An analysis of mode choice behaviour in Innsbruck

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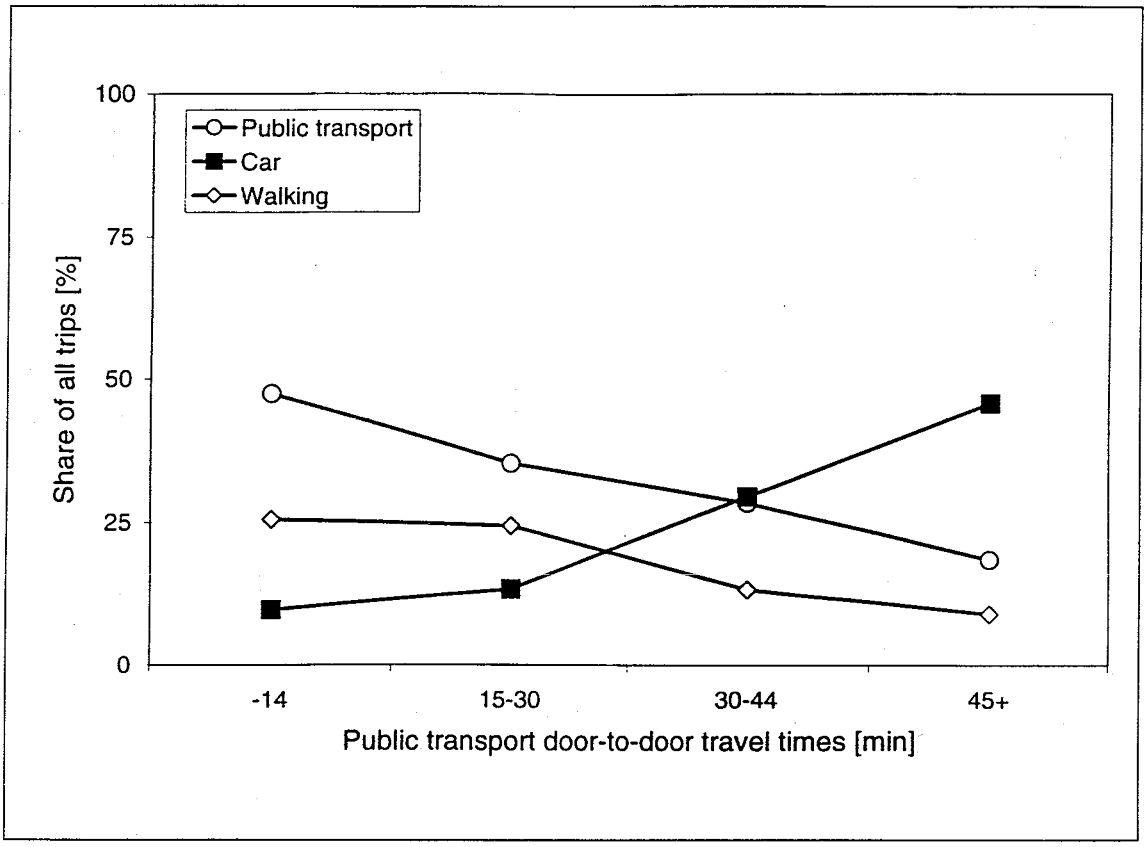

Stadt Innsbruck - Amt für Verkehrsplanung
Innsbrucker Verkehrsbetriebe GmbH

AN ANALYSIS OF MODE CHOICE BEHAVIOUR IN INNSBRUCK

Report
October 1998

An Analysis of Mode Choice Behaviour in Innsbruck

Report to the City of Innsbruck and the Innsbrucker Verkehrsbetriebe

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October 1998

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EINE ANALYSE DER VERKEHRSMITTELWAHL IN INNSBRUCK

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ZUSAMMENFASSUNG

Einleitung

Die Stadt Innsbruck hat sich die Förderung des Öffentlichen Personennahverkehrs zum Ziel gesetzt. Ein Verständnis des Verhaltens der Innsbrucker als Verkehrsteilnehmer ist dazu unerlässlich. Befragungen der Verkehrsteilnehmer sind deshalb ein notwendiger Teil der verkehrsplanerischen Arbeit. Es war deshalb erfreulich, daß es im Herbst 1997 möglich war, mit Mitteln der Stadt Innsbruck, der Innsbrucker Verkehrsbetriebe und eines europäischen Forschungsprojekts eine vertiefte Untersuchung zur Verkehrsmittelwahl der Innsbrucker Bevölkerung zu finanzieren. Die Inhalte der Befragung ergaben sich aus den sich überlagernden Interessen der drei beteiligten Institutionen, insbesondere:

- Erfassung der Nutzungshäufigkeit der verschiedenen Fahrscheinarten (siehe Axhausen, Köll und Bader, 1998a aber auch Anhang A).
- Untersuchung der Verkehrsmittelwahl und der Bereitschaft, das Verkehrsmittel zu wechseln mit Hilfe von zwei alternativen Befragungsmethoden.

Untersuchungsansatz

Der Ansatz ergab sich aus der Komplexität der Fragestellung und dem vorhandenen Budget. Es wurde eine Kombination aus telephonischer und schriftlicher Befragung gewählt. Die telephonische Befragung umfasste die folgenden Inhalte:

- Verfügbarkeit des Öffentlichen Verkehrs zu Hause und bei der Arbeit
- Verfügbarkeit eines Pkw
- Verfügbarkeit einer Wochenkarte, Monatskarte etc.
- Sozio-demographische Beschreibung des Befragten
- Detaillierte Beschreibung einer kürzlichen Fahrt zur Arbeit, zum Einkaufen oder zur Freizeit innerhalb von Innsbruck
- Erfassung der Fahrten mit dem öffentlichen Verkehr innerhalb der letzten Woche und die verwendeten Fahrscheinarten.

Die Beschreibung der Fahrt wurde kodiert und auf deren Grundlage ein schriftlicher Fragebogen erzeugt, der die Befragten um die Beurteilung möglicher neuer Fahrten bat. Dabei wurden zwei alternative Ansätze: Conjoint Analyse (CA) und Stated Preference (SP) verwendet.

Durchführung der Befragung

Die Befragung wurde in zwei Teilen durchgeführt (November-Dezember 1997 und Februar-März 1998). Ingesamt gaben 1215 Innsbrucker über 18 Jahre Auskunft, was einer Antwortrate von 66% entspricht. Die vertiefte schriftliche Befragung wurde dann von nochmals 65% der Angeschriebenen beantwortet. Diese hohen Antwort- und Rücklaufquoten lassen repräsentative Aussagen zu.

Die Ansätze: Conjoint Analyse und Stated Preferences

Beide Ansätze erkunden das Entscheidungsverhalten der Befragten, in dem sie ihnen eine Reihe neuer, hypothetischer Entscheidungssituationen vorlegen, in denen Variablen, die für die Verkehrsentscheidung wichtig sind, systematisch variiert werden. Diese Variation erfolgt so, daß statistisch saubere Modelle geschätzt werden können (Siehe auch FGSV, 1996).

In der Innsbrucker Untersuchung wurden als Alternativen berücksichtigt: der Pkw, der ÖPNV, das Fahrrad und das zu Fuß-Gehen. Als Variablen wurden herangezogen: die Zu- und Abgangszeiten, die Fahrzeiten, die Parkplatzsuchzeiten, die Wartezeiten, die Verlässlichkeit von Pkw und ÖPNV, der Fahrpreis und die Parkplatzkosten und der Radweganteil.

Bei der Conjoint Analyse haben die Befragten zwei Teilaufgaben. Die erste Teilaufgabe umfasst die Beurteilung der Wichtigkeit aller Variablen und die Bewertung der Ausprägungen dieser Variablen; jeweils auf einer Skala von 0 bis 10. Zum Beispiel: Wie wichtig ist Ihnen der Fahrpreis ? Wo auf der Skala liegt ein Preis von 10 Schilling für Sie ? Im zweiten Teil wurden den Befragten 14 Verkehrsmittelangebote mit Hilfe aller für das Verkehrsmittel relevanten Variablen geschildert und mussten von ihnen auf einer Skala von 0 bis 10 beurteilt werden.

Bei der Stated Preference Befragung wurden den Befragten 11 Entscheidungssituationen vorgelegt, die die für den Befragten verfügbaren Verkehrsmittel unter denkbaren neuen Randbedingungen beschrieben. Die Befragten mussten eines der Verkehrsmittel auswählen.

Wichtige Ergebnisse

Die erwachsenen Innsbrucker haben zu 82.9% einen Führerschein, 70.4% haben ein Auto zur Verfügung, aber nur 10.8% eine Monatskarte oder ähnliches. Insbesondere die Besitzer von Monatskarten, auch bei Autoverfügbarkeit, bevorzugen den öffentlichen Verkehr, ansonsten kommen neben dem Pkw auch das Fahrrad und das zu Fuß-Gehen zum tragen.

