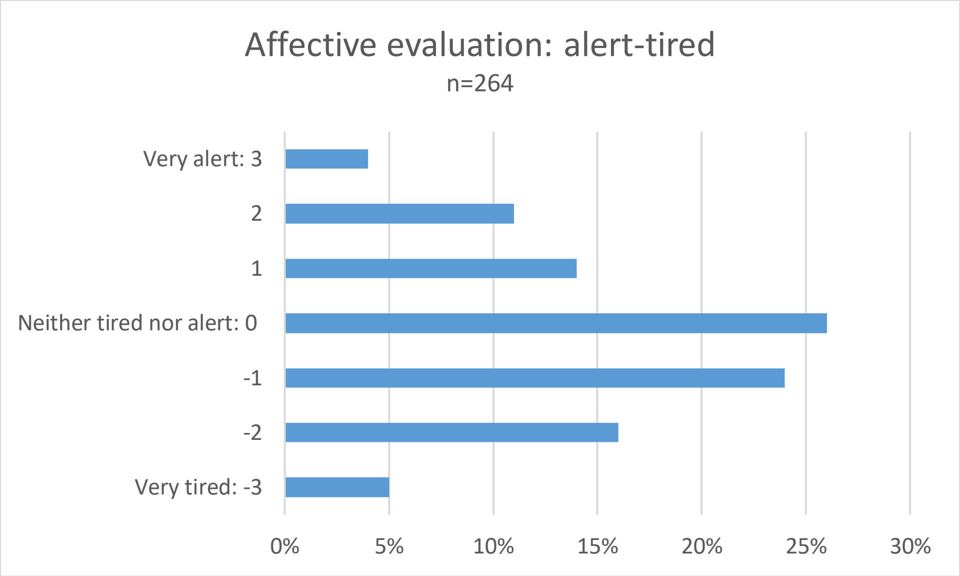


Figure 14: bar chart of frequency distribution according to affective evaluation statements from very alert to very tired

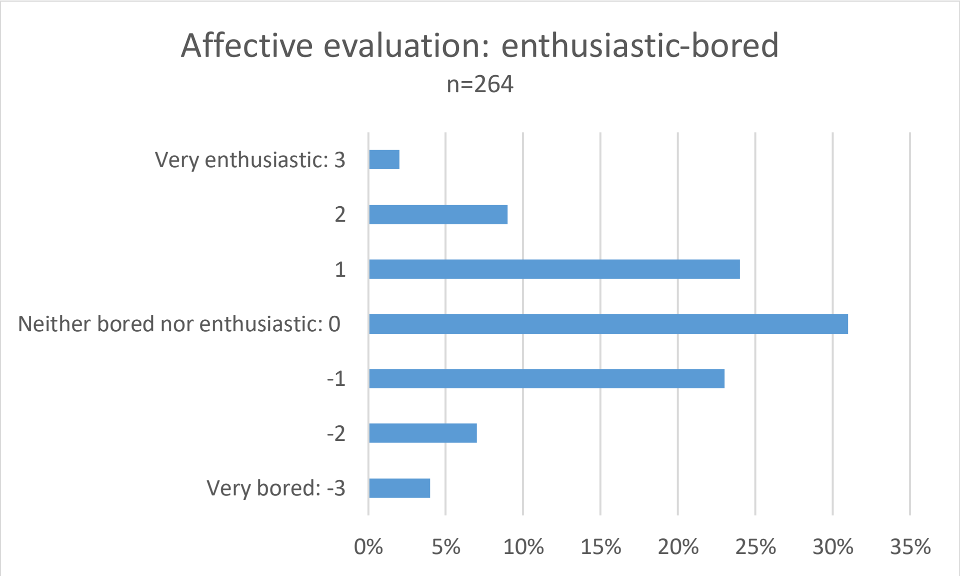


Figure 15: bar chart of frequency distribution according to affective evaluation statements from very enthusiastic to very bored

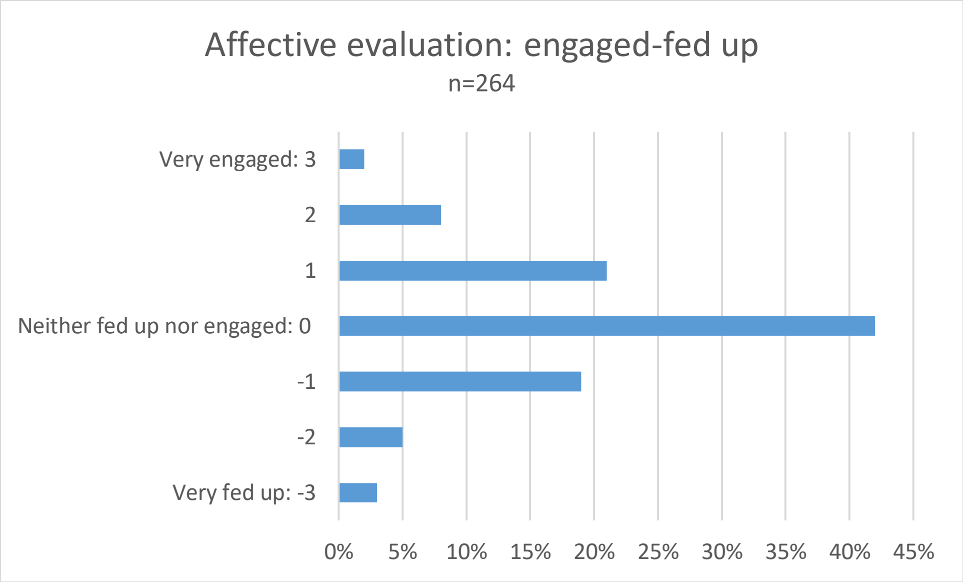


Figure 16: bar chart of frequency distribution according to affective evaluation statements from very engaged to very fed up

Cronbach's alpha: affective utility of travel time	
Number of items in the scale	6
Scale reliability coefficient	0.81

Table 4: Cronbach's alpha associated with combining indicators (hurried-relaxed, worried-confident, stressed-calm, tired-alert, bored-enthusiastic, and fed up-engaged) to measure affective utility of travel time

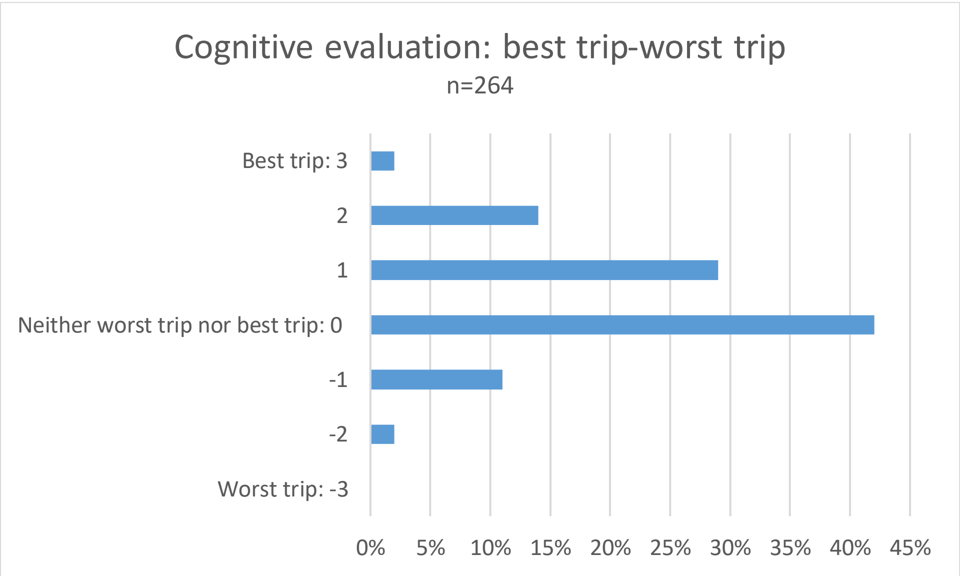


Figure 18: bar chart of frequency distribution according to cognitive evaluation statements from best trip to worst trip

