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Social Activity-Travel Patterns: The Role of Personal Networks and Communication Technology

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Technische Universiteit Eindhoven, op gezag van de rector magnificus, prof.dr.ir. C.J. van Duijn, voor een commissie aangewezen door het College voor Promoties in het openbaar te verdedigen op donderdag 13 september 2012 om 16.00 uur

door

Pauline Elisabeth Wilhelmina van den Berg

geboren te Bergeijk
Preface

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Pauline van den Berg
Eindhoven, July 2012
## Preface

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1. Introduction

1.1 Background and motivation
In the field of transportation there is a growing interest in the study of social activities. Social activities account for a large part of trips and they constitute the fastest growing segment of travel (Axhausen, 2005). Travel demand for social purposes is increasing, due to increasing car ownership and usage, increasing leisure time, ageing of the population and growing distances between social network members. Moreover, the travel patterns for social purposes differ from travel for other purposes, such as working and shopping in the sense that they are more heterogeneous in terms of timing and location.

In order to assess future transportation needs for social activities, we need to understand the nature of people’s social activities and the travel involved in these activities. Even though social activities account for a relatively large portion of travel, still little is known about the way these activities shape individuals’ time use and trip generation behavior (Axhausen, 2005; Carrasco and Miller, 2006). This research therefore focuses on travel behavior for social activities.

Over the last decades, researchers have attempted to explain individual travel behavior as a result of socio-demographic variables and characteristics of the built environment. It has been recognized however that the main motivator for social activity-travel stems from people’s social networks. Characteristics of people’s social networks (such as the number of network members, their role, emotional and geographical distance and the frequency of contact) can therefore
contribute to an understanding of social travel demand. Therefore, personal social networks need to be incorporated in analyses of social travel demand.

Another factor that is likely to influence social activity-travel behavior is the use of information and communication technology (ICT), such as email and mobile phones. The use of ICT’s for social interaction may reduce the need to meet face-to-face and may thus reduce travel. However, contacts via ICT may also be used for the making of plans and appointments for face-to-face contact, thus increasing social travel. In any case, ICT is likely to affect the intensity and nature of social interaction, which in turn will have an effect on social activity-travel behavior. The use of ICT therefore has to be studied to understand social travel behavior.

Although it has been recognized that the study of individuals’ social network characteristics and ICT-use for social interaction can provide new insights into the generation of social activities and travel involved, so far only a few empirical studies have been undertaken in order to incorporate social networks and ICT in models of (social) travel demand (Carrasco et al., 2008a; Frei and Axhausen, 2007; Kowald and Axhausen, 2010a). Knowledge about the way these factors influence social travel demand is still limited.

Therefore, in order to assess future needs for transportation and urban planning, more research is needed. We need to understand the nature of people’s social activities and travel and how these are affected by personal and household characteristics, the built environment, personal social networks and the use of information and communication technology. This requires an integrated analysis of these complex relationships.

1.2 Research questions and relevance

Given the background discussed above, the aim of this dissertation is to analyze the relationships between personal characteristics and attributes of the built environment, social networks, the use of ICT’s for social interaction and social activity-travel patterns. To achieve this aim, the following research questions will be addressed:

1. What is the effect of personal characteristics and properties of the built environment on social network characteristics?
2. What is the effect of personal characteristics and properties of the built environment on ICT-use for social purposes?
3. What is the effect of personal characteristics and properties of the built environment on social activity-travel patterns?
4. To what extent and how is the nature and strength of the relationship between personal characteristics and properties of the built environment and social activity-travel patterns mediated by the joint impact of ICT-use and characteristics of social networks?
Figure 1.1: Conceptual model

Figure 1.1 gives a visual representation of the four research questions that are addressed in this dissertation. Analyzing the relationships is relevant for transport policy as it will help to understand travel demand for social activities and how this is affected not only by personal and land-use variables, but also by people’s social network characteristics and their use of ICT’s for social interaction.

As the main objective of this study is to understand social activity-travel, the results can contribute to transport planning. However, this study also relevant for other disciplines. Face-to-face social activities, such as joint activities with friends or visiting relatives, involve meeting with other persons at a certain time and location. This (social) spatial-choice behavior is important for successful urban planning.

Moreover, social activities and mobility are important aspects of quality of life as the interaction with other people provides access to a variety of resources, such as instrumental and emotional support (social capital). This study is therefore also relevant with regard to broader concerns in society, such as social equity, social capital and the quality of life of people.

1.3 Approach

This study aims at analyzing the relationships between personal characteristics and attributes of the built environment, social networks, the use of ICT’s and social activity-travel patterns in the Netherlands. It therefore requires collecting data on each of these components for the same individuals. Another requirement for the data collection, to allow the estimation of the impact of the built environment, is to secure sufficient variation in characteristics of the built environment.

For each respondent, a social interaction diary is collected. The aim of the diary is to capture face-to-face social activities and travel, as well as social interactions by ICT’s (telephone and the Internet). In addition to communication mode, the diary includes for each social interaction the timing, duration, information of the contacted persons, travel distance and transport mode. Second, a questionnaire is used to collect data on the respondents’ socio-demographic
background. Characteristics of the built environment (urban density and the types of facilities in the area) are captured by postcode information. Finally, the ego-centered network approach is used to collect information on social network characteristics for a subsample of the respondents.

With respect to the analyses, the focus is on exploring and testing bivariate and especially multivariate relationships in the data. Separate relationships are analyzed with different regression and discrete choice models. To analyze simultaneously the relationships between social networks and ICT-use, a structural equation approach is used. As most of the data have a hierarchical clustered structure (several social interactions belong to the same respondents) multi-level analysis is used.

The results of the statistical analyses will provide a better understanding of spatial choice and travel behavior for social purposes and how this is affected by the use of ICT and personal social networks. Moreover, including these factors in models of transport demand will contribute to an improved modeling approach.

1.4 Outline
This dissertation is structured as follows. The next chapter describes the theoretical framework based on a review of the existing literature. It focuses on social activity-travel behavior, social networks and the use of ICT for social purposes. In the third chapter the data collection instruments are described, followed by a description of the actual data collection. Chapter 4 describes the basic sample characteristics.

In chapters 5 to 9, the results are presented. Chapter 5 focuses on social networks. It presents results of a negative binomial regression model to predict social network size, a mixed logit model to predict social network composition and a random effects model to predict the geographical distance between ego and alter.

Chapter 6 and 7 focus on ICT-use for social purposes. Chapter 6 presents the results of a path analysis on the contact frequency between social network members. In chapter 7 three analyses are presented that are based on the social interaction data. First a negative binomial model is presented, analyzing the factors that influence social interaction frequency, followed by a mixed logit model on the purpose of social interactions and a mixed logit model analyzing communication mode choice for social interaction.

In chapter 8 four analyses are executed to analyze social travel behavior. First, the number of social trips per respondent in two days is analyzed using a negative binomial model. Next, for each social trip the type of location is analyzed using a mixed logit model. Social trip distance is analyzed using a random effects model. The transport mode used for the social trips is analyzed using a mixed logit model.

Finally, chapter 9 presents the results of a path analysis, estimated to simultaneously test the direct and indirect relationships between socio-demographic
and land use variables, ICT-use, social networks and aspects of social travel behavior.

Chapter 10 concludes this dissertation by discussing the main findings and the possible directions of future research.
2. Theoretical framework

2.1 Introduction

The development of travel demand models started in the 1950’s. The earliest models were intended to forecast travel demand and support transportation planning decisions with regard to future infrastructure investments. The early travel demand models are most often referred to as aggregate models. The aggregate approach involves a four-step process. A four-step model takes trips as the unit of analysis and sequentially analyses four steps: trip generation, trip distribution, mode choice, and route choice. Trip generation determines the frequency of trips by purpose (from origins or destinations) as a function of population and land-use characteristics. The second step, trip distribution, distributes trips to destinations. Next, mode choice reflects the relative proportions of trips between each origin and destination by alternative modes. In the last step, these trips by a particular mode are assigned to the transportation network. The four-step trip-based model has dominated transport and urban planning since the 1960’s.

Toward the end of the 1970’s a shift took place from aggregate to disaggregate models. In this period data collection and model estimation were improved. Especially the econometrics of discrete choice models were developed (e.g. McFadden, 1981; Ben-Akiva and Lerman, 1985).

In the 1980’s transportation researchers began to recognize that measures of perceptions, attitudes and beliefs of travelers had to be incorporated in their choice models. Moreover, the traditional models lacked behavioral content. According to McNally (2000) they “do not reflect (a) the linkages between trips and activities, (b) the temporal constraints and dependencies of activity scheduling,
nor (c) the underlying activity behaviour that generates the trips. And there is little policy-sensitivity”. In addition, changes in urban, environmental and energy policy caused a reconsideration of travel demand modeling. This resulted in a shift toward activity-based frameworks.

In activity-based research, travel is regarded as being derived from participation in daily activities undertaken by persons and households and depending on the organization of those activities. It is recognized that activity decisions are made in a household instead of an individual context. Instead of individual trips, sequences or patterns of activity (-travel) behavior are the unit of analysis. These activity-travel patterns are scheduled in time and space and constrained by spatial, temporal, transportation and interpersonal interdependencies (Jones, 1990; McNally, 2000). Activity-based research takes the links between travel and household lifestyles into account. It focuses not only on predicting the phenomenon of travel behavior, but also on understanding and explaining it. Activity-based research used theories from other disciplines, such as sociology, economy and psychology to develop a structure for understanding travel behavior (Jones, 1990).

The activity-based approach in transportation was inspired by the time-geography literature (e.g. Hägerstrand, 1970), planning theory (Chapin, 1974), economy, sociology and psychology.

Hägerstrand (1970) argued that regional science is about people and not just about locations. As individuals carry out activities within a certain duration at certain times and locations, locations in space cannot be separated from the flow of time. This recognition led to his time-space concept, which describes the path that individuals follow in the series of activities of their lives. According to Hägerstrand the participation of individuals in time-space is influenced by three types of constraints: capability constraints, coupling constraints and authority constraints. These constraints limit the activities of the individual and shape their functioning in socio-economic systems and are therefore fundamental for their quality of life.

Chapin (1974) proposed a theoretical framework in which individuals’ motivations result in the propensity to participate in activities. He examined how people allocate their weekday and weekend time to different activities. Choices of activities are explained by individuals’ motivations and attitudes, personal characteristics and role relations, and opportunities in time and space.

Fried et al. (1977) extensively reviewed economic, geographical, sociological and psychological literature and proposed a synthesized theory of travel behavior. They addressed the question of why people participate in activities. Their theory suggested that (stable) social role structures strongly affect activity-travel behavior.

Following these theories, comprehensive activity-based models of transport demand have become the state-of-the-art in transport demand modeling and are being tested in practice (e.g. Arentze and Timmermans, 2004; Bhat, et al., 2004; Pendyala et al., 2005; Roorda et al., 2008). Activity-based models regard
travel demand as a complex phenomenon embedded in individuals’ activities in
time and space. They focus not only on predicting, but also on explaining travel
behavior. Models of activity-travel demand therefore require more temporal and
spatial detail as well as other variables that reflect changing urban and
transportation environments. This requires further development of the theory and
incorporation of concepts from several disciplines, such as psychology, sociology,
economy and geography (Jones, 1990).

In this respect there are three related factors that deserve further research
in activity-based analysis and that form the central focus of this dissertation. These
factors are social activity-travel, social networks and ICT-use for social interaction.
The next sections review theories and trends in the study of social-activity-travel
behavior and the influence of social networks and ICT therein.

2.2 Social activity-travel

First of all, social activities deserve further study, as this activity category has been
neglected in urban planning and travel behavior research. Recently, some studies in
this area have been undertaken (e.g. Schlich et al., 2004; Mokhtarian et al., 2006;
Carrasco and Miller, 2006; 2009; Farber and Páez, 2009), however, knowledge on
the factors influencing social activity-travel is still limited.

Social activity-travel demand is caused by the distribution of face-to-face
social activities over space. People travel somewhere to meet together, in order to
talk or chat, to have an enjoyable time, to discuss things, to perform a joint activity
and so on (Urry, 2003). Although social interaction does not require physical
proximity anymore, face-to-face contact remains important as it is one of the basic
needs of human beings.

To date, in transportation research, social activities and their associated
trips have received much less attention than travel for other purposes, such as
working or shopping. Social activity-travel differs from travel for working or
shopping as social activities are more heterogeneous in terms of timing and
location. Social activities include a wide range of activities, such as visiting friends
and relatives, going to a bar or restaurant or going to a sports club. While some of
these activities are planned long before or fixed in time, place and company, most
social activities are more flexible and spontaneous. Social travel is therefore more
difficult to predict than travel for work or shopping.

It has however been recognized that it is important to study social activity-
travel, because social activities account for a large part of trips and they constitute
the fastest growing segment of travel (Axhausen, 2005). In the Netherlands, visiting
relatives and friends is responsible for 14% of all trips and social recreational
activities are responsible for another 12% of all trips (Statistics Netherlands, 2008).
While most people make short trips on a day-to-day basis for work and shopping,
they travel longer distances for leisure or socializing (Larsen et al., 2006; Statistics
Netherlands, 2008).
Because of the longer travel distances, a larger share of social trips is made by car. Therefore, social travel is an important contributor to congestion and emissions caused by motorized traffic and should be a major concern for infrastructure planning as well as environmental policy.

People’s leisure time (which is dominated by social interactions with relatives and friends) has increased over the last decades, as well as car ownership and usage (Schlich et al., 2004). This has resulted in an increase of leisure activities, especially out of home leisure activities. This is expected to increase further with an aging population (e.g. Banister and Bowling, 2004; Newbold et al., 2005). Moreover, social travel distances are growing, as social networks are spread over longer geographical distances than before (Axhausen, 2002; Urry, 2003; Schlich et al., 2004; McPherson et al., 2006). All these factors are likely to result in increasing travel demand for social purposes, which increases the importance to study this type of activity-travel behavior. Despite this growing importance, social travel has received relatively little attention in travel behavior research (Axhausen, 2005; Ohnmacht, 2006; Larsen et al., 2006; Mokhtarian et al., 2006).

**Social activity space**

In order to understand the demand for social travel, we must understand the way in which social activities are distributed over space. To capture the spatial components of social interactions, the concepts of action space and activity space can be used. Action space corresponds to the locations the individual has information about and potentially uses. The individual has a certain subjective utility or preference he associates with these locations (Horton and Reynolds, 1971).

Activity space, or actual action space (Dijst, 1999), is that part of the environment, which a traveler actually uses for his/her activities during a certain period (Horton and Reynolds, 1971). Certain activities are fixed in time and space at base locations, such as the home and the work place. Activity spaces consist of a number of base locations and other activity places, and the routes between these locations.

Following the concept of activity space, a person’s social activity space is determined by locations that are frequently visited for social activities and the travel between these social activity locations. The locations where social activities take place can be divided into different categories. Harvey and Taylor (2000) divide social space into three categories: household space, workplace space and community space. Oldenburg (1999) also makes a distinction between three spaces that are important to people: first, second and third places. First and second places are home and work. He introduces the concept of third place, referring to: “public places that host the regular, voluntary, informal, and happily anticipated gatherings of individuals beyond the realms of home and work”. Third places can be places like a bar, a shop, a community centre or a church. According to Oldenburg, the number of traditional meeting places is declining due to city growth and other urban developments. This can make it more difficult for certain people to
fulfill their social needs. However, it is also possible that these traditional meeting places are being replaced by other types of social activity locations. Home and work locations may become more important places for social interaction.

Carrasco et al. (2008b) studied the locations where social interactions take place. They use the concept of social anchor points, which describes the main places where the individuals ‘move around’ when they interact with other network members. They stress that these social anchor points are to a large extent defined by the individual’s social network, either directly, such as the social network members’ homes, or indirectly, such as pubs or restaurants close to the network members’ home or workplace.

2.3 Social networks

As people’s social activity locations are to a large extent defined by their social network, it is important to incorporate social networks in the study of social travel behavior. Although the study of social networks is relatively new to transportation research, in social sciences there is a rich amount of literature on social networks (e.g. Wasserman and Faust, 1994; Marsden, 2005; Degenne and Forsé, 1999). In general, three different approaches can be distinguished: community studies and the social capital approach; the small world approach; and social network analysis.

Community studies and the social capital approach usually consider social networks as traditional tight structures of kinship, friendship and support that are highly place attached. Those communities depend on face-to-face social interactions that increase the social capital: “features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit” (Putnam, 1995). Communities with substantial social capital are characterized by dense networks of reciprocal social relations, high levels of trust among neighbors, and bonding relationships from formal organizations. Putnam (2000) regarded the decline in involvement in organizations in the last decades as a threat to social capital and economic prosperity (as he believes that social capital is essential for economic growth). According to Putnam this decline is caused by generational changes, the spread of TV, urban sprawl and travel. This view however undermines the role of travel and communication in the establishment and development of communities and social capital.

A different approach to social networks is the small world analysis. Small world analysis attempts to explain the small world phenomenon: the notion that all people are separated by only a short chain of intermediaries. A small world experience refers to an occasion where two (apparent) strangers find out they have a mutual friend or acquaintance. Whereas the community studies and the social capital approach focuses on small-scale local networks, the small world approach looks for large-scale patterns of links between these local groups. Especially weak ties form these long-distance links that are responsible for creating the small worlds. While the small world notion is recognizable and intriguing, it is not very
suitable for explaining people’s patterns of everyday life as it does not examine how social network ties are organized and reinforced through meetings and travel (Larsen et al., 2006).

A third approach is social network analysis. In this approach social networks are regarded as a set of actors (nodes) and relationships connecting these actors (Wasserman and Faust, 1994). Although the actors can be groups or organizations, usually an individual is taken as the unit of observation. Social network analysis is concerned with mapping the links between these individuals. It takes as its starting point the assumption that social life is networked, meaning that a larger structured web of social connections exist between people and technologies. It argues that strong social ties still exist, even though social networks are spatially spread as a results of the rapid development of transportation and communication technology (Wellman, 2001).

The three approaches discussed above stem from sociological studies on social networks. However, existing sociological studies have not paid much attention to travel aspects of social networks, such as the geographical distribution of social networks. On the other hand, social networks have also been neglected in the field of transportation. Only recently, the impact of social networks has been acknowledged within the activity-based approach of travel demand, and it is gaining interest.

Social networks in transportation research
In transportation research two lines of research into the effect of social networks on travel behavior have emerged recently. The first line of research focuses on the way people’s social networks influence their travel decisions by the exchange of information and opinions. Dugundji and Walker (2005), Páez and Scott (2007), Páez et al. (2008) and Dugundji and Gulyás (2008) have stressed the need to incorporate social influence effects in decision making, as social networks and especially decisions of others in the network, can have an influence on people’s decisions on trip destination, route, frequency, and mode. Hackney and Axhausen (2006) developed a multi-agent representation, to simulate social influence. Micro simulations of social networks in transportation have also been reported by Marchal and Nagel (2005). Schwanen (2008) emphasized the importance of social networks in coping with uncertainty when scheduling activities and trips. Han et al. (2011) presented an agent-based model for shopping activities, in which agents acquire information about the existence and characteristics of certain location choice alternatives through social interactions. Ettema et al. (2011) proposed a methodology for incorporating social influence on longer-term mobility decisions related to residential type, work status and consumption patterns.

The second line of research into the effect of social networks on travel behavior focuses on the more direct effects of social networks which are related to the desire of individuals to meet the people of their social network, as these people fulfill basic human needs like love, care, recognition, security, pleasure, arousal,
competition, and the need for information or knowledge (Arentze and Timmermans, 2008). Arentze and Timmermans (2008) proposed a theoretical framework to incorporate social activities and changing social networks in the micro simulation of activity-travel patterns. Ronald et al. (2009) reported a partial extension and implementation of this model. Illenberger et al. (2009) conducted a similar simulation. However, these network models are limited to small-scale simulations of travel and socializing and they lack an empirical basis. A method to generate population-wide friendship networks in geographical space was proposed and tested by Arentze et al. (2012).

The first data collections on social networks in the field of transportation contained small numbers of respondents. For example, Larsen et al. (2006) interviewed 24 respondents to explore the geographical spread of young people’s social networks in the North West of England and the consequences of this spread for social interaction and travel patterns. They asked their respondents to list up to 10 people they consider most important for their social network.

Ohnmacht (2006) combined quantitative data measuring an individual’s network geography with qualitative data of 30 interviews to examine the interplay between social networks and travel behavior. Silvis et al. (2006) used data from 24 three-day activity diaries in which respondents were asked to record all trips as well as all social interactions with friends and family to study how social networks influence travel behavior. They did not ask their respondents to list all their social network members.

Only a few larger data collections on social networks and travel have been carried out in which respondents were asked to list their social network members (Wellman et al., 2006; Frei and Axhausen, 2007; Van den Berg et al., 2008; Carrasco, 2009; Tillema et al., 2010; Kowald and Axhausen, 2010a).

Empirical analyses on individuals’ social networks in the transportation context are still scarce. The existing analyses so far have mainly focused on two aspects, namely travel distance (or the distance between homes of the contacting persons) and the frequency of travel, sometimes indicated through the frequency of face-to-face contact (in relation to contact frequency by ICT-mediated communication modes).

The geographical distribution of social networks is an aspect that has received little attention in sociological research. However, it is crucial to an understanding of travel. Therefore, recently some attempts have been made in transportation research to measure the size of social activity spaces and to map and analyze social networks in space (e.g. Schönfelder and Axhausen, 2003; Ohnmacht, 2006; Larsen et al., 2006; Frei and Axhausen, 2007; Carrasco et al., 2008b; Mok et al., 2010; Kowald and Axhausen, 2010b).

In addition to the spatial distribution of social networks, transportation researchers have noted the importance of contact frequency between social network members. The number of trips people make for social meetings is directly related to the frequency of face-to-face social interaction with their social network members.
However, since the widespread use of mobile phones and the Internet, face-to-face social contact cannot be treated separately from ICT-mediated social interaction.

Some authors found social network size to be related to contact frequency, although the findings differ. Carrasco and Miller (2006) and Silvis et al. (2006) suggest that people with a large social network are likely to have more social interactions than people with a small social network. However, Boase et al. (2006) found a negative relationship between the size of the social network and the total number of face-to-face and mediated interactions. E-mail seemed to be independent of social network size. These findings seem to indicate that larger social networks involve lower contact frequency social contacts. Also according to Dijst (2009) people seem to be capable to maintain large social networks by reducing contact frequency.

Based on data collected in the Connected Lives Study (Wellman et al., 2006), Carrasco and Miller (2009) used a multilevel ordinal model to study how often social network members socialize face-to-face. Their results show that the frequency of face-to-face social activities can be explained by personal and household characteristics, social network composition and characteristics of the relationship with the person with whom the social contact takes place. These characteristics of the relationship with the other person included the frequency of telephone, e-mail and instant message contact as well as the geographical distance between the home locations and the emotional distance.

The geographical distance between people is an important factor in explaining social interaction behavior. As social networks are becoming more geographically spread, ICT’s are becoming more important because they provide opportunities to maintain contacts over longer distances. A number of studies on the effect of (geographical) distance decay in the interaction between people with different communication modes have been carried out.

For example, Mok et al. (2010) studied the extent to which contact and support declines with distance, using data gathered in 1978 in the Toronto area. They found a drop in the frequency of face-to-face interaction at about five miles, a steadily decrease further away, and other substantial drops at 50 and 100 miles. For telephone contact they found a marked drop only at 100 miles.

Similarly, Tillema et al. (2010), analyzing data from the Netherlands, found that face-to-face and electronic communication frequencies decline with increasing physical distance.

Frei and Axhausen (2009) estimated a multilevel structural equation model of contact frequencies with social network members by different modes. They found that face-to-face contact frequency decreases fastest with distance. They found distance to have a negative effect on telephone and SMS contact frequency as well. For e-mail no effect was found.

In the context of the Pew Internet & American Life Project, Boase et al. (2006) also found that face-to-face contacts diminish with geographical distance. However, telephone calls (mainline and mobile phone) showed no relationship with
geographical distance, while the frequency of e-mail use increased with geographical distance.

Similarly, Larsen et al. (2006) found the frequency of face-to-face and telephone contact to decrease with geographical distance, and the frequency of e-mail communication to increase. According to Larsen et al. this can be explained by the relatively low costs of e-mail compared to long distance telephone calls and especially long distance travel.

Not only geographical distance but also relational distance between network members has been found to affect their communication frequency with different modes. According to Carrasco et al. (2008c) socially closer individuals are those who share more similar characteristics, and will be more inclined to interact than those more distant. This tendency of people to interact with others that are similar to them is called homophily (McPherson et al., 2001).

Other indicators for relational distance are how long ego and alter have known each other and the social category of their relationship, e.g. whether they are relatives, neighbors, colleagues, fellow club members or just friends. Several studies found that all communication means are used more for very close ties than for less close ties (Boase et al., 2006; Carrasco and Miller, 2009; Tillema et al., 2010).

Emotional closeness has also been found to affect the choice for a communication mode. Lo and Lie (2008) suggest that the level of trust towards the communication partner will affect the choice of communication tool employed. When the level of trust is lower, communication tools that provide more clues and information (synchronous modes) will be chosen.

Frei and Axhausen’s (2009) study showed that work mates are contacted less often face-to-face and by telephone, whereas relatives are contacted more often by telephone.

A study by Rivière and Licoppe (2005), comparing text messaging in Japan and France, indicated that in Japan, text messages are sent to all contacts, independent of relational distance. Telephone calls, which are relatively expensive, are mainly used to contact people that are emotionally very close, like parents or partners. In France SMS messages are mainly sent to the most intimate members of close circles and not to acquaintances or professional contacts (Rivière and Licoppe 2005).

The studies on social networks and travel discussed above all include to some extent the communication patterns between social network members with different types of communication media. The communication patterns between people are likely to have changed over the years as new ICT’s, such as e-mail and mobile telephones, have been introduced. These changing communication patterns in turn are likely to have an effect on social activity-travel demand. The next section discusses the relationship between ICT and social activity-travel.
2.4 ICT and social activity-travel

The importance of information and communication technologies (ICT) in people’s daily lives is increasing. Since the introduction of the mobile phone and the Internet at the end of the twentieth century, these technologies have spread very fast. In the Netherlands, the number of mobile phones per 100 inhabitants has increased from 3 to 100 between 1995 and 2005 (Statistics Netherlands, 2008). The percentage of Dutch households with home access to the Internet in 2007 was 83% (Statistics Netherlands, 2008).

Mobile phones and the Internet are being used more often and longer than a few years ago. Due to new ICT’s the possibilities for social interaction are increasing. ICT’s offer a number of services, such as voice call, SMS, e-mail, Instant Messaging (IM) and social networking services. It is important to differentiate between these forms of social interaction, instead of regarding ICT-mediated communication as one homogenous category. These communication modes differ in nature. They can be fixed in place, such as the landline telephone, or flexible (mobile). Contacts can be synchronous (phone calls, IM), or asynchronous (e-mail, SMS). Communication via ICT differs from face-to-face communication in the sense that it is not coupled with particular places and times.

According to Janelle (1995) it is important to distinguish between physical presence and telepresence and between synchronous and asynchronous presence. This results in four types of presence that are related to different communication modes: synchronous physical presence (face-to-face), synchronous telepresence (telephone, IM), asynchronous presence (refrigerator notes) and asynchronous telepresence (mail, e-mail, voicemail). This can be seen in Table 2.1.

With the introduction of mobile phones and the Internet especially the possibilities for (a)synchronous telepresence have increased. Communication between people by ICT does not take place independently of face-to-face contacts (Dijst, 2009). The rapid spread of ICT’s has prompted considerable speculation about the consequences for social contacts (Baym et al., 2004; Boase et al., 2006; Haythornthwaite and Wellman, 2002). It raised the concern that using the Internet is a solitary activity, which can be harmful to social relations (Haythornthwaite and Wellman, 2002; Turkle, 2011).