Die Analyse der Daten, insbesondere der zu den berichteten Wegen (revealed Preferences) und den Stated Preference Daten, mit Hilfe eines komplexen Logit-Models (Siehe Ben-Akiva und Lerman, 1985) ergab folgende wichtige Punkte:

- Die Innsbrucker wären bereit 2.0-2.5 Schilling für jede eingesparte Minute Reisezeit zur Arbeit und zum Einkaufen auszugeben. Der Wert liegt wesentlich tiefer für die Freizeitwege.

- Eine Minute Fußweg hat für die Innsbrucker dasselbe Gewicht wie 1.7 Minuten Fahrzeit zur Arbeit, respektive 1.1 Minuten zum Einkaufen oder 3.2 Minuten zur Freizeit.

- Eine Parkplatzsuchzeit hat für die Innsbrucker Autofahrer die folgenden Gewichte im Vergleich zum Fahren selbst: 1.7 zur Arbeit, 3.2 zum Einkaufen und 3.3 zur Freizeit.

- Die Innsbrucker sind sehr umsteigeempfindlich. Einmal Umsteigen ist ihnen gleich 14 Minuten Fahrzeit auf dem Weg zur Arbeit, respektive 9 Minuten beim Einkaufen oder 22 Minuten bei der Freizeit wert.

- Die Verlässlichkeit von öffentlichem Verkehr und Pkw-Verkehr wird im allgemeinen hoch eingeschätzt. Die Ergebnisse zeigen aber, daß die Innsbrucker sehr stark negativ auf Unzuverlässigkeit reagieren, so daß hier ein besonderes Augenmerk von Stadt und IVB liegen muß.

Gliederung des Berichts

Der Bericht schildert im ersten Teil die Geschichte und die Grundlagen der angewandten Befragungsmethoden (Conjoint Analyse und Stated Preferences). Im zweiten Teil werden dann die Befragung und deren Ergebnisse im Detail vorgestellt.

SCHLAGWORTE

Verkehrsmittelwahl - Stated Preferences - Revealed Preferences - Conjoint Analyse - Befragungen - Innsbruck - Verlässlichkeit

Report to the City of Innsbruck and the Innsbrucker Verkehrsbetriebe

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Abstract

This report presents the results of a survey undertaken jointly by the City of Innsbruck, the Innsbrucker Verkehrsbetriebe and the authors. The aim of the survey was to understand both the intensity with which the residents of Innsbruck use their season tickets and the ways, in which they decide between different modes of transport.

The survey involved in the first stage a telephone interview with 1200 respondents, which covered the following items:

- Availability of public transport at home and at work
- Availability of a car or of a season ticket
- Availability of parking at home and at work
- Socio-demographic description of the respondent
- a recent trip to either work, shopping or an evening leisure activity within the City of Innsbruck
- the number of trips undertaken by public transport during the past week and the usage of different ticket types

65% of these respondents replied to a Conjoint Analysis (CA) or Stated Preference (SP) survey, which had been based on their reported trip. The initial analysis raised doubts about the reliability of the CA results in all aspects, but a more detailed analysis was deferred.

The detailed choice modelling of the revealed preference (RP) and the SP data, including a joint estimate based on both sources, revealed a number of interesting results. In particular, that modelling the impact of waiting time without explicit consideration of service unreliability might overestimate the importance of the time spent waiting in comparison to the stress of unreliability.

Keywords

Stated Preferences - Conjoint Analysis - Innsbruck - Mode choice - Choice modelling - Comparison

1 INTRODUCTION

The City of Innsbruck together with the Innsbrucker Verkehrsbetriebe (IVB) aims to maintain and increase the public transport ridership within the city. Its current *Verkehrskonzept 1989/90* (Arbeitsgemeinschaft Retzko+Topp, Kirchhoff und Stracke, 1990), since updated in some respects, puts public transport at the forefront of its aims. For the further planning of its transport policy and the assessment of individual policy elements the City and the IVB require sound information about the current behaviour of the city residents and about their willingness to change behaviour.

This report documents a study undertaken to provide some insight into these issues. Its design merges the interests of the three parties involved in its financing:

- EU-funded project TASTe[1]: Comparison of different methods to measure the willingness to change behaviour
- City of Innsbruck: Mode choice behaviour in Innsbruck, in particular for leisure trips
- Innsbrucker Verkehrsbetriebe: Mode choice behaviour and usage intensities of public transport season tickets.

This report focuses on the measurement and modelling of mode choice behaviour, while a second report (Axhausen, Köll and Bader, 1998a) analyses the public transport usage intensities in Innsbruck, although Appendix A provides a review of the issues involved.

Transport policy tries to influence one or more of the dimensions of travel behaviour to achieve the goals of the municipality or the city concerned. The most frequently cited dimensions are respectively:

Dimensions of change	*Dimensions of concern*
• Departure time	• Congestion
• Route	• Parking
• Mode	• Safety
• Destination	• Noise and emissions

While the provision of new facilities or increases/decreases in the capacity of existing facilities could be a relevant measure, policy makers increasingly rely on *soft* measures, such as the provision of information, public awareness campaigns, changes in opening or working hours, car pooling initiatives etc. and *changes in pricing* of public transport, parking, bridges, motorways or other roads.

[1] The project TASTe aims to develop a *toolbox* for the assessment of transport policies. See for example TASTe (1997).

The evaluation of such measures, which are in general outside the current scope of transport policy or transport practise is a challenge for the generally applied transport planning methodology. This methodology has been developed in the main to describe the effects of changes in network capacities on travel behaviour (Schnabel and Lohse, 1997; Ortuzar and Willumsen, 1994; ITE, 1994; Papacostas and Prevedouros, 1993; Hutchinson, 1974 or Chicago Area Transportation Study, 1960), but travel behaviour was only conceived in terms of route, mode and destination choices. The methodology is based on models derived from the current situation in the study area and these models depend in their quality on the behavioural, network and situational variability of the study area. The supply situation is captured through inventories of the networks and services available and the demand situation is observed through surveys of the *revealed preferences* of the population, i.e. its actual travel behaviour. Policies not present in the study area cannot be modelled or only modelled by extrapolating from the current situation to ranges of values not currently present or to policies not currently present. While some policy measures are within a safe range for such extrapolation, most are not.

Politicians and their public, in most instances, do not like to experiment with such, sometimes drastic and expensive measures without prior qualitative and quantitative assessment of their likely impacts. The gap between the available information from the revealed preferences (RP) of the population and the information required to assess these future, hypothetical situations has been obvious for some time and has stimulated the development of a range of methodologies, which aim to close it. Examples are:

- *Expert forecasting and assessment*: Delphi-technique and similar
- *Personal intensive interviewing*
- *Stated-Response* (SR) methods in all their forms

The boundaries between the two last approaches are fluent, as both attempt to place the interviewee into a future, hypothetical situation and to obtain a response to that future situation from him, which can be modelled within the framework desired. Transport planning has not developed these techniques from scratch, but has adapted and modified them from other disciplines, which had to address similar situations earlier, here in particular marketing. Still, the methodological history of transport planning remains visible in the way in which this adaptation has taken place and in the way, in which these approaches are used today.

The overall structure of the report is as follows: the next section reviews two prominent methodologies to survey behaviour in hypothetical markets motivating the empirical comparison performed in the survey undertaken. The survey design and administration is then described followed by a section analysing the response behaviour. The main section of the report presents the results of the mode choice modelling undertaken with the data collected. A final section concludes and presents suggestions for further work, both practical and methodological.