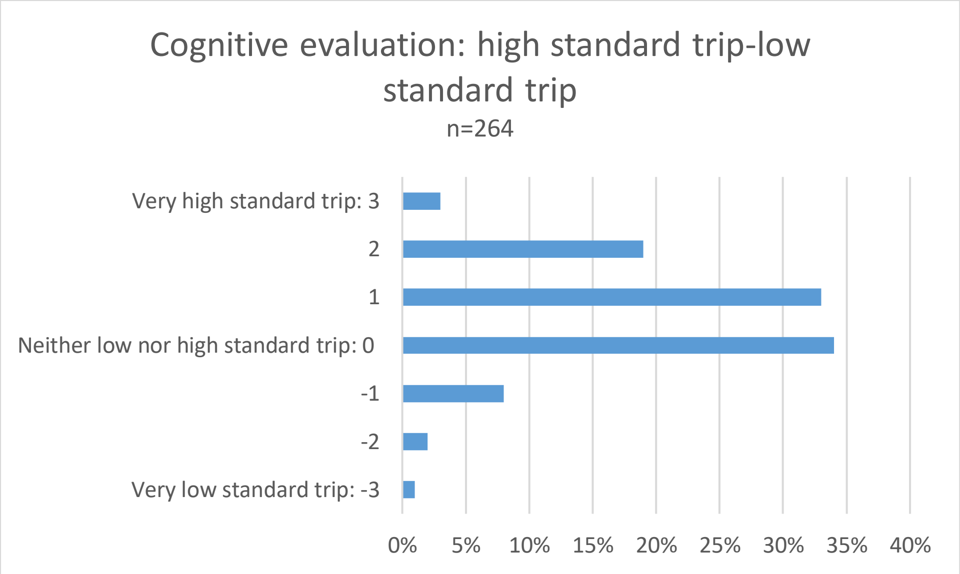


Figure 19: bar chart of frequency distribution according to cognitive evaluation statements from very high standard trip to very low standard trip

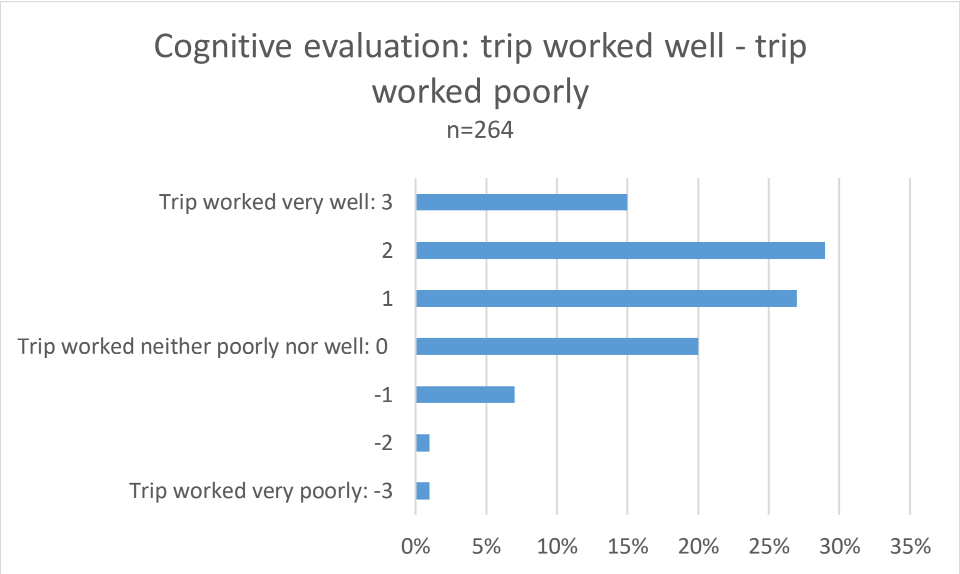


Figure 20: bar chart of frequency distribution according to cognitive evaluation statements from trip worked very well to trip worked very poorly

Cronbach's alpha: cognitive utility of travel time	
Number of items in the scale	3
Scale reliability coefficient	0.73

Table 3: Cronbach's alpha associated with combining indicators (worst trip-best trip, low standard trip-high standard trip, and trip went poorly-trip went well) to measure cognitive utility of travel time

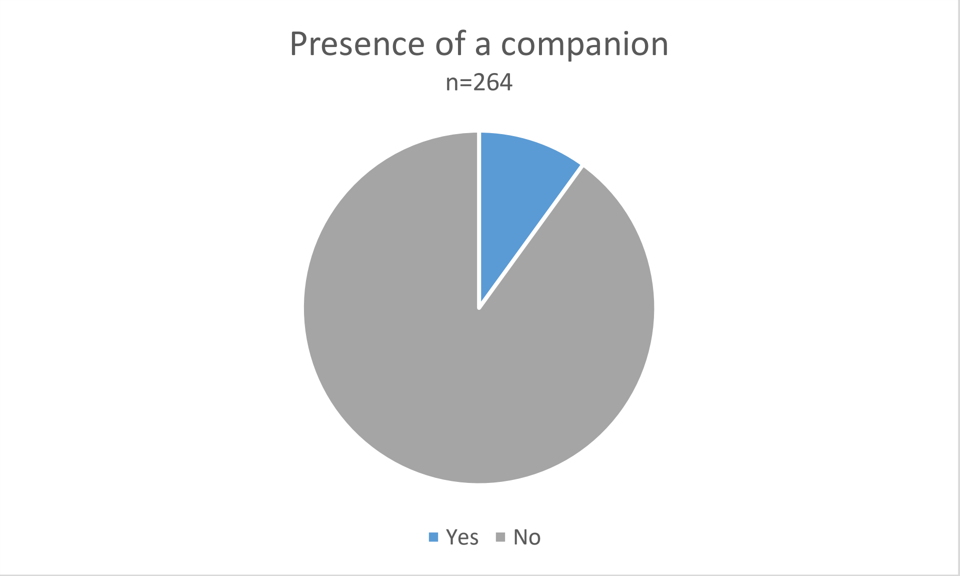


Figure 24: bar chart of frequency distribution according to presence of a companion

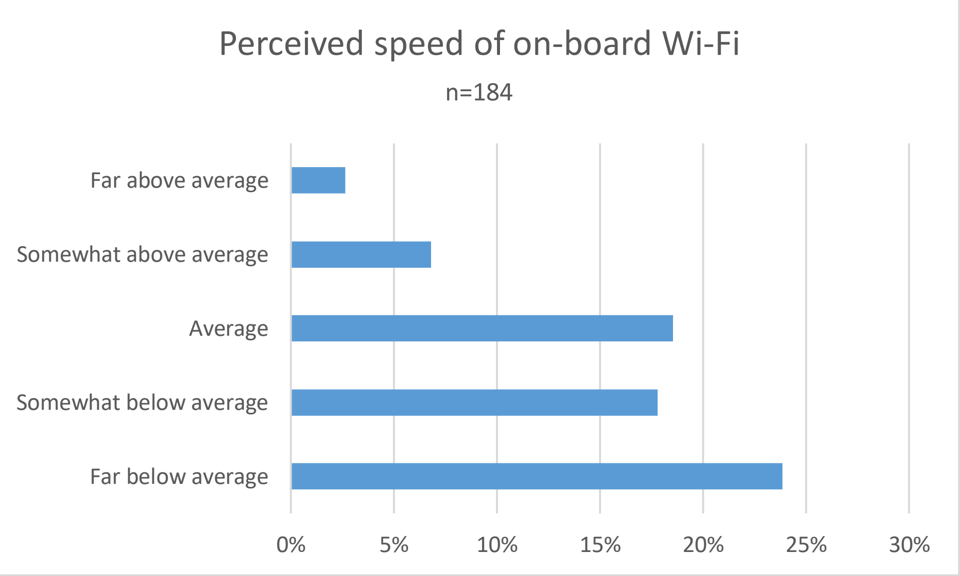


Figure 26: bar chart of frequency distribution according to perceived speed of on-board Wi-Fi