*Table 2.1: Four types of presence* (Janelle, 1995)

<table>
<thead>
<tr>
<th></th>
<th>Physical presence</th>
<th>Telepresence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Synchronous</strong></td>
<td><strong>Synchronous presence</strong></td>
<td><strong>Synchronous telepresence</strong></td>
</tr>
<tr>
<td></td>
<td>(face-to-face)</td>
<td>(telephone, instant messaging, tv, radio, teleconferencing)</td>
</tr>
<tr>
<td><strong>Asynchronous</strong></td>
<td><strong>Asynchronous presence</strong></td>
<td><strong>Asynchronous telepresence</strong></td>
</tr>
<tr>
<td></td>
<td>(refrigerator notes, hospital charts)</td>
<td>(mail, e-mail, fax, printed media, website)</td>
</tr>
</tbody>
</table>
In reaction to that concern, others stressed that the Internet should not be seen as a medium that influences its users through sheer exposure, but as a device that is actively used to achieve certain goals, the most important goal being communicating or socializing with others (Matei and Ball-Rokeach, 2002; Cho et al., 2003; Baym et al., 2004).

By offering alternatives to physical presence, mobile phones and the Internet have significant implications for activity-travel patterns. The relationship between ICT and activity-travel patterns has received a substantial amount of attention. The discussion of substitution of travel by electronic communication has been going on since the energy crisis at the beginning of the 1970's (Mokhtarian, 1990). Many studies have focused on the substitution effects of ICT’s in specific applications such as teleworking or teleshopping (Mokhtarian and Meenakshisundaram, 1999; Mokhtarian et al., 2006; Wang and Law, 2007). The substitution effect has been concentrated on most, but there are also other relationships between telecommunication and travel. Following the work of Salomon (1986) and Mokhtarian (1990), four different kinds of relationships can be distinguished:

1. substitution: as telecommunication increases, the number of trips decreases.
2. complementarity: (also referred to as enhancement or generation): as telecommunication increases, the number of trips also increases.
3. modification: telecommunication results in modification of aspects or trips, such as time, route, destination or transport mode.
4. neutrality: telecommunication has no effect on trips.

A large number of studies have looked into these possible effects of ICT’s on travel. Although the relationship between ICT and activity-travel patterns has received a substantial amount of attention, not many studies have focused on the effect of ICT on travel for leisure or social activities. However, it is highly probable that the effect of ICT on leisure and social travel differs from the effect on travel for other activities, such as work or shopping. Whereas the substitution effect received much attention for other activities, according to Mokhtarian et al. (2006), complementarity and modification are more likely than substitution for leisure or social activities, because ICT-based alternatives to these activities (if available) are rarely satisfying substitutes.

This argument is supported by Senbil and Kitamura (2003) who studied the relations between telecommunication and travel for the three types of activities distinguished by Chapin (1974): mandatory (work and work-related) activities, maintenance activities (grocery shopping, eating, household maintenance, etc.) and discretionary activities (leisure, sports, hobbies, etc.). Senbil and Kitamura (2003) used a simultaneous equations model on a data set compiled from a survey in the Osaka area to examine the relation between telecommunications and travel. They found substitution effects for work activities; for maintenance activities the effect
appeared to be neutral; and for discretionary activities they found complementary effects.

Regarding the effect of ICT-based communication on face-to-face social interaction, results also suggest neutrality or complementarity rather than substitution. For instance, Mokhtarian and Meenakshisundaram (1999) examined the relations between personal meetings (and related trips), transfer of an information object and electronic communication. The relationship between electronic communication modes and personal meetings or trips was not significant in either direction, suggesting neutrality instead of substitution or complementarity.

Similarly, Zumkeller (2002), analyzing data on telecommunications and trips in Germany, Korea and Sweden found that additional communication through ICT’s has no decreasing effect on individuals’ physical mobility.

Harvey and Taylor (2000) found a complementary relationship. Using time-use diary data from Canada, Norway and Sweden, they studied the impact of social contact on travel behavior in the light of the increasing tendency of people to work at home. They found that there is a tendency for people with low social interaction to travel more. Working at home (in isolation) will not diminish travel, but rather change the purpose of travel. People who need social contact and cannot find it at their workplace, will seek it elsewhere, thus generating travel.

Similarly, Thulin and Vilhelmson (2005) found that the Internet increases the amount of contact for youth, rather than replaces other modes of communication. Email and Instant Messaging were used primarily as complementary modes of communication, influencing neither telephone use nor face-to-face interaction and travel.

Kenyon (2006) found that increasing Internet use (time online) is associated with increasing time spent on online social network activities. However, no significant effect was found for offline social activities or travel time.

Overall, the results of these studies indicate a neutral or small complementary effect of ICT-mediated communication on face-to-face contact (including travel). However, as shown in the previous section, these effects may be mediated by characteristics of individuals’ social networks. For instance, higher distances between social network members, meaning more costs for face-to-face contact, potentially increase the probabilities of substitution by ICT.

In addition, social travel as well as social network composition and the use of ICT’s for social interaction may be affected by personal and land-use characteristics. These are discussed in the next section.

### 2.5 Personal and land-use characteristics

It has long been acknowledged that socio-demographic and land-use variables affect travel behavior. With regard to socio-demographics, findings from early activity-based research (e.g. Pas, 1984; Lu and Pas, 1999) suggest that travel behavior (number of trips, travel time and mode choice) is affected by age and
gender as well as employment and income, number of children and vehicle ownership. These socio-demographic variables have also been found to affect social activities and travel (e.g. Carrasco and Miller 2006; 2009; Farber and Páez, 2009). For instance, more free time (less work hours, weekend) increases the opportunities for (more or longer) social trips, whereas the presence of a partner and/or children in the household may lessen the need (or even be a constraint) for conducting social activities (e.g. Carrasco and Miller, 2006; Tilahun and Levinson, 2010), especially at long distance locations.

In addition, the spatial environment offers opportunities or constraints for social activity-travel. According to Cervero and Kockelman (1997) there are three dimensions of the spatial environment that influence travel demand: density, diversity and design. Urban density has received most attention in this regard. Urban density has been found to affect travel. For instance, high density leads to shorter travel distances, less car use and higher trip frequencies by public transport, by bike or on foot (Cervero and Kockelman, 1997). The number of (types of) facilities accessible in a walking distance is another land-use characteristic that offers opportunities for (social) activities (Simma et al., 2001), invoking travel.

In addition to social travel, personal and land-use characteristics have been found to affect social network characteristics of individuals. For instance, regarding social network size, Kowald and Axhausen (2010b) found positive effects for household income, household size and the number of previous residences. Being male and widowed was found to result in a smaller social network. Molin et al. (2008b) found social network size to be positively affected by living with a partner, being higher educated, working full time, and living in a household of 3 or more persons. In addition, Molin et al. (2008b) found social network composition (the proportions of relatives, friends, neighbors, colleagues and others) to be affected by gender, age, household composition, education, income and car ownership. The geographical distances between social network members have also been found to be influenced by personal characteristics (Molin et al., 2008b; Carrasco et al., 2008b).

Personal and land-use characteristics are also likely to affect ICT-use for social interaction. Personal characteristics, such as gender, age and income have been found to affect contact frequency between social network members (e.g. Carrasco and Miller 2009; Tillema et al. 2010; Frei and Axhausen 2009). For example, young, highly educated men were the forerunners in the adoption of mobile phones and the Internet and they may still have more ICT-mediated contacts, which in turn may affect social activity-travel behavior. According to Dijst (2009) the choice between synchronous and asynchronous communication modes can be explained by costs. Synchronous contacts often require more money, time and effort than asynchronous contacts. For instance, trying to establish synchronous contact involves the risk that the contact cannot be reached, making asynchronous forms of contacts more efficient. The cost argument could for example explain the higher use of SMS and e-mail by younger people (Dijst, 2009).
In addition, the opportunities people have for travelling can also explain their use of communication means (Larsen et al., 2006; Dijst, 2009). For instance, people without a car may be more likely to substitute face-to-face contact by ICT-mediated contact.

2.6 Conclusion

An examination of the relevant literature shows that although the relationships between social networks, ICT-use and social activity-travel patterns have been acknowledged, knowledge of these complex relationships is very limited. As knowledge of the relationships between ICT and social travel on the one hand, and social networks and social travel on the other hand is scarce, knowledge of the relationships between all three mechanisms is even more limited. Therefore, more research is needed on the way social activity-travel patterns are influenced by social networks, ICT-use and personal and land-use characteristics.

Moreover, the literature that is available shows that there might be substantial differences between countries and cultures in these relationships. In this dissertation these interrelationships will be analyzed in the Dutch context.

Although it has been recognized that the study of individuals’ social network characteristics can provide new insights in the generation of social activities and travel involved, only a few data collection efforts have been made so far in order to incorporate social networks in models of travel demand. Therefore, more empirical results, based on data collected especially for the study of social networks, social activities and travel behavior are needed in the field of transportation research. The next chapter presents the design and the execution of the data collection for this study.
3. Data collection

3.1 Introduction
As discussed in the previous section, the analysis of the relationships between personal characteristics and attributes of the built environment, social networks, the use of ICT’s and social activity-travel patterns, requires collecting data on all four of these sets of variables. For this purpose a data collection instrument was designed. The instrument consists of three parts: a two-day paper-and-pencil social interaction diary capturing social activity-travel and ICT-use for social interaction, a questionnaire on personal characteristics and a follow-up questionnaire on personal social network members. The next sections discuss these three data collection instruments, followed by a description of the actual data collection in section 3.5.

3.2 Social interaction diary
The main aim of this dissertation is to understand the demand for social travel. It is therefore important to know how many trips are made for social activities. In addition, it is relevant to understand the way in which social activities are distributed over space. This means it is important to gather information on the types of locations that are visited and the distances that are traveled to go to these locations. In addition, the travel mode choice is important to understand social travel demand.

To analyze the relationship between ICT-use and social activity-travel, it is important to have information on people’s social interactions. A social interaction can be generally defined as an activity performed by two or more individuals that
For this study it is relevant to gather information on the number of social interactions people have with their social network members, and which communication modes are used for different purposes or for different social network members. ICT-use is here thus limited to social interaction by electronic modes: telephone (landline, mobile, SMS) or via the Internet (e-mail, IM or social network services).

In addition, in order to understand the effect of social networks, it is important to collect detailed information on the persons with whom the social interactions take place.

To collect data on all these aspects of social activity-travel patterns and face-to-face and ICT-mediated social interactions, different approaches can be used, such as observations, interviews and diaries.

A diary seems to be the most appropriate method. Compared to observations and interviews, diaries are less time consuming for researchers and more familiar and unobtrusive to respondents, as diaries enable people to self-record their contacts with other people (Duck, 1991; Reis and Wheeler, 1991; Baumann et al., 1996; Lonkila, 1999; Baym et al., 2004; Fu, 2007).

In addition, diaries have been found to provide more accurate information on people’s activities and trips compared to interviews. For instance, Barnard (1986) compared data collected in Adelaide using a conventional home interview travel survey and an activity diary survey, and found that the latter gave “a much higher level of travel and out-of-home activity reporting”. Similar findings are reported from an English comparative study by Clarke et al. (1981). In the field of transportation activity-travel diaries have also been found to report higher numbers of trips compared to the travel survey (e.g. Clarke et al., 1981; Dijst, 1993) and have become a common instrument for data collection.

Essentially, activity-based diary research involves the recording of a detailed log of the activities (pertinent to the research) people engage in during a certain period of time. Diaries mainly differ regarding the type of information which is collected.

Recently, a number of attempts have been made to gather diary data on ICT-mediated and face-to-face communications in combination with activities and travel (e.g. Mokhtarian and Meenakshisundaram, 1999; Zumkeller, 2002; Kenyon, 2006; Crosbie, 2006; Silvis et al., 2006).

For instance, Mokhtarian and Meenakshisundaram (1999) used a communication diary to gather data on the number of communications of three different types: personal meetings (and related trips), transfer of an information object and electronic communication. Zumkeller (2002) designed a diary to collect data on contacts and trips, obtaining information on time, mode, purpose and distance for both types of activities. Crosbie (2006) designed a diary to record when, where, with whom, and how people communicate electronically and when,
how, where, and why they travel. Finally, Kenyon (2006) developed an accessibility diary which combines activities, communications and travel. Respondents were asked to record what they did, the start and end times of the activity, the participation or presence of others and what else they were doing at the time.

Although these diaries all combine social contacts and travel, none of them record information on the contacted persons to the level of detail required for the study of the relationships between social networks, ICT-use and social activity-travel patterns.

An exception is the study by Silvis et al. (2006) who designed a diary in which respondents were asked to record all trips and social interactions (such as visits, phone calls, and emails) for three days. Respondents also reported the type of location at which the interaction took place, whether they had traveled to get there, how long that trip was, what mode they took, and whether they traveled with others. For social interactions, the communication mode was asked. With regard to the contacted persons, respondents indicated whether that person was kin, and that person’s age, gender, and how long they had known the person. However, their sample consisted of only 24 respondents.

For this study, a similar kind of diary was designed to collect data on social interactions and social activity-travel patterns of a large number of respondents, including detailed information on the persons with whom the interaction took place.

Although diaries have proved to provide accurate data on activity-travel and communication patterns, they should be designed with care. Diary keeping is demanding for respondents. Therefore, the diary log needs to be straightforward and intuitive to use. Respondents need clear guidelines as to what kinds of activities they should record. These aspects have been taken into account when designing a social interaction diary for this study.

To prevent technical respondent burden, the interface of the diary was kept as simple as possible. The first part of the diary contained pages on which respondents could record their social interactions. Every social interaction could be recorded on a separate page. This was done in order to keep the interface clearly organized and to prevent respondents from having to use codes for certain attributes of the social interaction. The interaction pages included questions on the type of interaction (communication mode), the start and end times, the main purpose of the interaction, with whom the interaction took place and at what type of location.

To capture information on social activity-travel patterns, respondents were asked if the social interaction included a trip, especially for the social activity. If the interaction included a trip, the trip distance and transport mode were recorded as well. This can be seen in Figure 3.1.
1. **Type of interaction:**  
- □ Face-to-face  
- □ Mobile phone call  
- □ Land line phone call  
- □ Instant messenger  
- □ Send/read e-mail  
- □ Send/read SMS text  
- □ Other: ………………………  

2. **Time, from ………… until …………**  

3. **With whom did you interact?**  
*Use a unique name (or initials) per person.*  
1……………………………………  
2……………………………………  
3……………………………………  

4. **In case of more than 3 others, nr of**  
- …………men  
- …………women  

5. **Who took the initiative for the interaction?**  
- □ I did  
- □ (one of) the other(s)  
- □ Together  
- □ Not applicable  

6. **Was the interaction…**  
- □ routine  
- □ prearranged  
- □ coincidentally  

7. **Purpose of the interaction**  
*Choose 1 main purpose*  
- □ Joint activity, namely …………  
- □ Pay a visit  
- □ Receive guests  
- □ Talk/chat  
- □ Short question/message  
- □ Make an appointment  
- □ Give information/advice  
- □ Receive information/advice  
- □ Discussion  
- □ Other, namely ………………………  

8. **What did you do right before and after the interaction?**  
<table>
<thead>
<tr>
<th>before</th>
<th>after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>□</td>
</tr>
<tr>
<td>Study</td>
<td>□</td>
</tr>
<tr>
<td>Housework</td>
<td>□</td>
</tr>
<tr>
<td>Eat/drink</td>
<td>□</td>
</tr>
<tr>
<td>travel</td>
<td>□</td>
</tr>
<tr>
<td>Other, nl:…</td>
<td>□</td>
</tr>
<tr>
<td>Other, nl:…</td>
<td>□</td>
</tr>
</tbody>
</table>

9. **Where did the interaction take place?**  
- □ Home (go to question 13)  
- □ Residence of other person  
- □ Work  
- □ School  
- □ Shop  
- □ Café, bar, restaurant  
- □ On the road  
- □ Other, namely: ………………………  

10. **Were you there specifically for the interaction?**  
- □ No (go to question 13)  
- □ Yes  

11. **How far is this location?** ………………km  

12. **How did you get here?**  
*Choose 1 mode*  
- □ (1) car as driver  
- □ (2) car as passenger  
- □ (3) moped  
- □ (4) bus/tram/subway  
- □ (5) train  
- □ (6) bike  
- □ (7) walk  
- □ (8) other  

13. **Did this interaction save you a trip?**  
- □ no  
- □ yes: ………………km (one way),  
  per…………….  
*Choose the number of one transport mode, see 12*  

14. **Did you make an appointment during this interaction for which you will make a trip?**  
- □ no  
- □ yes: ………………km (one way),  
  per…………….  

15. **Did you modify a trip during this interaction?**  
- □ no  
- □ yes time/ route/ destination/ transp. mode  

---

**Figure 3.1: Social interaction page**
1. Name initials: .................................................................
   (Make sure this name corresponds with the name on the interaction page)

2. Age
   □ 0-9
   □ 10-19
   □ 20-29
   □ 30-39
   □ 40-49
   □ 50-59
   □ 60-69
   □ 70-79
   □ 80 or older
   □ Don’t know

3. Gender
   □ Male
   □ Female

4. Category
   □ My partner
   □ My father/mother
   □ My child
   □ My brother/sister
   □ Other relative
   □ Housemate
   □ Neighbour
   □ Colleague
   □ Fellow student
   □ Union/club member
   □ A friend
   □ An acquaintance
   □ A stranger

5. How strong is your relationship?
   □ Very strong
   □ Somewhat strong
   □ Not so strong
   □ Not strong at all

6. How long have you known each other?
   □ Not
   □ Less than 1 year
   □ 1 to 2 years
   □ 2 to 5 years
   □ 5 to 15 years
   □ 15 years or more

7. How far away does this person live?
   □ Same house
   □ 0-1 kilometre
   □ 1-2 km
   □ 2-5 km
   □ 5-15 km
   □ 15-30 km
   □ 30-60 km
   □ 60-100 km
   □ 100-200 km
   □ > 200 km, namely ………………..km
   □ Don’t know

8. Does this person use the below mentioned communication modes?
<table>
<thead>
<tr>
<th>yes</th>
<th>no</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. How often do you interact with each other in the below mentioned ways?
<table>
<thead>
<tr>
<th>Face-to-face</th>
<th>less than once a month</th>
<th>once a month</th>
<th>once every two months</th>
<th>once a week</th>
<th>twice a week</th>
<th>almost everyday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.2: Person’s page in social interaction diary
Respondents were asked to record all their social interactions during two days. For our study, social interactions were defined as all forms of contact: a joint activity, a conversation (either face-to-face, by telephone or online), a letter, fax, SMS (text message) or an e-mail. Interactions at home with only members of the household were not included, nor were interactions as a customer or work-related interactions. This was explained on the first page of the diary, as well as during the recruitment of respondents.

To prevent respondents from forgetting social interactions, they were asked to record their social interactions as shortly as possible after they occurred. In addition, they also received a worksheet which they could use during the day to remember their interactions, in case it was impossible to take the booklet along.

In the second part of the interaction diary the respondents were asked to fill in a page with questions about every person they had interacted with during the two diary days. The names were recorded both on the interaction pages and the person’s pages, so the information could be linked. This way, if respondents had more than one interaction with the same person, they had to record the information on this person only once.

The person’s page can be seen in Figure 3.2. The questions on each contacted person include age, gender, social category, distance and the contact frequency with different communication modes (face-to-face, telephone, e-mail, etc.).

3.3 Questionnaire on personal and land-use characteristics

In line with the conceptual model, it is hypothesized that socio-demographic characteristics and the spatial environment affect social activity-travel behavior, as well as social network characteristics and ICT-use for social interaction. Based on findings from the literature, the following personal characteristics are relevant to collect: age, gender, household composition (partner, children), level of education, income, work / school, access to transport modes, and access to and use of means of ICT (computer, mobile phone, etc.). In addition to the social interaction diary, a questionnaire was designed to gather data on these personal characteristics. The questionnaire can be seen in Appendix 1.

Regarding land-use characteristics, information can be derived from the postcode of the area. Findings from the literature suggest that especially urban density and the facilities in the residential location are relevant. Therefore, these two land-use characteristics are derived from the respondents’ postcodes.

3.4 Social network questionnaire

As discussed in the literature, the motivation to perform social activities is affected by people’s social networks. Therefore, in addition to the social activity diary, which was designed to capture the actual social activity behavior of respondents during two days, this study requires data on people’s social networks.
There are two ways to approach social networks: as whole or as ego-centered networks. In studies on whole networks the focus is on all nodes and ties of a population. This means that all actors are known beforehand and are “regarded for analytical purposes as bounded social collectives” (Marsden, 2005). Networks that can be approached as whole networks are usually formal networks; organized communities or groups with shared interests, like school classes, clubs or the inhabitants of a neighborhood.

If strict boundaries cannot be defined, or one is concerned with behavior on the level of individuals instead of a fixed group, such as in the case of travel behavior research, the ego-centered approach is more appropriate. This approach has been used by Wellman et al. (2006), Frei and Axhausen (2007), Molin et al. (2008b) and Carrasco (2009). Kowald and Axhausen (2010a) however collected data on connected rather than isolated personal networks, applying snowball sampling.

Ego-centered network studies concentrate on the network of a person (ego) which consists of all the people (or groups) he or she has a relationship with (alters) (Carrasco et al., 2008a).

Therefore, a social network questionnaire was designed to capture all social network members the respondents have a certain relationship with.

**Name generators**

To define who should be regarded as network members, a set of questions, called name generators can be used (Degenne and Forsé, 1999; Marsden, 2005). Generally, four name generating approaches can be distinguished (Van der Poel, 1993; Molin et al., 2008a). Firstly, the interaction approach asks for a record of all alters with whom the respondent (ego) interacts in a certain period (including casual and unknown contacts). In this approach a (long-term) diary can be used to reveal the social network (Fu, 2007). A disadvantage of this approach is that it does not take into account the strength or importance of the relationship.

Another approach is the role relation approach: a record of people with whom the individual has a certain role relationship, such as family, relatives, neighbors or friends. Thirdly, the affective approach asks respondents to record the people with whom they have a close personal relationship, or who are especially important to them.

Finally, the exchange approach concentrates on people with whom the individual has social exchange, such as help, social activities or talk about worries (e.g. Fischer, 1982).

Either approach captures a certain portion of the entire network. The choice between the different approaches clearly depends on the aim of the analysis. Instead of a single name generator, multiple elicitation techniques should be used whenever possible as this generally results in fewer forgotten social network members (Brewer et al., 2000; Molin et al., 2008a).
In the field of transportation different name generating approaches have been used. The Connected Lives Study (Wellman et al., 2006), drawing on the work of Wellman (1979) asked the respondents to name the persons who live outside their household, with whom they felt very close and somewhat close. Very close people consist of those persons with whom the respondent discusses important matters or regularly keeps in touch with, or are there for them if they need help. Somewhat close people were described as those persons who are more than just casual acquaintances, but not considered to be very close.

In a data collection about personal networks in different neighborhoods of Concepción, Chile, Carrasco (2009) used the same name generators as those used in the Connected Lives Study.

Frei and Axhausen (2007) used a similar name generator for very close network ties. They asked their respondents to record alters with whom they discuss important problems, with whom they stay in regular contact or whom they can ask for help. These questions cover the “very close” or “most important” contacts. The second name generator they used, asked for persons with whom the respondents spend leisure time. This name generator targets weaker ties against the background that leisure travel makes up the largest share of long distance travel.

Similarly, Kowald and Axhausen (2010a) asked their respondents to record the alters with whom they make plans to spend free time. Respondents could record up to 29 alters for this question. In addition, a second name generator was used, asking about other people with whom important problems are discussed. An extra 11 alters could be recorded here.

Other studies in the field of transportation that capture the link between social activity-travel, ICT and social networks used a limited approach with respect to social networks. Larsen et al. (2006) asked their respondents to list up to 10 people they consider most important for their social network. Tillema et al. (2010) asked respondents to record five relatives (excluding household members) and five friends with whom they communicate most frequently.

Whereas the social interaction diary captured a sample of the respondents’ social interaction contacts, for the social network questionnaire the focus is on the alters that are emotionally close, as these are the most important motivators for social interactions.

Therefore, in the social network questionnaire a set of name generating questions was used, similar to those used in the Connected Lives study (Wellman et al., 2006). In this name generator the affective approach is combined with the exchange and role approach. The name generators asked:

1. Think about the people you feel very close to.

   They are: people with whom you discuss important matters, or regularly keep in touch with, or that are there for you if you need help

   They can be household members, relatives, colleagues or fellow students, neighbors, club members and (other) friends.
2. Think about the people you feel somewhat close to. They are: people that are more than just casual acquaintances, but not very close. They can be household members, relatives, colleagues or fellow students, neighbors, club members and (other) friends.

These name generators were first used in the questionnaire to collect data on social network size for all respondents. Therefore, in the questionnaire these name generators were followed by the questions “how many people do you know whom you feel very close to” and “how many people do you know whom you feel somewhat close to”.

Apart from collecting information on social network size, these questions were also used to determine the maximum number of network members that could be recorded in the follow-up questionnaire. The answers to these questions from the questionnaire were analyzed. Figure 3.3 shows the cumulative percentage social network members by strength of tie.

The black line in Figure 3.3 shows the cumulative percentage of very close ties and the grey line shows somewhat close ties. As can be seen, the respondents’ social networks tend to consist of a few more somewhat close ties than very close ties. The majority of the respondents (96%) know up to 25 people they feel very close to and up to 40 people they feel somewhat close to. Therefore the follow-up questionnaire contained questions about (a maximum of) 25 very close and 40 somewhat close social network members.

![Figure 3.3: Cumulative percentage of social network members by tie strength](image)

Figure 3.3: Cumulative percentage of social network members by tie strength
The social network questionnaire consisted of a booklet with a page of questions about each social network member. These pages are similar to the person’s pages in the social interaction diary (Figure 3.2). The names did not have to be recorded in the social network questionnaire. The social network questionnaire contained a worksheet which could be used by the respondents to write down the names of their social network members.

Whereas others (e.g. Wellman et al., 2006; Frei and Axhausen, 2007) used a face-to-face interview to cover the social network data, in this study a paper and pencil questionnaire was used, in which respondents could self report their social network members. This was possible as the respondents were already familiar with this format, as it was similar to the person’s pages in the social interaction diary.

**Name interpreters**
In general, once all alters are elicited, additional questions are used to gather information on each alter. These additional questions are called name interpreters.

For the study of social activity behavior some information on each alter is required. Gender and age of the alter are relevant, especially in combination with the age and gender of the ego. This relates to homophily, which is the tendency of people to interact with others that are similar to them (McPherson et al., 2001).

Social activity behavior has also been found to be affected by relational and geographical distance between ego and alter. A measure for relational distance was captured in the name generators. How long ego and alter have known each other and the social category of their relationship (relative, neighbor, colleague, club member or other friend) are indicators of social closeness as well.

In addition, the contact frequency between ego and alter (with different communication modes) is relevant as well in order to predict how often people travel to meet each other.

Finally, the geographical distance between ego and alter is important, as this is also likely to affect their social activity behavior. For instance, a longer distance, indicating a longer travel time, is likely to result in fewer but longer social activity durations.

Therefore, respondents were asked to record the following information for each alter: gender, age, category, how long they have known each other, distance between homes, which communication modes the alter uses and the frequency of interaction with the alter by different modes.

**3.5 Data collection**
In total, 1500 social interaction diaries were printed. They were distributed between January and March 2008 in the region of Eindhoven, a medium-sized city in the south of the Netherlands. People aged 15 or over could participate.
A requirement for the data collection, to allow the estimation of the impact of the built environment, is to secure sufficient variation in characteristics of the built environment. Therefore, the sample was stratified by urban density. In the Netherlands, five classes of urban density are distinguished:

1. very high density (2500 or more addresses per km$^2$)
2. high density (1500 to 2500 addresses per km$^2$)
3. moderate density (1000 to 1500 addresses per km$^2$)
4. low density (500 to 1000 addresses per km$^2$)
5. very low density (less than 500 addresses per km$^2$)

The aim was to collect equal numbers of diaries for the five classes of urban density. A number of neighborhoods in Eindhoven and surrounding villages (Nuenen, Gerwen, Geldrop, Son en Breugel, Nijnsel and Sint Oedenrode) were selected, in which addresses were randomly selected.