2 Review of SP and CA methodologies[2]

2.1 Position of SP in a behavioural framework

Policy measures change the relative generalized costs of various behavioural alternatives and change behaviour as a result, but not necessarily in the direction intended as the behavioural system is much more complex than mostly acknowledged. Figure 1 shows a dynamic framework of travel behaviour to illustrate this point (Axhausen und Goodwin, 1991). Social norms and urban structures, which have to be accepted by the individual and household as given in the short term, constrain the life style choices for a given position in the life cycle. These long-term choices, such as housing type, residential location, family structure, type of work and work location, are based on the experiences of the person and household and on their available financial and social resources. They imply activity needs and desires, which are modulated by the seasonal and structural changes of the environment. The activities selected are then allocated and roughly scheduled by the household for an intermediate time horizon, such as the week or month, and the members of the household are provided with the resources required to achieve them, such as a bicycle, a car, a season ticket for public transport or a mobile phone. The member will schedule these activities and tasks in detail over a shorter time horizon, such as a couple of hours, a day or a small number of days. Scheduling includes the time, duration, location and order of activities plus the required resources (vehicles, money, information, information technologies etc.). The execution of the schedule requires a constant comparison between plan (schedule) and progress, i.e. actual activity performance, which can be better and quicker then expected, but also worse and slower. The person has then the choice of altering his schedule in various forms based on the information available at the time, the slack in the schedule and the importance of the remaining activities. Equally, the traveller has to monitor his progress against his expectations to take, if necessary, corrective action during the trip by rerouting in a general sense including both route, parking type, parking location and mode or by rescheduling the activity programme undertaken. The experience of schedule performance against plan will lead to a feedback to the higher levels of the hierarchy through changes in daily scheduling, household scheduling and in the life-style choices to resolve the conflicts, which have become visible. Given the complexity of this feedback system, it is unclear a-

[2] This section is based on Axhausen and Köll, 1997.

priori at which level of the hierarchy and at which time horizon a specific system change will become effective. It is useful to translate the framework into specific choices, which could be influenced, e.g.:

- Residential location
- Type of housing
- Resource availability, especially:
    - cars
    - season tickets
    - information technologies
    - parking facilities

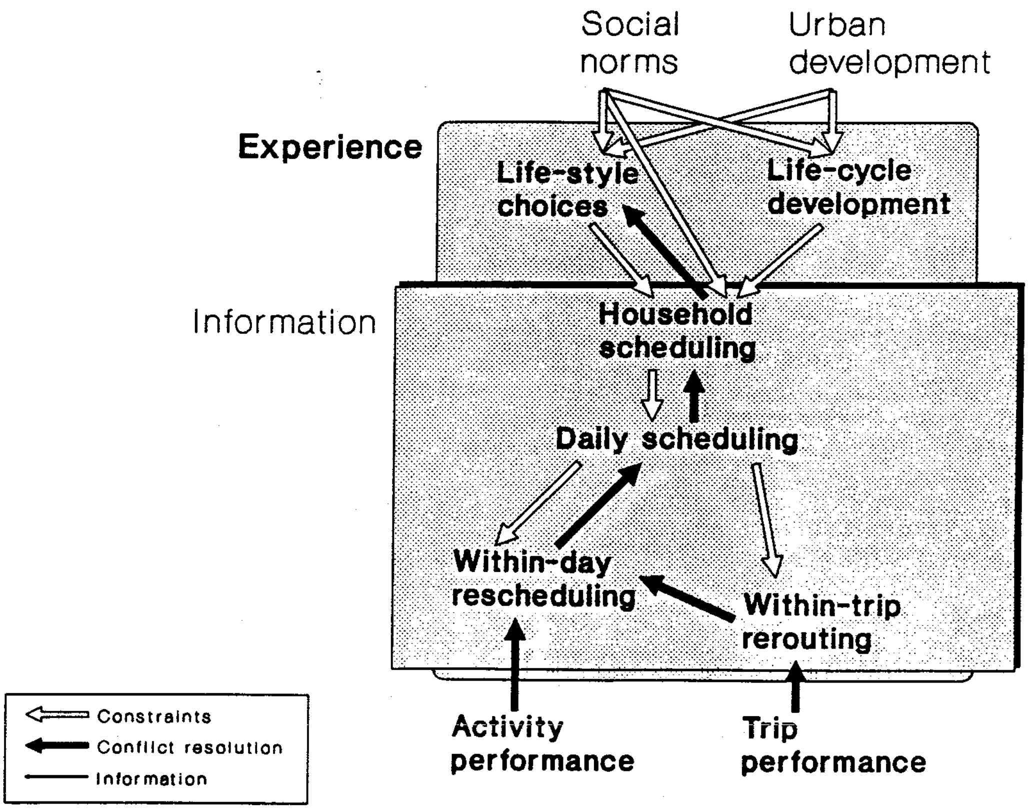
- Work/education location
- Amount of work/educational activities
- Work schedule/education schedule
- Resources at work/school (parking, information sources etc.)
- Commitment to other activities (church, social clubs, sports etc.) (amount, frequency and schedule)
- Location of other committed activities

- Choice of medium/long term projects, such as holiday preparation, education, training, visit to friends, information acquisition etc.
- General task and resource allocation in the household

- Activity schedule (including frequency and timing of the scheduling):
    - Sequence of activities
    - Start time of activities
    - Duration of activities
    - Location of activities
    - Size and membership of the party involved in the activities
    - Costs of activity participation or expenses involved and their allocation between the members of the party (including non-monetary costs, such as social goodwill or "time trading")
    - Size and membership of travelling party
    - Departure time (with implied preferred arrival time)
    - Mode sequence
        - Mode
        - Vehicle/means
        - Location of mode/means switch (station, stop, parking facility)
        - Type of mode switch facility (type of station or stop, type of parking)
        - Search strategies, if required
        - Costs of mode use and their allocation between travellers (s.a.)
        - Route
        - Speed

The very complexity of the choices involved force the travellers to rely very often on past choices, i.e. past solutions, to reduce the complexity of the decision and to speed it up, as time for generating a new good solution is often not available.

Figure 1 A dynamic framework of travel behaviour



Source: Axhausen and Goodwin (1991), 1025

It is also clear, that the amount of information provided by external sources, such as parking guidance systems or route guidance systems, is small in comparison with the information embodied in these past choices and experiences. This is especially true in the "activity space" of the traveller, i.e. the locations and networks, which are used regularly.

The framework implies, that each behaviour we observe should be understood against the specific situation of the traveller at that time in terms of:

- the activity schedule ahead (as part of the tasks, commitments and projects of the person)
- the immediate past in terms of activity and trip performance and schedule deviations, if any
- information available
- experiences available

and in terms of the personal preferences, suitable for this situation. This clockwork of different rhythms and sequences moving around longer-term trends and decisions requires an enormous amount of information from the traveller, which the analyst has to disentangle.

Transport planning models have, as a rule, ignored this complexity for a number of pragmatic and theoretical reasons, among them computing capacities, cost and difficulty of data collection, lack of explanatory models and difficulty of forecasting. The time horizon at which the models operate has never been properly identified, but their contents imply that they intend to model the medium- to long-term decision horizon[3].

There is one tradition, which tries to acknowledge this complexity, although can do so only in parts due to the otherwise required unacceptable interview durations: the *situational approach* of Socialdata (Brög und Erl, 1980 or 1983). While it has been able to identify constraints on behaviour in terms of information, tasks and preferences, the lack of proper choice and forecasting models has held its application back. The intensive interviews of this approach have been used to elicit responses to hypothetical situations, but in general, only one or two new situations, which made it impossible to generalize the results to models of wider scope. While the intensive testing of one scenario can be very useful, the clients generally prefer models of a wider scope even if that implies lower validity.

The alternative approaches, *Conjoint Analysis* or *Stated Preferences*, in the general tradition of the social sciences, sociology and microeconomics in particular, accept the complexity, but focus the attention of the respondent and researcher on those factors under the control of the authority or firm undertaking the study. This simplification is accepted as the price to obtain results of predictive value within an acceptable time frame (see Brög, 1997, for an opposing view).

The Stated-Preference or Conjoint-Analysis approach encompasses a wide variety of specific methodologies, which all share the aim of

- obtaining holistic statements of preference in a specified format
- for a series of (hypothetical) goods described by varying levels of a small number of attributes
- within a specified behavioral frame (overall context)

[3] It is surprising then, that they are developed and estimated on the basis of short-term data (travel diaries and screen line counts) which in turn are supplemented with long-term data (the equilibrium results of the network models used in choice modelling).

The decision problem is reduced for the respondent, as he has only the given response format, but he has both to imagine the stimuli and to adjust to the specified behavioural frame. The analyst looses the full behavioural context detail, but can focus on those aspects under management control. The control over the description of the hypothetical goods permits in addition the generation of well behaved statistical data for the estimation of appropriate forecasting models.

SP-methods can be placed into a larger family of survey methodologies, which all aim to obtain behavioural responses to hypothetical goods and situations. Lee-Gosselin (1996) suggested the name *Stated-Response* for all of the methods and then distinguishes SP, *Stated Tolerance*, *Stated Adaptation* and *Stated Prospect* depending on the control the interviewer exerts over the description of the good and the specification of the behavioural response. SP methods are the most rigid as they constrain for the respondent both the description of the good and of the response. This loss of subtlety is balanced by the lower demands on the respondent and by higher response speeds/shorter interviews, which make the methodology cheaper to apply and which make it easier to find participants for the surveys.