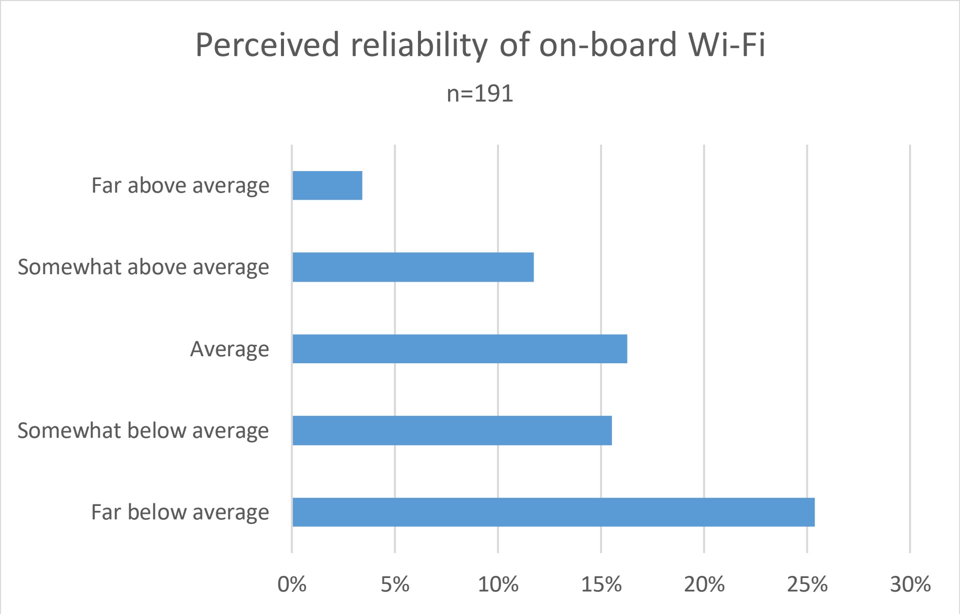


Figure 27: bar chart of frequency distribution according to perceived reliability of on-board Wi-Fi

Variable	VIF
Age	1.86
Working/studying using ICTs	1.62
Entertainment using ICTs	1.47
Trip duration	1.36
Crowdedness	1.31
Communication with other passengers	1.29
Entertainment by reading	1.28
Direction of travel	1.27
Presence of a companion	1.27
Communication using ICTs	1.24
Wi-Fi connectivity	1.22
Eating/drinking	1.21
Gender	1.20
Cohabiting	1.18
Working/studying	1.14
Mean VIF	1.3

Table 7: variance inflation factors, ranked from highest to lowest, associated with indicators that have less than three categories or are continuous

White test	P-value
Homoscedastic variance of residuals	0.31

Table 8: results of White test

Shapiro-Wilk W test	P-value
Normality of residuals	0.61

Table 9: results of Shapiro-Wilk W test

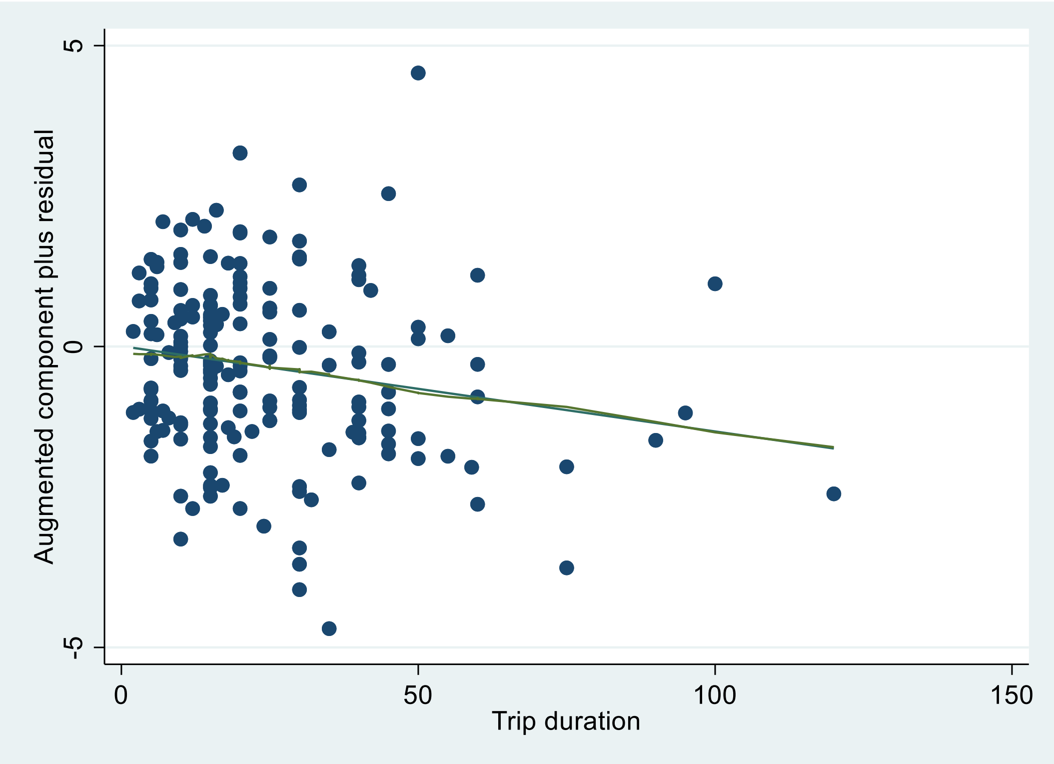


Figure 29: augmented partial residual plot of primary activity characteristic trip duration

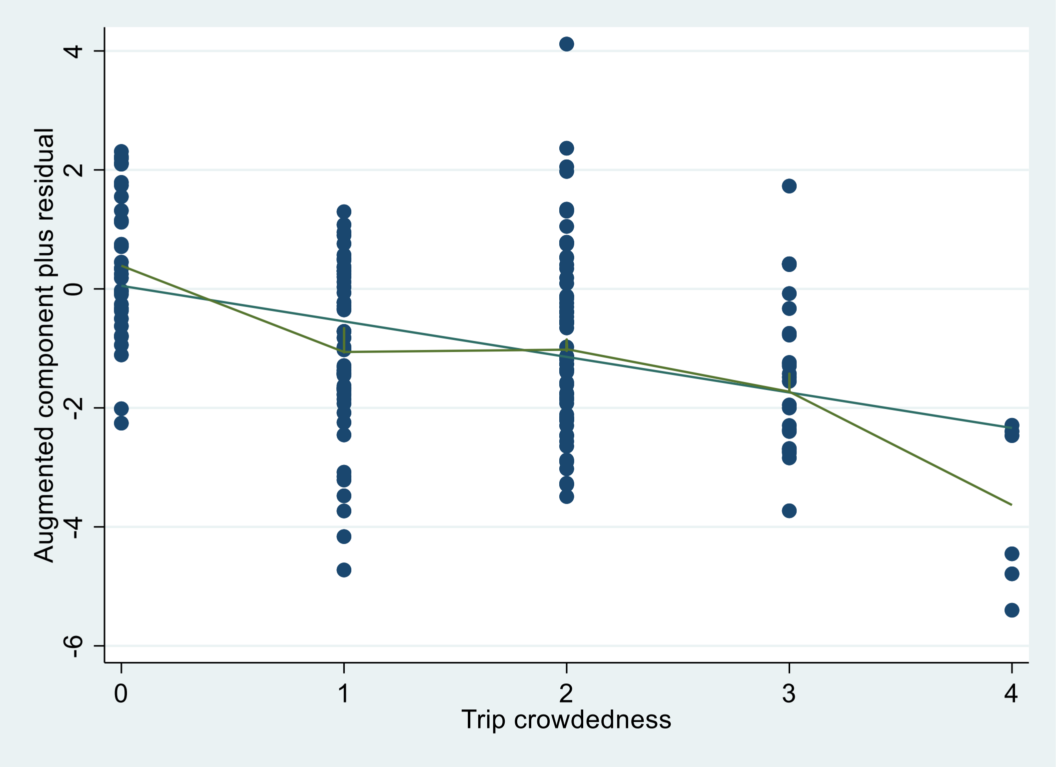


Figure 30: augmented partial residual plot of primary activity characteristic trip crowdedness