To recruit respondents, a personal approach was employed. A team of 12 students went by people’s homes to ask them if they were willing to participate in this study. If they were, they were given an explanation and they received a diary, which was collected approximately one week later. This personal approach was employed to increase the participation of respondents. As an incentive, 35 vouchers of €25.00 were allocated to respondents through a lottery system.

Out of 3699 people who answered the door, 1648 (45%) accepted a diary. Out of these, 747 useful diaries were returned. This results in an overall response rate of 20%. The distribution across the different levels of urban density is shown in Table 3.1.

The data on social interaction were collected using a two-day interaction diary. The respondents were asked to keep the diary for two successive days. They were allowed to choose the days of the week themselves. Theoretically this is not the best operational decision as respondents may report their social interactions for less active days to reduce respondent burden. However, this decision was made nevertheless as there were some serious concerns about the sample size, especially when more restrictions for the respondents would be added.

### Table 3.1: Response rates social interaction diary

<table>
<thead>
<tr>
<th>Urban density</th>
<th>People approached</th>
<th>Diaries accepted</th>
<th>% accepted</th>
<th>Diaries completed</th>
<th>% completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>659</td>
<td>344</td>
<td>52</td>
<td>136</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>894</td>
<td>334</td>
<td>37</td>
<td>154</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>735</td>
<td>318</td>
<td>43</td>
<td>159</td>
<td>22</td>
</tr>
<tr>
<td>4</td>
<td>798</td>
<td>351</td>
<td>44</td>
<td>159</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>613</td>
<td>301</td>
<td>49</td>
<td>139</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>3699</td>
<td>1648</td>
<td>45</td>
<td>747</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 3.2: Diary days across day of the week

<table>
<thead>
<tr>
<th>Day of the week</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>104</td>
<td>92</td>
<td>196</td>
<td>13</td>
</tr>
<tr>
<td>Tuesday</td>
<td>125</td>
<td>104</td>
<td>229</td>
<td>15</td>
</tr>
<tr>
<td>Wednesday</td>
<td>124</td>
<td>119</td>
<td>243</td>
<td>16</td>
</tr>
<tr>
<td>Thursday</td>
<td>97</td>
<td>125</td>
<td>222</td>
<td>15</td>
</tr>
<tr>
<td>Friday</td>
<td>100</td>
<td>87</td>
<td>187</td>
<td>13</td>
</tr>
<tr>
<td>Saturday</td>
<td>111</td>
<td>94</td>
<td>205</td>
<td>14</td>
</tr>
<tr>
<td>Sunday</td>
<td>67</td>
<td>102</td>
<td>169</td>
<td>11</td>
</tr>
<tr>
<td>Missing</td>
<td>19</td>
<td>24</td>
<td>43</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>747</td>
<td>747</td>
<td>1489</td>
<td>100</td>
</tr>
</tbody>
</table>

Fortunately, as indicated by Table 3.2 the distribution of diary days by days of the week is not severely biased. In total 1489 diary days were recorded (5 respondents kept the diary for only 1 day).

The participants of the social network study are a subset of the respondents who participated in the larger social interaction study. The social interaction study involved 747 respondents. A subset of 227 (30.4%) indicated to have no objections to be contacted for the follow-up survey. The paper and pencil social network questionnaire was mailed to them and 116 respondents actually completed the social network questionnaire. This means that a response rate of 51% was realized in this second round of surveying.

3.6 Conclusion

This chapter has presented a data collection effort to capture the links between ICT, social networks, the built environment and activity-travel patterns. The data collection instruments consists of a two-day paper-and-pencil social interaction diary to collect a subsample of the respondents’ (face-to-face and ICT-mediated) social interactions and related trips. Moreover, it captured detailed information on the persons with whom the social interaction took place. Personal and residential characteristics of the respondents were collected in a questionnaire. A follow-up questionnaire was designed to capture the complete ego-network, including characteristics of the alters, such as gender, age, distance between homes, and contact frequency.

The data collection effort presented here should allow improving our understanding of the relationships between ICT, social networks, the built environment and activity-travel patterns.

The response rates that were realized are relatively high, probably as a consequence of the personal approach and the compact and attractive format of the booklet that was used.

The next chapter presents the basic sample characteristics of the 747 social activity diaries and questionnaires and the 116 social network questionnaires.
4. Basic sample characteristics

4.1 Introduction
This chapter presents some descriptive statistics on the four concepts on which data were collected. First the personal and land-use characteristics of the 747 respondents of the social interaction diary and questionnaire are presented, followed by a description of the subsample of respondents who also completed the social networks questionnaire. The analyses are used to examine the quality of the samples and to compare them to the Dutch population to check how representative they are. Finally, some general information on social interaction and ICT-use, and social travel is presented.

4.2 Personal and land-use characteristics
Table 4.1 shows the personal and land-use characteristics of the 747 respondents of the social interaction diary and questionnaire. The sample is compared to the population of the Netherlands (Statistics Netherlands, 2008).

Overall, the sample is not completely representative of the Dutch population. As can be seen, the sample contains substantially more women than men. A larger share of women is usual in this type of study. However, this distribution is more uneven than usual. This may be related to the personal approach that was adopted. Women may be more likely to answer the door, probably because they spend more time at home.

The youngest and the oldest cohorts are somewhat underrepresented, which is typically observed in most surveys. The same goes for the overrepresentation of higher educated people in the sample.
In addition, the sample contains a higher percentage of people living with a partner (couples with or without children) compared to the Dutch population. People living in single-person households are underrepresented in the sample. This is probably partly due to the fact that the youngest and the oldest age groups are underrepresented in the sample and partly due to the personal approach of the data collection.

Although Table 4.1 shows that the sample is not severely biased, it is not completely representative of the Dutch population either. This means that, in the next chapters, we should be careful when generalizing the results of the analyses based on these data.

Table 4.1: Personal and land-use characteristics of the sample

<table>
<thead>
<tr>
<th></th>
<th>Sample (N)</th>
<th>Sample (%)</th>
<th>Netherlands (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>293</td>
<td>39</td>
<td>49</td>
</tr>
<tr>
<td>Female</td>
<td>452</td>
<td>61</td>
<td>51</td>
</tr>
<tr>
<td>Young age (&lt;30)</td>
<td>96</td>
<td>13</td>
<td>36</td>
</tr>
<tr>
<td>Middle age (30-50)</td>
<td>367</td>
<td>49</td>
<td>30</td>
</tr>
<tr>
<td>Old age (&gt;50)</td>
<td>281</td>
<td>38</td>
<td>34</td>
</tr>
<tr>
<td>Living with partner</td>
<td>582</td>
<td>78</td>
<td>72</td>
</tr>
<tr>
<td>Living without partner</td>
<td>162</td>
<td>22</td>
<td>28</td>
</tr>
<tr>
<td>Primary education</td>
<td>173</td>
<td>23</td>
<td>29</td>
</tr>
<tr>
<td>Secondary education</td>
<td>229</td>
<td>31</td>
<td>43</td>
</tr>
<tr>
<td>Higher education</td>
<td>442</td>
<td>46</td>
<td>28</td>
</tr>
<tr>
<td>Low (&lt;€3000,- p.m.)</td>
<td>430</td>
<td>58</td>
<td>63</td>
</tr>
<tr>
<td>High (&gt;€3000,- p.m.)</td>
<td>247</td>
<td>33</td>
<td>37</td>
</tr>
<tr>
<td>(missing)</td>
<td>70</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>No car in household</td>
<td>68</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>1 car in household</td>
<td>421</td>
<td>56</td>
<td>54</td>
</tr>
<tr>
<td>2 or more cars</td>
<td>249</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>No work</td>
<td>263</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>Part time work</td>
<td>282</td>
<td>38</td>
<td>27</td>
</tr>
<tr>
<td>Full time work</td>
<td>202</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>1 person household</td>
<td>82</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>2 person household</td>
<td>278</td>
<td>37</td>
<td>33</td>
</tr>
<tr>
<td>3 or more persons</td>
<td>383</td>
<td>51</td>
<td>32</td>
</tr>
<tr>
<td>No club membership</td>
<td>221</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>1 club</td>
<td>208</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>2 or more clubs</td>
<td>318</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>High density (&gt;1500 addr. per km²)</td>
<td>290</td>
<td>39</td>
<td>42</td>
</tr>
<tr>
<td>Medium density (1000-1500)</td>
<td>159</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Low density (&lt;1000 addr. per km²)</td>
<td>298</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>
4.3 Social networks

This subsection presents some general descriptive analyses of the social network data. First, the characteristics of the 116 respondents are analyzed. Second, the social network characteristics are described.

Sample characteristics social network questionnaire

Table 4.2 shows the characteristics of the subsample of respondents who completed the social network questionnaire. The respondents of the social network questionnaire are a subsample of the respondents of the social interaction diary and questionnaire. In total 116 respondents completed the social network questionnaire.

<table>
<thead>
<tr>
<th></th>
<th>Sub-sample (N)</th>
<th>Sub-sample (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Female</td>
<td>81</td>
<td>70</td>
</tr>
<tr>
<td>Young age (&lt;30)</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Middle age (30-50)</td>
<td>46</td>
<td>40</td>
</tr>
<tr>
<td>Old age (&gt;50)</td>
<td>61</td>
<td>53</td>
</tr>
<tr>
<td>Living with partner</td>
<td>85</td>
<td>73</td>
</tr>
<tr>
<td>Living without partner</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>Primary education</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td>Secondary education</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Higher education</td>
<td>53</td>
<td>46</td>
</tr>
<tr>
<td>Low (&lt;€3000,- p.m.)</td>
<td>68</td>
<td>59</td>
</tr>
<tr>
<td>High (&gt;€3000,- p.m.)</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>(missing)</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>No car in household</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>1 car in household</td>
<td>64</td>
<td>55</td>
</tr>
<tr>
<td>2 or more cars</td>
<td>33</td>
<td>28</td>
</tr>
<tr>
<td>No work</td>
<td>54</td>
<td>47</td>
</tr>
<tr>
<td>Part time work</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Full time work</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>1 person household</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>2 person household</td>
<td>51</td>
<td>44</td>
</tr>
<tr>
<td>3 or more persons</td>
<td>45</td>
<td>39</td>
</tr>
<tr>
<td>No club membership</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>1 club</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>2 or more clubs</td>
<td>59</td>
<td>51</td>
</tr>
<tr>
<td>High density (&gt;1500 addresses per km$^2$)</td>
<td>41</td>
<td>35</td>
</tr>
<tr>
<td>Medium density (1000-1500 addr. per km$^2$)</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Low density (&lt;1000 addr. per km$^2$)</td>
<td>40</td>
<td>35</td>
</tr>
</tbody>
</table>
As discussed, the first sample differed somewhat from the Dutch population. As can be seen in Table 4.2, the sample of the social network questionnaire is not completely representative of the Dutch population either. In this subsample the proportions of males and younger people are even a little more underrepresented than in the first sample. Compared to the first sample, the subsample has the same overrepresentation of higher educated people, and a stronger underrepresentation of full time workers.

**Social network size**
The 116 respondents of the social network questionnaire reported 2695 social network members. The average social network size, not including household members, is therefore 23.28 alters. The dataset consists of 1152 (43%) very strong and 1543 (57%) somewhat strong social network members, resulting in an average of 9.96 very strong and 13.36 somewhat strong network members. One might assume that people are more likely to forget weak ties than strong ties, however, the evidence is mixed on this point (Brewer et al., 2000).

Comparing these numbers to Hogan et al. (2007), who used the same name generators, we see almost identical numbers (very strong 11.6; somewhat close 12.2; total 23.8). Different name generating questions can lead to different social network sizes (Molin et al., 2008a). For instance, Molin et al. (2008b) used a number of exchange approach name generators, resulting in a mean network size of 13.3 alters.

**Social network composition**
Table 4.3 shows the distribution of social network members across social categories. As can be seen in Table 4.3, relatives and friends make up the largest portion of people’s social networks. On average, the reported social networks consist of 10.09 relatives, which is 43%. Respondents on average reported 8.23 friends (35%). The other categories, neighbors, colleagues or fellow students, and fellow club members on average make up 8%, 7% and 6% of people’s social network respectively. The network composition is largely similar to the composition found by Fischer (1982).

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>Mean N</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relatives</td>
<td>43</td>
<td>10.09</td>
<td>6.971</td>
</tr>
<tr>
<td>Friends</td>
<td>35</td>
<td>8.22</td>
<td>6.719</td>
</tr>
<tr>
<td>Neighbors</td>
<td>8</td>
<td>1.79</td>
<td>2.149</td>
</tr>
<tr>
<td>Colleagues</td>
<td>7</td>
<td>1.71</td>
<td>2.667</td>
</tr>
<tr>
<td>Club members</td>
<td>6</td>
<td>1.47</td>
<td>3.322</td>
</tr>
<tr>
<td>Total network size</td>
<td>100</td>
<td>23.28</td>
<td>14.286</td>
</tr>
</tbody>
</table>

37
Geographical distance between social network members

Table 4.4 shows the geographical distribution of social network members. The geographical distribution of social networks is crucial to an understanding of travel. Distances between social network members are growing as a result of new, cheaper and faster ways to travel and communicate over longer distances (Axhausen, 2002; Urry, 2003; Schlich et al., 2004; McPherson et al., 2006).

However, table 4.4 shows that 95% of all social network members still live within 200 kilometers from the ego.

Table 4.4: Geographical distance between social network members

<table>
<thead>
<tr>
<th>Distance</th>
<th>N</th>
<th>%</th>
<th>Cum. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 kilometer</td>
<td>363</td>
<td>13.5</td>
<td>13.5</td>
</tr>
<tr>
<td>1-2 kilometer</td>
<td>149</td>
<td>5.5</td>
<td>19.0</td>
</tr>
<tr>
<td>2-5 kilometer</td>
<td>381</td>
<td>14.1</td>
<td>33.1</td>
</tr>
<tr>
<td>5-15 kilometer</td>
<td>675</td>
<td>25.0</td>
<td>58.1</td>
</tr>
<tr>
<td>15-30 kilometer</td>
<td>217</td>
<td>8.1</td>
<td>66.2</td>
</tr>
<tr>
<td>30-60 kilometer</td>
<td>242</td>
<td>9.0</td>
<td>75.2</td>
</tr>
<tr>
<td>60-100 kilometer</td>
<td>211</td>
<td>7.8</td>
<td>83.0</td>
</tr>
<tr>
<td>100-200 kilometer</td>
<td>325</td>
<td>12.1</td>
<td>95.1</td>
</tr>
<tr>
<td>More than 200 kilometer</td>
<td>113</td>
<td>4.2</td>
<td>99.3</td>
</tr>
<tr>
<td>Don’t know</td>
<td>19</td>
<td>0.7</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>2695</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

4.4 Social interaction and ICT-use

In this subsection, some general descriptive analyses are presented regarding social interaction frequency and the use of different communication modes. First, the frequency of communication between social network members is established, analyzing the social network data. Next, the social interaction diary data are analyzed. The number of social interactions in two days per respondent, the distribution of social interactions across main purposes and the distribution of social interactions across communication mode are presented.

Communication frequency between social network members

Table 4.5 shows the frequency of communication between social network members, based on the social network questionnaire data, consisting of 116 egos and 2696 alters. It shows that the frequencies differ enormously between the different communication modes.
Table 4.5: Communication frequency between social network members

<table>
<thead>
<tr>
<th></th>
<th>F2F %</th>
<th>Telephone %</th>
<th>SMS %</th>
<th>E-mail %</th>
<th>IM %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>1.3</td>
<td>10.7</td>
<td>74.9</td>
<td>49.5</td>
<td>95.1</td>
</tr>
<tr>
<td>&lt; once a month</td>
<td>37.7</td>
<td>41.9</td>
<td>12.6</td>
<td>25.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Once a month</td>
<td>16.9</td>
<td>16.6</td>
<td>5.2</td>
<td>11.2</td>
<td>0.7</td>
</tr>
<tr>
<td>2-3x per month</td>
<td>14.6</td>
<td>14.1</td>
<td>3.8</td>
<td>8.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Once per week</td>
<td>16.2</td>
<td>10.0</td>
<td>1.7</td>
<td>2.9</td>
<td>0.6</td>
</tr>
<tr>
<td>2-5x per week</td>
<td>10.7</td>
<td>5.4</td>
<td>1.1</td>
<td>2.0</td>
<td>0.3</td>
</tr>
<tr>
<td>(Almost) every day</td>
<td>2.3</td>
<td>1.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Number of social interactions in two days

In total the 747 respondents recorded 8074 social interactions in two days, which is an average of 10.81 social interactions in two days per respondent, with a standard deviation of 6.45. Figure 4.1 shows the distribution of the number of social interactions in two days.

![Figure 4.1: Distribution of social interactions per respondent in two days](image-url)
Purpose of social interactions
Social interactions between people can be categorized into different purposes. The distribution of the recorded social interactions across main purpose is shown in table 4.6. This table shows that the largest part of social interactions is for the purpose of talking or chatting, followed by a short question or message and discussing or exchanging information or advice. The smallest portion of social interactions is for the purpose of visiting or receiving guests (7%). The purpose of the social interaction differs however by communication mode, which is shown in Table 4.8.

Table 4.6: Distribution of social interactions across main purpose

<table>
<thead>
<tr>
<th>Main purpose</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint activity</td>
<td>839</td>
<td>10</td>
</tr>
<tr>
<td>Visit /receive guests</td>
<td>594</td>
<td>7</td>
</tr>
<tr>
<td>Talk/chat</td>
<td>2226</td>
<td>28</td>
</tr>
<tr>
<td>Short question/message</td>
<td>1354</td>
<td>17</td>
</tr>
<tr>
<td>Make an appointment</td>
<td>852</td>
<td>11</td>
</tr>
<tr>
<td>Discuss, information or advice</td>
<td>1397</td>
<td>17</td>
</tr>
<tr>
<td>Other</td>
<td>773</td>
<td>10</td>
</tr>
<tr>
<td>Missing</td>
<td>39</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>8074</td>
<td>100</td>
</tr>
</tbody>
</table>

Distribution of social interactions across communication mode
Table 4.7 shows how the 8074 social interactions are distributed across the different communication modes. As can be seen, 52% of the interactions were face-to-face. This means that face-to-face communication is the dominant mode of interaction for this sample.

Baym et al. (2004) also found face-to-face to be the most used communication mode; 64% of college students’ interpersonal interactions were face-to-face. However, Chen et al. (2002) and Thulin and Vilhelmsen (2005) found that the telephone was the dominant communication mode.

Table 4.7: Distribution of social interactions across communication mode

<table>
<thead>
<tr>
<th>Communication mode</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face-to-face</td>
<td>4177</td>
<td>52</td>
</tr>
<tr>
<td>Mobile Phone call</td>
<td>836</td>
<td>10</td>
</tr>
<tr>
<td>Landline Phone call</td>
<td>1506</td>
<td>19</td>
</tr>
<tr>
<td>E-mail</td>
<td>858</td>
<td>11</td>
</tr>
<tr>
<td>SMS</td>
<td>449</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>248</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>8074</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 4.8 shows the main purpose of the interaction by communication mode. As can be seen, different communication modes are used for different purposes. Naturally, joint activities and visits are always face-to-face. SMS and mobile phone are used more often for a short question or message, whereas e-mail is mainly used for sharing information.

Table 4.8: Main purpose by communication mode

<table>
<thead>
<tr>
<th>Purpose</th>
<th>F2F %</th>
<th>Mobile %</th>
<th>Landline %</th>
<th>E-mail %</th>
<th>SMS %</th>
<th>Other %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint activity</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Visit /receive guests</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Talk/chat</td>
<td>29</td>
<td>29</td>
<td>31</td>
<td>16</td>
<td>15</td>
<td>59</td>
</tr>
<tr>
<td>Question/message</td>
<td>6</td>
<td>32</td>
<td>23</td>
<td>25</td>
<td>53</td>
<td>14</td>
</tr>
<tr>
<td>Make an appointment</td>
<td>2</td>
<td>21</td>
<td>23</td>
<td>17</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Discuss, info or advice</td>
<td>13</td>
<td>17</td>
<td>21</td>
<td>37</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Other</td>
<td>16</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

4.5 Social travel

In the social interaction diary respondents were asked to indicate where the interaction took place, if they were at this location especially for the social interaction and if so, how far from home this location was. In total, among 747 respondents 1878 social trips were recorded in 2 days. This is an average of 1.25 social trips per respondent per day. Figure 4.2 shows the distribution of the number of social trips per respondent.

![Figure 4.2: Distribution of number of social trips in two days](image)
Distribution of social trips across location types

Table 4.9 shows the distribution of social trips across different location types. As can be seen, most social trips are to the home of another person. This underlines the relevance of knowing the geographical spread of people’s social networks. Social trips to a bar or restaurant make up for only a relatively small portion of social trips.

<table>
<thead>
<tr>
<th>Location type</th>
<th>Sample (N)</th>
<th>Sample (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home of other person</td>
<td>635</td>
<td>33.8</td>
</tr>
<tr>
<td>Work location</td>
<td>149</td>
<td>7.9</td>
</tr>
<tr>
<td>Restaurant, bar, cultural</td>
<td>183</td>
<td>9.8</td>
</tr>
<tr>
<td>En route/ outside</td>
<td>137</td>
<td>7.3</td>
</tr>
<tr>
<td>Sports location</td>
<td>238</td>
<td>12.7</td>
</tr>
<tr>
<td>Other</td>
<td>536</td>
<td>28.5</td>
</tr>
<tr>
<td>Total</td>
<td>1878</td>
<td>100</td>
</tr>
</tbody>
</table>

Social trip distance

Trips for the purpose of social interaction have a mean distance of 11.4 kilometers. This is shown in Table 4.10, together with the natural log of the distance. The distribution of distance and ln(distance + 1) can be seen in Figure 4.3.

<table>
<thead>
<tr>
<th>Social travel distance (km)</th>
<th>Median</th>
<th>Mean</th>
<th>St.dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln (distance + 1)</td>
<td>1.61</td>
<td>1.75</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Figure 4.3: Distribution of social travel distance (km) and ln (distance +1)
Transport mode choice for social trips
The distribution of the social trips across transport modes can be seen in Table 4.11. As can be seen, the car is the dominant mode for social trips. A quarter of social trips are made by bike, and the use of public transport for social trips is very low. This distribution largely matches the modal split for social trips in the Dutch population (Statistics Netherlands, 2008), although the percentage of trips as a car driver is higher and the percentage of trips as a car passenger is lower in the sample.

Table 4.11: Distribution of social trips across transport modes

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Sample (N)</th>
<th>Sample (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car driver</td>
<td>834</td>
<td>44</td>
</tr>
<tr>
<td>Car passenger</td>
<td>202</td>
<td>11</td>
</tr>
<tr>
<td>Bicycle / moped</td>
<td>482</td>
<td>26</td>
</tr>
<tr>
<td>On foot</td>
<td>275</td>
<td>15</td>
</tr>
<tr>
<td>Other</td>
<td>85</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>1878</td>
<td>100</td>
</tr>
</tbody>
</table>

4.6 Conclusion
This chapter has presented some descriptive statistics on the samples and the main variables of interest for this study. Overall, the quality of the data collected with the social interaction diary and the social network questionnaire is adequate. Both samples differ somewhat from the population. However, apart from an overrepresentation of women, the samples do not show substantial or unusual selective non-response in terms of socio-demographic variables. Although the sample is not severely biased, we should be careful when generalizing the results of the analyses presented in the next chapters to the Dutch population, even if we control for socio-demographic variables in the analyses.
5. Predicting social network characteristics

5.1 Introduction

As social activities result from the desire to meet people from one’s social network, more insight in the size and composition of people’s personal networks is needed in order to understand the demand for social activity-travel.

Therefore, this chapter aims at answering research question 1: *What is the effect of personal characteristics and properties of the built environment on social network characteristics?* This question is visualized in the conceptual model in Figure 5.1.

---

*Figure 5.1: Conceptual model research question 1*
The first social network characteristic that is analyzed is network size, as this will give an insight in the resources and possibilities different people have for social activities. Secondly, social network composition is analyzed. This shows how the distribution of network members over different role categories is influenced by the ego’s personal and land-use characteristics. Finally, the geographical distance between ego and alter will offer insight in the spatial distribution of the social network.

This chapter therefore presents the results of three models: a negative binomial regression model to predict social network size, a mixed logit model to predict social network composition and a random effects model to predict the geographical distance between ego and alter. Similar analyses have been published earlier in Van den Berg et al. (2009).

The dependent variables (social network size, social network composition and geographical distance) were collected using the social network questionnaire. The explanatory variables (several personal characteristics of the egos and the land-use variable urban density) were collected in the questionnaire on personal and land-use characteristics.

5.2 Social network size

In the first model, social network size is predicted as a function of the ego’s socio-demographic variables. As the number of alters in the social network is a count variable, Poisson regression or negative binomial regression can be used. Negative binomial regression can be considered a generalization of Poisson regression, which allows the variance to differ from the mean. It assumes that the conditional mean $\lambda_i$ of $y_i$ is not only determined by a vector of covariates $x_i$ but also by a heterogeneity component $\varepsilon_i$ unrelated to $x_i$. For an outcome $Y$, the probabilities of observing any specific count, $y_i$, are given by the formula:

$$P(Y = y_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!}; y = 0,1,2,....$$

(5.1)

where $\ln(\lambda_i) = \beta'x_i + \varepsilon_i$.

In this model exp($\varepsilon_i$) has a gamma distribution with mean 1.0 and variance $\alpha$. The formulation of the negative binomial distribution which can be used to model count data with overdispersion is then derived as:

$$P(Y = y_i) = \frac{\Gamma(\theta + y_i)}{\Gamma(\theta) y_i! u_i^\theta (1 - u_i)^{y_i}}$$

(5.2)

where $\Gamma$ is the gamma distribution

$$u_i = \theta / (\theta + \lambda_i)$$
\[ \theta = \frac{1}{\alpha} \]

\(\alpha\) is a dispersion parameter, such that

\[ \text{Var}[y_i] = E[y_i](1 + \alpha E[y_i]) \]  \hspace{1cm} (5.3)

The model was estimated in Nlogit. The estimation results are shown in Table 5.1. The model has a R-squared of 0.325, indicating a good model fit.

The results show that gender does not have a significant effect on social network size. Regarding age, the coefficients are significant at the 0.1 level. When controlling for the other variables, older people on average are found to have smaller social networks than their younger counterparts. The log of the expected count is 0.2 higher for the youngest group and 0.2 lower for the oldest group. With the ageing of the population, this is something to keep in mind as this may indicate that senior citizens have less access to a variety of resources (Silvis and Niemeier, 2009), such as instrumental support (caring if they are sick, help with chores), emotional support or companionship.

Regarding household composition, the results show that people who live with a partner tend to have smaller social networks. The presence of children in the household is also found to negatively affect people’s social network size.

**Table 5.1: Predicting social network size**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.876</td>
<td>0.000</td>
</tr>
<tr>
<td>Male</td>
<td>0.068</td>
<td>0.566</td>
</tr>
<tr>
<td>Young (&lt;40)</td>
<td>0.212</td>
<td>0.065</td>
</tr>
<tr>
<td>Old (&gt;60)</td>
<td>-0.213</td>
<td>0.063</td>
</tr>
<tr>
<td>Living with partner</td>
<td>-0.492</td>
<td>0.005</td>
</tr>
<tr>
<td>Child(ren) under 18 in household</td>
<td>-0.243</td>
<td>0.062</td>
</tr>
<tr>
<td>Primary education</td>
<td>-0.243</td>
<td>0.187</td>
</tr>
<tr>
<td>Higher education</td>
<td>-0.011</td>
<td>0.938</td>
</tr>
<tr>
<td>High income (&gt; €3000,- per month)</td>
<td>0.000</td>
<td>0.158</td>
</tr>
<tr>
<td>Car in household</td>
<td>0.491</td>
<td>0.009</td>
</tr>
<tr>
<td>Work/school hours per week</td>
<td>-0.009</td>
<td>0.018</td>
</tr>
<tr>
<td>Nr. of clubs</td>
<td>0.078</td>
<td>0.245</td>
</tr>
<tr>
<td>High density (&gt;1500 addresses per km(^2))</td>
<td>-0.298</td>
<td>0.048</td>
</tr>
<tr>
<td>Low density (&lt;1000 addresses per km(^2))</td>
<td>-0.052</td>
<td>0.728</td>
</tr>
<tr>
<td>Dispersion parameter (\alpha)</td>
<td>0.237</td>
<td>0.000</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>Log likelihood function</td>
<td>-441.616</td>
<td></td>
</tr>
<tr>
<td>Restricted log likelihood</td>
<td>-654.661</td>
<td></td>
</tr>
<tr>
<td>Chi squared</td>
<td>426.090</td>
<td></td>
</tr>
<tr>
<td>McFadden Pseudo R-squared</td>
<td>0.325</td>
<td></td>
</tr>
</tbody>
</table>
This may indicate that people with a partner and children feel less need to maintain social ties outside the household, or they have fewer opportunities to do so. Kowald and Axhausen (2010b) however, found a positive effect of household size on the number of social network members. Molin et al. (2008b) also found a positive effect for living with a partner and for a household size of 3 or more persons. The reason for these different findings might be related to the fact that different name generators were used in these studies.