Aside: Brief history of SP and CA

Stated Preferences and Conjoint Analysis methods were first developed in the 1970's in response to the advances of psychometrics in the late 60's and early 1970's (Green and Rao, 1971). While the developers of the methodology moved then easily between transport and marketing, as can be shown by the work of J.J. Louviere (Louviere, Meyer, Stetzer and Beavers, 1971 etc.), this communality came to an end by the early 80's and two streams of development emerged under the names of Stated Preferences and Conjoint Analysis, which are clearly influenced by the respective professional concerns and methods of transport planning and marketing. The development of Conjoint Analysis is well documented in a series of scholarly reviews in the marketing research literature (Green and Srinivasan, 1978; Böcker, 1986; Huber, 1987; Louviere, 1988). The growing usage of the methodology in marketing over the last two decades is equally well documented by three surveys of market research firms (Cattin und Wittink, 1982; Wittink and Cattin, 1989 and Wittink, Vriens and Burhenne, 1994). The development of the methodology in transport planning can only be reconstructed from a series of How-to-manuals, which have been published over the years (Kocur, Adler, Hyman and Aunet, 1982; Pearmain, Swanson, Kroes and Bradley, 1991; FGSV, 1996 or Pearmain, Swanson and Ampt (forthcoming), but see also Bates, 1988; Hensher, 1994 or Axhausen, 1995). The usage of the methodology in transport planning has not been surveyed yet. Wittink et al.'s work does not give a good estimate as the firms most active in transport were outside the scope of their surveys.

The psychometric tradition (Krantz, Luce, Suppes and Tversky, 1971) had been concerned with the construction of metric scales of utility from non-metric rankings and ratings of conjoint (compound) goods, while the functional measurement tradition (Anderson, 1974) focused on the development of models of object perception. Both traditions were based on orthogonal designs of the stimuli (objects or descriptions of goods). The transformation of these traditions into a tool of market research and the change of name from conjoint measurement to conjoint analysis had been achieved by the early 70's (Green and Rao, 1971). Conjoint analysis was used to derive a) estimates of *utility part-worths* for each level of the attributes tested for each respondent and b) to forecast market shares for new products based on these part-worths. The estimation methodologies were based on the traditions of conjoint and functional measurement and paid substantial attention to the different functional forms possible. Practise in marketing settled quickly on the widely understood and available OLS-approach (ordinary least squares estimation), especially after various studies had shown it to be no worse than the more sophisticated approaches based on ranks. The spread of the methodology through market research was sped up by the co-development of personal computers and various PC-based implementations of conjoint analysis, of which the *Adaptive Conjoint Analysis* (ACA) approach was by far the most important (Sawtooth, 1996). This programme combines utility estimation with the adaptive generation of the stimuli for a large number of attributes, which makes commercial application easy for market research practioners.

While the first large review of Green and Srivasan (1978) had especially identified transport planning and urban public transport as a potential application area, market research firms did not initially obtain a foothold in this market, in contrast to air transport, which they entered via the market research of the airlines. While the early documented applications in transport had been performed in the US (see for example Kocur, Hyman et al., 1982; Louviere and Hensher, 1982; Lerman and Louviere, 1978; Norman, 1977; Davidson, 1973) the first wide-spread offical acceptance of the methodology in transport planning was tied to work in the UK and the Netherlands (see for example the first UK Value of Time study (MVA, ITS and TSU, 1987)). The practioneers in the UK were normally transport demand modellers, which cast the analysis of the data into their framework of aggregate logit-modelling of choices (e.g. Ben-Akiva and Lerman, 1985), which had been developed in the 1970's. The now Stated-Preference methodologies were added to an existing set of SR-methods, such as *transfer pricing* (Stated Tolerance) (e.g. Bonsall, 1983) or the *Priority Evaluator,* a methodology developed in the UK to obtain preferences for public services under explicit public-sector budget constraints (Hoinville, 1971, 1973 or 1977; Pearmain, 1989). While various response formats were used in SP work (see below), the choice between alternatives became dominant by the 1990's in spite of its drawbacks (see below), again reflecting the influence of the general choice-based paradigm of transport demand modelling. The surge in SP applications in transport stimulated the development of various software tools to automate the generation of stimuli and performance of *computer-aided personal interviews* (CAPI).

The current return of SP to the US, the coming together of professional market researchers and transport planners in the commercialized public transport firms (bus, rail and air) and the growing interest in market research in choice-based conjoint formats (Louviere and Woodworth, 1983 or Sawtooth, 1995) opens up new opportunities for the further development of the methodology, both in application and model estimation (i.e. hierarchical logit-structures, joint estimation of SP and RP data (Ben-Akiva, Morikawa and Shiroishi, 1992 or Morikawa, Ben-Akiva and Yamada, 1991), utility functions of individuals etc.).

2.2 Core SP methodology and implementations

The core of the SP-methodology was defined above as:

- statements of preference in a given format for a
- series of goods, described by varying levels of a small number of attributes
- within a given behavioural frame

This definition needs to be complemented by the aim of the data collection, which is to develop estimates of the utility functions of the respondents or groups of respondents. These four aspects will be discussed in the next four subsections.

2.2.1 *Formats of the preference statements*

A number of formats have been developed to obtain holistic statements of the preference of the respondent for a given good. A good in the tradition of Lancaster (1966) is any physical good or service which can be described by the bundle of services it provides in terms of its characteristics, such as price, quality, weight, colour, comfort, reliability, prestige, brand etc. The respondent has the task to judge this bundle of attributes as one. SP methodologies, in contrast to other approaches are not interested in judgements about the individual attributes (See for example Schubert, 1991 and Tscheulin, 1992 for alternative approaches).

The following main formats are used in practise[4]:

- *Rating* of a single good on a given scale
- *Ranking* of a set of goods in order of preference
- *Choosing* between two or more competing goods. In the case of two goods it is common practise to request a statement of the strength of preference (likelihood of purchase)

Rating

In the case of rating the respondent is offered one good at a time and is asked to judge it on a common scale. Normally Likert-scales or related 7- and 9-point scales are used, but other scales (percent out of hundred) are equally common. This is an easy to understand format, but does not force the respondent to make trade-offs, as he could rate all goods offered in sequence with the same value. In spite of the ease of understanding its implementation is difficult for the respondent, as he has to keep track of past decisions and has to maintain the scaling consistently through a reasonably long list of goods.

Ranking

In ranking exercises the respondent is offered a set of goods, up to 15 or 20, which must be brought into a unique sequence of preference. This forces the respondents to make trade-offs, although ties can be accommodated, if desired. The ranking task is difficult and time-consuming for the respondent, as he has to make potentially n*(n-1) comparisons to obtain the unique sequence requested. To reduce this difficulty the respondent is often asked to group the goods first into a small number of classes, then rank the classes and finally rank goods within the classes. While the original conjoint analysis literature used models based directly on rank, such as MANOVA (see Kruskal, 1965), to derive the

[4] In the transport literature the transfer pricing approach (see Bonsall, 1983) and the priority evaluator (Hoinville, 1971, 1973 or 1977; for later applications see Pearmain, 1989) are frequently subsumed under SP. These two forms of SR-methodology will be excluded here from further discussion following the classification of Lee-Gosselin, 1996.

utility estimates, the transport literature interpreted the ranks as a sequence of a binary choices to fit the data into their choice-based paradigm.

Ranking is still a popular approach in application, as it generates a large number of data items quickly and can be interesting and challenging for the respondent. Unfortunately, the literature has documented many cases, in which the utility estimates vary substantially depending on which part of the ranking sequence is used for estimation (See for example Ortuzar und Garrido, 1991; Ben-Akiva, Morikawa and Shiroishi, 1992 or Johnson and Orme, 1996). While rules-of-thumb are available for the selection of rank information for estimation, caution is necessary.

Choosing

In choice-SP's the respondent has the task of selecting one good out of a small set of two to maybe five alternative goods. The advantage of this format is that it is simple to understand, quick and mimics the real life situation rather well. Its main disadvantage is that it generates little information for the utility estimation, as it only identifies the best alternative.

In the case of the choice out of two alternative goods many applications replace the simple choice question by asking the respondent to indicate the strength of their preference. A typical format is a scale of likelihood of purchase (certainly yes, in most cases, in many cases ... or some other similar formulation). Some authors have suggested that the respondents should express the strength of their preference by indicating the utility-equalizing payment balancing the weaker with stronger option. While gaining additional information, which can be used in estimation as an indication of choice probability, the analyst has the additional problem of estimating, which choice probability was meant by which scale item. This problem is normally not addressed leading to the unsatisfactory practise of determining the implied choice probabilities untested a-priori (Ortuzar and Garrido, 1994).

