Communication Technology and Travel Demand Models

Maria Börjesson

Division of Systems Analysis and Economics
Unit for Transport and Location Analysis
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Abstract

Transportation planners have traditionally focused on physical travel only, and disregarded the fact that other modes of communication may influence travel demand. However, modern telecommunications are rapidly increasing the accessibility to activities that previously only could be reached by physical transportation. This development calls for methods to analyse interactions between telecommunications and transport systems. The objective of this thesis is to accomplish a better understanding of if and how impacts of information technology could be implemented in travel demand models. An important part of this issue is to investigate what kind of data that is needed.

This thesis also aims at investigating whether the Communication Survey, KOM, collected by Swedish Institute for Transport and Communications, SIKA, can be used to improve transport modelling with respect to how modern telecommunications influence travel demand. KOM is a one-day travel and communication diary survey, including information on the respondents telecommuting habits as well as socio-economic status. One problem was the small sample size in KOM, which made the analyses uncertain. Since KOM is collected on a yearly basis, it is still possible to apply similar analysis methods within a few years, using a larger data set, which might enable extended analyses. The small sample in KOM available to date is best suited for general descriptive analyses of communication patterns in Sweden. The main conclusions of the paper are therefore connected to the methods and future data collection.

The thesis includes three papers. The first paper tested a model approach that assumes substitution between travel and non-travel based communication, using the KOM database. Travel demand models are in general constructed as nested logit models with frequency, mode and destination choice levels. In the paper, non-travel based modes of communication were included in the choice set of such a model. The non-travel based modes of communication considered were Internet (and e-mail), ordinary mail and telephone contacts. The model was developed for post and bank activities only, since that was the only activity for which the numbers of contacts and trips were large enough to allow model estimation. Several conclusions could be drawn. Describing the utility of the non-travel based alternatives is difficult and needs more research. The analysis is also very sensitive to how activities are defined. It is further essential that the data collection is more process oriented than traditional cross-sectional data is when analysing travel and telecommunications interactions. That is, habits of performing particular activities, including both trips and different types of contacts, must be studied.

The second and third papers investigate telecommuting. As a first step to reach the goal of forecasting telecommuting, the second paper examined the characteristics
of current telecommuters by use of KOM. This was mainly accomplished by estimating a telecommuting adoption model of logit type. However, only 122 employees out of 7578 actually telecommutes full days at home. These telecommuters work primarily in information- and service-based industrial sectors concerned with computers, finance or communication. The difficulties in describing the utility of the telecommunications based alternatives (representing "no travel") concerned also the telecommuting adoption model. Also impacts on travel from telecommuting were investigated. Comparing the average commuting distance showed that employees who exclusively telecommute full days have longer commuting distances than others, but that other telecommuters do not have longer average commuting distances. Telecommuting in general does not seem to be influenced by low accessibility to the labour market.

The third paper used data collected from a working site within the company Ericsson, located in the office district of Nacka Strand in Stockholm during the autumn 2002. The telecommuting frequency was substantially higher at Ericsson than in the workforce as a whole. The propensity to adopt telecommuting was modelled as a function of socio-economic variables and access to technical equipment, work task suitability and management attitudes, as perceived by the employees. The focus was to identify tools that the company can use to promote telecommuting, and to find incentives for the company to promote telecommuting. Technical equipment, suitable work tasks and managers attitude were identified as constraints for telecommuting. The employees also perceived that they became more efficient and saved time when telecommuting.
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## List of papers:  

(I) Börjesson M., 'A Communication Choice Model’.  

(II) Börjesson M., 'Telecommuting and work travel demand modelling in Sweden’.  


1. Introduction

Transportation planners have traditionally focused on physical travel only, and disregarded the fact that other modes of communication may influence travel demand. However, modern telecommunications are rapidly increasing the accessibility to activities that previously only could be reached by physical transportation. This development calls for methods to analyse interactions between telecommunications and transport systems. These interactions are complex, as they are probably highly dependent on, for instance, psychological and economical factors and access to information about new alternatives. The process is further lagged in time. That is, human behaviour changes much slower than the development of telecommunications services and facilities.

The objective of this thesis is to accomplish a better understanding of if and how information technology impacts should be implemented in travel demand models. An important part of this is to investigate what kind of data that would be needed.

The data primarily used in this thesis is a one-day travel and communication diary survey called the Communication Survey (KOM). KOM is collected by the Swedish Institute for Transport and Communications (SIKA) on a yearly basis. Communication is defined as transmitted contacts by mail, e-mail, phone, cell phone, Internet, fax or video and teleconferences. KOM further includes traditional socio-economic and geographic data, but also data concerning access to telecommunications equipment and telecommuting habits. This data is collected partly for modelling purposes. Until now, however, KOM has not been used for estimation of travel and communication behaviour models. It is thus desirable to investigate to what extent such modelling works in practice. The second aim of this thesis is therefore to identify the strengths as well as the weaknesses of KOM, as a data sample suitable for model estimation. This knowledge is valuable for future collection of data, to be used for estimation of integrated contact and travel demand models.