Regarding car ownership, the results indicate that the average social network size is larger for people with a car in their household. This finding is in line with Willmott (1988). This suggests that car ownership helps people to get or keep in contact with others.

People who work or study more, are found to have a smaller than average social network, probably because they have less time to keep in contact with others. This finding is in contrast with Molin et al. (2008b) who found full time workers to have a larger than average social network.

Finally, high urban density is found to have a negative effect on social network size. This means that people living in urban areas on average have fewer social network members. This may indicate that in lower density (rural) areas traditionally strong local networks still exist (Aoki et al., 1996).

5.3 Distribution of alters across social categories

The next model is estimated to predict the probability distribution of social network members across social relationship categories based on the ego’s socio-demographic variables. To that effect, a mixed logit model for panel data is estimated.

In contrast to the standard logit model, mixed logit models can account for random taste variation. In addition, the model for panel data can account for correlation of observations from the same individual. For the mixed logit model, that takes into account heterogeneity and repeated measures, the utility for individual $i$ for alternative $j$ on choice occasion $t$ would be:

$$U_{ijt} = \beta^' x_{ijt} + \varepsilon_{ijt}$$

(5.4)

where $x_{ijt}$ is a vector of covariates with parameters $\beta_i$ to be estimated. $\varepsilon_{ijt}$ is an unobserved random term that is iid extreme value distributed, independent of $\beta_i$ and $x_{ijt}$. Each random parameter $\beta_i$ is defined as the average preference in the population, $b_i$ and an individual deviation, $\eta_i$ which represents the individual’s preference relative to the average preference for a particular social category. The utility is:

$$U_{ijt} = b^' x_{ijt} + \eta_i x_{ijt} + \varepsilon_{ijt}$$

(5.5)
If \( \beta_i \) were known, the probability that individual \( i \) chooses alternative \( j \) at choice occasion \( t \) would be standard logit:

\[
P_{ij}(\beta) = \frac{e^{\beta_j x_{it}}}{\sum_j e^{\beta_j x_{it}}} \tag{5.6}
\]

However, since \( \beta_i \) is random and not known, the (unconditional) choice probability is the integral of this logit formula over the density of \( \beta_i \). Assuming that the preferences vary in the population with density \( f(\beta | \theta) \), where \( \theta \) are the parameters of this distribution, the actual probability is (Greene, 2002a):

\[
P_{ij}(\theta) = \int L_i(\beta) f(\beta | \theta) d\beta \tag{5.7}
\]

As the integral does not have a closed form, the probability cannot be calculated exactly. Therefore, the integral is approximated through simulation using draws from the mixing distribution.

In the model the choice between the relationship categories (relatives, neighbors, colleagues, club members and (other) friends) is considered and the first one, relatives, serves as the reference category. Random parameters (standard deviations of unobserved heterogeneity) are estimated for the alternative specific constants. They are estimated as normally distributed parameters. 100 Halton draws are used in the simulation.

The results, shown in Table 5.2, indicate that the ego’s socio-demographic characteristics influence the choice of relationship category to a good extent. The estimated model has a McFadden R-squared of 0.296.

The constants in Table 5.2 indicate that on average, people have fewer neighbors, colleagues and club members in their social network compared to relatives. The proportion of (other) friends does not significantly differ from the proportion of relatives, after correcting for the socio-demographic variables. The standard deviations show preference heterogeneity for friends.

The results indicate that men have smaller proportions of colleagues in their social network compared to females. This is after controlling for work hours.

With respect to age and household composition no significant effects are found on social network composition. Income does not significantly affect social network composition either.

Lower educated people are found to have larger proportions of neighbors in their social network. This may be related to the fact that lower educated people tend to stay longer at the same address (or neighborhood), whereas higher educated people change residence more often and move away further from their birthplace.
However, it may also be related to a cultural difference between lower and higher educated people.

As expected, people who work or study more hours, have larger proportions of work or study mates in their social network.

People without a car, are found to have a larger proportion of club members in their social network. A possible explanation for this is that clubs are usually local and club members can thus be contacted without traveling far.

Involvement in clubs obviously has a positive effect on the proportion of club members in ones social network. Club membership is also associated with a higher likelihood of friends and colleagues. This finding is consistent with Fischer (1982).

Urban density is not found to significantly affect social network composition. Finally, people with a small social network, have a smaller proportion of colleagues in their social network.

**Table 5.2: Predicting distribution of alters across social categories**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Friend</th>
<th>Neighbor</th>
<th>Colleague</th>
<th>Club</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.266</td>
<td>-2.607***</td>
<td>-2.455***</td>
<td>-4.089***</td>
</tr>
<tr>
<td>Nonrandom parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>-0.123</td>
<td>-0.215</td>
<td>-0.671**</td>
<td>0.351</td>
</tr>
<tr>
<td>Young (&lt;40)</td>
<td>0.173</td>
<td>0.157</td>
<td>0.143</td>
<td>-0.152</td>
</tr>
<tr>
<td>Old (&gt;60)</td>
<td>-0.352</td>
<td>0.480</td>
<td>-0.507</td>
<td>0.127</td>
</tr>
<tr>
<td>Partner</td>
<td>-0.433</td>
<td>0.578</td>
<td>0.423</td>
<td>0.268</td>
</tr>
<tr>
<td>Presence of children</td>
<td>-0.002</td>
<td>0.578</td>
<td>-0.400</td>
<td>-0.915</td>
</tr>
<tr>
<td>Primary education</td>
<td>0.218</td>
<td>0.758**</td>
<td>0.084</td>
<td>0.225</td>
</tr>
<tr>
<td>Higher education</td>
<td>0.270</td>
<td>0.107</td>
<td>0.381</td>
<td>0.046</td>
</tr>
<tr>
<td>High income</td>
<td>0.254</td>
<td>-0.171</td>
<td>-0.391</td>
<td>0.395</td>
</tr>
<tr>
<td>Work/school hours</td>
<td>-0.010</td>
<td>-0.012</td>
<td>0.024**</td>
<td>-0.024</td>
</tr>
<tr>
<td>No car</td>
<td>-0.079</td>
<td>0.257</td>
<td>-0.138</td>
<td>1.030*</td>
</tr>
<tr>
<td># clubs</td>
<td>0.219**</td>
<td>0.122</td>
<td>0.224*</td>
<td>1.051***</td>
</tr>
<tr>
<td>Low urban density</td>
<td>-0.028</td>
<td>-0.130</td>
<td>0.089</td>
<td>0.214</td>
</tr>
<tr>
<td>High urban density</td>
<td>0.283</td>
<td>0.250</td>
<td>0.178</td>
<td>0.500</td>
</tr>
<tr>
<td>Network size &lt; 11</td>
<td>-0.256</td>
<td>-0.569</td>
<td>-1.275**</td>
<td>-0.922</td>
</tr>
<tr>
<td>Standard deviations</td>
<td>0.300**</td>
<td>0.209</td>
<td>0.107</td>
<td>0.379</td>
</tr>
</tbody>
</table>

| Additional metrics              |         |          |           |         |
| Number of observations (alters)| 2534    |          |           |         |
| Number of groups (egos)        | 116     |          |           |         |
| Log likelihood function        | -2871.868|         |           |         |
| Restricted log likelihood      | -4078.316|         |           |         |
| Chi squared                    | 2412.895| Df       | 70        |
| McFadden Pseudo R-squared      | 0.296   |          |           |         |

***significant at the 0.01 level, **0.5 level, * 0.1 level
5.4 Geographical distance
The last model in this chapter predicts the geographical distance between the homes of social network members. The explanatory variables in the models are the ego’s socio-demographic characteristics and social network size and the social category of the alters. To analyze the effect of the explanatory variables on geographical distance, a linear regression model could be used. However, the data has repeated measures for each respondent in the sense that each respondent has several alters who each live at a certain distance to the respondent. These distances per respondent might be correlated and cannot be regarded as independent measurements. The unexplained variation across groups (distances per respondent) can be captured in simple shifts of the regression function (i.e., changes in the intercepts) by using an effects model. Let \( y_{it} \) be the distance of trip \( t \) of individual \( i \). The structure is (Greene, 2002b):

\[
y_{it} = \mu_i + \beta^\prime x_{it} + \varepsilon_{it}
\]

(5.8)

where \( \varepsilon_{it} \) is a random disturbance term with \( E[\varepsilon_{it}] = 0 \) and \( \text{Var}[\varepsilon_{it}] = \sigma_{\varepsilon}^2 \).

The effects may be fixed or random. In the case of a fixed effects model \( \mu_i \) is a separate constant term for each unit (individual). In a random effects model \( \mu_i \) is an individual specific disturbance, which is assumed to be independent from the regressors. As the model contains regressors with no within group variation (personal characteristics are constant for the trips of a person), a random effects model of the following form is estimated:

\[
y_{it} = \alpha + \beta^\prime x_{it} + \varepsilon_{it} + u_i
\]

(5.9)

where \( E[u_i] = 0 \), \( \text{Var}[u_i] = \sigma_u^2 \).

In the estimated model, the dependent variable (the geographical distance) is treated as a continuous variable. Therefore, the distance categories were recoded to the middle value of the category (0; 0.5; 1.5; 3.5; 10; 22.5; 45; 80; 150; \( X \) km). For the highest class, the number of kilometers filled in after ‘> 200 km, namely…’ was used. Thus, \( X \) is an exact value specified by the respondent. For a better model, the logarithm of the values was used. The social category “neighbor” is excluded from the analysis, as the distance for this category is (almost) always 0-1 km and therefore a constant.

The estimation results are shown in Table 5.3. The R-squared of the model is 0.081 which means that 8% of the variation in the dependent variable distance can be explained by the explanatory variables. Table 5.3 shows that 19% of the unexplained variation is associated with individuals (egos) and 81% with the ego-alter relationships.

50
The results show that most of the personal and land-use characteristics do not significantly influence the geographical distance between the homes of the ego and his social network members. Only two personal and land-use characteristics are found to have a significant effect (at the 0.1 level) on the geographical distance between home locations of ego and alter.

High income is found to have a positive effect on geographical distance between social network members. This may suggest that people with a higher income are content to travel further for meeting their social network members. The same was found by Molin et al. (2008b) and Carrasco et al. (2008b).

People who live in lower density areas have their social network members living closer by. The same was found by Fischer (1982), who explains this finding by the fact that people in lower density areas have larger proportions of relatives living very close. In addition, he points out that “the smaller the community, the more people pick and keep friends from nearby”.

### Table 5.3: Predicting geographical distance

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.201</td>
<td>0.000</td>
</tr>
<tr>
<td>Male</td>
<td>0.063</td>
<td>0.484</td>
</tr>
<tr>
<td>Young (&lt;40)</td>
<td>0.019</td>
<td>0.861</td>
</tr>
<tr>
<td>Old (&gt;60)</td>
<td>0.013</td>
<td>0.918</td>
</tr>
<tr>
<td>Living with partner</td>
<td>-0.101</td>
<td>0.262</td>
</tr>
<tr>
<td>Child(ren)</td>
<td>-0.063</td>
<td>0.540</td>
</tr>
<tr>
<td>Primary education</td>
<td>-0.147</td>
<td>0.203</td>
</tr>
<tr>
<td>Higher education</td>
<td>0.046</td>
<td>0.603</td>
</tr>
<tr>
<td>High (&gt;€3000,- per month)</td>
<td>0.170</td>
<td>0.070</td>
</tr>
<tr>
<td>No car in household</td>
<td>-0.080</td>
<td>0.575</td>
</tr>
<tr>
<td>Work/school hours per week</td>
<td>0.004</td>
<td>0.210</td>
</tr>
<tr>
<td>Nr. of clubs</td>
<td>-0.076</td>
<td>0.109</td>
</tr>
<tr>
<td>High urban density</td>
<td>0.059</td>
<td>0.594</td>
</tr>
<tr>
<td>Low density</td>
<td>-0.177</td>
<td>0.080</td>
</tr>
<tr>
<td>Small network (&lt;11)</td>
<td>0.037</td>
<td>0.721</td>
</tr>
<tr>
<td>Colleague</td>
<td>-0.337</td>
<td>0.000</td>
</tr>
<tr>
<td>Club member</td>
<td>-0.541</td>
<td>0.000</td>
</tr>
<tr>
<td>Friend</td>
<td>-0.236</td>
<td>0.000</td>
</tr>
</tbody>
</table>

| Number of observations (alters)                     | 2313        |
| Number of groups (egos)                             | 107         |

| Effects: Idiosyncratic Var [e]                      | 0.480       | Std. dev. | 0.693 | Share    | 0.806 |
| Individual Var [u]                                  | 0.115       | Std. dev. | 0.340 | Share    | 0.194 |

| Total sum of squares                                | 1203        |
| Residual sum of squares                             | 1105.1      |
| R-squared                                           | 0.081       |
Finally, the role relationship between ego and alter is found to significantly affect geographical distance. All three categories have a negative coefficient, indicating the relatives (the reference category) are associated with the longest distances. This is in line with findings from Molin et al. (2008b) and Carrasco et al. (2008b). The shortest distances are found for club members. This is a plausible finding as people usually join clubs close to home.

5.5 Discussion

As social activities are responsible for a substantial proportion of trips conducted by individuals and households, travel demand is to a large extent determined by the size and spatial distribution of people’s social networks. In this analysis a negative binomial regression model was estimated to predict the size of the social network (number of alters) as a function of the socio-demographic characteristics of the ego. The results indicate that age, household composition (living with a partner and presence of children), car ownership, work status and urban density influence social network size.

The second model was a mixed logit model estimated to predict the distribution of alters across the social categories. The results show significant effects for gender, education, work status, involvement in clubs, urban density and social network size.

The third model presented in this chapter was a random effects model to analyze the geographical distance between social network members. It was found that high income is associated with social network members at longer distances. People living in low urban density areas have their social network members closer by. Finally, social category was found to significantly influence geographical distance between ego and alter as well, with shorter distances for colleagues, club members and friends compared to relatives.

Molin et al. (2008b) carried out a similar analysis on data that were collected in 1987, also in the Dutch context. As the variables and the analyses used in both studies are not completely equal, it is difficult to compare the results. However, their findings seem to differ substantially from the findings presented in this dissertation. This may be related to the use of different name generators. However, it may also indicate that social network composition and travel demand that stems from social networks has changed over the last two decades.

This chapter focused primarily on social network size, composition and geographical distribution. In order to get more insight into social travel demand, the next chapter will look into contact frequency between social network members by different communication forms.
6. Social interaction between social network members

6.1 Introduction

Social travel demand is directly related to the frequency of face-to-face contact between people. However, as new ICT’s offer alternatives to face-to-face contact, it is also important to predict the contact frequencies with ICT-mediated communication modes and to understand which factors affect the choice for a communication mode.

To gain insight into these factors, this chapter addresses the second research question: *What is the effect of personal characteristics and properties of the built environment on ICT-use for social purposes?* This question is shown in Figure 6.1.

![Figure 6.1: Conceptual model research question 2](image-url)
As a first step in answering research question 2, this chapter analyses how often social network members interact by different communication modes, based on characteristics of the ego (gender, age, education level) and characteristics of the ego-alter relationship (the distance between their homes, strength, duration and type of relationship). Just like the previous in chapter, in this chapter the data from the social network study are used. In addition to the social network questionnaire, a number of socio-demographic characteristics of the egos, gathered in the larger study, are used.

The next section discusses the methods used. Section 6.3 presents the results of the analysis. The results presented in this chapter have been published in Van den Berg et al. (2010a).

6.2 Model structure

To analyze the influences of ego and ego-alter link characteristics on the frequencies of social interaction with different communication modes, and the relationships between these frequencies, a multilevel path analysis is conducted.

Path analysis is a special case of structural equation modeling (SEM). SEM is a method that is increasingly used in travel demand modeling (e.g. Lu and Pas, 1999; Golob, 2001). With this method a set of equations can be computed simultaneously. The model can have several endogenous variables, which can be functions of the exogenous variables and of other endogenous variables. Whereas SEM can include latent variables (also known as factors, constructs or unobserved variables), path analysis only includes measured variables. As all the variables in this model are observed characteristics or behavior, path analysis is used.

As the data have a hierarchical structure (multiple alters per ego) the alters that belong to the same ego cannot be treated as independent observations. Instead, they have to be treated in clusters. For that reason, multi-level path analysis is used (Jöreskog and Sörbom, 2001). Multi-level models recognize the existence of hierarchy in the data by allowing for residual components at each level.

In this analysis, a two-level model is estimated, which allows for variation in contact frequency at the within-level (level of ego-alter links) and the between-level (level of respondents) and which includes residuals at both levels. The respondent-level residuals, often called ‘cluster effects’, represent unobserved respondent characteristics that affect the outcomes for ego-alter links as they lead to correlation between outcomes for ego-alter links of the same ego. For an in-depth review of multi-level (structural equation) models the reader is referred to (Hox and Roberts, 2010).

In this model, the respondents’ personal characteristics gender, age and education are used to explain the between-level patterns. The ego-alter link characteristics (tie strength, type of relationship, duration of the relationship and geographical distance) are used to explain the variance at the within level. A similar analysis was executed by Frei and Axhausen (2009).
As the sample size of the social network questionnaire is relatively small (116 respondents) the number of exogenous variables that can be used in this model is restricted. For that reason some categorical variables were recoded into binary variables even though this means a loss of information.

Moreover, only the most important socio-demographic characteristics of the egos could be entered into the model. As young, highly educated males were the forerunners in the adoption of new ICT’s (mobile phone and the Internet) they are hypothesized to still have higher ICT-mediated contact frequencies with their social network members. Therefore the personal characteristics gender, age and education level are used as explanatory variables in this model. These variables were collected in the larger study.

The path diagram of the model capturing the links between personal characteristics, ego-alter link characteristics and social interaction frequencies with different communication modes can be seen in Figure 6.2. The pathways (arrows) in the path model represent the hypothesized effects. The variables on the right are endogenous variables, hypothesized to be influenced by the exogenous variables on the left. The exogenous variables are allowed to correlate. The grey arrows represent the links at the between (ego) level and the black arrows represent the links at the within level (the ego-alter relationship). At the within level, links are also present between the endogenous variables. It is hypothesized that the contact frequencies with different modes are complementary at the within level: network members with high ICT-mediated contact frequencies are likely to have a high face-to-face contact frequency as well. The causal effects in the model are hypothesized...
to be unidirectional, i.e. no two variables in the model are reciprocally related, either directly or indirectly. Face-to-face contact frequency is hypothesized to be affected by all three mediated communication modes; telephone contact frequency is affected by e-mail and SMS contact frequency, and e-mail contact frequency is affected by SMS contact frequency.

6.3 Results

The multilevel path analysis model was estimated using the statistical software package LISREL (Jöreskog and Sörbom, 2001). A number of different model specifications were tested, with different (transformations and levels of) explanatory variables. The best final model, identified based on the goodness-of-fit statistics, is presented here. The estimates of the model are shown in Table 6.1.

The coefficients represent increases or decreases in the number of interactions per year per communication mode. The interpretation of the results is therefore straightforward. However, the measurements were not very precise, as the number of interactions were measured in an ordinal fashion and recoded to the middle value of the category.

Effects at the within level

Figure 6.3 shows the significant effects at the within level (i.e. the ego-alter relationship). With regard to the endogenous variables the results indicate positive relationships between the contact frequencies by different modes. Except for the relationship between SMS and face-to-face contact frequency, all relationships are highly significant. Social network members who have high ICT-mediated contact frequencies are likely to have higher frequencies of face-to-face contact as well. This is in line with findings from earlier studies (e.g. Tillema et al., 2010; Frei and Axhausen, 2009) and supports the hypothesis of complementarity. This indicates that, since the use of e-mail and mobile phones is still increasing, social trips, which are made for face-to-face contact, are likely to increase as well.

Regarding the exogenous variables, tie strength is found to have a positive effect on the contact frequencies with all communication modes. This indicates that social network members who are relationally very close interact more often than somewhat close network members, which is an intuitive finding, that is in line with other studies (e.g., Boase et al., 2006; Carrasco and Miller, 2009; Tillema et al., 2010). The largest positive effect is found for telephone contact. Having a very close relationship results in almost 2 extra telephone calls per month (21.6 per year).

The type of relationship between ego and alter is also found to significantly affect contact frequency. In line with findings from Carrasco and Miller (2009), the results show that relatives have 8 fewer face-to-face interactions per year, compared to friends. Therefore, as social networks become less family oriented and more friend oriented, increased social trips may be expected in the
future. In addition, relatives have lower e-mail contact frequencies and higher telephone contact frequencies compared to friends. Frei and Axhausen (2009) also found that relatives are contacted more often by telephone.

For the duration of the relationship the results indicate that social network members who have known each other at least fifteen years have substantially lower face-to-face contact frequencies compared to social network members who have known each other shorter. It results in almost 2 interactions per month fewer. The contact frequencies by e-mail are also found to be lower for social network members who have known each other 15 years or more. However, they tend to have higher telephone contact frequencies. These findings seem to indicate that after having known each other for some time, people tend to switch to a less intimate communication mode. It also shows that social networks are dynamic, as communication patterns with social network members change over time.

Table 6.1: Results communication frequency between social network members

<table>
<thead>
<tr>
<th>From/to</th>
<th>F2F fr.</th>
<th>Telephone fr.</th>
<th>E-mail fr.</th>
<th>SMS fr.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Within level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>21.052 **</td>
<td>14.030 **</td>
<td>5.861 **</td>
<td>2.199</td>
</tr>
<tr>
<td>Telephone freq.</td>
<td>0.411 **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-mail frequency</td>
<td>0.192 **</td>
<td>0.264 **</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMS frequency</td>
<td>0.002</td>
<td>0.635 **</td>
<td>0.232 **</td>
<td></td>
</tr>
<tr>
<td>Very strong tie</td>
<td>7.588 **</td>
<td>21.625 **</td>
<td>6.602 **</td>
<td>8.227 **</td>
</tr>
<tr>
<td>Relatives</td>
<td>-8.132 **</td>
<td>13.549 **</td>
<td>-5.873 **</td>
<td>1.203</td>
</tr>
<tr>
<td>Known 15 yrs</td>
<td>-22.651 **</td>
<td>4.676 *</td>
<td>-3.705 *</td>
<td>-1.039</td>
</tr>
<tr>
<td>Ln(distance)</td>
<td>-12.193 **</td>
<td>-3.620 **</td>
<td>1.114 **</td>
<td>-1.407 **</td>
</tr>
<tr>
<td>Error variance</td>
<td>3161.88 **</td>
<td>1877.38 **</td>
<td>908.88 **</td>
<td>578.59 **</td>
</tr>
<tr>
<td><strong>R²</strong></td>
<td>0.266</td>
<td>0.255</td>
<td>0.055</td>
<td>0.033</td>
</tr>
<tr>
<td><strong>R² reduced form</strong></td>
<td>0.158</td>
<td>0.119</td>
<td>0.023</td>
<td>0.033</td>
</tr>
<tr>
<td><strong>Between level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11.691</td>
<td>2.475</td>
<td>8.421 *</td>
<td>-1.075</td>
</tr>
<tr>
<td>Young (&lt;30)</td>
<td>38.916 **</td>
<td>8.437</td>
<td>8.044</td>
<td>8.240 *</td>
</tr>
<tr>
<td>Old (&gt;60)</td>
<td>26.607 **</td>
<td>17.009 **</td>
<td>-4.292</td>
<td>-2.822</td>
</tr>
<tr>
<td>Error variance</td>
<td>1636.82 **</td>
<td>689.57 **</td>
<td>250.56 **</td>
<td>105.87 **</td>
</tr>
<tr>
<td><strong>R²</strong></td>
<td>0.143</td>
<td>0.129</td>
<td>0.148</td>
<td>0.158</td>
</tr>
<tr>
<td><strong>R² reduced form</strong></td>
<td>0.143</td>
<td>0.129</td>
<td>0.148</td>
<td>0.158</td>
</tr>
</tbody>
</table>

**significant at the 0.05 level, * 0.1 level
As expected, geographical distance has the highest negative effect on face-to-face contact frequency. Telephone and SMS contact frequencies are also found to decrease with increasing distances. These findings are in line with Frei and Axhausen (2009). In the case of e-mail contact frequency, distance is found to have a small positive effect, which was also found by Larsen et al. (2006).

**Effects at the between level**
At the between level, the effect of the characteristics of the ego are tested. The significant effects are shown in Figure 6.4.

With regard to gender, the results indicate that male egos on average have 8 e-mail interactions with their social network members per year more than female egos. This partly supports the hypothesis that the forerunners with regard to e-mail still have higher contact frequencies for this mode. For the other communication modes the gender effects are not significant. These findings are similar to Frei and Axhausen (2009).

Age is also found to significantly affect communication frequency with social network members. The youngest and the oldest age cohorts are both likely to have higher face-to-face contact frequencies with their social network members, with more than 3 extra interactions per month for the youngest group and more than 2 extra interactions per month for the oldest group. This finding is in line with Carrasco and Miller (2009), whereas Frei and Axhausen (2009) found a negative coefficient for the oldest age cohort. The youngest age group also has higher SMS
frequencies, whereas the oldest group has higher telephone contact frequencies. This indicates that the older generation tends to hold on to the mode they are familiar with, whereas the younger generation is faster in adopting the newer modes.

Finally, the effect of education level on the frequency of social interactions with the different modes is tested. In contrast to Frei and Axhausen (2009) who only found a positive coefficient for e-mail, the results indicate that higher educated egos tend to have higher contact frequencies with all three mediated communication modes. This again shows that the forerunners in the use of ICT still have higher ICT-mediated contact frequencies with their social network members.

The R-squares in Table 6.1 indicate that the explanatory power of the exogenous variables is relatively strong in the case of face-to-face contact frequency and telephone contact frequency and only modest for e-mail and SMS contact frequency.

Based on the error variances in Table 6.1, it can be calculated that 34% of the unexplained variation in face-to-face contact frequency is associated with respondents (between-level). For telephone, e-mail and SMS these percentages are 27%, 22% and 15% respectively.

![Diagram](image_url)

*Figure 6.4: Significant effects at between level*
Table 6.2: Goodness-of-fit of the model

<table>
<thead>
<tr>
<th>Degrees of Freedom</th>
<th>387</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Information ML Chi Square</td>
<td>459.707</td>
</tr>
<tr>
<td>Chi Square / Degrees of Freedom</td>
<td>1.187</td>
</tr>
<tr>
<td>Root Mean Square Error of Approximation (RMSEA)</td>
<td>0.0118</td>
</tr>
<tr>
<td>90 Percent Confidence Interval for RMSEA</td>
<td>0.00664; 0.0158</td>
</tr>
<tr>
<td>P-Value for Test of Close Fit (RMSEA &lt; 0.05)</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 6.2 shows the goodness-of-fit measures of the model. In general, the goodness-of-fit measures of the model are adequate. The value of Chi Square divided by the model degrees of freedom is 1.187. Rules of thumb (e.g. Golob, 2001; Washington et al., 2003) suggest that for correct models this measure should be smaller than 2 or at least smaller than 5, but preferably around 1. Another goodness-of-fit measure is the root mean square error of approximation (RMSEA), which should preferably be between 0.02 and 0.05 (e.g. Washington et al., 2003). The estimated model has a RMSEA of 0.012.