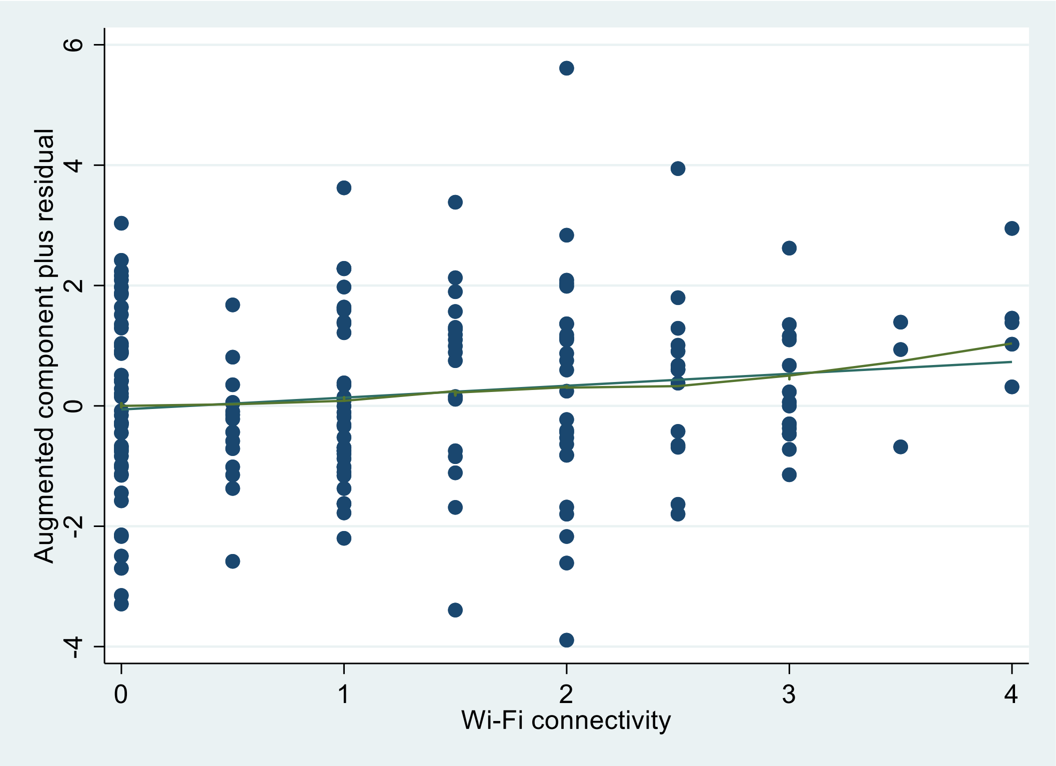


Figure 31: augmented partial residual plot of primary activity characteristic Wi-Fi connectivity

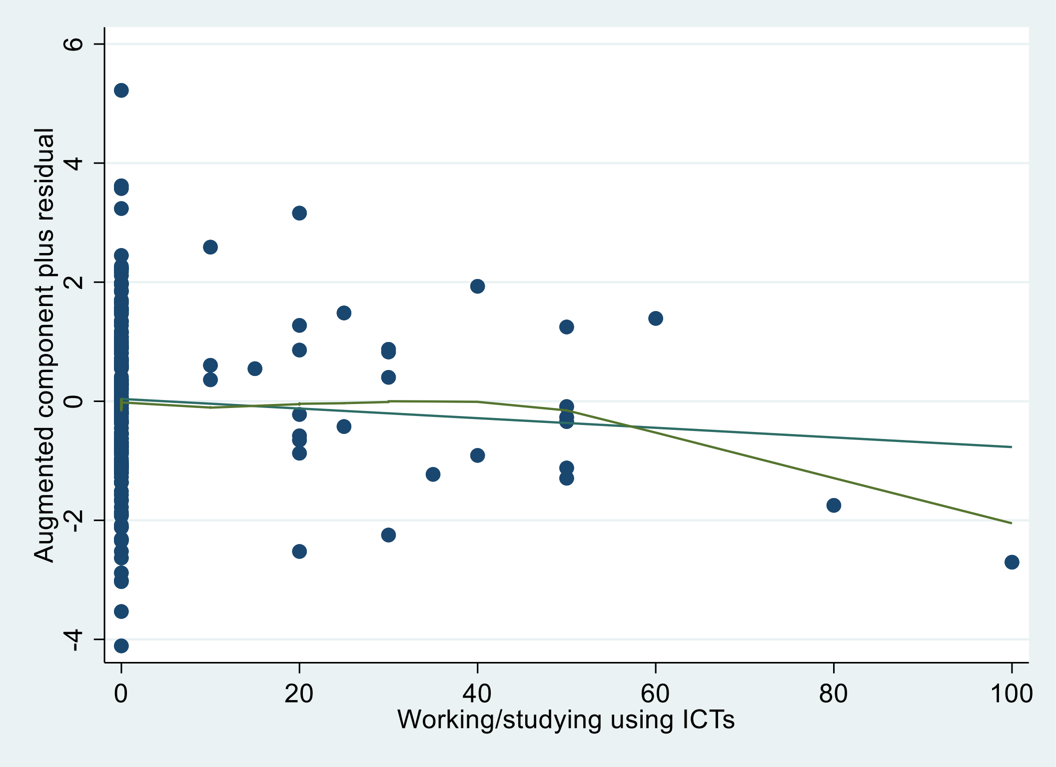


Figure 32: augmented partial residual plot of working/studying using ICTs as a secondary activity

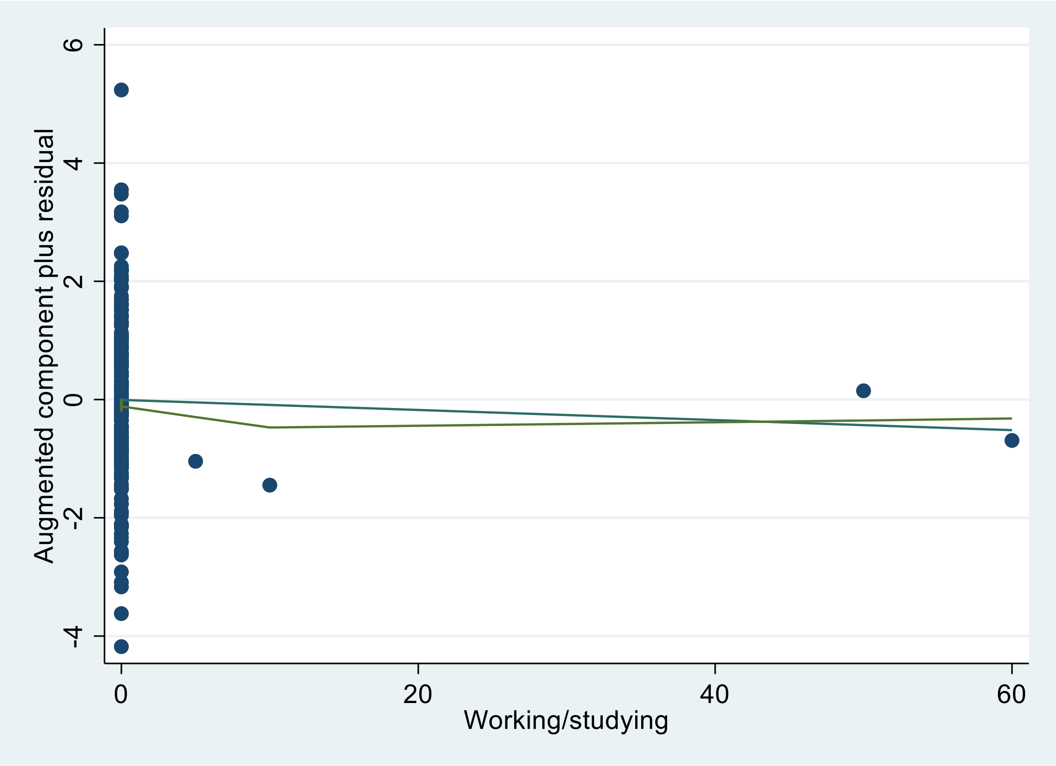


Figure 33: augmented partial residual plot of working/studying as a secondary activity