When analysing travel and telecommunications interaction, it is worth emphasizing that telecommunications are not new. For instance, the telephone has already influenced both land use and travel patterns. The question is to what extent the specific characteristics of modern telecommunications may have a further impact.
2. Scope of the present thesis

This thesis considers how the demand for transport is influenced by telecommunications-based services and applications. Telecommunications and travel demand interactions are often categorised as (Mokhtarian and Meenakshisundaram, 1999):

*Substitution*: Telecommunications replace travel.

*Generation*: Telecommunications stimulate or complement travel, for instance by increasing access to information.

*Modification*: Telecommunications neither generate nor substitute travel, but change the travel pattern, for instance by time, mode or route.

*Neutrality*: The use of telecommunications and travel is not influenced by each other.

*Indirect (or rebound) effects*: The above described effects influence the travel demand and land use in a longer perspective. For instance, the option to telecommute on a regular basis may increase the acceptance of longer commuting distances, and hence land use.

It is worth pointing out that these effects are not mutually exclusive. The interactions between travel demand and telecommunications are ruled by different mechanisms, depending on the activity and of the actors involved. Analysis should be adjusted with respect to this. Activities that require transportation or telecommunications are usually divided into four categories with respect to the involved actors. C stands for Consumer and B stands for Business. The scope of this thesis is restricted to the first two categories, and the others will not be further mentioned. Paper one, ‘A communication model’, focuses on substitution effects of postal and banking activities. Paper two, ‘Telecommuting and work travel demand modelling in Sweden’, and paper three, ‘Incentives for promoting telecommuting - A case study in Stockholm’, consider telecommuting. Both substitution effects and indirect effects are analysed in paper two.

**C2B: Labour force: Flexible working arrangements and mobile working**

As an increasing number of people are working in the service sector, home computers and Internet access have increased the possibility of flexible working arrangements (Golob and Regan, 2001). Flexible working arrangements refer to the spatial and temporal flexibility of working at home or at a remote centre. Home-based and mobile information technology has also improved the possibilities for self-employed by increasing the efficiency of communication with clients, suppliers and collaborators. In this thesis, the flexible work arrangement telecommuting is only considered.
B2C: Services and products: online shopping, e-booking, tele-medicine, e-banking etc.

Few e-commerce observers believe that online shopping will replace a large proportion of ordinary shopping. Shopping is often linked to other activities and involves social contact and recreation. However, online shopping may become more attractive in the future. Largely, this is dependent on prices and how technology advances. Golob and Regan (2001) note that as shopping stands for such a large part of travel, even a small part of substitution can have a vast effect on transport. Online grocery shopping is hypothesised to be important for travel and activity behaviour because it is a repetitive kind of shopping. It may be particularly important to working mothers (Gould, 1998).

For any type of shopping, Internet may be used as a search tool to compare prices and products. This might have extensive effects on transport behaviour, although it is hazardous to predict the net effects. In addition to online shopping, Internet can be used for many other types of service, although banking is the most successful Internet-based services so far. One reason is probably that banking seldom is carried out for pleasure or recreation, as shopping may be. Another reason may be that the price difference between the (cheaper) communication-based service and the more expensive visit-based service often is large. In paper one in this thesis, tele-banking was investigated as a pilot example of telecommunications-based household service adoption. Primarily the substitution effect was considered.

C2C: Social contacts: Internet, e-mail and mobile phones

Social relations and the connected travel and telecommunications interactions are of a complicated nature. The telephone has for a long time played a dominant role in social relations and related travel and land use. New technology, for instance cell phones and e-mail, are the next step in this development. However, these relationships are very complex and should be investigated separately in a sociologic framework.


Business travel is highly dependent on social relations. It is therefore difficult to assess how business travel is influenced by telecommunications. Tele- and videoconferences are yet rare, for instance, only 8% of the companies in Sweden have such equipment (SIKA, 2002).

Information- and communications technology also offers a possibility to increase the efficiency of the existing infrastructure supply. Such functions are named ITS (Intelligent Transport Systems) and include a) technology aimed to directly increase the efficiency of the traffic system and b) technology aimed to influence the passenger demand in such a way that the road capacity is optimally utilized (Polydoropoulou and Ben-Akiva, 1999). The first type includes traffic- and cruise
control systems as well as safety systems. The latter refers to automatic debiting systems and user-friendly traffic information systems. Such information systems are referred to as ATIS (Advanced Traveller Information Systems). Since this thesis is focused on telecommunications that influence the demand for transport, ITS functions are not fully considered here.