6.4 Discussion

In this chapter the contact frequency by different communication modes (face-to-face, telephone, e-mail and SMS) between social network members has been analyzed. Based on the social network data, a multilevel path analysis model was estimated. At the between level, characteristics of the ego (gender, age, education level) explain the frequencies and at the within level, characteristics of the ego-alter relationship (the geographical distance between their homes, tie strength, duration and type of relationship) serve as explanatory variables.

At the level of the ego-alter relationship (within level) positive relationships were found between the contact frequencies by different modes, supporting the hypothesis of complementarity.

Moreover, characteristics of the relationship between ego and alter were found to be highly significant. Relational closeness (strength of tie) was found to have a positive effect on contact frequency with all modes. The contact frequency was found to decrease as costs (related to distance) increase. The duration of the relationship (how long ego and alter have known each other) and the social category (relative or friend) were also found to affect contact frequency.

At the level of the ego (between level) the earlier adopters of ICT’s (young, highly educated males) were hypothesized to still have higher ICT-mediated contact frequencies with their social network members. This hypothesis is partly supported by the results. With regard to face-to-face contact higher frequencies were found for the youngest and the oldest cohorts. In addition, the oldest group has higher telephone contact frequencies, suggesting that the older generation tends to hold on to the mode they are familiar with, whereas the younger generation is faster in adopting the newer modes.
The results presented in this chapter are relevant for transport policy. The finding of complementarity between the different communication modes is important. It indicates that, since the use of e-mail and mobile phones is still increasing, face-to-face interactions, requiring social trips, are likely to increase as well. Policy makers should therefore reckon with increasing (social) travel. Moreover, ICT’s are important for the maintenance of social networks that are becoming more geographically spread. Although the frequency of face-to-face communication (and trips) was found to decrease with geographical distance, occasional physical meetings tend to be necessary to maintain contacts (Tillema et al., 2010). Therefore long-distance trips may increase as new ICT’s are spreading worldwide and are providing better and cheaper ways to maintain strong social relationships over long distances.

Finally, the results showed that the oldest age group has a higher face-to-face contact frequency than average. Therefore, social travel demand may increase in the near future, as the number of senior citizens in our society is growing.

Although the analyzed links can help to better understand social travel behavior, a number of aspects deserve further research. For instance, the literature indicates that the relationship between social network distances and communication frequencies with different modes might differ substantially between different cultures. Although our findings are highly in line with findings from Zürich (Frei and Axhausen, 2009), similar analyses for other cultural contexts (outside Europe) would be desirable.

Moreover, the sample used in this chapter, consisting of the social networks of 116 respondents, is relatively small. Therefore, the number of explanatory variables was restricted. More detail would be desirable.

To gain more insight in the factors influencing the use of ICT for social interaction, the next chapter analyses social interaction frequency, the purpose of social interaction and the choice for a communication mode, based on the data collected using the social interaction diary.
7. Social interaction and ICT-use

7.1 Introduction

Like the previous chapter, this chapter addresses the second research question on the factors influencing the use of ICT for social interaction. The previous chapter focused on the use of ICT for social interaction with social network members. However, social interactions also take place with other people, such as acquaintances and strangers, who are not considered to be (very close of somewhat close) social network members. This chapter therefore analyzes the relationships between personal and land-use variables and the use of ICT for social interaction based on the social interactions reported in the diaries. As the social interaction diary dataset consists of a larger sample than the social network questionnaire data, these relationships can be analyzed in more detail.

This chapter presents three analyses based on the social interaction diary data. Section 7.2 presents a negative binomial model estimated to analyze the factors that influence the actual social interaction frequency of people, based on data collected in the social interaction diary. In section 7.3 a mixed logit model is presented, analyzing the purpose of these social interactions. Finally, in section 7.4 the communication mode choice for each social interaction is analyzed using a mixed logit model. The results of section 7.2 and section 7.4 were presented earlier in Van den Berg et al. (2011a).

The three dependent variables that are analyzed (the number of social interactions, the choice for a purpose and the choice for a communication mode), are considered to be sequential decisions on social interaction.
7.2 The number of social interactions

This section analyzes the factors that influence the number of (face-to-face and ICT mediated) social interactions people have in two days. The analyses are based on the social interaction diary data. In order to examine the effect of the personal characteristics on the number of social interactions a negative binomial model is estimated. For a description on the model, see section 5.2. The estimation results of the model are shown in Table 7.1. The model has an R-squared of 0.111.

The frequency of face-to-face social interaction is found to be influenced by a number of personal and household characteristics. However, no significant gender effect is found in this model, whereas others (Lu and Pas, 1999; Carrasco and Miller, 2006) found that females undertake fewer social activities than males.

With regard to age, the results indicate that the oldest age group has fewer social interactions, and the youngest group has more social interactions than average. The log of the expected number of interactions in two days is 0.112 higher for the youngest group and 0.112 lower for the oldest group. This finding is in line with findings from other studies (e.g. Carrasco and Miller, 2006; Farber and Páez, 2009). However, results from the previous chapter showed that the oldest cohort has higher than average face-to-face and telephone contact frequencies with social network members. This may indicate that the oldest cohort mainly interacts with social network members and less with acquaintances or strangers.

Living with a partner has a negative effect on the number of social interactions. This finding is in line with Tillema et al. (2010). It is a plausible finding as people living with a partner would tend to perform more social activities at home with their partner and those interactions occurring inside the home with only household members were not recorded. However, the presence of children in the household has a significant positive effect on the number of social interactions.

Regarding education level findings from the previous chapter showed that higher educated people on average have more frequent ICT-mediated social interactions with their social network members. In line with those findings, this model shows that the average number of social interactions is lower for people with primary education and higher for people who are higher educated.

The results show that working full time has a negative effect on the number of social interactions. This is a plausible finding as more time spent on working implies less time for social activities.

Car ownership is not found to have a significant effect on the number of social interactions. This may seem surprising as car ownership makes it easier to visit others. Note however that the dependent variable is the total number of face-to-face as well as ICT-mediated social interactions. People without a car may therefore substitute face-to-face interactions by ICT-mediated contacts.

Social network size is also found to have an effect on the number of social interactions per day. The log of the number of social interactions in two days is found to be 0.256 lower for people with a small social network. People with a larger
social network on average have more social interactions. This is a plausible finding as a larger social network increases the opportunities for social contact. This finding is consistent with Carrasco and Miller (2006) and Silvis et al. (2006). It is however in contrast with Boase et al. (2006) who found a negative relationship between the size of the social network and the total number of face-to-face and mediated interactions.

The positive parameter for club membership shows that if people are involved in one or more clubs, they have a higher number social interactions than average. This is a plausible finding as it suggests that clubs generate meetings or activities of a social nature.

Finally, the results indicate that people on average have fewer social interactions in the weekend. This is in line with Mokhtarian and Meenakshisundaram (1999) who also found the number of personal meetings as well as mediated communications to be lower in the weekend compared to weekdays. Studying only face-to-face social visits, Kemperman et al. (2006) found larger numbers during the weekend. However, many types of social interaction that are more likely to take place more frequently during weekdays, such as mediated contacts and short talks were not included in their study.

### Table 7.1: Estimation results for number of social interactions

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.496</td>
<td>0.000</td>
</tr>
<tr>
<td>Male</td>
<td>-0.001</td>
<td>0.418</td>
</tr>
<tr>
<td>Young (&lt;30)</td>
<td>0.112</td>
<td>0.002</td>
</tr>
<tr>
<td>Old (&gt;50)</td>
<td>-0.112</td>
<td>0.002</td>
</tr>
<tr>
<td>Partner</td>
<td>-0.139</td>
<td>0.000</td>
</tr>
<tr>
<td>Children</td>
<td>0.139</td>
<td>0.000</td>
</tr>
<tr>
<td>Low education</td>
<td>-0.145</td>
<td>0.000</td>
</tr>
<tr>
<td>High education</td>
<td>0.145</td>
<td>0.000</td>
</tr>
<tr>
<td>No work</td>
<td>-0.019</td>
<td>0.709</td>
</tr>
<tr>
<td>Full time work</td>
<td>-0.144</td>
<td>0.004</td>
</tr>
<tr>
<td>Car</td>
<td>0.000</td>
<td>0.626</td>
</tr>
<tr>
<td>Small social network (&lt;12)</td>
<td>-0.256</td>
<td>0.000</td>
</tr>
<tr>
<td>Large social network (&gt;32)</td>
<td>0.172</td>
<td>0.001</td>
</tr>
<tr>
<td>Club member</td>
<td>0.105</td>
<td>0.016</td>
</tr>
<tr>
<td>Weekend days</td>
<td>-0.193</td>
<td>0.000</td>
</tr>
<tr>
<td>Dispersion parameter α</td>
<td>0.166</td>
<td>0.000</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>747</td>
</tr>
<tr>
<td>Log likelihood function</td>
<td>-2262.760</td>
</tr>
<tr>
<td>Restricted log likelihood</td>
<td>-2545.917</td>
</tr>
<tr>
<td>Chi Squared</td>
<td>566.313</td>
</tr>
<tr>
<td>McFadden Pseudo R-squared</td>
<td>0.111</td>
</tr>
</tbody>
</table>
7.3 The purpose of social interactions

The next model is used to analyze the main purpose for social interaction. A mixed logit model is estimated because each respondent has several choice situations and preference heterogeneity between the respondents is expected. The mixed logit model accounting for heterogeneity and repeated measures for the same individual was described earlier in section 5.3.

The choice between joint activity, visiting, talking, a short question or message, making an appointment, discussing and ‘other’ is considered. The last category, other, serves as the reference category in the model. Thus, the coefficients estimated are interpreted relative to choosing the purpose ‘other’ for social interaction. There are two groups of explanatory variables in this model: personal characteristics of the ego and characteristics of the relationship with the contacted person(s). After deleting cases with missing values, 5822 useful cases are entered in the analysis.

For each respondent, 100 Halton draws are used. Random parameters are estimated for the alternative specific constants. The random parameters are estimated as normally distributed parameters. Table 7.2 shows the estimation results. The model has an R-squared of 0.128, indicating a modest goodness-of-fit.

The constants in the model indicate that, if all explanatory variables are evaluated at zero, people on average are more likely to interact for the purpose of talking or a short question or message and less likely to interact for the purpose of visiting, relative to other purposes.

The standard deviations indicate that the unobserved preference heterogeneity terms for all purposes except visiting are highly significant. This indicates substantial variation across individuals in the overall preference for a social interaction purpose.

With regard to the personal and household characteristics the results indicate that males on average are less likely to interact for the purpose of a joint activity, visiting, talking or a short question or message. The youngest age group is found to be more likely to choose the purpose of making an appointment. The oldest group is found to be less likely to interact for the purpose of talking and for a short question or message.

People living with a partner are less likely to have social interactions for the purpose of a joint activity or for talking. This is a plausible finding as people living with a partner would tend to interact with their partner at home for these purposes and those interactions occurring inside the home with only household members were not recorded. The presence of children in the household is not found to significantly affect the choice for a main social interaction purpose.

The results indicate that lower educated people and people who do not work are less likely to interact for the purposes of talking, short questions or messages, making an appointment and discussing or sharing information. Higher educated people and people who work full time are more likely to interact for the
purpose of discussing or sharing information. This is an intuitive finding, indicating that education level and full time work are related to a need or preference for sharing information.

For car ownership no significant effect is found on the purpose of a social interaction. A large social network is found to have a negative effect on choosing joint activities and talking as a social interaction purpose.

Table 7.2: Estimation results for social interaction purpose

<table>
<thead>
<tr>
<th>Random parameters</th>
<th>Joint activity</th>
<th>Visit / host</th>
<th>Talk</th>
<th>Question</th>
<th>Appointment</th>
<th>Discuss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.074</td>
<td>-1.283 **</td>
<td>1.384 **</td>
<td>1.179 **</td>
<td>0.316</td>
<td>0.316</td>
</tr>
</tbody>
</table>

**Nonrandom parameters**

| Male               | -0.429 * | -0.391 * | -0.418 ** | -0.376 ** | -0.170       | 0.109   |
| Age < 30           | 0.397    | 0.393     | 0.387      | 0.501      | 0.663 *      | 0.038   |
| Age >50            | -0.161   | -0.308    | -0.488 **  | -0.424 *   | -0.257       | 0.134   |
| Partner            | -0.585 ** | 0.200     | -0.434 **  | -0.142     | -0.252       | 0.083   |
| Children           | -0.429   | -0.139    | -0.154     | -0.171     | -0.163       | -0.064  |
| Low education      | -0.345   | 0.015     | -0.325 *   | -0.426 **  | -0.487 **    | -0.383 * |
| High education     | 0.279    | 0.003     | 0.074      | 0.049      | 0.020        | 0.460 ** |
| No work            | -0.150   | -0.338    | -0.264 *   | -0.579 **  | -0.224       | -0.320 * |
| Full time work     | 0.200    | 0.137     | 0.220      | 0.138      | 0.253        | 0.408 *  |
| Car                | 0.360    | 0.190     | 0.172      | -0.068     | 0.124        | -0.297  |
| Small network      | -0.192   | -0.227    | -0.203     | -0.138     | -0.121       | -0.048  |
| Large network      | -0.801 ** | 0.158     | -0.292 *   | -0.222     | -0.270       | -0.257  |
| Club member        | 0.240    | 0.199     | -0.051     | 0.280      | 0.048        | 0.282 *  |
| Saturday           | 0.370    | 0.570 **  | 0.254      | 0.093      | 0.114        | -0.201  |
| Sunday             | -0.105   | 0.663 **  | -0.203     | -0.271     | 0.209        | -0.363  |
| Group              | 0.702 ** | 0.572 **  | -0.392 *   | -1.559 **  | -1.634 **    | -0.704 **|
| 1 Relative         | -0.071   | -0.155    | -0.042     | 0.139      | -0.442 *     | 0.172   |
| Very strong tie    | 0.884 ** | 0.528 *   | 0.473 **   | 0.390 *    | 0.371        | -0.248  |
| Somew. strong      | 0.755 ** | 0.657 **  | 0.517 **   | 0.315      | 0.596 **     | 0.248   |
| Known 15 yrs       | -0.003   | 0.808 **  | 0.155      | 0.262      | 0.564 **     | 0.047   |
| Ln distance        | -0.118 * | 0.055     | 0.202 **   | 0.002      | 0.100 *      | 0.133 **|

St. deviations 0.380 ** 0.102 0.288 ** 0.434 ** 0.525 ** 0.377 **

Number of observations 5822
Number of groups 741
Log likelihood function -9836.79
Restricted log likelihood -11329.09
R-squared 0.132
R-squared adjusted 0.128

** significant at the 0.01 level, * 0.05 level
People who are involved in one or more clubs are found to be more likely to discuss or share information. Whereas a positive effect on joint activities would be expected, this effect is not significant.

With regard to day of the week the results indicate that people are more likely to visit or receive guests during the weekend. This is a plausible finding as people have more free time during the weekend and visits tend to take more time than social interactions for other purposes.

As was the case in the previous chapter, in this model the characteristics of the contacted person(s) are found to be highly significant in explaining social interaction behavior, in this case the purpose of the social interaction. Social interactions with a group are more likely to be for the purpose of a joint activity or a visit and less likely for talking, questions or messages, making an appointment and discussing or sharing information. Social interactions with a relative are less likely to have the purpose of making an appointment.

If the tie between ego and alter is very strong or somewhat strong the interaction is more likely to have the purpose of a joint activity a visit, talking, a question or making an appointment, relative to the purpose ‘other’. If ego and alter have known each other 15 years or more they are more likely to make an appointment and visit each other, relative to other purposes. Finally, the results indicate that if the distance between ego and alter is larger, they are less likely to perform joint activities and more likely to interact for the purpose of talking, a question or message, making an appointment or discussing. This is probably also related to a different communication mode. The next section analyzes the choice for a communication mode for social interaction.

### 7.4 Communication mode choice

The last model in this chapter is used to analyze the communication mode choice for social interaction. Again, a panel mixed logit model (as described in section 5.3) is estimated because each respondent has several choice situations and preference heterogeneity between the respondents is expected. The choice between face-to-face, landline phone, mobile phone, SMS, e-mail and IM is considered. The first category, face-to-face, serves as the reference category in the model. Thus, the coefficients estimated are interpreted relative to choosing face-to-face social interaction.

As in the previous model, the explanatory variables in this model are the personal characteristics of the ego as well as the characteristics of the contacted person(s). Again in this model, the alternative specific constants are introduced as random parameters. They estimated as normally distributed parameters in order to allow parameters to get both negative and positive values. Again, 100 Halton draws are used in the simulation.
After deleting cases with missing values, 6237 useful cases were entered in the analysis. The estimation results can be seen in Table 7.3. An R-squared of 0.364 indicates a high goodness-of-fit of the model. The constants in Table 7.3 are all negative. This indicates that, if all explanatory variables are evaluated at zero, people on average are more likely to choose face-to-face contact relative to the other communication modes. IM has the largest negative coefficient.

There is evidence of heterogeneity in communication mode choice. The unobserved preference heterogeneity terms for all five modes are highly significant. This indicates substantial variation across individuals in the overall preference for a communication mode.

Regarding gender, the results indicate that men have a larger likelihood of choosing IM and mobile phone for social interaction and a smaller likelihood of choosing SMS. This is in contrast with Tillema et al. (2010) who found male respondents to communicate less frequently via electronic modes.

With respect to age the results show that the youngest group is more likely to choose mobile phone, SMS and IM and less likely to choose the landline phone. The oldest age group has a smaller likelihood of choosing mobile phone and SMS and a larger likelihood of choosing the landline phone, relative to face-to-face. This indicates that younger people are faster in adopting new ICT-based modes and the older generation tends to hold on to communication modes they are familiar with, which was also found in the previous chapter. The low costs for SMS and IM may also explain its popularity among the youngest age group (Dijst, 2009).

Living with a partner is found to have a positive effect on choosing e-mail. People with children under 18 have a larger likelihood of choosing landline telephone and a smaller likelihood of choosing mobile telephone. This may be explained by the fact that people with children spend more time at home, where a landline phone is available.

Higher educated people are found to have a larger likelihood of choosing e-mail and a smaller likelihood of choosing IM. People who do not work or study are more likely to choose the landline phone, and less likely choose mobile phone, whereas people who work full time are less likely to use the landline phone. This is a plausible finding as people who do not work probably spend more time at home where a landline phone is available.

People who own a car are found to be less likely to choose the landline phone for social interaction, relative to face-to-face.

Social network size is not found to significantly affect the choice for a communication mode. People who are actively involved in clubs or voluntary associations are found to be more likely to choose the landline phone for social interactions, relative to face-to-face. The explanation for this finding is unclear.

With respect to day of the week the results indicate that on Saturdays people are less likely to have landline phone and e-mail contact and on Sundays they are less likely to use their mobile phone for social interaction.
Table 7.3: Estimation results for communication mode choice

<table>
<thead>
<tr>
<th></th>
<th>Landline phone</th>
<th>Mobile phone</th>
<th>SMS</th>
<th>E-mail</th>
<th>IM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-2.044 **</td>
<td>-2.690 **</td>
<td>-2.848 **</td>
<td>-2.992 **</td>
<td>-5.090 **</td>
</tr>
<tr>
<td><strong>Nonrandom parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>-0.124</td>
<td>0.319 *</td>
<td>-0.456 *</td>
<td>0.111</td>
<td>0.734 *</td>
</tr>
<tr>
<td>Age &lt; 30</td>
<td>-0.894 **</td>
<td>0.720 **</td>
<td>0.987 **</td>
<td>-0.162</td>
<td>1.888 **</td>
</tr>
<tr>
<td>Age &gt; 50</td>
<td>0.293 *</td>
<td>-0.642 **</td>
<td>-1.615 **</td>
<td>0.331</td>
<td>-1.010</td>
</tr>
<tr>
<td>Partner</td>
<td>0.070</td>
<td>0.001</td>
<td>0.160</td>
<td>0.338 *</td>
<td>-0.634</td>
</tr>
<tr>
<td>Children</td>
<td>0.375 **</td>
<td>-0.268 *</td>
<td>-0.232</td>
<td>0.307</td>
<td>-0.170</td>
</tr>
<tr>
<td>Low education</td>
<td>0.102</td>
<td>-0.241</td>
<td>0.375</td>
<td>-0.312</td>
<td>0.401</td>
</tr>
<tr>
<td>High education</td>
<td>0.015</td>
<td>0.151</td>
<td>0.119</td>
<td>0.706 **</td>
<td>-0.806 *</td>
</tr>
<tr>
<td>No work</td>
<td>0.301 **</td>
<td>-0.469 **</td>
<td>-0.090</td>
<td>-0.123</td>
<td>0.109</td>
</tr>
<tr>
<td>Full time work</td>
<td>-0.328 **</td>
<td>0.048</td>
<td>-0.023</td>
<td>-0.121</td>
<td>-0.048</td>
</tr>
<tr>
<td>Car</td>
<td>-0.334 *</td>
<td>0.249</td>
<td>-0.254</td>
<td>-0.202</td>
<td>0.038</td>
</tr>
<tr>
<td>Small network</td>
<td>0.140</td>
<td>0.048</td>
<td>0.103</td>
<td>0.205</td>
<td>-0.229</td>
</tr>
<tr>
<td>Large network</td>
<td>-0.178</td>
<td>-0.005</td>
<td>-0.154</td>
<td>-0.037</td>
<td>-0.123</td>
</tr>
<tr>
<td>Club member</td>
<td>0.220 *</td>
<td>-0.001</td>
<td>-0.026</td>
<td>0.157</td>
<td>0.156</td>
</tr>
<tr>
<td>Saturday</td>
<td>-0.369 **</td>
<td>-0.094</td>
<td>0.090</td>
<td>-0.777 **</td>
<td>0.090</td>
</tr>
<tr>
<td>Sunday</td>
<td>-0.159</td>
<td>-0.484 *</td>
<td>0.198</td>
<td>-0.185</td>
<td>0.160</td>
</tr>
<tr>
<td>Group</td>
<td>-2.436 **</td>
<td>-2.625 **</td>
<td>-2.356 **</td>
<td>-0.447 **</td>
<td>-1.079 **</td>
</tr>
<tr>
<td>1 Relative</td>
<td>0.592 **</td>
<td>0.871 **</td>
<td>-0.206</td>
<td>0.221</td>
<td>-0.048</td>
</tr>
<tr>
<td>Very strong tie</td>
<td>0.688 **</td>
<td>1.456 **</td>
<td>1.900 **</td>
<td>-0.327 *</td>
<td>1.064 **</td>
</tr>
<tr>
<td>Somewh. strong</td>
<td>0.427 **</td>
<td>0.667 **</td>
<td>1.157 **</td>
<td>-0.191</td>
<td>0.587</td>
</tr>
<tr>
<td>Known 15 years</td>
<td>0.447 **</td>
<td>-0.050</td>
<td>-0.056</td>
<td>-0.209</td>
<td>-0.312</td>
</tr>
<tr>
<td>Ln distance</td>
<td>0.317 **</td>
<td>0.153 **</td>
<td>0.169 **</td>
<td>0.432 **</td>
<td>0.501 **</td>
</tr>
<tr>
<td><strong>St. deviations</strong></td>
<td>0.568 **</td>
<td>0.615 **</td>
<td>0.731 **</td>
<td>0.794 **</td>
<td>1.463 **</td>
</tr>
</tbody>
</table>

Number of observations | 6237 |
Number of groups       | 743  |
Log likelihood function | -7083.819 |
Restricted log likelihood | -11175.20 |
R-squared               | 0.366 |
R-squared adjusted      | 0.364 |

** significant at the 0.01 level, * 0.05 level

Regarding the characteristics of the contacted persons, many significant effects are found in this model as well. The negative coefficients for group indicate that social interactions with more than one person (a group) are most likely to be face-to-face interactions. The highest negative coefficients are for telephone interactions. This finding was expected, as telephone is not very suitable for interacting with more than one other person.
For interacting with relatives, positive effects are found for landline and mobile telephone. This is in line with findings from the previous chapter, which showed higher than average telephone frequencies with relatives in the social network. Frei and Axhausen (2009) also found that relatives are contacted more often by telephone.

People who have known each other long (15 years or more), are more likely to contact each other by landline telephone, relative to face-to-face. This is in line with findings in the previous chapter, showing higher than average telephone contact frequencies, and lower face-to-face contact frequencies for social network members who have known each other at least 15 years.

The results show that if the tie between ego and alter is very strong, they are less likely to interact by e-mail, and more likely to interact using telephone, SMS and IM, relative to face-to-face. This finding is in contrast with Tillema et al. (2010) who indicate that asynchronous modes, such as e-mail and other modes become more important at the expense of face-to-face as relational distance increases. For somewhat strong ties positive effects are found for telephone and SMS.

The results for geographical distance show positive coefficients for all ICT-mediated modes. This indicates that, if distance increases, people are more likely to choose ICT-mediated modes over face-to-face contacts. E-mail and IM have the largest coefficients, indicating that these modes are most likely to be chosen if distance increases. This finding is in line with other studies (e.g. Boase et al., 2006; Larsen et al., 2006), as well as with the findings from chapter 6.

### 7.5 Discussion

In this chapter the relationships between personal and land-use variables and the use of ICT for social interaction was analyzed, based on the social interaction diary data. Three models were presented, analyzing the number of social interactions, the choice for a purpose and the choice for a communication mode for each social interaction.

The factors that influence social interaction frequency, were analyzed in section 7.2. A negative binomial model was estimated to analyze for each respondent the number of social interactions. The results suggest that younger, higher educated people on average have more social interactions. Work was found to have a negative effect. The presence of a partner was found to reduce the number of social interactions, whereas the presence of children in the household was found to have a positive effect. Social network size and club membership were found to have a positive effect on the number of social interactions.

Next, the purpose of social interactions was analyzed in a mixed logit model. With regard to the personal and household characteristics the results showed significant effects for gender, age, living with a partner, education and work hours. Social network size and involvement in one or more clubs were also found to affect
the choice for a social interaction purpose. With regard to day of the week the results indicated that people are more likely to visit or receive guests during the weekend, compared to other purposes.

The characteristics of the contacted person(s) were also found to significantly affect the purpose of the social interaction. Significant effects were found for the number of contacted others, the role, the strength of tie between ego and alter, the duration of the relationship and the geographical distance between ego and alter.

Finally, to analyze the communication mode choice for each social interaction, a mixed logit model was estimated. Personal characteristics were found to significantly affect communication mode choice. The results indicate that younger people are faster in adopting new ICT-based modes, whereas older people tend to hold on to familiar modes. People who spend more time at home where a landline phone is available (people who work less, have children, and no car), tend to choose the landline phone. Gender, education, social network characteristics and day of the week were also found to affect communication mode choice.

Communication mode choice was also found to be affected by characteristics of the contacted person. Social interactions with a group are most likely to be face-to-face interactions and least likely by telephone. For interacting with relatives, positive effects are found for landline and mobile telephone and e-mail. People who have known each other at least 15 years are more likely to contact each other by landline telephone. With regard to emotional distance the results showed that if the tie between ego and alter is very strong, they are more likely to interact using telephone, SMS and IM, relative to face-to-face, which is in contrast with other findings (Tillema et al., 2010). The findings with regard to geographical distance were in line with other findings, suggesting that if geographical distance increases, ICT-based modes (especially e-mail and IM) become more important at the expense of face-to-face.

Although this analysis provides interesting results on social interaction behavior, there are factors that may affect communication mode choice which were not included in our empirical data. For instance, the information content, quality, intimacy or urgency were not taken into account in this study, whereas this is likely to affect the choice of communication mode (Tillema et al. 2010).

Overall, the findings from this chapter are largely consistent with earlier findings in the literature and the previous chapter and offer further insights into understanding social interaction behavior. The results show the importance of including characteristics of the contacted person(s) to explain communication mode choice, underlining the importance of including social networks in the study of social interaction and social travel demand. The next chapter analyzes social travel demand in more detail.
8. Social activity-travel patterns

8.1 Introduction
As discussed before, the study of social activity-travel patterns is important as social activities account for a large and growing segment of travel (Axhausen, 2005) and the travel patterns for social purposes differ from travel for other purposes, such as working and shopping. A first step in order to understand social travel demand is to analyze how social travel aspects are affected by people’s socio-demographic characteristics and characteristics of the built environment.