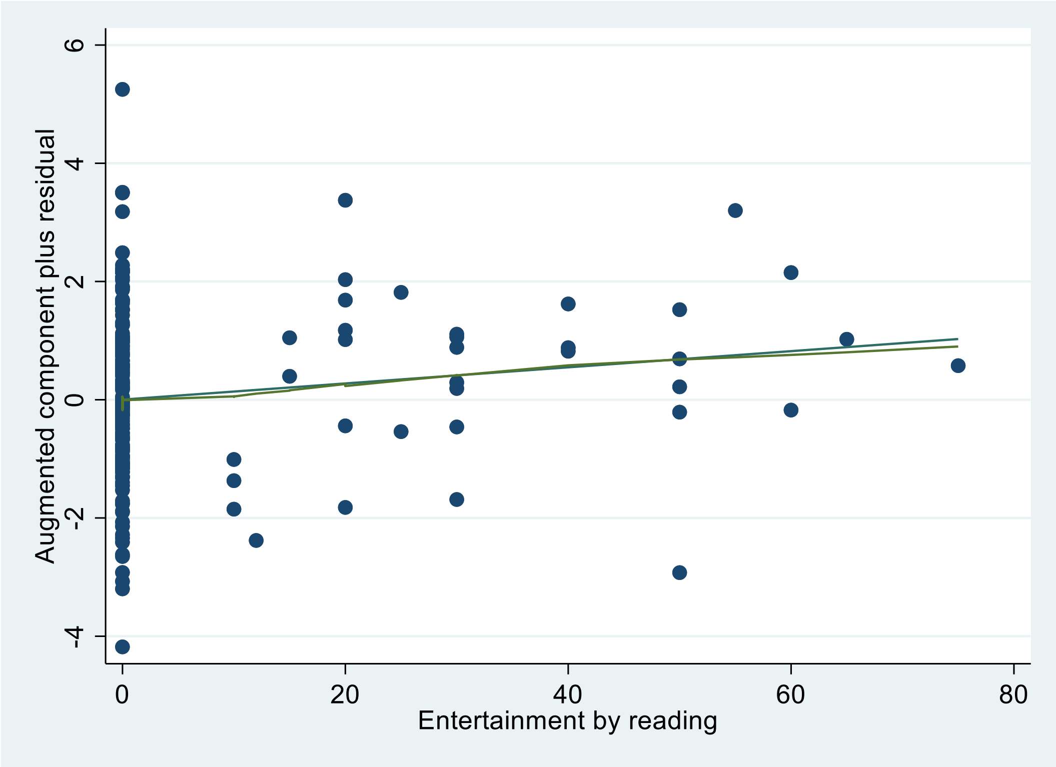


Figure 34: augmented partial residual plot of entertainment by reading as a secondary activity

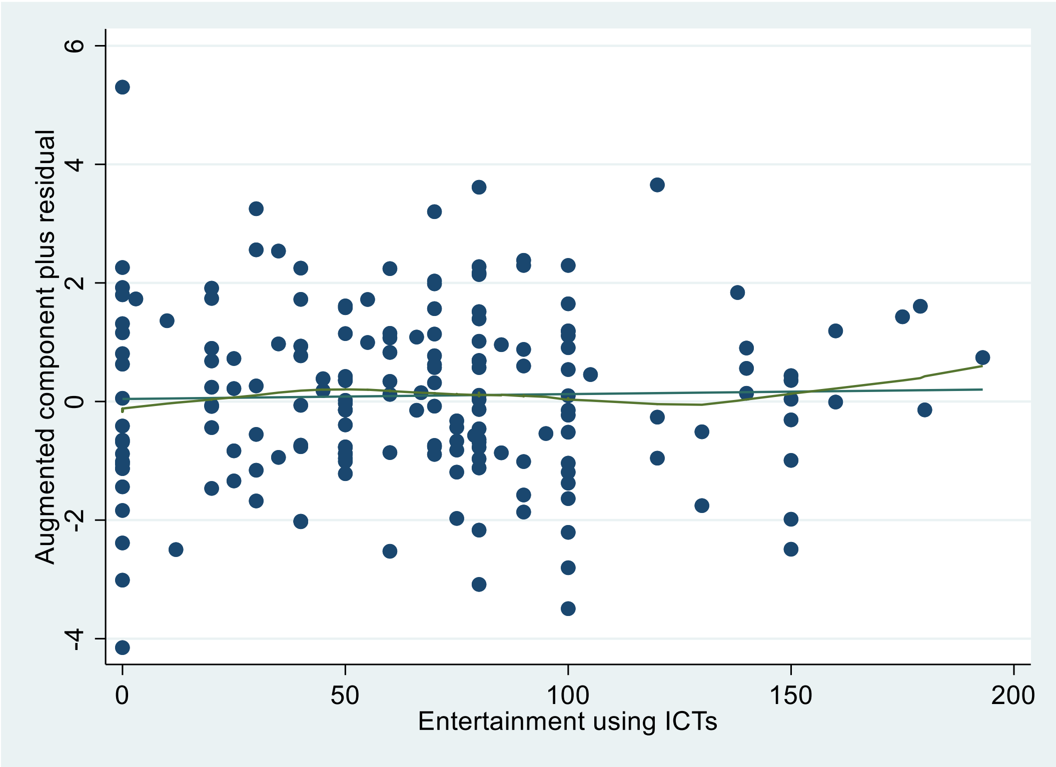


Figure 35: augmented partial residual plot of entertainment using ICTs as a secondary activity