2.2.2 *Generation of the descriptions of the goods*

The respondents are presented with a number of goods, which are grouped into various contexts depending on the preference format chosen. These goods are characterized by a number of selected attributes, which each occur at a specified number of levels, e.g.:

- price at two levels: 5 ECU and 8 ECU
- comfort at three levels: low, medium and high
- Brand at four levels: VW, Mercedes, Opel or Ford

It is possible to present the goods with *full* or *partial* profiles. In the case of full profiles, which is the rule in SP and the preferred option in Conjoint Analysis, the good is described simultaneously by all attributes which have been selected as relevant (see below for the question of how and how many attributes to select). In the case of partial profiles the good is described by a subset, traditionally two attributes at a time. The subset can vary between goods. This approach is still important as ACA implements it in its procedure.

In the case of full profiles the number of possible goods, which could be presented, becomes large very quickly growing combinatorially:

$$\prod 2^{n_2} 3^{n_3} 4^{n_4} 5^{n_5} \ldots$$

$$n_i \text{ : Number of attributes with i levels}$$

$$\sum_i n_i = \text{Number of attributes}$$

While early studies used *full factorials*, i.e. all possible combinations, practise adopted *fractional factorials* very quickly to reduce the number of goods to a size manageable for the respondent without fatigue or loss of interest. Fractional factorials are a subset of the full factorials with a-priori specified statistical properties:

- they are (nearly) orthogonal, i.e. the main effects of the attributes can be estimated independently, but for a known amount of confounding with known higher order interactions
- they specify the number, if any, of higher-order, in particular two-way, interactions which can be estimated independently

The fractional factorials of a given full factorial are catalogued in a number of sources (Addelman, 1962a, b; Hahn and Shapiro, 1966; Kocur, Adler et al., 1982 or McLean and Anderson, 1984) and are also available in a number of software packages (SAS or SPSS, for example). Especially in the case, when no catalogued design is available, it is possible to generate the design as a random selection from the full factorial, which is tested for an acceptable correlation structure, i.e. orthogonality and absence of a strong "factorial" structure in the factor-analytic sense. A simple analysis of correlations can be misleading.

The loss of the three-way and higher interactions is judged to be no significant problem (Louviere, 1988), but the two-way interactions can be a problem, especially, if they are confounded with a weak main-effect, i.e. if the strength of the estimate of a main effect is attributable to a confounding two-way interaction of two different main effects, e.g. if the estimate of {A} is actually {A + C*E}. If the designer of the study is concerned about an interaction at the outset, then he should choose a design, which permits the independent estimation of the interaction. If the concern arises after the study, then careful analysis of the data is required, although the confounding cannot be removed after the fact.

In the case of ranking and choice-SP's it is advisable to remove dominant and dominated goods from the sets. That is goods which are either better/equal or worse/equal to all other alternatives in the set of goods presented. While such *anchor* goods are recommended in rating SP's at the top and the bottom of the set to provide the respondent with a feeling for the scales of the attribute levels, it is not necessary to do so in ranking and choice-SP's.

Factorial designs can produce unrealistic combinations of attribute levels, especially if there are strong correlations in the real markets; e.g. price and distance in rail travel, speed and road type, brand name and prestige etc. It is either possible to remove such combinations in advance or to formulate the values of the "dependent" attributes as a function of a selected independent attribute. The function then specifies differences between or ratios of the variables concerned. It is possible this way to ensure enough variability in the data sets for estimation. For example in the case of travel times by bus and car, the rule could be: bus travel time = car travel time + (-0.2; 0.2; 0.4) * car travel time.

Fowkes and his colleagues (e.g. Fowkes, 1991; Fowkes and Wardman, 1988 and 1992; Pearmain, Swanson and Ampt, forthcoming) have pointed out, that strictly orthogonal designs can be undesirable, if the interest of the study is the ratio of two main effect parameters, such as the value-of-time-savings in transport. In this case deviations can improve the estimates of the ratio. They also point out that in this case, the goods need to be selected in a way, which offers a wide range of choices in the ratios and not in the values of main effects themselves.

In the case of choice and rating-SP's a *decision situation*, i.e. the group of goods to be ranked or the set of goods to be selected from, needs to be constructed. Louviere (1988) suggests a two-stage procedure of a) constructing m goods from a suitable fractional design with the n attributes for each good and b) a second fractional design with m attributes coded zero (not present) and one (present) indicating the presence of the m^{th} good in the decision situation. Most transport applications use a different approach, in which they associate the first n_1 attributes of a fractional factorial with good 1, second n_2 with good 2 and so on. The first approach is suited to situations, in which the choice set can be variable in real life, as is the case with most consumer goods or destinations in transport, while the second approach is suited to situations in which the choice set will not vary, as is case with mode choice or tv channels.

Number of preference statements

The number of goods or decision situations (groups of goods) to be presented is a function of the model to be estimated (i.e. the number of parameters), the acceptable multicollinearity in the design and the level of aggregation of the analysis (e.g. person or group).

In the case of individual level models the estimation requires at least n+1 decisions/preference statements from the respondent to estimate the n parameters of the model. It is therefore not surprising that such models concentrate on simple main-effects models and a limited number of attributes to avoid overloading and fatiguing the respondents. Up to 20 decision situations plus some are deemed acceptable in conjoint analysis practise (Sawtooth, 1996).

For transport planning SP-practise lower values reflecting the higher loads of choice or ranking tasks are suggested (nine to twelve). Johnson and Orme (1996) suggest on the basis of a detailed analysis of studies conducted with the Sawtooth CBC-software that up to 20 decision situations could be acceptable.

The way, in which transport planning SP studies define their fractional factorials, results often in fractional factorials with a relatively large number of choice situations, in particular when interaction effects are explicitly estimated as well. It is therefore common practise to block the fractional factorial into groups of nine to twelve choice situations, which are then administered to each respondent. The model can then only be estimated at the group level, where all blocks are pooled. The total number of attributes is normally restricted to a maximum of 12-15, with a maximum of 5 to 6 per choice alternative, e.g. 5 attributes to define the car option, 4 to define the public transport option and 3 for cycling in a hypothetical mode choice study.

In the methods described so far, each respondent is presented with a fixed number of choice situations for which the structure, i.e. the coding of the levels, as 0, 1, 2 or +,- is known in advance. The exact values of the levels can be customized (see below).

Many authors have objected to this approach, arguing that many choice situations will not elicit new information as prior choices will already have revealed where the utility boundaries are located. To remove such redundant choice situations they have suggested *adaptive designs*, where the prior choices are used to construct the next choice situation/good. The most important of these approaches is the ACA approach, which dominates the commercial conjoint analysis market with the software of the same name (Sawtooth, 1996). In transport the work of Holden (1993) has received most attention. The attractions of these approaches are obvious, as they reduce the number of choices required from each respondent and as they make each choice situation more interesting for the respondent, because they are increasingly focused on the choice boundary. Still, concerns have been raised about the statistical properties of these approaches, in particular that they generate correlations between subsequent choice situations violating the (implicit) assumption of the analysis, that each observation can be treated as independent (Bradley and Daly, 1993).

The hybrid ACA approach falls slightly outside to what has been described so far as the orthodoxy of SP and conjoint analysis studies. The ACA approach combines both compositional and decompositional elements by starting the procedure with explicit questions about the importance and weight of each attribute followed by pairwise comparisons. Its main advantage is its ability to accommodate large number of attributes (20 or more), as the process screens out the unimportant ones early for each respondent.

2.2.3 Behavioural frame

The model of transport behaviour presented above suggests that a choice can only be understood against the frame of the particular situation, in which it was taken (e.g. schedule, resource availability, time pressure, information available, experience obtained so far, presence of other travellers etc.). It is therefore necessary to specify this behavioural frame to the respondent to assure that all respondents act/decide under the same constraints/assumptions.

This issue has not been addressed intensively in the market research conjoint literature until recently (Green and Krieger, 1995). It is also not addressed in *experimental economics* (Hey, 1992). In contrast, in the related *contingent valuation*[5] literature (see for example Mitchell and Carson, 1989) on environmental (public good) evaluation these frame effects have been central methodological concerns

[5] *Contingent Valuation* (CV) is the name given to a range of survey approaches developed by economist to obtain valuations of public goods. This literature seems to independent from the conjoint and SP literatures, although developing at the same time. CV surveys generally employ auction models to obtain one valuation, or willingness-to-pay, for a specified public good. Experimental designs are not employed even if more than one scenario is tested.

from the start. The transport SP literature became quickly aware of the issue and is addressing it normally by using past journeys as the starting point for the construction of the choice situations, in particular of the values of the attribute levels. This base journey is typically the one just made, a journey made yesterday or the last journey of a particular type. The respondent is asked to use the constraints of that journey as his reference. While this clearly improves the realism of the answers, the analyst has the problem of characterizing these constraints properly in the estimation. The description of the base journey and of the socio-demographics of the respondent might or might not be sufficient for this task. Clearly the SP-literature, as known to the authors, has not made this aspect of the SP interview a concern so far.