3. Literature

The discussion about whether telecommunications substitute passenger transportation has been appearing in transport literature since the 1970s. According to Mokhtarian (1998) the oil crisis was the start of it all, which coincided with the start of the information era. Niles et al. (1976) was one of the first studies in the field. Since then, an extensive body of research has been produced in the field. The vast majority of this has concentrated on telecommuting, often in pilot projects. However, other application-specific services, such as tele-shopping, and teleconferencing have also been addressed.

The field can be divided into empirical studies and behavioural model studies. There have also been studies that Salomon (1998) calls 'armchair studies', which mainly expose ideas for future research. He emphasises that such studies are important, but must not be confused with forecasts. One example of this is Grübler (1989), who shows how different technologies have come and disappeared in S-shapes since about 1800, with increasing frequency. He argued that the length of canals, railroads and surface roads, relative to their saturation level, all followed a S-shaped pattern. Grübler then implies that this development can be used to forecast new types of technology, which is just what Salomon objects to. Mattsson and Höjer (2000) also criticise Grübler for this reason, and further question the quality of the data he uses.

Considering correlations between amount of transport and telecommunications, which have been found in many studies, the general problem is to prove a casual relationship. Mokhtarian and Salomon (2002) stress that such correlation just as well may be due to a third party correlation.
Empirical studies

Mokhtarian and Salomon (2002) divide all empirical studies into three classes: The macro scale comprehensive approach, the micro scale application specific approach and the micro scale comprehensive approach, which is characterised by a disaggregate analysis that is not application specific, but has a wider perspective.

The macro scale approach analyses the telecommunications and transport sectors on an aggregate level. The advantage of this approach is that it gives an understanding of the development in the large perspective and the disadvantage is that it gives no explanation of the underlying mechanisms (Mokhtarian and Salomon, 2002).

An example of this kind of studies is Plaut (1997), who studies the demand for travel and telecommunications in different industrial sectors in 9 Western-European countries. Input-output methodologies and formal statistical tools were used. The relationship between the use of telecommunications and transportation services was computed by Spearman correlation. The correlation was positive, indicating that the complementary effect dominates over the substitution effect. This was true for all sectors, and also in all sub-sectors of the transportation service industry.

Grübler (1989) collected historical data on the amount of communication and transport in France, from 1825 to 1985. Travel was measured by number of passenger-km and communication was measured by number of transmitted messages. He presented the amount of communication and transport in the same graph, as a function of time. Grübler then argued that the curves are parallel which implies a casual relationship between communication and travel. The conceptual explanation is that increased opportunities to contact others and acquire information increase the need for, or wish to, travel. However, Höjer and Mattsson (2000) find several weak points in Grübler’s analysis. They show that the non-linear scale of the y-axis and the choice of base year that Grübler chose significantly exaggerate the relationship between transport and communication. For instance, communication has increased much faster than travel from 1975 to 1985. The quality of the data can also be questioned. For instance, the definition of communication was not constant during the measurement period. Finally, the argument that a correlation proves a casual relationship is weak, and should not provide a base for forecasts.

The application specific approach considers an isolated application, and it is the most common type of analysis approach. Applications are such as telecommuting, tele-shopping and teleconferencing. Below, telecommuting and tele-shopping studies will be briefly reviewed, and studies concerning other application specific
services will be omitted, since they are beyond the scope of this thesis. Most
application specific studies are short-term, and therefore tend to overestimate
substitution effect and underestimate generation effects that tend to be more long-
term (Mokhtarian and Meenakshisundaram, 1999). The nature of the studies,
isolating the applications, can also add to overestimation of substitution effects, as
trips with other purposes may be generated. On the other hand, narrowing the
focus may be necessary in order to deepen the studies enough.

As mentioned, studies of travel related impacts on telecommuting have been
considered for nearly three decades, often in pilot projects. Normally studies on
travel impacts on telecommuting use multi-day travel-diary surveys, collected
some time after the program has started, and sometimes also before. A control
group of non-telecommuters is often used for comparison. Indications of the travel
pattern, such as number of trips and length of trips for different modes are often
used to analyse the travel impacts.

In these studies results diverge somewhat for non-commute travel, but the most
dominant effect seems to be a total reduction in commute travelling, causing a net
impact of travel substitution. However, Niles (1991) found that the total amount of
travel did not decrease due to telecommuting, but that the use of car for
commuting decreased. Balepur et al. (1998), on the other hand, found an increased
car-use for commuting due to more travel outside rush time, but still a net
reduction of transport. In many of the earlier studies, the substitution effect is

In a Swedish study, Skåmedal (1999, 2000) found lower substitution due to more
half-day telecommuting. A large share of half-day telecommuters was also found
in another Swedish study carried out by SIKA (1998:4). Skåmedal found little
evidence for indirect long-term impacts such as on land use or on car ownership,
which is in accordance with Mokhtarian and Salomon’s (2002) observation that no
significant effect on residential location has been proved to date. Skåmedal points
to the fact that Mokhtarian (1998) found that telecommuting is often adopted for a
limited time, normally 17-24 months, which may be one explanation for the small
long-term impacts. If telecommuting becomes a more permanent arrangement,
these effects might be larger.