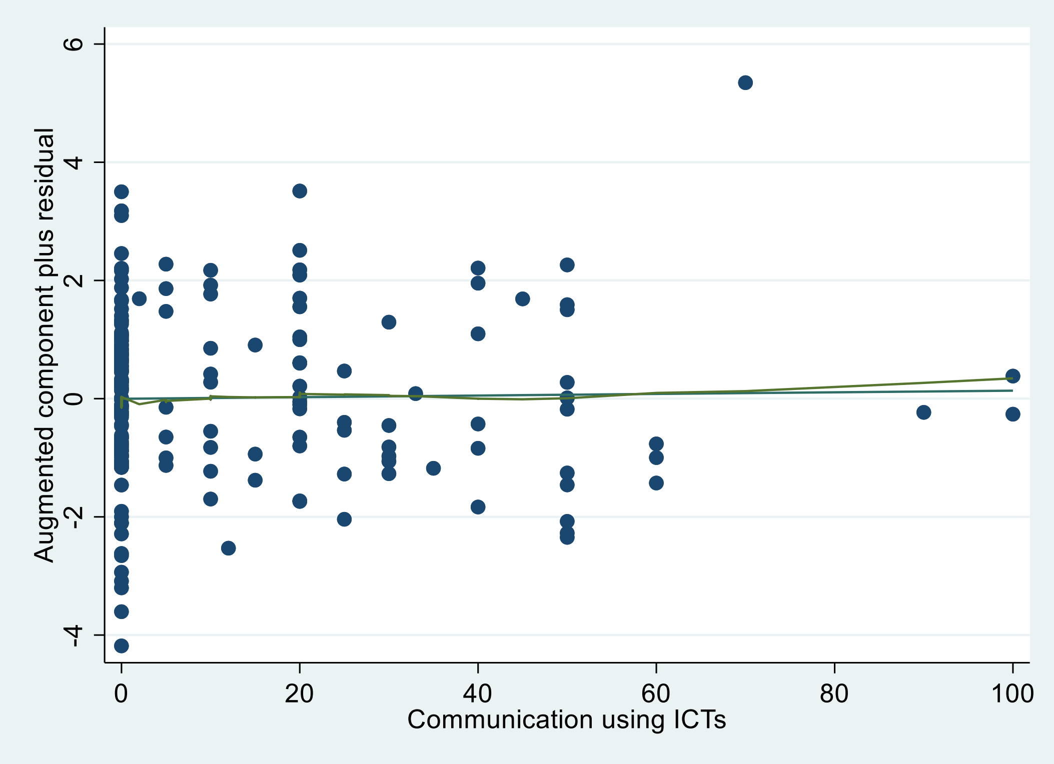


Figure 36: augmented partial residual plot of communication using ICTs as a secondary activity

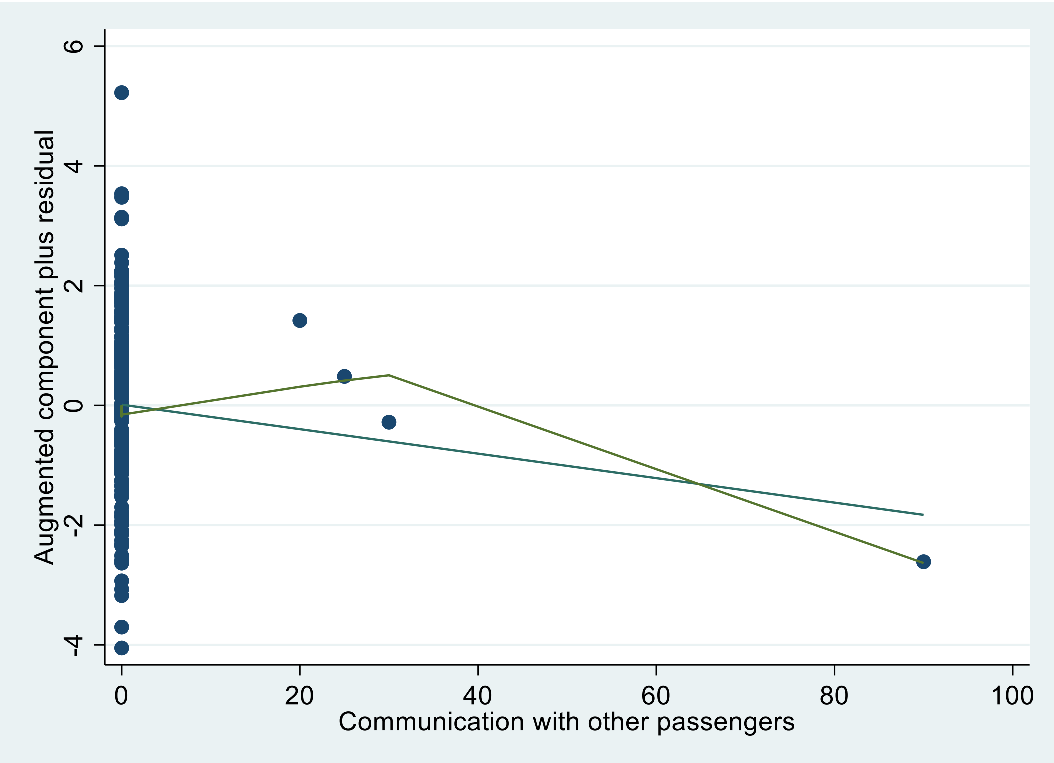


Figure 37: augmented partial residual plot of communication with other passengers as a secondary activity