The approach of the transport literature assures that a cross-section of situations is reflected in the data. This will be acceptable in many cases to the client, but it might be necessary to specify this behavioural frame more precisely to reflect a particular market or behavioural situation better. This greater precision is at the expense of the scope of the model, as specifying the behavioural frame clearly indicates that the model estimated is only valid for this frame. There are no studies known to the authors, in which the effects of different frames were tested.

2.2.4 Utility model

The proper specification of the underlying utility model was a major concern of the traditions underlying SP and conjoint analysis. Initially three main preference models and three main forms of aggregation were tested. The preference models are:

- the vector model:

  $$u_i = ß_0 + ß_1 y_{ip}$$

  which stipulates that the utility of attribute i is a linear function of the value of the attribute i for good p

- the ideal point model:

  $$u_i = ß_0 - ß_i(y_{ip} - y_i^*)^2$$

  which calculates the utility of an attribute in terms of the deviation of the attribute value from some ideal value y_i^*

- the part-worths model:

$u_i = \beta_{ip}$

which determines a separate utility value for each value of each attribute.

The aggregation rules are:

- Linear additive rule:

  $u_p = \sum u_{ip}$

  which adds the utilities across the attribute values u_{ip} of the product p

- Non-additive models:

  Multiplicative: $u_i = \prod u_{ip}^{\beta(i)}$

  Disjuntive: $u_i = \prod [1/u_{ip}]^{\beta(i)}$

  which do not allow for the simple trade-offs of the linear model

- Lexicographic rule, which describes the choice as a sequential process of ranking products using one attribute at a time in their order of importance, and stopping when the attribute considered gives an unique best alternative. Among the three products:

Product	Attribute values		
	1	2	3
A	10	30	5
B	10	28	50
C	8	50	2

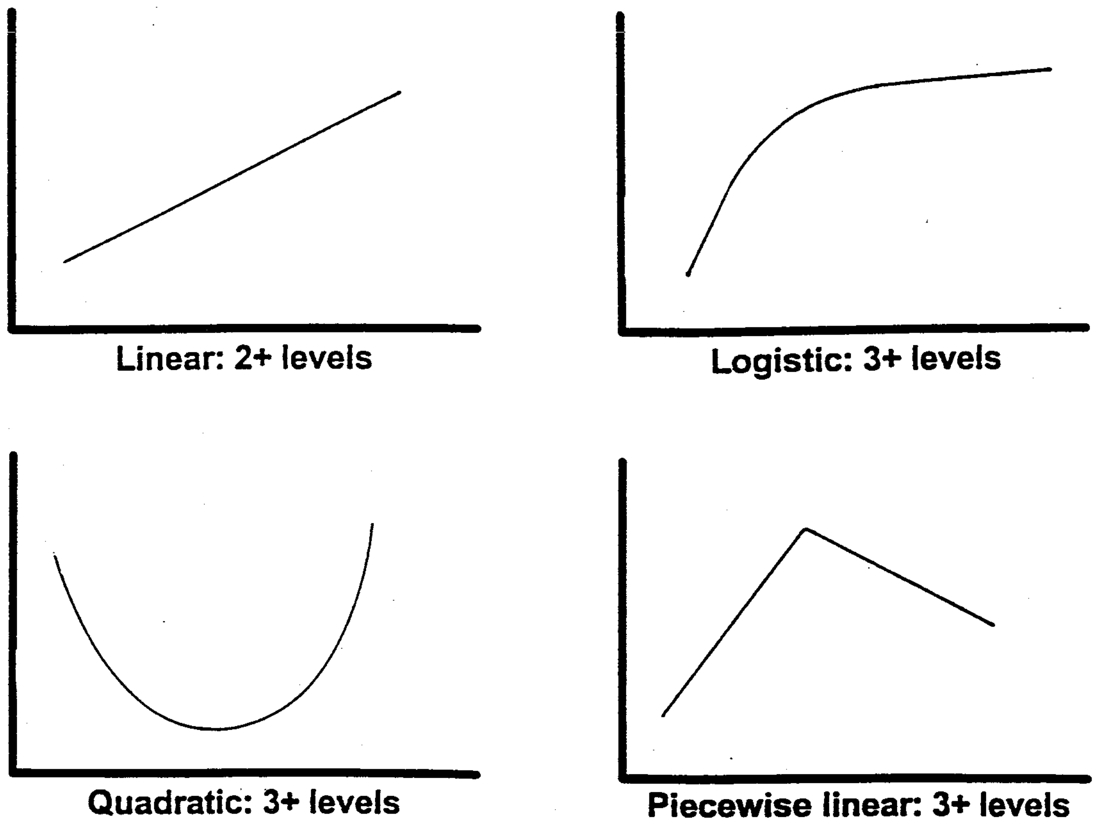
  The lexicographic chooser with the attribute order: 1, 2, 3, would first choose A and B as equal on attribute 1 and then decide on A as better on attribute 2.

The conjoint analysis and SP-practise settled soon on the linear additive models, as the most flexible model form, which can accommodate the two other utility formulation (through dummies and quadratic terms) and includes the lexicographic rule, as a particular pattern of parameter values (e.g. $\beta_1 >> \beta_3 >> ... >> \beta_n$). Conjoint analysis prefers the part-worths model, whereas SP uses the vector description. Current practice does not spend time on analysing these issues.

While the overall model form is not discussed any more, the detailed specification is still a major issue, as it determines the number of levels to be tested for each attribute. The conjoint analysis practise is relatively unconcerned with the specification of the number of levels per attribute, as the widely used ACA approach screens out irrelevant levels. This is feasible as many attributes in CA studies are ordinal, i.e. list of brands or unrelated product characteristics, which are captured in their respective utility through the quasi-dummy part-worths. Against the background of the usual vector-model SP studies would describe these from the start as dummy variables to indicate their presence or absence, thereby increasing the number of attributes to be tested. SP studies are also focused more strongly on continuous variables, such as costs, distances or times. For the continuous variables it is necessary to specify a-priori the functional form of the attribute (linear, quadratic, cubic, log etc.) as this in turn specifies the minimum number of levels required to test for this functional form (Figure 2).

A discussion of the estimation techniques is not required, as these are covered in detail in for example: Ben-Akiva and Lerman, 1985; Train, 1986; Chatterjee and Price, 1977; Daganzo, 1979; Greene, 1994; Wrigley, 1985; Pudney, 1989 or Box, Hunter and Hunter, 1978; Winer, 1971; Montgomery, 1984. It should be pointed out though, that the analysis in general ignores the serial correlation between preference statements, which can have serious effects on the parameter estimates. The simple correction methods for the t-statistics might not suffice (Louviere and Woodworth, 1983).

Figure 2 Minimum number of levels per attribute and functional form



Source: adapted from FGSV (1996), 25

2.3 SP-survey protocols and process

The core of the SP approach defines the task of the respondent and the number of choice situations to be answered and how they are constructed. It does not specify, what model/hypothesis is being tested, how the values of attribute levels are derived and how the choice situation is presented to the respondent. This section will first discuss these three issues before summarizing the discussion by describing the overall process of a SP-study.

2.3.1 Model specification

The SP experiments are based on a known set of attributes and assumptions about the functional form of their influence for a given behavioural frame. These three sets of assumptions define a hypothesis about an abstract behavioural model, which is to be tested with the SP. It has to be stressed again, that this abstract model is a serious, but necessary simplification of the real decision process, as compared with the travel behaviour model above. The closer the stipulated behavioural frame is to the current environment the better, but the possibility to define future, hypothetical situations is a real strength of the approach. The degree of the simplification will vary with the study object and the behavioural frame, but it should always be kept in mind. The simplification is the price paid to obtain operational models with testable properties, such as goodness-of-fit or parameter significance.

The hypothesis to be tested should be developed from three sources:

- the *client*, who needs to specify the behavioural frame(s) of interest, the attributes of the good under management influence and the study object/good
- the *literature* as a source of information about the study domain, in particular providing information about the relative weights of attributes from prior studies
- the *traveller/customer* through in-depth personal or focus group discussions specifying possible behavioural responses and relevant attributes.

The three sources should, if the time and budget available permit, all be consulted to obtain a rounded view of the problem, as the client might be preoccupied with the new idea/good, as the literature might be addressing yesterday's concerns, while the customers could ignore new possibilities.

There is a natural tendency for this process to generate a collection of attributes, which is too numerous to be tested in a single SP-experiment, at least of the choice-type. Three approaches can be pursued in this case unless it is possible to pare the number down to a manageable level a-priori:

- the *ACA approach*, which uses the respondent's reaction in a first screening part of the survey to pare the number down. This has the disadvantage that some attributes, which are of particular interest to the client, could be lost. The client might want the respondent to react to this attribute.