Based on the state-of-art, Mokhtarian (1998) concludes that telecommuting will
probably not result in a significant reduction of travelling. On the other hand,
telecommuting may cause daily travel to become more flexible and allow more
leisure travel. Latent or induced demand is further likely to increase, if
telecommuters avoid travelling, especially during rush hours.
Because trips for household maintenance constitute a large share of all shopping trips, much of the research has focused on on-line daily shopping (Golob and Regan, 2001). Koppelman et al. (1991) show that tele-shopping primarily is perceived as an electronic catalogue, and is not likely to substitute store shopping but rather catalogue shopping. However, as the tele-shopping alternative is becoming user-friendlier and more similar to store shopping, this may change. Still, Mokhtarian and Salomon (2002) remark, the attitudes towards in-home and out-of-home shopping are likely to change more slowly than the services. The preferences and attitudes are further varying extensively in the population, requiring segmentation when carrying out analyses. Gould (1998) concludes that working mothers are more inclined to use tele-shopping services than others. Tacken (1990) shows that older people (because of low mobility) and families with more than one worker (because of lack of time) were more prone to use tele-shopping services in a study from the Netherlands.

Mokhtarian and Salomon (2002) hypothesise several possible travel related impacts from tele-shopping activities, for instance because shopping is often trip-chained. Using Internet as a search tool may change shopping destinations. Times of shopping are also likely to change, as the time-restrictions are relaxed. Freight travel is, of course, generated through home-delivery. If the frequency of shopping increases, with the requirement of fast delivery, this could add to the total amount of transport. These possible relationships point to the fact that tele-shopping will neither have any vast effect on reduction or stimulation of travel as they are likely to cancel out.

Disaggregate analysis that is not application specific often analyses the number of, or the time spent on, each mode of communication, often over some time. The purposes of communication are in general not considered. For instance, Mokhtarian and Meenakshisundaram (1999) have used time-dependent structural equation modelling, in order to model the impact of five modes of communication (phone, fax, e-mail, sending an object and personal meetings) and the number of trips on themselves over time. Socio-economic factors were controlled for in the analysis, and seasonal dummies were included. A significant positive cross-mode correlation was found over time for all modes of communication except physical object. The result thus indicated a net complementary effect and all modes of communication except physical object had also increased over time.

Zumkeller (2002) has compared physical mobility and the amount of communication in different segments of the population. He made the distinction between trips and contacts and collected cross-sectional data in order to measure these. A diary survey was developed to collect information on purpose, where the activity occurred and distance to the location for each contact. Similar data was collected for all trips. Zumkeller showed that people with high physical mobility
also tend to have a high level of telecommunications use, and he therefore draws the conclusion that the complementary effect outweighs the substitution effect.

On the basis of the Norwegian national personal travel survey 1997/1998, and a connected survey on the use of information technology, Hjorthol (2002) studied the relationship between mobility and the use of home computers. Hjorthol argues that a net generation, i.e. complementary, effect would have been indicated, if finding a positive correlation between car use and use of a home computer. Car use and use of a home computer was in fact significantly correlated, but not correlated if controlling for income. The correlation was thus in this case due to a correlation with the third factor income. It was shown that men and high-income groups more often have home computers and use cars more frequently. Thus, neither a complementary effect, nor a substitution effect, could be verified.

Bhat et al. (2003) used a hazard-based duration structure to investigate two forms of information and communication technologies (ICT) impacts on travel for non-daily shopping. The ICT use was measured by the availability of a mobile telephone and whether the individual had access to personal email at home. Hence, these measures were less rigorous than what, for instance, Mokhtarian and Meenakshisundaram (1999) used, because of restrictions set by the data. The data consisted of a six-week activity-travel diary collected in Germany, 1999. The travel impact was measured by the duration time between out-of-home shopping occasions. To capture the true influence of ICT use on travel, the impact of ICT use was endogenous in the model. That is, they controlled for the fact that unobserved factors may influence ICT use and duration between out-of-home shopping activities in the same direction. The result pointed to the fact that unobserved factors in fact do increase both ICT use and out-of-home shopping. Ignoring this fact would have resulted in an underestimation of the substitution effect. This may be one reason for the weak substitution effect found in some studies, not controlling for effects of either unobserved or observed factors.