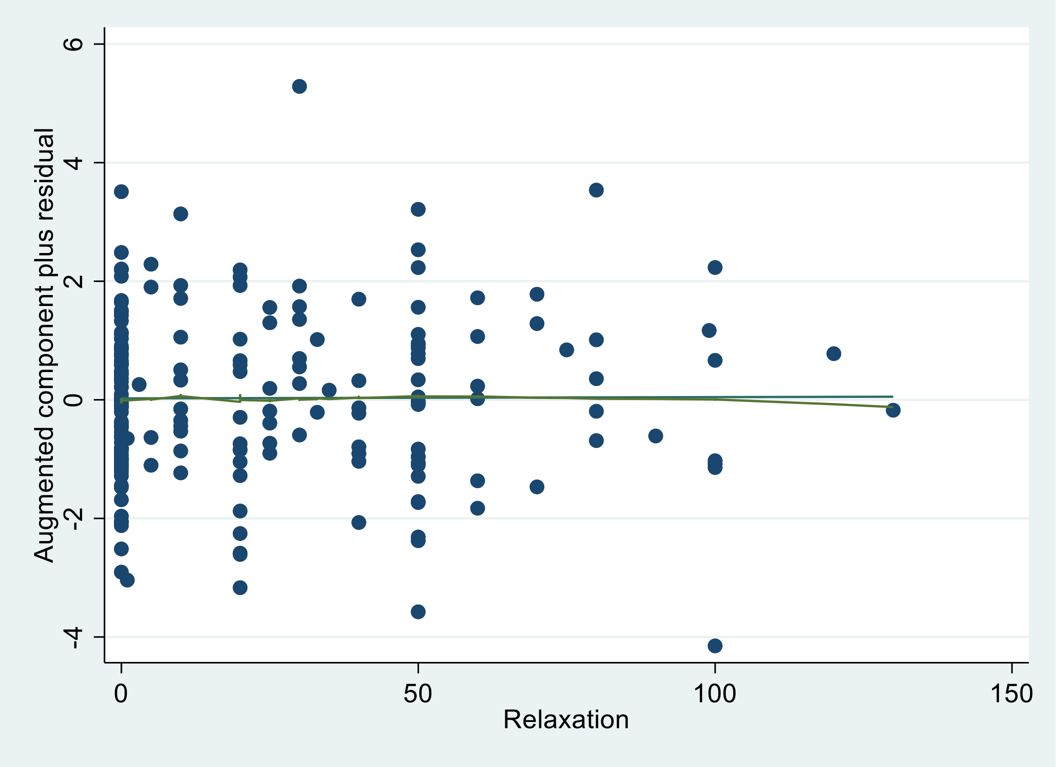


Figure 38: augmented partial residual plot of relaxation as a secondary activity

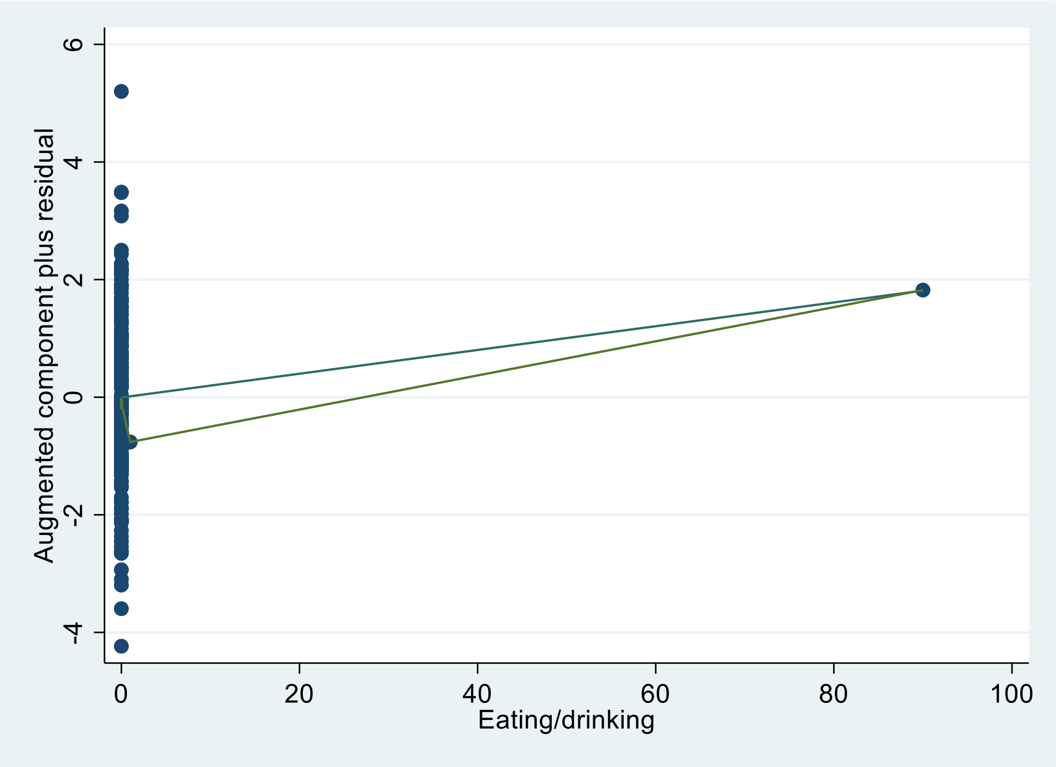


Figure 39: augmented partial residual plot of eating/drinking as a secondary activity

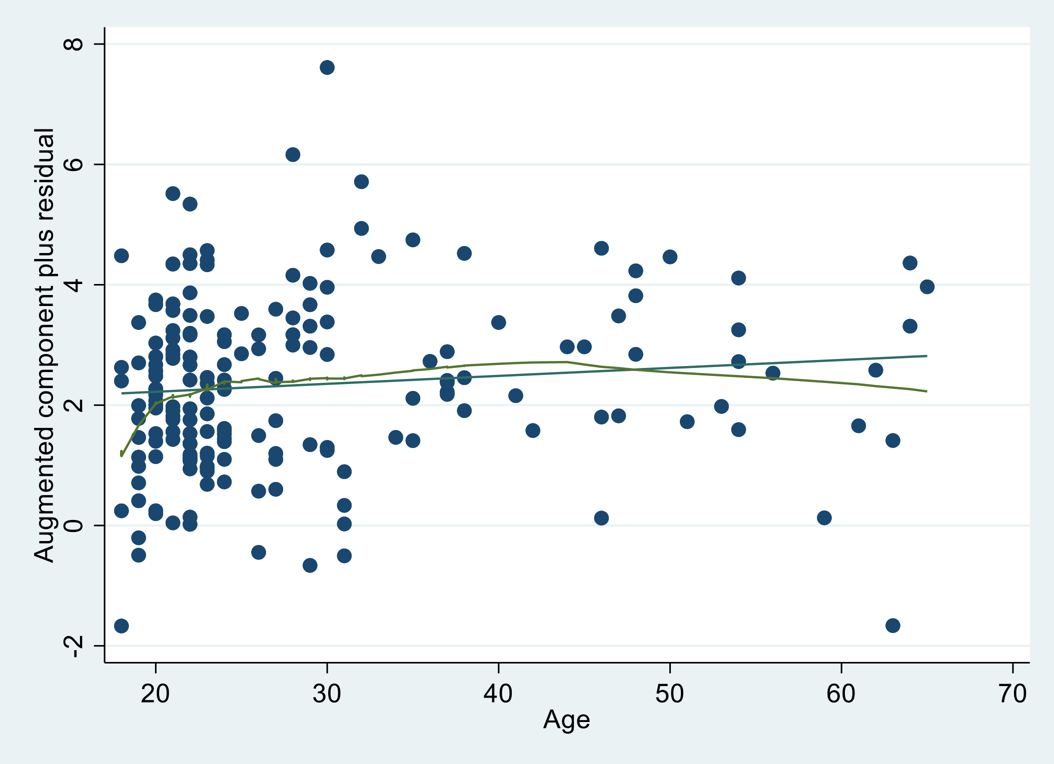


Figure 40: augmented partial residual plot of age as a sociodemographic control indicator