- the *hierarchical approach* suggested by Louviere and Timmermans (1990a-d) and others. In this approach the attributes are distributed across a number of SP-experiments of lower rank, which measure trade-offs within particular abstract concepts, such as comfort, style, accessibility etc. These concepts are then used in a single higher rank SP to obtain trade-offs at the concept level.

- the *linked approach*, where one or a small number of attributes are present in a series of SP-experiments. The parameters of a particular SP are then scaled against the parameters of these common attributes (the estimate could be derived from a SP or RP study). The approach has the advantages of simplicity and of an explicit scaling, but the disadvantage that a master attribute/experiment has to be defined. In transport applications popular choices have been costs or fare and mode choice.

  The explicit scaling is an advantage as it is known, that minor attributes can be overvalued by respondents, if the major attributes are not present in the SP or not evoked. An example would be an SP looking at bus stop design without fare, travel time or reliability attributes.

The attribute set defines one side of the equation, the decision alternatives offered define the other side of the equation. The conjoint tradition largely circumvents this problem by concentrating on objects or services of the same type, i.e. cars, credit cards, tv sets. The basic service provided is the same and all alternatives can be described with the same attributes. The attribute "brand" captures the prestige differences perceived by the respondent. In transport or similar applications this cannot be taken for granted. In the most widely studied case of mode choice very different services are offered by a car drive, a bicycle ride, a bus or a LRT trip, which need to be described by different attributes. The number of alternatives is a crucial issue, as the defined set might or might not be the relevant set for the respondent given the specified behavioural frame. The omission of relevant alternatives biases the results, as respondents either choose second best alternatives, refuse to choose at all or start to choose randomly. If the number of alternatives described with attributes becomes too large to handle, then it is possible to employ the linked approach again, but this time linking the sets of choice alternatives through one or more common members.

In addition to the described alternatives frequently undescribed alternatives, such as "None of the above", are added. While Sawtooth (1995) suggests only the use of the "None of the above" category in choice SP's, transport planners have used a wider variety of alternatives capturing responses at different levels of the trip response hierarchy, e.g. change of destination in the case of a mode choice SP, departure time change in the case of a route choice SP etc. Their inclusion can increases the realism of the SP task, but also increases the complexity for the respondent and lowers the precision of the estimated models, as the not described alternatives can only be included with alternative specific constants[6].

2.3.2 *Determination of attribute level values*

The hypothesis specifies the number of levels per attribute, but not the values of these levels. For the case that the values are fixed before the interview the recommendation is to choose values, which cover the natural variability for the study object at may be the 10% and 90% percentile for a two-level attribute and similar definitions for attributes with more levels. While most applications use levels which are symmetrical around the mean and equal differences between levels, there is no necessity to do so. The differences between the levels must be large enough to be noticeable, i.e. have a behavioural impact. The prior determination of the attribute level values requires that these are relevant to all respondents. This is normally true in consumer market research, but the experience in transport shows that it is normally not the case in its applications.

Transport applications have therefore either to resort to a-priori market segmentation to ensure the homogeneity of the respondents or to obtain the relevant values from the respondent.

A-priori segmentation

In this approach, the natural values are determined from prior surveys of travel behaviour. The respondents are then classified by location, car ownership, licence ownership or other relevant variables and are sent or given the appropriate SP with fixed values for the attribute values. This approach is costly and error-prone and is therefore rarely implemented.

Customized SP experiments

In customized SP experiments, which are the standard and preferred approach in transport research, the researcher will select a fixed experimental design and attribute level values, which are defined relative to user specified values, e.g.

- travel time of the user minus 5 minutes
- 0.5 * fare paid by the user
- maximum of the search times given

[6] Unless some further information about the alternative is available from other parts of the interview.

The rules are supplemented by constraints, which ensure that the values remain in a realistic range, in particular to avoid negative values for prices, distances or travel times, and in realistic proportions.

Customized SP's consist of three phases. In the first phase, the details of the trip, journey or purchase of interest are recorded. These details cover at minimum the selected attributes, but normally additional attributes are collected as well. In the second phase the customized SP is calculated and implemented and made available to the respondent. In the third phase the respondent participates in the SP. The usual forms of survey administration can be employed: PAPI (paper and pencil interview), CAPI or CASI (computer-aided self-interview) etc. The most frequently implemented protocols are:

- *On-line PAPI*
  Phase I) Interviewer conducts prior interview (in transport frequently a travel diary and/or a transfer price experiment)
  Phase II) Interviewer constructs SP-experiment (description of the goods in the form of rating cards or choice/ranking sets
  Phase III) Respondent performs SP
- *Off-line PAPI* (e.g. Polak, Jones, Vythoulkas, Meland and Tretvik, 1991)
  Phase I) Respondent participates in a PAPI travel diary and returns it to the researcher
  Phase II) The diary is coded and a PAPI-SP is generated on the basis of a selected trip and its attributes and sent to the respondent within a day or two of receipt of the survey.
  Phase III) Respondent performs PAPI-SP and returns it to the researcher
- *On-line CAPI* (e.g. most of the recent transport SP's in the literature)
  Phase I) CAPI travel diary or relevant survey
  Phase II & III) CAPI SP is generated on-line and administered to the respondent

Each of the three has advantages and disadvantages, but the choice is generally not based on survey methodological concerns, but on questions of costs and availability of interviewers and CAPI terminals plus the structure of the overall study.

2.3.3 Presentation formats

SP tasks can be presented in any format, which allows the respondent to see, understand and integrate the different attributes of the experimental design:

- *Written descriptions* either as a listing of the attribute values or as a written text, may be in the form of an advertisement or product description. This is the standard format, in particular for CAPI interviews

- *Pictorial descriptions* are possible, but require substantial care, as the picture or sketch used must be concrete enough to convey the attribute values, but abstract enough to avoid contamination through other picture elements (for a detailed discussion see Swanson, Ampt and Jones, 1997). The quickly growing multi-media capabilities of CAPI-software will no doubt increase the use of pictorial descriptions in SP.

- *Prototypes* can be employed, where the goods have a manageable size and weight. While very vivid and present for the respondent, the same concerns as with pictures have to be addressed: Can the design attributes be distinguished and recognized ? Is there any contamination through outside variables ?

Mixtures of these formats are possible, but must be treated with care to avoid an imbalance in the impact of the different information sources. Pictures could, for example, dominate a written description.

2.3.4 Study process

SP/CA studies should follow the logic of all interview/survey research, which suggests the following elements in the following order:

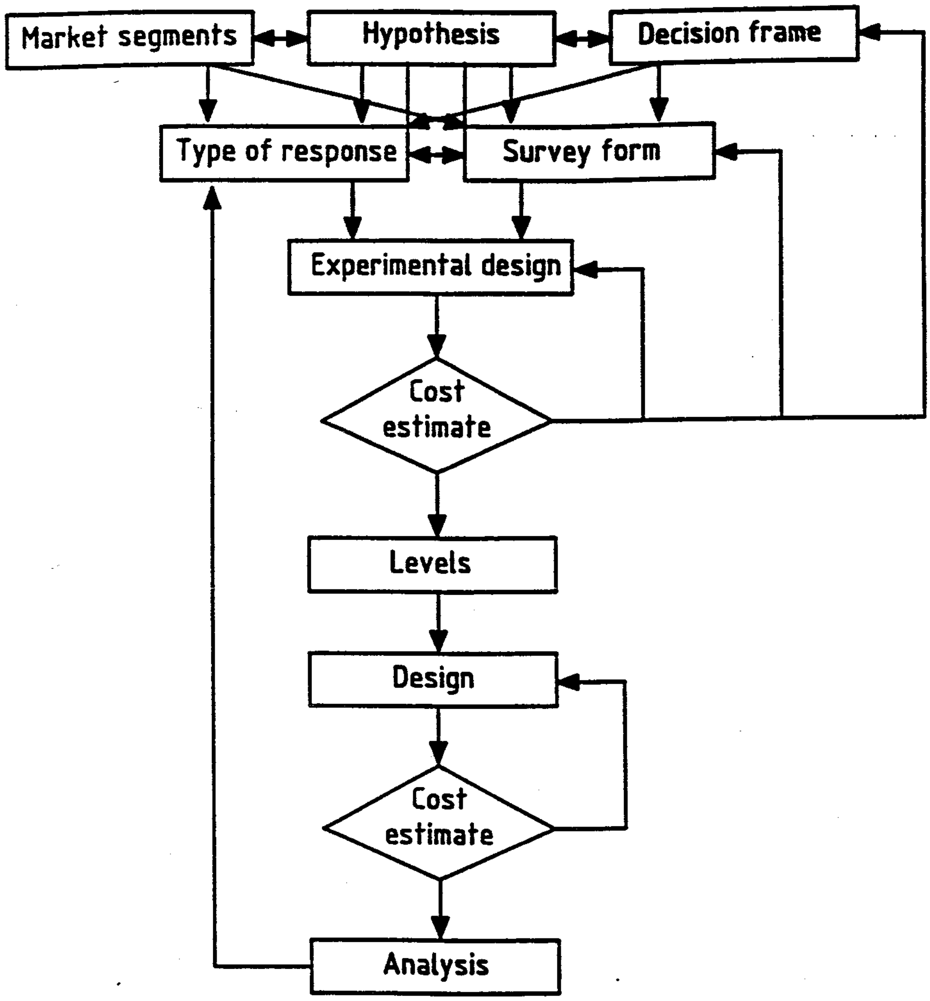
- *Literature review*
- *Focus groups* or *in-depth interviews*
- *Instrument development*
- Small scale *pilot* of the instrument
- *Revision* of the instrument
- *Application*

This process and the requirements of each step are discussed in depth in all basic survey methodology textbooks and does not need to be rehearsed here again. The process of the instrument development is specific enough to warrant a discussion at this point. Figure 3 gives an overview of the elements and their feed-backs.