**Behavioural modelling studies**

Most behavioural modelling studies concern telecommuting. Mokhtarian and Salomon (1994, 1996 and 1997) have developed a model framework, in which they model the choice and the preference to telecommute separately. The gap between the preference and the actual choice that they observe is attributed to lack of external facilitators or constraints (such as family, unsuitable work tasks, a negative attitude from employer or lack of space at home). A negative preference to telecommute is primarily attributed to internal constraints (such as a need of personal interaction or other psychological factors) or weak lifestyle related drives (like long-term objectives related to family, work or hobbies etc). They found that
attitudinal factors measuring drives and constants are superior to factors revealing objective socio-economic status. Socio-economic status factors are often used as proxy variables for attitude related factors, but are often too coarse to capture them. Also, a socio-economic variable like children in the household may work as a proxy variable for a drive (to spend less time travelling) and a constraint (household distractions at home), and thus outweighing the effect of it.

The variables that have been used in models of telecommuting adoption are primarily related to household structure and work. In some cases also work travel and policy related variables have been included. As transportation planning increasingly has come to deal with policy measures, of which telecommuting is one, it is an important task to find measures to promote telecommuting rather than just to forecasting it. Nevertheless, few modelling studies actually include any wider range of policy related variables, because that often requires stated preference (SP) data, which brings about other disadvantages stated below. Examples of policy related variables included in the studies referred below, using revealed preference (RP) data, are to be able to borrow a computer from the employer (Mannering and Mokhtarian, 1995) and if required to pay to park at work (Popuri and Bhat, 2003).

Mannering and Mokhtarian (1995) have developed an MNL model of the choice to telecommute using RP data. In this study they distinguished between “never telecommute”, “low-telecommuting frequency” (less than once/week) and “high telecommuting frequency” (more than once/week). Bagley and Moktharian (1997) used a similar approach, but made a distinction between home- and centre-based telecommuting, although the centre based work form was rare in the referred study. Drucker and Khattak (2000) compared ordered logit, ordered probit, and multinomial logit models, modelling the choice to telecommute with the choice set following Mannering and Mokhtarian. The ordered models did not seem to increase the model fit substantially. Popuri and Bhat (2003) have developed a joint discrete choice model of home-based telecommuting adoption and frequency (number of days per week) choice, using RP data. They estimate different utility functions for the telecommuting frequency choice and the choice to adopt telecommuting at all. Graaf and Rietveld (2002) have applied a slightly different approach and modelled the determinants of time spent on in-home and out-of-home paid work, respectively, using a bivariate regression model and RP data.

There are several studies based on SP data, which have revealed much of the telecommuting adoption process (Sullivan et al, 1993 and Moktharian and Salomon, 1997). Due to the large number of employees who report that they would prefer to but do not in fact telecommute, however, RP data gives a more realistic picture of telecommuting when it comes to forecasting.
hand, a small number of telecommuters in the sample is often a problem when using RP data.

Brewer and Hensher (2000) argue that it is particularly important to investigate the interaction between employees and employers more in depth. This interaction may be the explanation for the gap between the stated and the revealed preference for telecommuting, as it is clearly not only the employee who decides to telecommute but also the employer. They propose an interactive game-theoretic approach to model the telecommuting adoption, including bargaining, negotiation and arbitration.

The number of behavioural models concerning other application specific services is much smaller. However, Timmermans et al. (undated) modelled the adoption of tele-shopping using logit models.

Ben-Akiva et al. (1996) observe that information technology may influence travel behaviour in two ways, by offering new activities and by supplying current information. They suggest that these new opportunities could be integrated in the structures of mode and destination choice in conditional travel demand models. For instance, new activities could be integrated by adding new telecommunications-based alternatives in the choice set. Salomon (1998) stresses that such a framework allows a comparison of the advantages and disadvantages of the traditional and the new technology-based activities. An absolute condition is that a broader set of factors, in addition to time and costs, are taken into account.

Salmon and Mokhtarian (2002) list a number of factors that should be included in a behavioural model of the adoption of telecommunications-based services, to measure the utility of the alternatives. They argue that a given activity may answer a number of purposes beside the main purpose. Both alternatives based on telecommunications and on travel should therefore be described with respect to all these qualities of the purpose. These include a social, psychological and aesthetic content as well as quality and personal characteristics, in addition to time and cost. Such a model would show how the individuals, by utility maximization, make trade offs between the alternatives based on telecommunications and travel. Salmon and Mokhtarian remark that this kind of framework is application specific, but that more complex model structures may be applied to model a whole day’s decisions, in order to analyse the travel impact more comprehensively.