This chapter addresses research question 3: *What is the effect of personal characteristics and properties of the built environment on social activity-travel patterns?* This question is visualized in Figure 8.1, which shows again part of the conceptual model.

![Conceptual model research question 3](image)

*Figure 8.1: Conceptual model research question 3*
The analyses presented in this chapter are based on the social interaction diary data. For each face-to-face social interaction, the diary asked whether or not this interaction included travel especially for the interaction. If this was the case, the trip distance and transport mode were asked.

In this chapter four analyses are presented. The dependent variables in the four models are regarded as sequential decisions, meaning that the dependent variables of the earlier models are explanatory variables in the following models.

First, the number of social trips per respondent in two days is analyzed in section 8.2. Next, in section 8.3 for each social trip the type of location is analyzed. Similar analyses have been published before in Van den Berg et al. (2010b). Section 8.4 analyzes for each social trip the travel distance. Finally, in section 8.5 the transport mode choice for the social trips is analyzed. Similar analyses as presented in section 8.4 and 8.5 have been published in Van den Berg et al. (2011b) with a special focus on senior citizens.

8.2 Number of social trips

In this section the number of social trips in two days is analyzed, using a negative binomial model. For a description of the model, see section 5.2. The explanatory variables in the model are the respondents’ personal characteristics and properties of the built environment. The estimation results of the model are shown in Table 8.1.

The results indicate that, when controlling for the other characteristics, gender and age do not significantly affect the number of social trips people make. Whereas the results from section 7.2 showed that the oldest group has fewer social interactions, the number of trips for social activities is not lower for this group. This means that senior citizens in the sample are as mobile as their younger counterparts with regard to social activities.

Regarding household composition no significant effect is found for living with a partner, whereas they were found to have fewer social interactions. The presence of children in the household was found to have a positive effect on the total number of social interactions. The results from this analysis show that people with children also make more trips for social activities. This indicates that the presence of children is a motivation rather than a constraint for undertaking social activities.

Although only significant at the 0.10 confidence level, the results indicate that higher educated people are likely to make more social trips and lower educated people make fewer social trips than average. This finding suggests that if the education level of people increases in the future, social trip making might increase as well.

The results further indicate that involvement in clubs or unions is positively related to the number of social trips. This is a plausible finding, as clubs or unions often organize (social) meetings and activities.
Table 8.1: Negative binomial model for number of social trips in two days

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.721</td>
</tr>
<tr>
<td>Male</td>
<td>-0.001</td>
</tr>
<tr>
<td>Young (&lt;30)</td>
<td>0.037</td>
</tr>
<tr>
<td>Old (≥50)</td>
<td>-0.036</td>
</tr>
<tr>
<td>Partner</td>
<td>-0.000</td>
</tr>
<tr>
<td>Children</td>
<td>0.157</td>
</tr>
<tr>
<td>Low education</td>
<td>-0.092</td>
</tr>
<tr>
<td>High education</td>
<td>0.092</td>
</tr>
<tr>
<td>High (&gt;3000/month)</td>
<td>0.000</td>
</tr>
<tr>
<td>Full time work (&gt;35 hours per week)</td>
<td>-0.160</td>
</tr>
<tr>
<td>No work</td>
<td>0.170</td>
</tr>
<tr>
<td>Car</td>
<td>0.082</td>
</tr>
<tr>
<td>0 clubs</td>
<td>-0.257</td>
</tr>
<tr>
<td>2 or more clubs</td>
<td>0.167</td>
</tr>
<tr>
<td>Urban (&gt;1500 addresses per km²)</td>
<td>0.015</td>
</tr>
<tr>
<td>Rural (&lt;1000 addresses per km²)</td>
<td>0.087</td>
</tr>
<tr>
<td>Dispersion parameter α</td>
<td>0.434</td>
</tr>
</tbody>
</table>

Number of observations 747
Log likelihood function -1515.752
Restricted log likelihood -1636.969
Chi Squared 242.434
McFadden Pseudo R-squared 0.074

The model has a relatively low R-squared of 0.074, which indicates that the explanatory power of the personal and land-use variables is only modest. This calls for an inclusion of other variables besides personal and land-use characteristics to explain the number of trips people make for social activities. Therefore this study includes the effects of social network characteristics and ICT-use for social interaction. These effects will be analyzed in chapter 9.

8.3 Location type choice

This section analyzes the choice for a type of location for face-to-face social interactions. A distinction is made between seven location categories: the home of another person, a work location, a bar, restaurant or cultural facility, en route or a public space outside, a sports facility, and other locations. The first category (home of other person) serves as the reference category. The explanatory variables are personal and land-use characteristics, day of the week and social activity purpose. The model used for this analysis is a mixed logit model for panel data. For a description of the model, see section 5.3. For each respondent, 100 Halton draws
are used. In this model, the alternative specific constants are introduced as random parameters. The random parameters in this study are estimated as normally distributed parameters. The estimation results are shown in Table 8.2.

Although the coefficients for work and ‘other’ are not significant, the random parameters for the constants are negative for all categories. This indicates that (if all variables are evaluated at zero) a base preference exists for social trips to the home of another person. This again underlines the importance of knowing the spatial distribution of people’s social networks.

**Table 8.2: Mixed logit model for location type choice for social trips**

<table>
<thead>
<tr>
<th></th>
<th>Work</th>
<th>Bar, rest.</th>
<th>Sport</th>
<th>En route/</th>
<th>Other</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.998</td>
<td>-3.194 ***</td>
<td>-1.898 **</td>
<td>-1.741 **</td>
<td>-0.282</td>
<td></td>
</tr>
<tr>
<td><strong>Nonrandom parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>-0.077</td>
<td>0.141</td>
<td>0.035</td>
<td>-0.039</td>
<td>-0.049</td>
<td></td>
</tr>
<tr>
<td>Young (&lt;30)</td>
<td>-0.175</td>
<td>0.822 *</td>
<td>-0.014</td>
<td>0.202</td>
<td>0.350</td>
<td></td>
</tr>
<tr>
<td>Old (&gt;50)</td>
<td>-0.301</td>
<td>0.968 **</td>
<td>0.666</td>
<td>0.326</td>
<td>0.194</td>
<td></td>
</tr>
<tr>
<td>Partner</td>
<td>0.192</td>
<td>0.469</td>
<td>0.612</td>
<td>0.298</td>
<td>0.423 *</td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td>0.158</td>
<td>-0.152</td>
<td>0.324</td>
<td>0.052</td>
<td>0.399</td>
<td></td>
</tr>
<tr>
<td>Low education</td>
<td>0.863 *</td>
<td>-0.524</td>
<td>-0.659</td>
<td>-0.425</td>
<td>-0.208</td>
<td></td>
</tr>
<tr>
<td>High education</td>
<td>0.153</td>
<td>0.069</td>
<td>-0.558 *</td>
<td>-0.482</td>
<td>-0.008</td>
<td></td>
</tr>
<tr>
<td>High income</td>
<td>0.724 **</td>
<td>0.581 **</td>
<td>0.097</td>
<td>0.884 ***</td>
<td>0.227</td>
<td></td>
</tr>
<tr>
<td>No work</td>
<td>-0.949 *</td>
<td>-0.249</td>
<td>0.079</td>
<td>-0.232</td>
<td>0.090</td>
<td></td>
</tr>
<tr>
<td>Full time work</td>
<td>0.938 **</td>
<td>0.471</td>
<td>0.687 *</td>
<td>0.205</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>-1.767 ***</td>
<td>0.071</td>
<td>-1.526 ***</td>
<td>-0.471</td>
<td>0.139</td>
<td></td>
</tr>
<tr>
<td>No clubs</td>
<td>0.417</td>
<td>0.054</td>
<td>0.033</td>
<td>0.135</td>
<td>-0.101</td>
<td></td>
</tr>
<tr>
<td>More clubs</td>
<td>0.099</td>
<td>-0.234</td>
<td>0.424</td>
<td>0.231</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Low density</td>
<td>0.560</td>
<td>0.354</td>
<td>0.112</td>
<td>-0.421</td>
<td>-0.260</td>
<td></td>
</tr>
<tr>
<td>High density</td>
<td>-0.569</td>
<td>0.370</td>
<td>-0.403</td>
<td>-0.819 **</td>
<td>-0.199</td>
<td></td>
</tr>
<tr>
<td>Saturday</td>
<td>-1.584 ***</td>
<td>0.016</td>
<td>0.063</td>
<td>-0.767 *</td>
<td>-0.711 ***</td>
<td></td>
</tr>
<tr>
<td>Sunday</td>
<td>-2.249 ***</td>
<td>0.463</td>
<td>-0.216</td>
<td>0.556</td>
<td>-1.637 ***</td>
<td></td>
</tr>
<tr>
<td>Joint activity</td>
<td>-0.237</td>
<td>1.537 ***</td>
<td>2.386 ***</td>
<td>1.528 ***</td>
<td>-0.102</td>
<td></td>
</tr>
<tr>
<td>Visit</td>
<td>-2.462 ***</td>
<td>-2.162 ***</td>
<td>-1.366 ***</td>
<td>-1.362 ***</td>
<td>-2.299 ***</td>
<td></td>
</tr>
<tr>
<td><strong>Standard deviations</strong></td>
<td>1.389 ***</td>
<td>0.947 ***</td>
<td>1.462 ***</td>
<td>1.036 ***</td>
<td>0.796 ***</td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>1436</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of groups</td>
<td>602</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted Log-Likelihood</td>
<td>-2572.967</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log-Likelihood function</td>
<td>-1887.153</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.267</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared adjusted</td>
<td>0.256</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** significant at the 0.01 level, ** 0.05 level, * 0.1 level
With respect to gender no significant effects are found. With respect to age, the results indicate that both the oldest and the youngest group are more likely to go to a bar or restaurant for a social activity, relative to a home location.

The presence of a partner has a positive effect on choosing ‘other’ locations for social trips. The presence of children (under 18) in the household has no significant effect on the choice for a social trip location type.

Regarding level of education the results show that lower educated people are more likely to travel to a work location for a social activity. The highest educated group is less likely to go to a sports location for social activities.

High income has a positive effect on social trips to a work location, a bar, restaurant or cultural facility and a public space outside. As expected, people who work or study full time are more likely to interact at their work or study location, whereas people who do not work or study have a high negative coefficient for this location. In addition, full time workers are more likely to travel to a sports location for a social activity.

Car ownership is found to have a negative effect on choosing to travel to a work or sports location for social activities. Club membership is not found to have a significant effect on the choice of a location type for social trips. People who live in higher density areas are less likely to interact at public places outdoors.

As expected, during the weekend people are less likely to interact at their workplace. Social trips to a public space outdoors are less likely on Saturdays. On Saturdays and Sundays ‘other’ locations are also less likely to be chosen, relative to the home of another person.

Finally, significant coefficients are also found with respect to the main purpose of the social interaction. For the purpose of joint activities bars or restaurants, outdoor public space and sports or club facilities are more likely to be chosen, relative to the home of another person. Visits are, obviously, more likely to take place at the home of the other person, as indicated by the high negative coefficients for all five categories.

There is evidence of heterogeneity in the choice for a location type for a social trip. The unobserved preference heterogeneity terms for all categories are highly significant. This indicates substantial variation across individuals in the overall preference for a location type. The model has an R-squared of 0.267, which indicates an acceptable goodness-of-fit.

8.4 Trip distance for face-to-face social interaction

In this section the travel distance to the location of face-to-face social activities is analyzed. The model that is estimated predicts for each social activity the travelled distance, as a result of personal and land-use characteristics, day of the week and main purpose of the social activity. In addition, the type of location is used as an explanatory variable for social trip distance.
As the data has repeated measures (multiple trips per respondent), a random effects model is estimated to account for heterogeneity within and between respondents. The random effects model was described earlier in section 5.4.

The mean distance per trip is 11.39 kilometers. For a better-fitting model the dependent variable distance (in kilometers) was transformed into the logarithm of the distance +1.

The estimation results are shown in Table 8.3. The model has an R-squared of 0.140, which means that 14% of the variance can be explained by the independent variables. Table 8.3 shows that 69% of the unexplained variation is associated with respondents and 31% with the individual trips.

The results show that there is a positive coefficient for males that is significant at the 0.1 level. This indicates that males are likely to travel further for face-to-face social interactions. The same goes for younger and higher educated people. This may be explained by the fact that most university students move to a different city to study, while keeping in contact with friends and relatives from their previous home location. In addition, in the Netherlands, all students get a public transport reduction card, making it cheaper for them to travel longer distances by train.

Regarding household composition the results indicate that people with children tend to travel shorter distances. A reason for this is probably that children are a constraint for long trips. The presence of a partner is not found to significantly affect social trip distance.

Whereas people with a higher income were found to have their social network members living further away in section 5.4, income is not found to result in longer social trip distances. Work status is not found to significantly affect social trip distance either.

Strikingly, car ownership is not found to significantly influence the distance traveled for social activities either, whereas one would expect car owners to travel longer distances.

People living in low urban density areas are found to travel shorter distances for social activities than average. This is in line with findings from section 5.4, showing that people in low density areas have their social network members living closer by. Whereas one would expect that people in higher urban density areas travel shorter distances for social interaction as they have more possible locations for social interaction in their vicinity, this effect was not found.

The results indicate that during the weekend people are likely to travel longer distances for social interactions. This can be explained by the fact that people have more free time in the weekend. The positive effect for Sundays is only significant at the 0.1 level.

The results show that people are likely to travel further for the purpose of joint activities and visiting. This is a convincing finding, which is probably also related to a longer duration of these activities.
Finally, social interactions at a work location, a bar or restaurant, a public space outdoors and ‘other’ locations are associated with longer distances relative to the home of an other person. This indicates that people tend to travel further for these types of locations that are less often chosen.

Table 8.3: Random effects model for social trip distance

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.231</td>
<td>0.000</td>
</tr>
<tr>
<td>Male</td>
<td>0.168</td>
<td>0.059</td>
</tr>
<tr>
<td>Young (&lt;30)</td>
<td>0.345</td>
<td>0.008</td>
</tr>
<tr>
<td>Old (&gt;50)</td>
<td>0.046</td>
<td>0.716</td>
</tr>
<tr>
<td>Partner</td>
<td>-0.005</td>
<td>0.966</td>
</tr>
<tr>
<td>Children</td>
<td>-0.182</td>
<td>0.087</td>
</tr>
<tr>
<td>Low education</td>
<td>-0.086</td>
<td>0.459</td>
</tr>
<tr>
<td>High education</td>
<td>0.169</td>
<td>0.066</td>
</tr>
<tr>
<td>High income (&gt;€3000/month)</td>
<td>0.009</td>
<td>0.920</td>
</tr>
<tr>
<td>Full time work (&gt;35 hours/week)</td>
<td>0.117</td>
<td>0.285</td>
</tr>
<tr>
<td>No work</td>
<td>0.111</td>
<td>0.297</td>
</tr>
<tr>
<td>Car in household</td>
<td>0.104</td>
<td>0.504</td>
</tr>
<tr>
<td>0 clubs or unions</td>
<td>-0.025</td>
<td>0.818</td>
</tr>
<tr>
<td>2 or more clubs or unions</td>
<td>-0.114</td>
<td>0.226</td>
</tr>
<tr>
<td>Urban (&gt;1500 addresses/km²)</td>
<td>-0.054</td>
<td>0.611</td>
</tr>
<tr>
<td>Rural (&lt;1000 addresses/km²)</td>
<td>-0.247</td>
<td>0.021</td>
</tr>
<tr>
<td>Saturday</td>
<td>0.223</td>
<td>0.022</td>
</tr>
<tr>
<td>Sunday</td>
<td>0.196</td>
<td>0.075</td>
</tr>
<tr>
<td>Joint activity</td>
<td>0.248</td>
<td>0.000</td>
</tr>
<tr>
<td>Visit</td>
<td>0.474</td>
<td>0.000</td>
</tr>
<tr>
<td>Work location</td>
<td>0.881</td>
<td>0.000</td>
</tr>
<tr>
<td>Bar / restaurant / culture</td>
<td>0.259</td>
<td>0.017</td>
</tr>
<tr>
<td>Sport location</td>
<td>0.147</td>
<td>0.152</td>
</tr>
<tr>
<td>Public space outdoors</td>
<td>0.313</td>
<td>0.006</td>
</tr>
<tr>
<td>Other location</td>
<td>0.195</td>
<td>0.009</td>
</tr>
</tbody>
</table>

Number of observations (trips) 1436
Number of groups (respondents) 508
Total Sum of Squares 1335.2
Residual Sum of Squares 1148.1
R-squared 0.140
Effects: idiosyncratic Var [ε] 0.814  Std.dev. 0.902  Share 0.691
individual Var [u] 0.364  Std.dev. 0.603  Share 0.309
8.5 Transport mode choice for face-to-face social interaction

The final model in this chapter is used to predict the transport mode choice for those face-to-face social interactions that include a trip made for the purpose of the interaction. A panel mixed logit model (as described in section 5.3) is estimated, because each respondent has several choice situations and preference heterogeneity between the respondents is expected. The choice between car as driver, car as passenger, bicycle and walking is considered. The first category, driver, is the largest category and serves as the reference category in the model. Thus, the coefficients estimated for passenger, bicycle and walk are interpreted relative to choosing to drive a car for the social trip.

Again, all socio-demographic and land-use variables are included in the model, as well as the purpose of the social activity, the type of location and the trip distance. For each respondent, 100 Halton draws are used. The alternative specific constants are introduced as random parameters. The random parameters in this study are estimated as normally distributed parameters in order to allow parameters to get both negative and positive values. Table 8.4 shows the estimation results of the mixed logit model.

The constants in the model represent the estimates for passenger, bicycle and walking relative to car as driver when all explanatory variables in the model are evaluated at zero. The constants indicate that, if all explanatory variables (including distance) are evaluated at zero, people are less likely to travel as a car passenger and more likely to walk or cycle to go to the location of the social activity, compared to driving. The latter may seem unlikely, however, it should be realized that this holds after having corrected for travel distance. In other words, this result indicates that a base preference for walking or cycling exists that is offset by distance.

There is evidence of heterogeneity in the transport mode choice. The unobserved preference heterogeneity terms for passenger, bicycle and walking are highly significant. This indicates substantial variation across individuals in the overall preference for a transport mode. The model has an R-squared of 0.412, which indicates a high goodness-of-fit of the model.

Males are found to be less likely to be car passenger than females. This finding is in line with Golob and Hensher (2007) and Schmöcker et al. (2008) who also found that males, compared to females, are more likely to drive and less likely to be passengers.

With regard to age the results indicate that younger people are more likely to choose the bicycle, relative to driving.

Although only significant at the 0.1 level, the results suggest that people who live with a partner are more likely to be a car passenger. This is a plausible finding, as we can assume that partners often travel together by car to a social activity location. The presence of children is found to have a negative effect on walking to a social activity location.
Table 8.4: Mixed logit model for transport mode choice for social trips

<table>
<thead>
<tr>
<th></th>
<th>Passenger</th>
<th>Bicycle</th>
<th>Walk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-3.895</td>
<td>2.181</td>
<td>5.825</td>
</tr>
<tr>
<td><strong>Non-random parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>-1.861</td>
<td>-0.046</td>
<td>-0.175</td>
</tr>
<tr>
<td>Young</td>
<td>0.902</td>
<td>1.507</td>
<td>0.045</td>
</tr>
<tr>
<td>Old</td>
<td>-0.849</td>
<td>-0.033</td>
<td>0.534</td>
</tr>
<tr>
<td>Partner</td>
<td>1.066 *</td>
<td>-0.513</td>
<td>-0.325</td>
</tr>
<tr>
<td>Children</td>
<td>-0.615</td>
<td>0.256</td>
<td>-1.016**</td>
</tr>
<tr>
<td>Low education</td>
<td>1.375 **</td>
<td>0.486</td>
<td>-0.808 *</td>
</tr>
<tr>
<td>High education</td>
<td>-0.718</td>
<td>-0.347</td>
<td>-0.228</td>
</tr>
<tr>
<td>No work</td>
<td>-0.442</td>
<td>-0.327</td>
<td>-0.848 **</td>
</tr>
<tr>
<td>Fulltime work</td>
<td>0.024</td>
<td>-0.476</td>
<td>-0.700</td>
</tr>
<tr>
<td>High income</td>
<td>0.176</td>
<td>0.239</td>
<td>0.337</td>
</tr>
<tr>
<td># cars</td>
<td>-0.618 *</td>
<td>-1.473 ***</td>
<td>-0.971 ***</td>
</tr>
<tr>
<td>No clubs</td>
<td>0.363</td>
<td>-0.288</td>
<td>-0.458</td>
</tr>
<tr>
<td>2 or more clubs</td>
<td>0.324</td>
<td>0.744 **</td>
<td>-0.284</td>
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<tr>
<td>Urban</td>
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<td>0.835 **</td>
<td>0.599</td>
</tr>
<tr>
<td>Rural</td>
<td>-0.999 *</td>
<td>-0.225</td>
<td>0.242</td>
</tr>
<tr>
<td>Saturday</td>
<td>0.928 **</td>
<td>0.240</td>
<td>0.898 *</td>
</tr>
<tr>
<td>Sunday</td>
<td>0.937 *</td>
<td>-0.267</td>
<td>0.519</td>
</tr>
<tr>
<td>Visit</td>
<td>0.551</td>
<td>0.498</td>
<td>0.023</td>
</tr>
<tr>
<td>Joint activity</td>
<td>0.223</td>
<td>0.265</td>
<td>0.567 *</td>
</tr>
<tr>
<td>Work</td>
<td>-2.603 ***</td>
<td>1.182 ***</td>
<td>-0.984</td>
</tr>
<tr>
<td>Bar / rest.</td>
<td>2.425 ***</td>
<td>1.092 ***</td>
<td>0.818</td>
</tr>
<tr>
<td>Sport</td>
<td>1.065 **</td>
<td>0.616 *</td>
<td>-1.004 *</td>
</tr>
<tr>
<td>Public space</td>
<td>1.026 *</td>
<td>1.103 **</td>
<td>1.109 **</td>
</tr>
<tr>
<td>Other</td>
<td>0.246</td>
<td>0.728 **</td>
<td>-0.081</td>
</tr>
<tr>
<td>Ln (km)</td>
<td>0.818 ***</td>
<td>-1.346 ***</td>
<td>-4.513 ***</td>
</tr>
<tr>
<td><strong>Standard deviations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Number of groups</td>
<td>602</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted Log-Likelihood</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Log-Likelihood function</td>
<td>-1237.135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.440</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared adjusted</td>
<td>0.430</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** significant at the 0.01 level, ** 0.05 level, * 0.1 level

Regarding education level, lower educated people are found to be more likely to travel to a social activity location as a car passenger and they are less likely to walk.

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People who do not work are found to be less likely to walk to a social activity location. Income is not found to affect transport mode choice for social trips.

As expected, car ownership is found to result in a larger likelihood of choosing to drive. This is indicated by the negative coefficients for the three other modes. Club membership is found to have a positive effect on the choice to cycle to a social activity location. This is probably related to the fact that most people join clubs close to their home, within a cycling distance.

With respect to urban density the results suggest that people who live in urban areas are more likely to cycle, relative to driving. This can probably be explained by shorter distances in urban areas. People living in rural areas are less likely to travel as a car passenger.

The results show that on Saturdays and Sundays people are more likely to travel to a social activity location as a car passenger, suggesting that they go somewhere together with someone else. For Saturdays a positive coefficient is found for walking as well.

Regarding the purpose of the social activity the results show that for a joint activity people are more likely to choose to travel by bike or on foot, relative to driving. This may be related to the fact that in some cases the joint social activity consists of walking or cycling together.

For social trips to a work location people are less likely to travel as a car passenger, and more likely to cycle. For social trips to a bar or restaurant people are more likely to travel as a car passenger. This indicates that people often travel together to this type of location. The coefficient for bike is positive as well. The reason for this may be that going to a bar or restaurant often involves drinking alcohol.

Social trips to a sports location are more likely to be travelled to as a car passenger or by bike, and less likely on foot. Positive coefficients are found for riding as a passenger, cycling and walking to a public space outdoors. This is plausible, as the joint activity of touring, walking or cycling might be the main purpose of the social interaction in public space. A positive coefficient for cycling is found for social trips to ‘other’ types of locations.

Finally, regarding distance the results show that if the travel distance increases, people are more likely to travel as a car passenger and less likely to cycle, and especially walk, which is a plausible finding.

8.6 Discussion

In order to analyze the effect of personal characteristics and properties of the built environment on social activity-travel patterns, four models were estimated in this chapter. The four dependent variables are regarded as sequential decisions individuals make regarding social activity-travel.
First, in order to estimate the number of social trips in two days a negative binomial model was estimated. High education and involvement in clubs were found to result in more social trips, whereas full time work was found to result in fewer social trips. Even though the focus of other studies is rarely on social trips, these findings seem to be in line with results from other studies.

The second model was a random parameters logit model to predict the type of location travelled to for a social activity. The results indicated a base preference for social trips to the home of another person. Both the oldest and the youngest group were found to be more likely to go to a bar or restaurant for a social activity, relative to a home location. The presence of a partner, level of education, income, work status, car ownership, urban density and day of the week were also found to affect location type choice for social activities. Significant coefficients were also found with respect to the main purpose of the social interaction. For the purpose of joint activities bars or restaurants, outdoor public space and sports or club facilities were more likely to be chosen, relative to the home of another person. Social trips for the purpose of visiting are, obviously, more likely to have the home of the other person as destination.

The third model was a random effects model which was estimated to analyze the travel distance for social activities. Longer trip distances were found for males, younger people and higher educated people. Shorter trips were found for people with children and people living in urban areas. Social interactions during the weekend and interactions for the purpose of visiting and joint activities were found to be associated with longer distances. Finally, social interactions at a work location, a bar or restaurant, a public space outdoors and ‘other’ locations were found to be associated with longer distances relative to the home of another person.

The fourth model was a random parameters logit model to predict the travel mode choice for social trips. The choice between the four main transport modes (car as driver, car as passenger, bicycle and walking) was considered. The results indicated a base preference for walking and cycling. However, the tendency to walk or cycle decreases rapidly as the trip distance increases. Significant effects were found for gender: males are less likely to be car passenger. Larger likelihoods of choosing to ride along were found for weekend days and for people who live with a partner and lower educated people. Significant effects were also found for work hours, club membership, car ownership, urban density, the purpose of the social activity and the type of location.

9.1 Introduction

In the previous chapters the effects of personal characteristics and properties of the built environment on social network characteristics, ICT-use for social interaction and social activity-travel patterns have been analyzed in detail in separate models. However, it is hypothesized that social activity-travel behavior is not only affected by socio-demographic and land-use characteristics, but also by people’s social network characteristics and their ICT-use for social interaction. Thus, to better understand social activity-travel demand, it is important to analyze the relationships between socio-demographic and land use variables, ICT-use, social networks and aspects of travel behavior simultaneously.

This chapter therefore answers research question 4: To what extent and how is the nature and strength of the relationship between personal characteristics and properties of the built environment and social activity-travel patterns mediated by the joint impact of ICT-use and characteristics of social networks? This research question is visualized in the full conceptual model in Figure 9.1.

Whereas the previous chapters have answered parts of this research question in detail, this chapter addresses the relationships between socio-demographic and land use variables, ICT-use, social networks and aspects of travel behavior simultaneously. However, compared to the analyses in the previous chapters, the level of detail is somewhat lower here, to keep the model restrained.
In order to analyze the direct and indirect relationships between socio-demographic and land use variables, ICT-use, social networks and aspects of travel behavior a path analysis is used. The analysis is based on the data that were collected with the social interaction diary. Parts of the results were presented earlier in Van den Berg et al. (2011c).

9.2 Model structure
As indicated, the goal of this chapter is to analyze the direct and indirect relationships between socio-demographic and land use variables, ICT-use, social networks and aspects of travel behavior. This question requires a method that can capture the relationships between several dependent and independent variables. Therefore, path analysis is used.