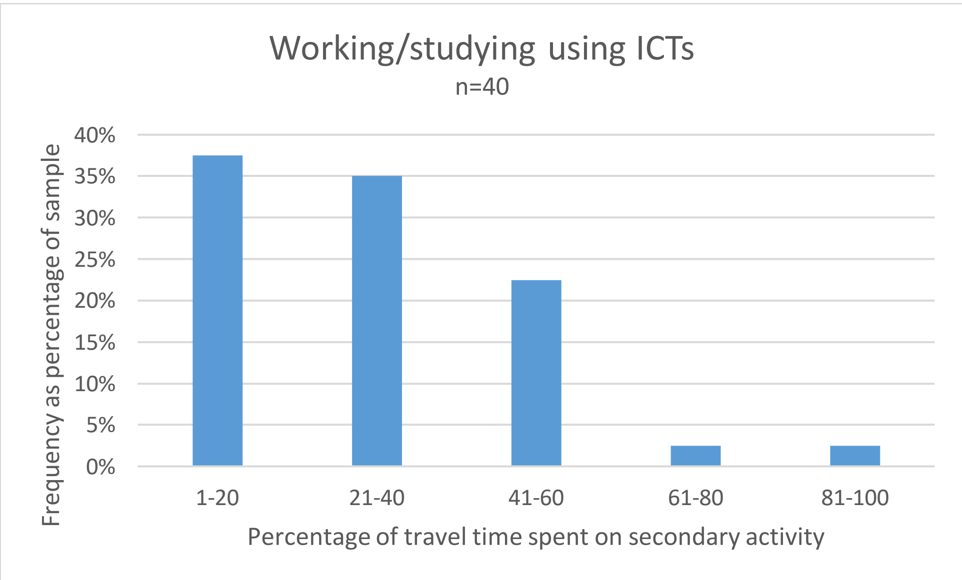


Figure 41: bar chart of frequency distribution of working/studying using ICTs

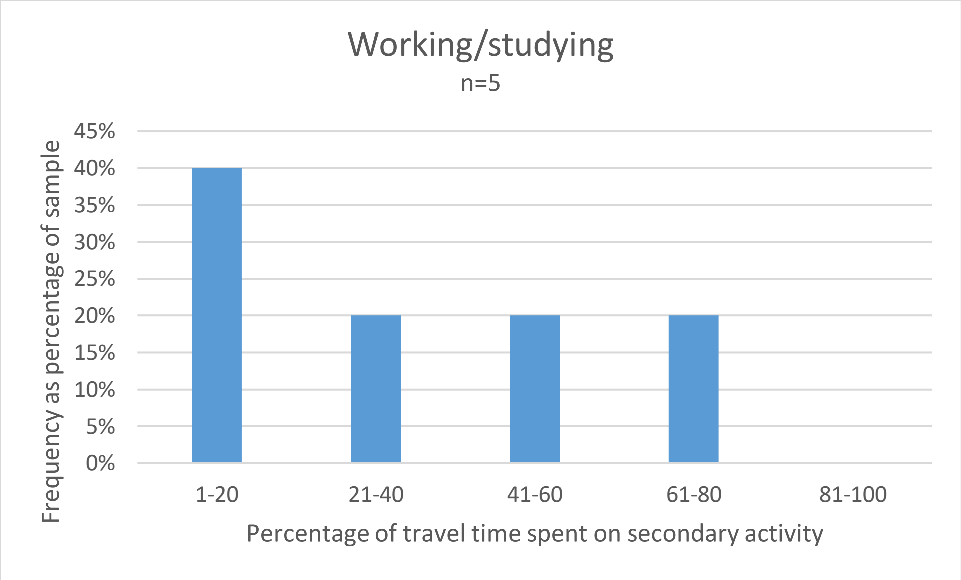


Figure 42: bar chart of frequency distribution of working/studying

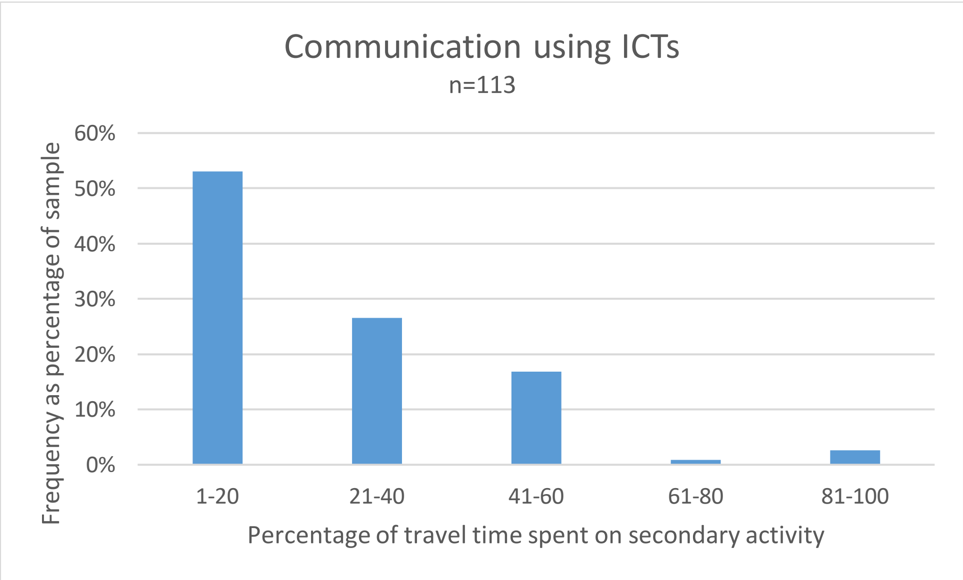


Figure 45: bar chart of frequency distribution of communication using ICTs

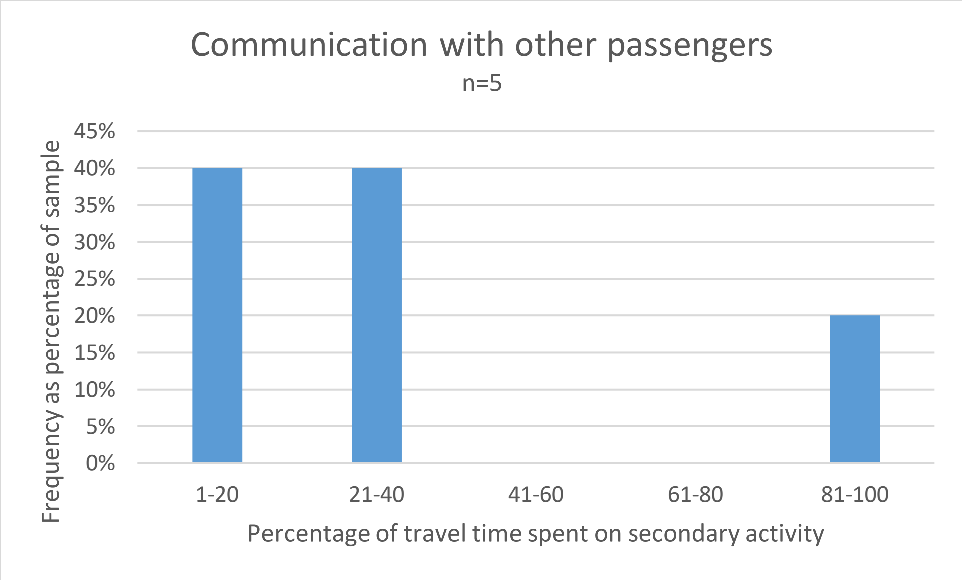


Figure 46: bar chart of frequency distribution of communication with other passengers

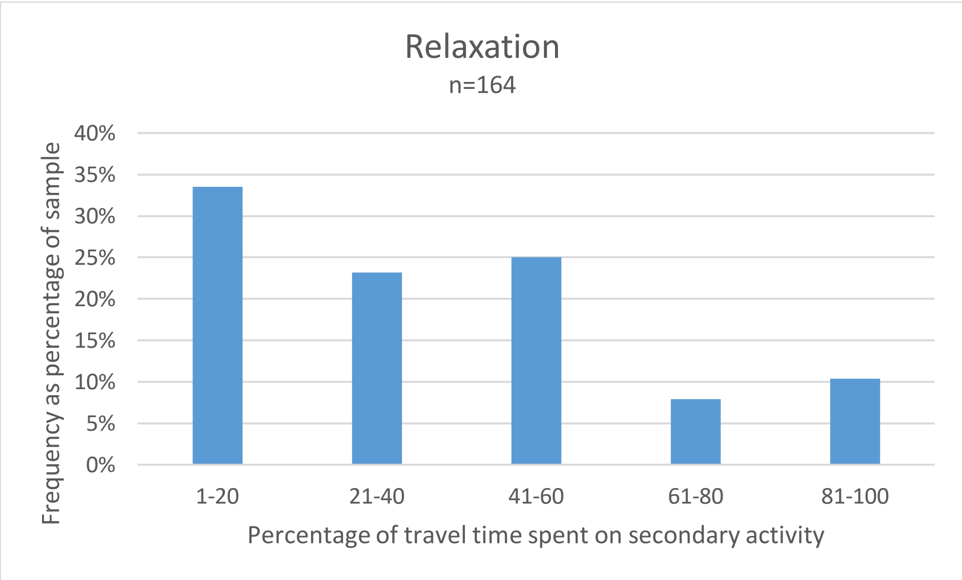


Figure 47: bar chart of frequency distribution of relaxation

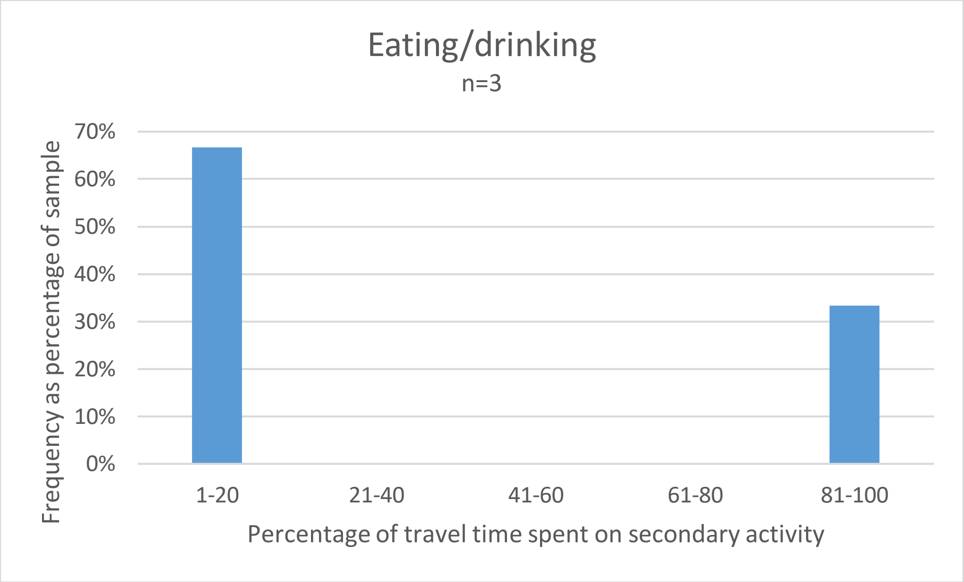


Figure 48: bar chart of frequency distribution of eating/drinking

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