Bowman and Ben-Akiva (2000), have developed a prototype hierarchical nested logit model system of this kind, for Portland, Oregon. The model is based on the concept ‘activity pattern’. Each activity pattern was defined by a primary activity, primary tour type and by number and purpose of secondary tours. Primary activity was defined as ‘work’, ‘school’ or ‘other’. The choice set of activity patterns
contained 55 alternatives, including one stay-at-home-pattern, 30 ‘work’ patterns, 12 ‘school’ patterns and 12 “other” patterns.

Since the decisions of activities and tours are assumed to be simultaneous, all tour related decisions are conditioned of a given activity pattern and the secondary tour decisions are conditioned on the chosen primary tour. By including the maximum expected utility at the higher choice levels, the lower choice levels influence the utility of the alternatives higher up in the model system. The choices considered for each primary and secondary tour are time of day, destination and mode. If having access to data including information on telecommunications-based activities, these could theoretically be included at all these levels. This would enable analysis of effects of telecommunications with respect to a whole day’s travel pattern. For instance, the model may include an activity pattern with the primary activity “work” to be conducted at home, which would thus include secondary tours only.

An advantage is that the model may be integrated with other components of forecasting model systems, including the transport supply and land use. The model system may be estimated with travel (and communication) diary surveys, like present forecast models. The disadvantage is that the model is very complicated since the number of alternatives of an activity pattern is immense. To define and describe the telecommunications-based alternatives also requires very detailed data.

Hensher and Golob (2002) proposed a framework in which activities take place in the ‘communication space’ and are characterised by multi-dimensional vectors including physical, social, material and aesthetic content. The individuals then maximize their utility with respect to all these dimensions, when choosing an activity. In this framework, the ‘mix of content’ differentiates broader defined activities, which may include whole sets of trips and contacts. For instance, the activity ‘shopping’ could include both sending an order to a store by the Internet and drive there later to pick up the commodities.

Hensher and Golob further point to the fact that cross-section data do not provide sufficient information to understand the adoption of certain activities and therefore the travel behaviour. As the behavioural response to the technology-led transition is slow, a framework in which cohort effects, period effects and adoption cycles can be analysed is needed. Panel data is therefore essential.
4. Data and methods

4.1 Data

No data has been collected specifically for paper one and paper two of this thesis. Data collection is an expensive and time-consuming process. Therefore, an existing database, KOM, was used. Nevertheless, the design and the quality of the data are essential for the analysis. One of the objectives of this thesis was therefore to identify strengths and weaknesses of KOM, as a database for modelling-based analysis of travel and telecommunications interactions. The conclusions from this experiment may improve the design of data collection for future studies.

KOM is a one-day travel and communication diary survey, carried out on commission of the Swedish Institute for Transport and Communications Analysis (SIKA). Each respondent was to report all performed trips and contacts during one day. Contacts were defined as communication by mail, e-mail, phone, cell phone, Internet, fax or video and teleconferences. Up to 30 outgoing contacts were registered for each respondent. Incoming contacts were not collected at all. For each contact the registered data included, except mode of communication, purpose, start time and duration and place where the contact was taken. Similar data was collected for each trip. KOM further included traditional socio-economic and geographic data but also data concerning access to as well as experience of computers and telecommunications equipment. The data was collected from randomly selected individuals between 15 and 84 years old. The response rate was about 67 percent. For a more detailed description, see the technical report of KOM (Tomth, 2001).

In the first paper, KOM data from 1999 and 2000 was used. These databases included 2405 observations altogether. In the second paper, concerning telecommuting, the data collected during 1999 could not be used because this data set lacked some important information. Instead KOM data from 2000 and 2001 was mainly used. The reason for not using the data set collected during 2001 in paper one, was that only part of this data set is available to date. The total number of observations in KOM 2000 and 2001 was 3339.

In both studies, the database RES from year 1999 and 2000 was used as a complement to KOM. RES is a one-day travel-diary survey similar to KOM, but not including contact data. RES is also collected on commission of SIKA and includes the same information on the respondents travel behaviour, telecommuting habits and socio-economic status as KOM. The target populations in RES and
KOM were identical except a slight difference with respect to age group. In KOM, the target population consisted of Swedes between 15 and 84 whereas the target population in RES consisted of Swedes between 6 and 84. For a more detailed description of RES, see the technical report (SIKA and SCB, 2001).

A disadvantage of using KOM and RES when studying telecommuting was the small number of observed telecommuters. In a data set collected at one working site within the company Ericsson, located in a business district in Nacka Strand, Stockholm, the share of telecommuters was extensively higher, since telecommuters are over represented in certain sectors of the industry. The response rate was lower than in KOM, approximately 55%, which was considered remarkably high in comparison to previous surveys carried out in the company. However, only 65% of the returned questionnaires could be used in the analysis, as partial non-response was extensive. Unfortunately, this data did not include any information concerning residence location or commuting distances.