Although many alternative specifications can be examined and compared against data, some hypotheses are formulated a priori, based on the results of the existing literature and findings from previous chapters. In line with the findings from earlier studies, it is hypothesized that socio-demographic and land-use variables are exogenous and affect ICT-use for social interaction, social network size and the social activity-travel variables. The first step in building the model is therefore to determine the significant effects of the socio-demographic and land-use variables on the social network, ICT-use and social travel variables.

As discussed earlier, ICT-use and social networks are considered as additional resources that offer opportunities for social activities (including travel). These variables are hypothesized to directly affect the social travel variables or mediate the relationships between socio-demographic and land-use characteristics. For example, older people stayed behind in the adoption of mobile phones and the Internet and they may still have a lower ICT-mediated contact frequency, which in turn can lead to fewer social trips. On the other hand, older people are likely to have more time for social activities, which can result in more social travel. However, they may be less mobile and therefore have fewer possibilities to maintain their social network, resulting in a smaller social network and fewer social trips.
In addition, social network size will not only have a positive effect on social travel, but also on the number of social interactions via ICT, as social interactions can emerge from people’s social networks. Within the ICT-use variables, telephone interactions are allowed to affect Internet interactions, and the other way around.

Regarding the causal relationships between the social travel variables the number of trips by different modes are regressed on each other. A substitution effect between the different transport modes is hypothesized.

The number of trips by different modes can add to the total travel distance, however, the total social travel distance is also allowed to influence the number of trips by the different modes. There are feedback loops between total travel distance and the numbers of trips by different modes. This means that the individual not necessarily first decides on the number of trips (and total travel distance is a consequence of this decision), yet the individual can also adjust the number of trips to the travel distance.

The model structure is visualized in Figure 9.2.
9.3 Results
This section presents the results of the path analysis model. The model is estimated using the statistical software package LISREL (Jöreskog and Sörbom, 2001). Despite non-normality in the data, the maximum likelihood method is used to estimate the models.

First, the significant effects of the socio-demographic and land-use variables on the social network, ICT-use and social travel variables are determined. The relationships that are significant at the 0.1 level, are entered in the model. Next, the proposed relationships between the endogenous variables are added. The links between the endogenous variables that are not significant at the 0.1 level are removed in a stepwise procedure, resulting in the final model.

In Table 9.1 the unstandardized coefficients and t-statistics of direct and total effects of the final model are presented.

Effects of socio-demographic and land-use variables
Many significant relationships are found between the (exogenous) socio-demographic and land-use variables and the endogenous variables. With regard to gender the results suggest that being male results in a smaller social network (3 network members fewer), and fewer telephone calls for social interaction (more than 2 calls per week fewer). No significant direct effects of gender on social travel behavior are found, whereas results from section 7.4 showed that males are likely to travel longer distances for social activities. Small negative indirect effects are found for males on the number of walks, bike trips, car trips and social travel distance.

With respect to age the results indicate a negative effect on social contact via the Internet. This indicates that older people still lag behind in adopting this communication mode, which is in line with findings from chapter 6 and 7. The results further show that older people are likely to make more car trips for social activities than average. An indirect positive effect is also found on social travel distance. The positive effect of age on social travel is a surprising finding which is at variance with findings from others (e.g. Farber and Páez, 2009).

The presence of children (under 18) in the household is found to result in 2 extra walking trips per month and 4 extra bike trips per month for social purposes. This seems in contrast with section 8.5 where people with children were found to be less likely to walk, compared to driving for social trips. However, this can probably be explained by the fact that the total number of social trips is higher for people with children, as was found in section 8.2. A negative effect of the presence of children on social trip distance was found in the previous chapter, and by others (Carrasco et al., 2008b). In this model, no significant direct effect is found and a positive indirect effect of children on total travel distance is found, which can be explained by the fact that people with children tend to make more short trips.

Full time workers are found to make 6 telephone calls per month fewer for social interaction. This is in line with findings from chapter 7. They also make
fewer walking trips for social activities than the average. This may be caused by the fact that they have less free time.

High education is found to result in interactions 2 extra telephone interactions and 3 extra Internet interactions per week. This suggests that high education is related to more ICT-use, which is in line with findings from chapters 6 and 7. Higher education is also associated with longer distance travel, which was also found in chapter 8. It results in an extra car trip per week and 43-52 extra kilometers per week for social activities. A positive indirect effect is found on the number of walks and a negative indirect effect is found on the number of bike trips.

As expected, and in line with the previous chapter, car ownership is found to have a positive effect on the number of car trips for social activities. It results in 4 or 5 extra car trips per week. A negative effect is found for bike trips. In line with the previous chapter, no direct effect of car ownership on travel distance is found. However, the total effect is positive.

The number of clubs an individual is actively involved in is found to have a positive effect on social network size. An extra club results in 3 extra social network members. It also has a positive effect on the number of walks and bike trips, which is in line with findings from the previous chapter. Positive indirect effects are also found for the number of ICT mediated social interactions, the number of car trips and social travel distance. These findings suggest that clubs generate social activities and travel, showing the importance of including this variable in models of social activity-travel behavior.

People living in low density areas are likely to have a larger social network than average. This suggests that in low density areas traditionally strong local networks still exist (Aoki et al., 1996). Living in low density areas results in 1 or 2 extra car trips per week for social activities. A positive indirect effect on social travel distance is found as well. These effects were hypothesized because of longer travel times, as a result of longer distances in low urban density areas.

The results for the number of types of facilities within 1 km show a negative effect on the number telephone calls. The explanation for this is unclear. The number of types of facilities has a positive effect on the number of bike trips for social activities, suggesting this to be a measure for activity opportunities within a biking distance.

Finally, the day of the week affects ICT-use for social interaction as well as social travel behavior. During the weekend, people tend to have fewer ICT-mediated social interactions, and fewer walking and cycling trips. This is in line with findings from section 7.2 and Mokhtarian and Meenakshisundaram (1999) who found the number of social interactions to be lower in the weekend, compared to weekdays. With regard to social travel distance, a positive effect was found, suggesting that people make fewer but longer trips for social activities during the weekend. This can be explained by the fact that people have more free time during the weekend. The significant direct effects of the exogenous variables are shown in Figure 9.3.
Table 9.1: Path analysis model estimates (unstandardized effects)

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Network size</th>
<th>Tel. contacts</th>
<th>Internet contacts</th>
<th>Walk trips</th>
<th>Bike trips</th>
<th>Car trips</th>
<th>Travel distance</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Exogenous variables</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>-3.01**</td>
<td>-0.65***</td>
<td></td>
<td>-0.02***</td>
<td>0.01***</td>
<td></td>
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</tr>
<tr>
<td>Total effect</td>
<td></td>
<td>-3.01**</td>
<td>-0.69***</td>
<td>-0.03</td>
<td>-0.01*</td>
<td>-0.02</td>
<td>-0.06**</td>
<td>-1.71**</td>
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<tr>
<td>Age</td>
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<td></td>
<td></td>
<td></td>
<td>-0.00**</td>
<td>0.00</td>
<td>0.00***</td>
<td>0.10***</td>
</tr>
<tr>
<td>Total effect</td>
<td></td>
<td>-0.00**</td>
<td>-0.02***</td>
<td>0.00*</td>
<td>0.00*</td>
<td>0.01***</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td>0.13**</td>
<td>0.30***</td>
<td></td>
<td>0.13**</td>
<td>0.26***</td>
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<td>1.35</td>
</tr>
<tr>
<td>Total effect</td>
<td></td>
<td>0.13**</td>
<td>0.26***</td>
<td>0.14**</td>
<td>1.35</td>
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<td>Full time</td>
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<td>-0.44*</td>
<td>-0.24***</td>
<td></td>
<td></td>
<td>0.02</td>
<td>0.00</td>
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<td>Total effect</td>
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<td>-0.44*</td>
<td>-0.22***</td>
<td>-0.01</td>
<td></td>
<td>0.02</td>
<td>5.22**</td>
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<td>High educ.</td>
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<td>0.90***</td>
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<td>0.19</td>
<td>12.41***</td>
<td>14.74***</td>
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<tr>
<td>Total effect</td>
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<td>0.68***</td>
<td>0.90***</td>
<td>0.05***</td>
<td>-0.09**</td>
<td>0.31**</td>
<td>14.74***</td>
<td></td>
</tr>
<tr>
<td>Car</td>
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<td></td>
<td>-0.41*</td>
<td>1.50***</td>
<td>0.02</td>
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<tr>
<td>Total effect</td>
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<td>0.04**</td>
<td>0.03*</td>
<td>0.07**</td>
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<td>-0.00*</td>
<td>0.01**</td>
<td>0.33*</td>
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<td></td>
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<td>-0.09*</td>
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<tr>
<td>Total effect</td>
<td></td>
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<td>0.00***</td>
<td>0.01***</td>
<td>0.00***</td>
<td>-0.00***</td>
<td>0.01***</td>
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</tr>
</tbody>
</table>

* Significant at .10 level, ** significant at .05 level, ***significant at the .01 level
Figure 9.3: Significant direct effects of socio-demographic and land-use variables
Effects of social network size
The number of social network members is found to have a positive effect on the number of social interactions via telephone and Internet. This suggests that social network size has a positive effect on the use of ICT for social contacts. These findings are in line with findings from section 7.2 indicating that people with a large network have more social interactions. Social network size also influences the number of trips with different transport modes. The number of social network members has a positive effect on the number of bike trips. Positive indirect effects are found for the number of car trips and social travel distance. These findings show the importance of including social networks in the study of (social) activity-travel behavior.

Effects of ICT-use
With regard to the effects of ICT-use for social interaction the number of Internet interactions is found to have a positive effect on the number of telephone interactions. The results show a positive effect of the number of telephone interactions on the number of car trips for social activities. This indicates a complementary effect, which was also found by Senbil and Kitamura (2003). In addition, a direct positive effect of telephone interactions on social travel distance is found. The number of Internet interactions is found to have a positive indirect effect on the number of car trips and social travel distance. A small indirect negative effect of both telephone and Internet interactions is found on the number of bike trips.

Effects between social travel variables
The social travel variables also affect each other. A substitution effect between the different modes was hypothesized. A negative effect is found of the number of car trips on the number of bike trips. The number of bike trips however has a larger positive effect on the number of car trips. This suggests complementarity rather than substitution between the different transport modes.

The results suggest that social travel distance is negatively affected by the number of walks, and positively affected by the number of bike trips and car trips, with, as expected, a higher coefficient for car trips. In addition, small positive effects are found of travel distance on the number of walks and car trips. This suggests that social travel distance is not only a consequence of the number of trips with different modes, but that individuals also adjust the number of trips to the total travel distance. Figure 9.4 shows the direct effects of the endogenous variables that are significant at the 0.10 level.

Table 9.2 shows the goodness-of-fit of the model. Several measures are reported. Based on the rules of thumb, these measures suggest that the model provides an adequate fit of the data, as the value of Chi Square divided by the model degrees of freedom and the Normed Fit Index are close to 1 and the RMSEA is (close to) 0.

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9.4 Discussion

This chapter has aimed to increase our understanding of social activity-travel, and how this is affected by socio-demographic and land-use variables, ICT-use and social network characteristics. Whereas the previous chapters captured these relationships separately, in this chapter the links between these variables were analyzed simultaneously. Based on the social interaction diary data, a path analysis model was estimated. Overall, the findings are largely consistent with the literature and findings from earlier chapters. However, as the effects of personal and land-use variables, ICT-use and social networks were analyzed simultaneously in this chapter, the results offer further insights into social travel behavior compared to the previous chapters.

The results showed many significant effects of socio-demographic characteristics on social travel behavior. For example, females, club members and people living in low density areas have larger social networks, resulting in more social interactions and social travel. Older people have fewer mediated interactions,
but make more (longer) car trips for social activities than average. High education results in more mediated social interactions, more car trips and longer social travel distance. The presence of children and club membership result in more short trips for social activities. Full time workers were found to make fewer telephone calls and walking trips for social activities than the average. Car ownership results in more car trips and less bike trips for social activities.

The effects of the characteristics of the built environment showed interesting results as well. As expected, living in low density areas was found to be related to fewer bike trips, more car trips and indirectly, longer travel distances for social activities. The effects of the number of facility types within a walking distance were only moderate in explaining social interaction and travel behavior. It was only found to have a positive effect on the number of bike trips for social activities.

During the weekend people have fewer mediated social interactions and they make fewer but longer social trips.

In addition, as expected, social network size was found to positively affect the number of social trips by different modes as well as social travel distance either directly or indirectly, showing that social networks generate social activities and travel. As social network distances are growing, social travel demand is likely to increase.

With regard to ICT-use the results suggest a small complementary effect as the number of Internet interactions has a positive effect on the number of telephone interactions. Telephone interactions in turn were found to have a positive effect on the number of car trips and travel distance.

Although a substitution effect between the different transport modes was hypothesized, the results suggest complementarity rather than substitution. This indicates that people use multiple transport modes instead of a single one for their social activity-travel.

Social travel distance was found to be negatively affected by the number of walks, and positively affected by the number of bike trips and car trips. In addition, small positive effects were found of travel distance on the number of walks and car trips, suggesting that social travel distance is not only a consequence of the number of trips with different transport modes, but that individuals also adjust the number of trips they make to the total travel distance.
10. Conclusion and discussion

10.1 Summary and findings

The aim of this dissertation was to analyze the relationships between personal characteristics and attributes of the built environment, social networks, the use of ICT’s and social activity-travel patterns. To achieve this aim, four research questions have been addressed:

1. What is the effect of personal characteristics and properties of the built environment on social network characteristics?
2. What is the effect of personal characteristics and properties of the built environment on ICT-use for social purposes?
3. What is the effect of personal characteristics and properties of the built environment on social activity-travel patterns?
4. To what extent and how is the nature and strength of the relationship between personal characteristics and properties of the built environment and social activity-travel patterns mediated by the joint impact of ICT-use and characteristics of social networks?

To answer these questions a data collection instrument was designed, consisting of a two-day paper-and-pencil social interaction diary, a questionnaire on personal characteristics and a follow-up questionnaire on personal social network members. The data were collected between January and March 2008 in the region of Eindhoven, among 747 respondents aged 15 or over. The social network questionnaire was completed by 116 respondents.
In order to analyze the effect of personal characteristics and properties of the built environment on social network characteristics, three models were estimated in chapter 5, based on data from the social network questionnaire. A negative binomial regression model was estimated to predict the size of the social network (number of alters) as a function of the socio-demographic characteristics of the ego. The results indicate that age, household composition (living with a partner and presence of children), car ownership, work status and urban density influence social network size.

The second model was a mixed logit model estimated to predict the distribution of alters across the social categories. The results show significant effects for gender, education, work status, involvement in clubs, urban density and social network size.

The third model presented in chapter 5 was a random effects model to analyze the geographical distance between social network members. Income was the only personal characteristic that was found to have a significant effect on social network distances. People living in low urban density areas have their social network members closer by. Finally, social category (type of relationship between ego and alter) was found to significantly influence geographical distance between ego and alter as well.

In chapter 6 the effect of personal characteristics and properties of the built environment on ICT-use for social purposes was analyzed. Based on the social network data, a multilevel path analysis model was estimated to analyze the contact frequency by different communication modes (face-to-face, telephone, e-mail and SMS) between social network members. At the level of the ego-alter relationship (within level) positive relationships were found between the contact frequencies by different modes, indicating complementarity. The contact frequency was found to decrease as costs (related to distance) increase. Moreover, relational closeness (strength of tie) was found to have a positive effect on contact frequency with all modes. The duration of the relationship (how long ego and alter have known each other) and the social category (relative or friend) were also found to affect contact frequency. At the level of the ego (between level) the results indicated that (to some extent) the earlier adopters of ICT’s (young, highly educated males) have higher ICT-mediated contact frequencies with their social network members. Especially the older generation tends to hold on to the mode they are familiar with, whereas the younger generation is faster in adopting the newer modes.

A complementary perspective to the use of ICT for social interaction was given in chapter 7. It showed the results of three models that were estimated based on the social interaction diary data, analyzing the factors that influence social interaction frequency, the purpose of social interactions and communication mode choice for social interaction.

A negative binomial model was estimated to analyze for each respondent the number of social interactions. Significant effects were found for age, education,
work, the presence of a partner, the presence of children in the household, social network size and club membership.

The purpose of social interaction was analyzed in a mixed logit model. With regard to the personal and household characteristics significant effects were found for gender, age, living with a partner, education, work hours, social network size and club membership. The purpose of the social interaction was found to be affected by the day of the week, as well as by the characteristics of the contacted person(s). Significant effects were found for the number of contacted others, the role, the strength of tie between ego and alter, the duration of the relationship and the geographical distance between ego and alter.

To analyze the communication mode choice for each social interaction, a mixed logit model was estimated. Personal characteristics (gender, age, education, work, children, car ownership) were found to significantly affect communication mode choice. Social network characteristics and day of the week were also found to affect communication mode choice. Communication mode choice was also found to be affected by characteristics of the contacted persons.

In order to analyze the effect of personal characteristics and properties of the built environment on social activity-travel patterns, four models were estimated in chapter 8. First, in order to estimate the number of social trips in two days a negative binomial model was estimated. Only three personal characteristics (education, work hours and involvement in clubs) were found to significantly affect the number of trips for social activities.

The second model was a random parameters logit model to predict the type of location travelled to for a social activity. The results indicated that age, the presence of a partner, level of education, income, work status, car ownership, urban density and day of the week were found to affect location type choice for social activities. Significant coefficients were also found with respect to the main purpose of the social interaction.

The third model was a random effects model which was estimated to analyze the travel distance for social activities. Several personal characteristics (gender, age, education, presence of children) were found to affect social travel distance. In addition, significant effects were found for urban density. Finally, the day of the week and the type of location were found to affect social travel distance.

The fourth model was a random parameters logit model to predict the travel mode choice for social trips. Significant effects were found for gender, education, living with a partner, work hours, club membership, car ownership, urban density, day of the week, the purpose of the social activity, the type of location and trip distance.

The aim of chapter 9 was to simultaneously analyze the relationships between social activity-travel, socio-demographic and land-use variables, ICT-use and social network characteristics. Based on the social interaction diary data, a path analysis model was estimated, capturing the links between these variables. The results showed many significant effects of socio-demographic characteristics on

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social travel behavior. The effects of the characteristics of the built environment showed interesting results as well. In addition, as hypothesized, social network size was found to positively affect the number of social trips by different modes as well as social travel distance either directly or indirectly, showing that social networks generate social activities and travel. As social network distances are growing, social travel demand is likely to increase. With regard to ICT-use the results suggest a small complementary effect of Internet interactions on the number of telephone interactions. Telephone interactions in turn are found to have a positive effect on the number of car trips and travel distance. Regarding the causal relationships between the social travel a negative effect was found of the number of car trips on the number of bike trips. However, a larger positive effect in the opposite direction was found, suggesting complementarity rather than substitution between the different transport modes. Social travel distance was found to be negatively affected by the number of walks, and positively affected by the number of bike trips and car trips. In addition, small positive effects were found of travel distance on the number of walks and car trips, suggesting that social travel distance is not only a consequence of the number of trips with different transport modes, but that individuals also adjust the number of trips they make to the total travel distance.

10.2 Discussion and directions of future research

The main emphasis of this dissertation is improving our understanding of social activity-travel behavior and the importance of social networks and ICT-use in explaining this behavior, rather than building an explicit forecasting model. The models that were estimated in this dissertation provide interesting results on social activity-travel patterns. They show empirical evidence that, in addition to socio-demographic variables and characteristics of the built environment, characteristics of people’s social networks as well as the use of information and communication technology, are important in explaining individual social travel behavior.

As shown in this dissertation, the personal network approach is a very useful method for collecting social network data in order to expand the personal and land-use characteristics traditionally used to analyze activity-travel behavior. The results from this dissertation strongly show that the social networks play a relevant role in explaining the generation of social activities. For instance, is was shown that social networks generate social activities and travel as social network size was found to positively affect the number of social trips by different modes as well as social travel distance.

In addition, the models showed the relevance of with whom the social interaction took place. Social network characteristics and characteristics of the alters (geographical distance, tie strength, type of relationship, duration of the relationship) were found to influence the choice for a communication mode (face-to-face vs. an ICT-mediated mode). This underlines the relevance of including the social context in the study of social activity-travel.
Another main contribution of this dissertation is the design of a data collection method to gather information about social interactions, including ICT-use and social activity-travel, as well as detailed information on the contacted persons. Using the social interaction diary a relatively large-scale data collection was carried out.

Analyzing the social interaction diary data, the role of information and communication technologies in activity generation was studied. The results suggest an overall complementary effect, as the use of ICT’s was found to have a (small) direct influence on social activity-travel behavior. In addition, the results showed complementarity between the different communication modes. This indicates that, since the use of e-mail and mobile phones is still increasing, face-to-face interactions, requiring social trips, may increase as well.

Moreover, new ICT’s have increased possibilities to maintain and to build new social ties over long distances. Although the frequency of face-to-face communication (and trips) was found to decrease with geographical distance, the results show that (occasional) physical meetings tend to take place with most contacts. As the access to and the use of ICT’s is still increasing, long distance contacts can be maintained better and cheaper, which may imply that long distance trips will increase in the near future.

A final contribution of this dissertation was to empirically study social activity-travel demand, by analyzing the number of trips made for social activities, the way in which social activities are distributed over space, and the travel mode choice for these social trips. Social travel is important and necessary, as it allows us to visit our friends and relatives and to explore the world around us. However, social activities are responsible for a large and growing share of travel, which also has negative effects. Social travel is an important contributor to congestion and emissions caused by motorized traffic and is therefore a major concern for infrastructure planning as well as environmental policy. The results of this research are potentially useful for local, regional, national and international transport policymakers and planners.

With regard to the travel behavior for social activities, the results suggest that senior citizens in the sample are as mobile as their younger counterparts. The increasing income level of senior citizens and their increasing car ownership will probably lead to increasing future travel demand for social purposes. Therefore, social travel demand is likely to increase as the number of senior citizens in our society is growing. Policymakers should therefore reckon with increasing (social) travel in the near future.

In addition to providing insight into social activity-travel, this research touches on the matter of social equity and social exclusion. As social interaction with other people provides access to instrumental and emotional support, it is important to measure the impact of changing levels of accessibility and mobility on social activity participation. In spite of the increasing overall levels of health, income, mobility and access to ICT’s, the issues of social equity and social
exclusion become more pressing with the ageing of the population and demand for continued research into social interaction behavior.

However, the main contribution of this dissertation is showing empirical evidence that in addition to socio-demographic variables and characteristics of the built environment, characteristics of people’s social networks as well as the use of information and communication technology, are important in explaining individual social travel behavior and need to be explicitly taken into account.

Although this study provides interesting results on social activity-travel behavior, some challenges for future research remain. A key challenge is implementing these factors in an operational activity-based model of (social) travel demand. In an agent-based model, characteristics of personal social networks can be added as links between individual agents, who plan and perform social activities together. Ideally, a social activity generation model should incorporate the socio-demographic characteristics of the egos and alters, as well as social network composition. The use of ICT can be incorporated as a mode of social interaction, as a way to maintain the social network, and as a tool to plan face-to-face social activities (Carrasco, 2006).

In addition, future research needs to address a series of challenges, in order to achieve a comprehensive understanding of the role of social networks and ICT in (social) activity-travel behavior. A first challenge regarding data collection is to collect larger scale data, without compromising the quality and depth of the presented method.

For instance, the social network questionnaire was completed by a relatively small subsample (116) of respondents. This restricted the number of explanatory variables in the models presented in chapter 5 and 6.2. In order to fully understand the relationship between social network composition and social activity-travel behavior, a larger sample would be desirable.

Moreover, the data on which the other analyses were based was collected using a two-day social interaction diary. Because of the short period (2 days) it provides only a small sample of people’s social activities. Social interactions with specific persons are only collected if they occurred within these two days. Moreover, repetitive patterns in social activities are not captured in such a short period. Although the maximum reasonable amount of response burden should be taken into account, it would be desirable to collect longitudinal diary data to get an impression of recurring activities and locations, including weekly routines of people. New GPS technologies provide a promising way of collecting longitudinal travel data without asking too much effort from respondents.

Another topic that deserves further research concerns the dynamics of social networks. The analyses presented in this dissertation assume a static social network. However, social networks change over time, as ties become stronger or weaker or even end, for instance after a lifecycle event such as changing home location. This is a topic that is now starting to appear in our field of research (Sharmeen et al., 2010).
Regarding the study of the effect of ICT on social activity-travel some future challenges remain as well. In this study ICT-use is defined as social interaction by telephone or via the Internet. It is thus limited to social interaction. The use of ICT’s for arranging a social trip (e.g. making reservations, buying tickets, checking routes, weather and travel conditions) were not taken into account, whereas this could clearly affect social travel behavior.

Moreover, although the data was collected recently, the possibilities of ICT’s have already increased since. For instance, 99% of the ICT-mediated social interactions collected were telephone calls and messages, emails and Instant Messaging. Other types of ICT-mediated social interactions, such as communicating through a social network site or forum, tweeting and online gaming were hardly recorded in the diaries. However, they are becoming more important. Future research into the effects of these forms of social communication is therefore desirable.

The study of the spatial distribution of social networks and social activities is another research challenge. In this study only the distances to the activity locations, and the distances between homes of ego and alters were captured. The specific addresses of the locations would clearly offer much more information on the spatial context of social activity locations and the spatial structures of social networks. Although it increases respondent burden, collecting data on geographical locations of alters and social activities seems possible (e.g. Frei and Axhausen, 2007; Carrasco et al. 2008a; Kowald et al., 2010).

A final, more specific future challenge is to focus specifically on senior citizens and their social activity-travel behavior. Many countries all over the world are experiencing a sharp rise in the ageing population. Older people have more leisure time compared to their younger (working) counterparts, and potentially spend more time on social activities. According to the results the elderly of today seem to be as mobile as their younger counterparts with respect to the number of social trips. Therefore, this group can possibly increase social travel demand.

On the other hand, the results indicated that the oldest age group on average has a smaller social network. Having a smaller social network might mean that senior citizens have less access to a variety of resources (Silvis and Niemeier, 2009), such as instrumental support (caring if they are sick, help with chores), emotional support or companionship, while they in particular rely on their social network to obtain these resources (Agneessens et al., 2006). Personal network analysis can therefore not only give relevant insights in the social activity-travel behavior of senior citizens, but can also raise the matter of accessibility, social capital and social equity.
References


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Appendix 1: Questionnaire

Deel 3: Vragenlijst

Dit is het laatste deel van dit interactie-dagboekje. In dit deel worden een aantal vragen gesteld over u en uw huishouden, uw ICT-gebruik en uw sociale netwerk.

We willen u eerst een paar vragen stellen over het dagboekje.

1. Op welke dagen heeft u het dagboekje ingevuld?

   Dag 1: ...........................................dag  ............-.............-2007
   Dag 2: ...........................................dag  ............-.............-2007

2. Was de eerste onderzoeksdag, waarop u het dagboekje heeft ingevuld, een normale dag voor u?
   (Het kan zo zijn dat u een andere dag had dan normaal, bijvoorbeeld omdat u ziek bent geweest of omdat u vakantie heeft gehad)

   □ Ja, het was een normale dag
   □ Nee, het was geen normale dag, namelijk:

   [Leeg vakje voor ingevulde gegevens]
3. Hoeveel tijd heeft u die dag besteed aan onderstaande activiteiten?

<table>
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<th>Minuten</th>
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</table>

4. Was de tweede onderzoeksdag, waarop u het dagboekje heeft ingevuld, een normale dag voor u?

- Ja, het was een normale dag
- Nee, het was geen normale dag, namelijk: 

5. Hoeveel tijd heeft u die dag besteed aan onderstaande activiteiten?

<table>
<thead>
<tr>
<th>Activiteit</th>
<th>Uur en</th>
<th>Minuten</th>
</tr>
</thead>
<tbody>
<tr>
<td>werken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>studeren</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reizen/verplaatsen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huishoudelijk werk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persoonlijke verzorging (slapen, douchen, aankleden, eten)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vrije tijd</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nu volgen er een aantal vragen over uzelf en uw huishouden.