4.2 Methods

In this thesis, primarily logit and nested logit models have been used. For a reference, see Ben-Akiva and Lerman (1985). The software package ALOGIT was used in all studies.

In paper one, a nested logit model of travel and contact substitution was estimated. Travel demand models are in general constructed as nested logit models with frequency, mode and destination choice levels. In this work, non-travel based modes of communication were also included in the choice set of such a model, as suggested by Salomon (1998) and Ben-Akiva et al. (1996). The included modes of contact were Internet, mail and telephone. The model is schematically presented in figure 1. Only post and bank trips and contacts were included in the model, as that was the only activity for which the number of contacts was large enough to allow model estimation given the available data set. The basic assumption of the model approach was that travel and contacts are substitutes although they do not lead to exactly the same activity.
In the second paper segments of the working force with higher propensity to telecommute were identified. A K-means cluster analysis was first carried out using SPSS. This descriptive method was used to supplement the logit model estimation. The frequency of full telecommuting days from home was modelled as dependent on the characteristics of the employees. The prime interest was to forecast a reduced work trip frequency. The hypothesis that telecommuters might choose place of work and residence differently than other employees, which would affect demand models, was also investigated. This was accomplished by estimating different time and cost parameters for telecommuters and non-telecommuters in an existing travel demand model system.

The third paper discusses the future potential of telecommuting given the present telecommuting situation at the company Ericsson. The focus was on identifying tools that the company can use to promote telecommuting. The propensity to adopt telecommuting was modelled as a function of socio-economic variables and access to technical equipment, work task suitability and management attitudes, as reported by the employees. Incentives for the company to promote telecommuting were also evaluated by the employees’ perception of advantages and disadvantages connected to telecommuting.
5. Conclusions

Paper one and two of the present thesis show that the adoption of both tele-banking and telecommuting are significantly correlated with socio-economic status. One common problem connected to the first two papers was the small data samples, which limited the analyses. However, since KOM is collected on a yearly basis, it is possible to apply similar analysis methods within a few years, using a larger data set, which might enable extended analyses.

A common conclusion for the papers is that the alternatives representing "no travel" are very difficult to describe. For tele-banking there was problems of specifying the cost of the services, it was further impossible to describe the cost of the Internet connection, as the cost structure of the market is complicated. Some employees even have free connection from their employer. Even if the cost of a permanent connection was known, this cost covers not only bank and postal activities. An attempt to use only socio-economic variables as proxy variables for preferences and computer literacy caused high correlations in the model structure, and did not seem to be accurate enough. Specifying the alternative representing "no travel" with respect to telecommuting, met the same difficulties. Only socio-economic variables were used as proxy variables for preferences and constraints. To be able to measure the utility more adequately, more research and other types of data are needed.

We now turn to the model approach in the first paper, see figure 1. One of the inclusive value parameters was significantly larger than one, indicating problems with the model structure and approach. An inadequate description of the contact-based alternatives may also have contributed to these problems. The inclusive value parameter that was significantly larger than one, when using the original model structure showed in figure 1, was at the top level. This is the level of trip and contact generation, which indicated that the problems with the model structure primarily were here. The reason may be that the model assumed a one-to-one substitution between the modes of communication, which most likely is a too strong assumption. That is, the model assumed that one contact substitutes one trip, or vice versa, although a contact may complement a trip, or for instance, 6 contacts may substitute one trip. This problem could, at least partly, be handled if having access to a larger data set than at present. Then we could, for instance, allow the choice of a contact to be conditioned on the choice of a trip.

A restraint with the use of a cross-sectional data set is that only trips and contacts performed the same day can be connected to each other. Related activities performed the day after or before will not be considered, which weakens the analysis. This calls for a more process-oriented data collection. Instead of using
traditional cross-sectional data, the habits of performing particular activities, including both trips and different types of contacts, must be studied. In order to do this, we need to define a set of activities, which are likely to be influenced by telecommunications in the future.

Another problem relating to the model approach in paper one concerns the definition of activities. When assuming substitution at a one-to-one level, as in this model, we assume that the goal of the contact is the same as the goal the replaced trip would have had. However, the actual activities are in such cases not exactly the same. In reality, substitutable activities may be very different. For instance, downloading a movie via Internet or to go to a restaurant may sometimes be substitutes. However, the broader the activities are defined, the more difficult it is to identify and specify when substitution actually takes place. A fundamental problem when using the present model framework is that the activities must be narrowly specified for this reason.

Hence, the observed substitution effect will in general be dependent on the definition of the activities in this kind of analysis. The types of activities, and their qualities, for which substitution would be an option are also very technology dependent and therefore uncertain, causing the forecasts to become uncertain.