6. Wat is uw postcode?

□ □ □ □ □

7. Hoe lang woont u al op uw huidige adres?

□ Minder dan 1 jaar
□ 1 tot 2 jaar
□ 2 tot 5 jaar
□ 5 tot 15 jaar
□ 15 jaar of langer

8. Wat is uw leeftijd?

□ □ jaar

9. Wat is uw geslacht?

□ Man
□ Vrouw

10. In welk land bent u geboren?

□ □ □ □ □ □

11. In welk land is uw vader geboren?

□ □ □ □ □ □ □

12. In welk land is uw moeder geboren?

□ □ □ □ □ □ □
13. Wat is uw gezinsituatie?

□ éénpersoons huishouden
□ (echt)paar zonder inwonende kinderen
□ (echt)paar met inwonend(e) kind(eren)
□ éénoudergezin
□ overig

14. Hoeveel personen van onderstaande leeftijdklassen zijn er in uw huishouden aanwezig? Inclusief uzelf

□ 0 tot 5 jaar
□ 6 tot 11 jaar
□ 12 tot 17 jaar
□ 18 tot 34 jaar
□ 35 tot 64 jaar
□ 65 jaar of ouder

15. Wat is uw positie in het huishouden?

□ Alleenstaande / ouder / partner
□ Inwonend kind
□ Overig

16. Wat is uw hoogst voltooide opleiding?

□ Geen opleiding
□ basisonderwijs
□ lbo/vbo/lts/vmbo
□ mavo/ulo/mulo
□ havo/mms
□ vwo/atheneum/gymnasium
□ mbo
□ hbo/bachelor
□ universiteit
17. Bent u momenteel nog bezig met een opleiding?

□ Ja
□ Nee (ga verder naar vraag 24)

18. Wat voor opleiding volgt u?

□ basisonderwijs
□ vmbo
□ mavo
□ havo
□ vwo/atheneum/gymnasium
□ mbo
□ hbo
□ universiteit

19. Hoeveel uur besteedt u gemiddeld per week aan uw opleiding op onderstaande plaatsen?
(Vult u alstublieft álle invulvelden in. Als u op een van onderstaande locaties geen tijd besteedt aan uw opleiding, vult u dan 0 in)

Op school/universiteit
□ uur per week

Thuis
□ uur per week

Elders
□ uur per week

20. Hoeveel dagen per week gaat u naar uw school/universiteit?
□ dagen per week

21. Wat is de gemiddelde reistijd in minuten tussen uw woning en uw studieadres?
□ minuten
22. Hoe gaat u meestal naar uw studieadres?
(Kiest u het hoofdvervoermiddel)
☐ auto als bestuurder
☐ auto als passagier
☐ trein
☐ bus/tram/metro
☐ brom-/snorfiets
☐ fiets
☐ lopend
☐ anders

23. Hoeveel mensen spreekt u gemiddeld per (school)dag op uw opleiding?
Ongeveer [ ] personen

24. Verricht u betaald werk?
☐ Ja
☐ Nee (ga verder naar vraag 30)

25. Hoeveel uur besteedt u gemiddeld per week aan betaald werk op onderstaande plaatsen? (inclusief overwerk, exclusief reistijd) laat u a.u.b. geen invulvelden open, vul eventueel 0 in

Op vast werkadres (niet thuis) [ ] uur per week
Thuis [ ] uur per week
Elders [ ] uur per week

26. Hoeveel dagen per week gaat u naar uw werk?
[ ] dagen per week
27. Wat is de gemiddelde reistijd in minuten tussen uw woning en uw werk?


minuten

28. Hoe gaat u meestal naar uw werk?
(Kiest u het hoofdvervoermiddel)

□ auto als bestuurder
□ auto als passagier
□ trein
□ bus/tram/metro
□ brom-/snorfiets
□ fiets
□ lopend
□ anders

29. Hoeveel mensen spreekt u gemiddeld per werkdag voor uw werk?
(Vult u eventueel 0 in, laat alstublieft geen velden open)


Collega’s


Klanten (gasten/bezoekers/leerlingen)


Leveranciers


Anderen

30. In welke categorie het netto maandinkomen van uw huishouden?

□ 1000 euro of minder
□ 1001-2000 euro
□ 2001-3000 euro
□ 3001-4000 euro
□ Meer dan 4000 euro
31. Hoe vaak doet u onderstaande activiteiten, en doet u ze dan meestal alleen of samen met anderen?

<table>
<thead>
<tr>
<th>Activiteit</th>
<th>Hoe vaak</th>
<th>Samen of alleen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nooit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 x per jaar of minder</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enkele keren per jaar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 of 3 x per maand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 x per week</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enkele keren per week</td>
<td></td>
</tr>
<tr>
<td></td>
<td>altijd alleen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>meestal alleen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>zowel alleen als samen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>altijd samen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>nvt</td>
<td></td>
</tr>
</tbody>
</table>

- Naar de kerk/moskee
- Naar een café/bar of terras
- Uit eten
- Naar een discotheek of houseparty
- Naar toneel/concert/musical/opera
- Naar een museum/galerie/tentoonstelling
- Naar een casino of speelhal
- Naar de bioscoop
- Naar een sportwedstrijd (kijken)
- Op vakantie
- Naar een pretpark
- Naar een sauna of beatysalon
- Naar de stad/winkelen
32. Wat is de afstand van uw woning naar de dichtstbijzijnde onderstaande voorzieningen?

<table>
<thead>
<tr>
<th>Voorziening</th>
<th>&lt;1 km</th>
<th>1 á 2 km</th>
<th>2 tot 5 km</th>
<th>&gt; 5 km</th>
<th>Weet niet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supermarkt</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Basisschool</td>
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</tr>
<tr>
<td>Huisarts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halte voor openbaar vervoer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sportvelden/sportvoorziening buiten</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sporthal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bibliotheek</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sociaal-cultureel centrum/buurthuis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Café/terras</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>restaurant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>discotheek</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>winkelcentrum voor niet dagelijkse boodschappen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

33. Wilt u voor onderstaande voorzieningen aangeven hoe tevreden u bent over het aantal van deze voorzieningen in uw directe woonomgeving en hoe tevreden u bent over de kwaliteit ervan?

<table>
<thead>
<tr>
<th>Voorziening</th>
<th>Tevreden over aantal?</th>
<th>Tevreden over kwaliteit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>eetgelegenheden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>café’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>jeugdvoorzieningen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ontmoetingsruimten</td>
<td></td>
<td></td>
</tr>
<tr>
<td>uitgaansgelegenheden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>culturele voorzieningen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

34. Heeft u een langdurige aandoening of handicap die u belemmert bij het verplaatsen/reizen?

- □ Ja, ik word daardoor sterk belemmerd
- □ Ja, ik word daardoor licht belemmerd
- □ Nee
35. Bent u in het bezit van een rijbewijs?

□ Ja
□ Nee

36. Heeft u de beschikking over een auto?

□ Ja, wanneer ik wil
□ Ja, in overleg
□ Nee

37. Welke vervoermiddelen zijn er in uw huishouden aanwezig?

□ Auto’s
□ Fietsen
□ Anders, namelijk: ..............................................
□ Anders, namelijk: ..............................................

38. Bent u in het bezit van een abonnement of kortingskaart voor het openbaar vervoer?

□ Ja, voor de trein
□ Ja, voor bus/tram/metro
□ Ja, voor zowel trein als bus/tram/metro
□ Nee, ik heb geen abonnement of kortingskaart

39. Hoe vaak gebruikt u onderstaande vervoerswijzen?

<table>
<thead>
<tr>
<th></th>
<th>nooit</th>
<th>&lt; 1 x per maand</th>
<th>1x x per maand</th>
<th>2x x per maand</th>
<th>&gt; 2 x x per maand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto als bestuurder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto als passagier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trein</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus/tram/metro</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brom-/snorfiets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lopen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

123
40. Beoefent u één of meerdere sporten?

☐ Ja
☐ Nee (ga door naar vraag 42)

41. Welke sporten zijn dat, doet u ze wel of niet bij een vereniging en hoeveel tijd besteedt u er aan?

<table>
<thead>
<tr>
<th>Welke sport?</th>
<th>Bij een vereniging?</th>
<th>Hoeveel uren per maand?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ja</td>
<td></td>
</tr>
<tr>
<td></td>
<td>nee</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ja</td>
<td></td>
</tr>
<tr>
<td></td>
<td>nee</td>
<td></td>
</tr>
</tbody>
</table>

42. Heeft u één of meerdere (andere) hobby’s?

(Bijvoorbeeld muziekinstrument spelen, zingen, dansen, toneelspelen, schilderen, tekenen, fotograferen, tuinieren, knutselen, handwerken, ‘doe-het-zelven’, iets verzamelen, puzzelen, (gezelschaps)spe- len, lezen, wandelen of fietsen)

☐ Ja
☐ Nee (ga door naar vraag 44)

43. Welke hobby’s zijn dat, doet u ze wel of niet bij een vereniging en hoeveel tijd besteedt u er aan?

<table>
<thead>
<tr>
<th>Welke hobby?</th>
<th>Bij een vereniging?</th>
<th>Hoeveel uren per maand?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ja</td>
<td></td>
</tr>
<tr>
<td></td>
<td>nee</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ja</td>
<td></td>
</tr>
<tr>
<td></td>
<td>nee</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ja</td>
<td></td>
</tr>
<tr>
<td></td>
<td>nee</td>
<td></td>
</tr>
</tbody>
</table>
44. Verricht u vrijwilligerswerk of mantelzorg?
(Bijvoorbeeld op het gebied van politiek, godsdienst, cultuur, sport, hobby, hulp of school, jeugd- of clubhuiswerk, buurtvereniging of buurtcentrum, vrouwenorganisatie, bejaarden- of gehandicaptenhulp, hulp in huishouding, beroeps- of vakorganisatie, vereniging voor mensenrechten, natuur- of dierenbescherming)

□ Ja  □ Nee (ga door naar vraag 46)

45. Om welk soort vrijwilligerswerk gaat het, doet u dat wel of niet bij een vereniging en hoeveel tijd besteedt u er aan?

<table>
<thead>
<tr>
<th>Vrijwilligerswerk?</th>
<th>Bij een vereniging</th>
<th>Hoeveel uren per maand?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>□ ja □ nee</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>□ ja □ nee</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>□ ja □ nee</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>□ ja □ nee</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>□ ja □ nee</td>
<td></td>
</tr>
</tbody>
</table>

46. Bent u actief lid van onderstaande verenigingen of organisaties?

<table>
<thead>
<tr>
<th>Actief lid?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Politieke partij of politieke vereniging □ ja □ nee</td>
</tr>
<tr>
<td>Vakbond of werkgeversorganisatie □ ja □ nee</td>
</tr>
<tr>
<td>Organisatie op het gebied van natuur of milieu □ ja □ nee</td>
</tr>
<tr>
<td>Organisatie met een specifiek maatschappelijk doel □ ja □ nee</td>
</tr>
<tr>
<td>Studie- of studentenvereniging □ ja □ nee</td>
</tr>
<tr>
<td>Vrouwenvereniging of -bond □ ja □ nee</td>
</tr>
<tr>
<td>Buurttvereniging of buurtcentrum □ ja □ nee</td>
</tr>
<tr>
<td>Organisatie op het gebied van godsdienst □ ja □ nee</td>
</tr>
<tr>
<td>Organisatie op het gebied van (thuis)zorg □ ja □ nee</td>
</tr>
<tr>
<td>Ander soort vereniging of organisatie, namelijk: □ ja □ nee</td>
</tr>
<tr>
<td>Ander soort vereniging of organisatie, namelijk: □ ja □ nee</td>
</tr>
</tbody>
</table>
47. Hoeveel uren per week besteedt u aan huishoudelijke bezigheden?
   (zoals opruimen, schoonmaken, wassen, strijken, boodschappen doen, koken, e.d.)

   [ ] uur per week

48. In welke mate bent u het eens met onderstaande stellingen?

<table>
<thead>
<tr>
<th>Stelling</th>
<th>Heel on</th>
<th>Opeens</th>
<th>Neutraal</th>
<th>Opeens</th>
<th>Heel on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ik heb te weinig tijd om contact te onderhouden met mijn familie/vrienden/kennissen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik heb vaak last van stress of werkdruk.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik zou graag meer tijd voor mezelf willen hebben.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik zou graag meer tijd voor hobby's willen hebben.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik heb een overvolle agenda.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik heb te weinig vrije tijd</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik moet in mijn vrije tijd vaak rekening houden met anderen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik kom in mijn vrije tijd niet toe aan dingen die ik eigenlijk wil doen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Het kost mij veel moeite om mijn vrijetijdsactiviteiten te plannen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Te veel van mijn vrijetijds-activiteiten zijn versnipped.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

De volgende vragen gaan over uw bezit en gebruik van ICT (internet en telefoon)

49. Hoeveel pc's/laptops zijn er in uw huishouden aanwezig?

   [ ] 0
   [ ] 1
   [ ] 2
   [ ] 3
   [ ] 4
   [ ] 5
   [ ] 6 of meer
50. Hoe vaak maakt u gebruik van een computer?
- (bijna) iedere dag
- enkele keren per week
- 1 keer per week
- 2 of 3 keer per maand
- 1 keer per maand of minder
- Nooit (ga door naar vraag 52)

51. Hoeveel uur per week maakt u gebruik van een computer?

[ ] uur per week

52. Heeft u thuis een internetaansluiting? Zo ja, wat voor een aansluiting?
- Nee, geen internetaansluiting
- Ja, via telefoonlijn en modem
- Ja, via ISDN
- Ja, via de kabel
- Ja, via ADSL
- Ja, weet ik niet
- Ja, anders, namelijk

53. Hoe vaak maakt u gebruik van internet?
- (bijna) iedere dag
- enkele keren per week
- 1 keer per week
- 2 of 3 keer per maand
- 1 keer per maand of minder
- Nooit (ga door naar vraag 62)

54. Hoeveel uur per week maakt u gebruik van internet?

[ ] uur per week
55. Hoe lang maakt u al gebruik van internet?

jaar

56. Kunt u aangeven hoe vaak u gemiddeld gebruik maakt van internet voor onderstaande activiteiten?

<table>
<thead>
<tr>
<th>Activiteit</th>
<th>Nooit</th>
<th>1 x per jaar of minder</th>
<th>enkele keren per jaar</th>
<th>2 of 3 x per jaar</th>
<th>1 x per maand</th>
<th>enkele keren per week</th>
<th>(bijna) iedere dag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gericht informatie zoeken</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funsurfen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-mail</td>
<td></td>
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</tr>
<tr>
<td>Msn</td>
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<tr>
<td>Chatbox</td>
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<tr>
<td>Iets kopen of bestellen</td>
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<tr>
<td>On line gaming</td>
<td></td>
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</tr>
<tr>
<td>Internetbankieren</td>
<td></td>
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</tr>
<tr>
<td>Discussieforum</td>
<td></td>
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</tr>
<tr>
<td>Downloaden van muziek/films</td>
<td></td>
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<tr>
<td>Bijhouden van een weblog of internetsite</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

57. Hoeveel e-mails stuurt u gemiddeld per week?

(Vult u eventueel 0 in; laat aub geen invulvelden open)

Voor privé-doeleinden

Voor zakelijke doeleinden

Als u geen gebruik maakt van Msn (Instant Messenger) gaat u dan verder met vraag 62.
58. Hoeveel contactpersonen heeft u op uw msn (Instant Messenger)?

Personen

59. Met hoeveel van deze contactpersonen heeft u minstens één keer per maand contact via msn (Instant Messenger)?

Personen

60. Hoeveel van deze contactpersonen heeft u nooit ontmoet?

Personen

61. Hoeveel gesprekken voert u gemiddeld per week via msn?

Voor privé-doeleinden

Voor zakelijke doeleinden

62. Bent u (persoonlijk) in het bezit van één of meerdere mobiele telefoon(s)?

□ Ja
□ Nee (ga verder met vraag 67)

63. Hoeveel mobiele telefoons heeft u persoonlijk?

<table>
<thead>
<tr>
<th>prepaid</th>
<th>Met abonnement</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 0</td>
<td>□ 0</td>
</tr>
<tr>
<td>□ 1</td>
<td>□ 1</td>
</tr>
<tr>
<td>□ 2</td>
<td>□ 2</td>
</tr>
<tr>
<td>□ 3 of meer</td>
<td>□ 3 of meer</td>
</tr>
</tbody>
</table>
64. Hoe lang heeft u al een mobiele telefoon?

   jaar

65. Hoe vaak maakt u gebruik van een mobiele telefoon voor onderstaande activiteiten?

<table>
<thead>
<tr>
<th></th>
<th>nooit</th>
<th>1 x per jaar of minder</th>
<th>enkele keren per jaar</th>
<th>1 x per maand</th>
<th>2 of 3 x per maand</th>
<th>1 x per week</th>
<th>enkele keren per week</th>
<th>(bijna) iedere dag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bellen</td>
<td>□</td>
<td>□</td>
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<td>Sms'en</td>
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<tr>
<td>Muziek luisteren</td>
<td>□</td>
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<tr>
<td>Spelletjes</td>
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<tr>
<td>Wekker</td>
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<td>□</td>
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<tr>
<td>Herrinering/agenda</td>
<td>□</td>
<td>□</td>
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<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

66. Hoeveel sms-berichtjes stuurt u gemiddeld per week?

   [□] Voor privé-doeleinden
   [□] Voor zakelijke doeleinden

67. Heeft u thuis een vaste telefoon?

   [□] Ja
   [□] Nee
68. Hoeveel keer belt u gemiddeld per week (met vaste en/of mobiele telefoon)?

☐ Voor privé-doeleinden

☐ Voor zakelijke doeleinden

69. In hoeverre bent u het eens met onderstaande stellingen?

<table>
<thead>
<tr>
<th>Stelling</th>
<th>Hoeaantal eens</th>
<th>oneens</th>
<th>neutraal</th>
<th>eens</th>
<th>helemaal eens</th>
<th>nvt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ik vind dat ik sociale contacten even goed kan onderhouden via telefoon als face-to-face.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Als ik minder zou bellen, dan zou ik ook minder behoefte hebben om met iemand af te spreken.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Als ik iemand bel, kan dit een bezoek aan hem of haar vervangen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Als ik iemand vaak bel, heb ik meer behoefte om bij hem/haar op bezoek te gaan.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Als ik minder zou bellen, dan zou ik mijn vrienden/familie vaker willen zien.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doordat ik iemand bel, heb ik meer behoefte om hem of haar vaker te zien.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Als ik iemand heb gebeld, heb ik vaak zin om met hem of haar af te spreken.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Als ik minder zou bellen, zou ik meer behoefte hebben aan face-to-face contact.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
70. In hoeverre bent u het eens met onderstaande stellingen?

<table>
<thead>
<tr>
<th>Stelling</th>
<th>Helemaal eens</th>
<th>Helemaal oneens</th>
<th>Neutraal</th>
<th>Oneens</th>
<th>Nvt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Als ik minder zou e-mailen/msn'en, zou ik mijn vrienden/familie vaker willen zien.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Als ik iemand e-mail/msn, heb ik vaak zin om met hem of haar af te spreken.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Als ik iemand vaak e-mail/msn, heb ik meer behoefte om hem of haar te zien.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Ik vind dat ik sociale contacten even goed kan onderhouden via e-mail/msn als face-to-face.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Als ik minder zou e-mailen/msn'en, zou ik minder behoefte hebben om met iemand af te spreken.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Door het gebruik van e-mail/msn, heb ik meer behoefte om mijn vrienden en bekenden te zien.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Als ik iemand e-mail/msn, kan dit een bezoek aan hem of haar vervangen.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Doordat ik e-mail/msn met iemand, heb ik minder behoefte om hem of haar te zien.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

71. Zijn er mensen die u heeft leren kennen via internet en waarmee u nu ook face-to-face contact heeft?

□ Ja, ongeveer [ ] personen
□ Nee

72. Hoe vaak gaat u op bezoek bij familie?

□ (bijna) iedere dag
□ enkele keren per week
□ 1 keer per week
□ 2 of 3 keer per maand
□ 1 keer per maand of minder
□ Nooit
73. Hoe vaak krijgt u bezoek van familie?

- (bijna) iedere dag
- enkele keren per week
- 1 keer per week
- 2 of 3 keer per maand
- 1 keer per maand of minder
- Nooit

74. Hoe vaak gaat u op bezoek bij vrienden/bekenden?

- (bijna) iedere dag
- enkele keren per week
- 1 keer per week
- 2 of 3 keer per maand
- 1 keer per maand of minder
- Nooit

75. Hoe vaak krijgt u bezoek van vrienden/bekenden?

- (bijna) iedere dag
- enkele keren per week
- 1 keer per week
- 2 of 3 keer per maand
- 1 keer per maand of minder
- Nooit

76. Hoe vaak spreekt u buren/buurtenoten?

- (bijna) iedere dag
- enkele keren per week
- 1 keer per week
- 2 of 3 keer per maand
- 1 keer per maand of minder
- Nooit
77. In hoeverre bent u het eens met onderstaande stellingen?

<table>
<thead>
<tr>
<th>Stelling</th>
<th>Helemaal onens</th>
<th>Oneens</th>
<th>Neutraal</th>
<th>Eens</th>
<th>Helemaal eens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ik voel mij helemaal thuis in de buurt waar ik woon.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik ken alle mensen in de buurt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik ben helemaal tevreden met de buurt waar ik woon.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik zou liever ergens anders willen wonen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

78. In welke mate bent u het eens met onderstaande stellingen?

<table>
<thead>
<tr>
<th>Stelling</th>
<th>Ja</th>
<th>Soms</th>
<th>Neen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ik heb mensen met wie ik goed kan praten</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik voel me van andere mensen geïsoleerd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik heb mensen bij wie ik terecht kan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik heb mensen die me echt begrijpen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik maak deel uit van een groep vrienden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ik vind mijn sociale contacten oppervlakkig</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

79. Hoe tevreden bent u met uw vrienden en kennissen?

- Buitengewoon tevreden
- Zeer tevreden
- Tevreden
- Redelijk tevreden
- Niet zo tevreden
80. Denk aan de mensen met wie u een heel sterke band heeft.

Dit zijn mensen - met wie u belangrijke dingen bespreekt,
- of waarmee u regelmatig contact heeft,
- of die er voor u zijn als u hulp nodig heeft.

Denkt u hierbij aan de leden van uw huishouden, (andere)familie, collega's of studiegenoten, buurtgenoten, verenigingsgenoten en andere vrienden.
(Noteert u eventueel voor uzelf hun namen).

Met hoeveel personen heeft u een heel sterke band?


personen

81. Denk nu aan de mensen met wie u een redelijk sterke band heeft.

Dit zijn mensen die meer zijn dan gewoon kennissen, maar waarmee u niet heel close bent.

Met hoeveel personen heeft u een redelijk sterke band?


personen

Dit is het einde van de vragenlijst. Hartelijk dank voor uw medewerking!
Waardebon

Als beloning voor het volledig invullen van dit boekje maakt u kans op een waardebon van € 25,-

Wilt u hieronder uw adresgegevens invullen zodat we u kunnen benaderen als u één van de winnaars bent?

<table>
<thead>
<tr>
<th>Naam</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adres</td>
<td></td>
</tr>
<tr>
<td>Postcode</td>
<td>Plaats</td>
</tr>
<tr>
<td>Telefoon</td>
<td></td>
</tr>
<tr>
<td>E-mail</td>
<td></td>
</tr>
</tbody>
</table>

Vervolgonderzoek

Voor het vervolg van dit onderzoek zijn we geïnteresseerd in de samenstelling van uw sociale netwerk. We zouden u graag een aantal vragen stellen over de mensen met wie u een heel sterke band heeft en over de mensen met wie u een redelijk sterke band heeft.

Mogen we uw adresgegevens gebruiken om u voor dit vervolgonderzoek te benaderen?

□ Ja
□ Nee

Vragen of opmerkingen

Indien u nog vragen of opmerkingen heeft, kunt u die hieronder kwijt.

Nogmaals hartelijk dank voor uw medewerking!
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Social Activity-Travel Patterns: The Role of Personal Networks and Communication Technology

Social activities are responsible for an important portion of trips and they constitute the fastest growing segment of travel. Moreover, social activities and mobility are important aspects of people’s quality of life. Therefore, social activities are important for transport planners to take into account. As social activities involve meeting with other persons at a certain time and location, the spatial-choice behavior for social activities is critical for successful urban design and planning.

Over the last decades, researchers have attempted to explain individual (social) travel behavior as a result of socio-demographic and land-use variables. However, recently, it has been acknowledged that other variables that offer opportunities for social mobility have to be added. As social travel demand is derived from a wish or need to perform activities with other people, it is important to incorporate social networks into the study. Moreover, social activities are likely to be influenced by the use of new information and communication technologies (ICT’s), as these ICT’s offer new possibilities for the maintenance of social networks that are becoming more geographically spread. Knowledge about the relationship between ICT’s, social networks and social activity-travel behavior is rather limited. In order to assess future transportation needs for social activities, research is needed. The aim of this dissertation is therefore to study the way in which social activity-travel patterns are influenced by people’s personal characteristics, properties of the built environment, ICT-use and social networks.
To that end, a data collection instrument was designed. The instrument consists of a two-day paper-and-pencil social interaction diary a questionnaire on personal characteristics and a follow-up questionnaire on personal social network members. The social interaction diary captured data on ICT-mediated social interactions, as well as face-to-face social activities and travel for these activities. In addition, the social interaction diary was used to collect data on the people with whom the respondents interacted during those two days, including age, gender, social category, distance and frequency of communication with different modes. In addition to the social interaction diary a questionnaire was designed to gather data on the respondents’ personal and residential characteristics. To allow the estimation of the impact of the built environment a requirement for the data collection was to secure sufficient variation in characteristics of the built environment. To this end, the sample was stratified by urban density. The data were collected between January and March 2008 in the region of Eindhoven, among 747 respondents, aged 15 or over.

To capture the respondents’ social networks, a follow-up questionnaire was used, which was mailed to a subsample of the respondents. In this social network questionnaire, respondents were asked to record information on all their social network members, including gender, age, social category, how long they have known each other, distance to their homes and the frequency of interaction with each alter by different modes (face-to-face, telephone, SMS, e-mail, IM). The social network questionnaire was completed by 116 respondents.

Quantitative analyses were performed on the data. The analyses focus on exploring and testing multivariate relationships in the data. Analyses were carried out to examine the effects of personal characteristics and properties of the built environment on size and composition of social networks; contact frequency and choice between different communication modes, and social activity-travel patterns. The analyses also explored to what extent and how the nature and strength of the relationship between personal characteristics and properties of the built environment and social activity-travel patterns is mediated by ICT-mediated communication and characteristics of social networks.

Regression and discrete choice models were used to predict one dependent variable as a function of one or more independent variables. To analyze simultaneously the direct and indirect dependencies between use of communication technology, social networks and activity-travel patterns, a structural equation approach was used. Because the data have a hierarchical structure (individuals (egos) have multiple alters or interactions), multi-level analysis was used.

The estimation results of the models allow us to reconstruct the generation of social activities and travel demand for social purposes. The empirical results suggest that the built environment, ICT-use and social networks all play an important role in the generation of social activity-travel and have to be taken into account in transport policy.
Curriculum Vitae

Pauline van den Berg was born on February 1st, 1980, in Bergeijk, the Netherlands. After finishing pre-university education in 1998 at Rythovius college in Eersel, she studied Cultural Anthropology at Catholic University of Nijmegen. She graduated in 2002.

From 2002 to 2007 she studied Architecture, Building and Planning at Eindhoven University of Technology. She graduated in 2007 within the Urban Planning Group. Her graduation project dealt with the design of a data collection instrument for collecting data on social networks, ICT and social activity-travel patterns.

After her graduation she continued her research on the role of social networks and ICT in social activity-travel patterns at the Urban Planning Group in a PhD project of which the results are presented in this dissertation.

Her research interests are in the areas of human behavior and its social and cultural context, urban and transport planning, activity-travel behavior and data collection techniques.