It is further shown in the thesis that telecommunications-based activities that have a direct impact on travel, such as tele-shopping and telecommuting, have not yet taken off, at least not when the present data was collected (1999-2000). However, it is likely that the behaviour response is lagged in time and that properties of the technology will change considerably in time, which could have a vast effect on the adoption rate of telecommunications-based services. This must also be considered when designing future research.

A large issue in this field concerns what kind of data that should be collected. Based on the conclusions from this thesis, some aspects of future data collection and research are discussed below. Salomon and Mokhtarian (2002) argue that while stated preference (SP) data is the only way to evaluate telecommunications services that not yet are available in reality, it also brings about several disadvantages in telecommunications and travel interaction research. SP data may cause behavioural overreactions to technical development based on futuristic ideas. SP data analyses therefore risk to over-estimate substitution effects. In telecommuting studies in particular, there are in general a large number of employees who report that they prefer to, but do not in fact telecommute. This is also true for the study carried out in paper three, in this thesis. Besides the earlier mentioned reasons, this gap may be due to the fact that the choice to telecommute is not taken by the employee alone, but rather jointly with the employer. A number
of other constraints or perceived disadvantages may further prevent a positive preference to turn into a positive choice.

For telecommuting, revealed preference data may therefore be necessary. In order to be able to study the more long-term travel and land use impacts and adoption cycles of telecommuting, panel data is also needed. To increase the share of telecommuters in revealed preference data, which is low in the work force as a whole, data collection should be focused on employees and labour management of industrial sectors in which this share is relatively high. It is shown in paper two, that these are primarily information- and service-based industrial sectors. The underlying causes for not telecommuting or not supporting telecommuting must also be in focus, both from employees’ and from management’s perspective. If labour management’s negative attitude is a common reason for not telecommuting, the next step is to analyse their role closer.

Constraints restraining the adoption of other application specific telecommunications services may also exist. Still, these are not likely to be as many and as strong as for telecommuting, since in this case the individual can in general make these decisions more independently. The advantages of using SP data for this kind of studies might therefore outweigh the disadvantages. However, it is essential that the alternatives are made as realistic as possible to the respondents.

6. Further research

One method to collect SP data and to give a picture of the alternatives that is as realistic as possible is ‘information acceleration’ or ‘accelerated learning’. The basic idea of information acceleration is that respondents are faced with the new alternatives by a simulator. The simulator should be used in order to build up an environment that is as realistic as possible.

The method of information acceleration was originally developed at Sloan School of Management, MIT, for testing the market potential of electric cars (Urban et al. 1990). Since then, the method has been adjusted for transportation research (Koutsopoulos et al., 1993). Walker and Ben-Akiva (1996) presented an information accelerator, used to collect data on how people learn about ATIS functions and whether they adopt the services or not.
The basic idea of information acceleration is to enable analysis of adoption of alternatives that are not yet available to the users or are still rare in society. Another reason for employing the method is that the processes and the choices are complex, and difficult to isolate with more traditional methods of data collection. The advantage of the SP method is that the researcher to a great extent controls the experiment. Hence, this method is well suited for studying travel and communication technology interactions. As we have seen, the telecommunications-based activities that have a direct impact on travel, such as tele-shopping have not yet have taken off on a large scale, and the adoption of this services are thus still relatively rare. However, future technology is likely to change these services, and the main point of using information acceleration is that such new science concepts would be possible to evaluate. Finally, as concluded above, a more process oriented analysis and data collection is needed, but adds to the complexity of the surveys and may decrease the quality of the collected data. Information acceleration makes it possible to collect such data without reducing the quality. Using this method would improve the possibilities of describing the 'no travel' alternatives.

The most important issues when designing experiments with information acceleration is to define what services and technology that are to be analysed. To do this, the potential for new services and technological developments need to be assessed. In order to make the analyses sensitive to the most important factors, the most relevant variables that influence the choices must also be identified.

The simulation could be designed by using multimedia or video equipment. The respondent should be able to search information about the new alternatives freely. To avoid biases, the individuals’ actual behaviour should be collected as well. The SP and the RP data could then be combined in the analysis (Ben-Akiva et al., 1999).

It is an advantage if respondents belong to segments of the population in which the adoption rate of telecommunications services is large, as that increases their understanding of new alternatives and their ability to handle multi-media information sources. To define such segments, the results from paper one would be useful.

A final important issue of developing experiments on travel and telecommunications interactions is to design them as to enable implementation of the results in travel demand forecast models. For instance, if the frequency of shopping trips decreases, due to e-shopping, the frequency of other trips may increase. This could happen because time would be released from the earlier shopping trips or because the individuals would be more flexible, since e-shopping is available any time of the day. Such effects may be implemented in forecast
models. Destination choices for other trip purposes may also change, since these other trips are often chained with shopping trips. This could be implemented in transport demand models by revising origin-destination matrixes.
References