The first three steps, definition of the market segments, of the hypothesis and of the behavioural frames to be studied, have to be undertaken together, as there are numerous interactions: an attribute can be irrelevant for a particular behavioural frame; a choice alternative is not available to a market segment or a behavioural frame is irrelevant for a market segment. The three aspects have to be consistent.

In CA market segmentation is frequently performed on the basis of the utility functions estimated. This a-posteriori segmentation is implemented at the aggregate level in transport applications through the use of socio-economic variables in the specification of the utility functions. Any a-priori segmentation has to be based on the overall modelling framework into which the SP-results are to be integrated. In transport modelling this implies the socio-demographic categories of the trip generation and distribution models.

Figure 3 Development process of an SP



Source: adapted from FGSV (1996), 23

Based on the first three choices, the survey protocol and the format of the preference statements have been selected to achieve the best fit with the study objectives, including the ability to estimate precise utility models. The experimental design (number of attributes, levels and choice alternatives) plus the choice of adaptive or customized varieties follows from the decisions so far.

A cost estimate is required at this point in the process to avoid unnecessary work later in the process. In transport planning SP practise the rule-of-thumb is that a minimum of 30, but better 50-70 returned surveys/interviews are required per block of choice situations, market segment and behavioral frame. For example:

Three blocks of 12 choice situations each
Two market segments (e.g. males and females, car owners and non-car-owners etc.)
Two behavioral frames (e.g. work and shopping trips on a weekday)

Minimum sample size: 30 * 3 * 2 * 2 = 360 successful interviews/returned surveys
Preferred sample size: 60 * 3 * 2 * 2 = 720 successful interviews/returned surveys

Johnson (1996) suggests, that the sample size is determined as a function of the desired precision for the estimate of the choice proportions.

If the cost estimate is higher than the budget available, then a reduction of the complexity preferred so far or a simplification of the survey protocol is required. If not, then the next two steps concern the determination of the values of the attribute levels, including any analysis of existing data (s.a.) and the final design of the survey instrument (format of presentation, development of software, prototypes, pictures and forms etc.). A final cost estimate should be performed before the design is finalized and approved.

As a last step, or jointly with the selection of the attribute level values, the instrument should be tested with regards to its ability to estimate the desired models from its results. It is possible to specify utility functions for a hypothetical population and to use these functions to answer the SP instrument. The resulting hypothetical answers should be used in an estimation of the planned type and it should be verified that the specified utility functions can be recovered from the data and the parameters estimated with sufficient precision. If not, a further iteration starting with the format of the preference statement is required.

2.4 Valid contexts for SP

The internal validity of SP results in forecasting has been documented in numerous studies (See Louviere and his collaborators in a transport context or the literature in Green and Srivasan, 1978 or Leigh, McKay and Summers, 1984 from marketing). The studies of internal consistency use hold-out choice tasks of various formats, which are part of the SP/CA interview. These studies have consistently shown that the models derived can identify the choices made satisfactorily. The various studies in the transport literature, which have estimated joint models from SP and RP data, support this conclusion, as these models reveal scale differences, i.e. differences in variability of the error terms, but reveal in general identical functional structures. Furthermore, the growing use of the technique indicates that the clients are satisfied with the results, which in turn must indicate a satisfactory track record in terms of insights and prediction.

More important for the practise in transport or public goods provision is the issue of when to conduct the study during the overall public decision process to which the study belongs. The transport and market research literature is generally silent on this point, but the contingent valuation literature does discuss it at length. Mitchell and Carson (1989) summarize their discussion as shown in Figure 4.

Figure 4 Valid contexts for SP studies

	Obligation to pay perceived as:		
	Amount offered	Uncertain amount	Fixed amount
	Provision of good perceived as contingent on revealed preference		
Motivation	True preference revelation (TP)	Variable (SB_1)	Overpledge (SB_2)
Direction	True value	Uncertain	Overbid
Strength	Strong	Weak to moderate	Strong
	Provision of good perceived as likely, regardless of revealed preference		
Motivation	Free Ride (SB_3)	Free Ride (SB_4)	Nonstrategic – Minimize effort (ME)
Direction	Underbid	Underbid	Random
Strength	Strong	Weak to moderate	Moderate

Source: Mitchell and Carson (1989), 144

CV studies establish willingness-to-pay (WTP), normally in terms of entry fees for a facility or of dedicated taxes, an instrument frequently used in the US to pay for particular services or investments. They argue that it is possible to define a-priori expectations about the respondent's response strategy on the basis of two dimensions: the perceived obligation to pay the stated amount and the importance of the survey in the decision process. Only in one of the six resulting cases (the good will only be provided, if the WTP of the population (respondents) is high enough and if the price will be fixed at the WTP results) can we a-priori expect, that the respondents will reveal their true preferences. In all other cases will we either encounter strategic behaviour misguiding the analyst (Free riding or overpledging) or random behaviour of unknown properties. This approach highlights the need to engage in SP/CA surveys at particular points in the planning/design cycle, in particular, if the respondents have to give WTP indications, as is certainly frequent in transport related studies. This point is early in decision process, well before the decision has been taken to go ahead with the service/investment. Other policy biases remain even at this point, but they can be much more easily identified and dealt with.

3 SURVEY APPROACH AND ADMINISTRATION[7]

The section above has outlined the *stated-preference* methodology and its cousin *conjoint analysis* as possible tools to solicit information about future behavioural changes. The aim of this study was to apply both methodologies to compare their results using the mode choice behaviour of the residents of Innsbruck as an example. The methodological interest had to be balanced with the substantive interests, which required the drawing of a large sample of respondents. This requirement led to the choice of a combination of a telephone survey with a follow-on postal survey, which was based on the answers in the telephone survey (for the pioneering study see Polak, Jones, Vythoulkas, Meland and Tretvik, 1991), where ideally one would have wished to use a computer-based interview for the CA/SP elements of the work.

The telephone survey covered the following topics (See Appendix B for the detailed questions):

- Availability of public transport at home and at work, where relevant, in terms of distance to the nearest stop and number of lines available
- Availability of a car or of a season ticket
- Availability of parking at home and at work, in terms of distance to the parking space, its type and its costs.
- Socio-demographic description of the respondent, including the ownership of a driving licence
- a recent trip to either work, shopping or an evening leisure activity within the City of Innsbruck including destination, access-, wait-, in-vehicle, parking search and egress times, transfers, availability of seat, means of public transport (bus, trolley or tram), fare and parking fee (for the chosen and the competing modes)
- the number of trips undertaken by public transport during the past week and the usage of different ticket types (one half of the sample reported numbers and usage for the week as

[7] Axhausen, Köll and Bader (1998a and b) have also reported this work.

a whole, while the other half reported trips per and the ticket used on that day for each of the seven days)

The information was coded and the trip description was used to generate postal SP and CA surveys, which were sent to the respondents generally within four (two working) days.

Conjoint analysis survey

CA, as a term, covers a whole range of different approaches, which calculate individual utility part worths using both compositional and decompositional approaches (Schubert, 1991). The chosen hybrid approach combines both compositional and decompositional elements (Green and Krieger, 1996) by offering first a series of rating tasks, in which the respondent has to judge the importance of an attribute and the desirability of different levels of the attribute, and by then offering a set of full profiles, which the respondent has to rate as a whole. The first part allows the estimation of utility by adding (composing) it from the assessment of individual attributes and their levels. The second part allows the estimation of the part worths of the different attributes by decomposing the joint rating of the alternatives offered.

Each respondent was sent 14 tasks of the first type (5 pages with three each, including the reported mode from the target trip) (See Figure 5 for an example) and 14 tasks of the second type (5 pages with three each, including the reported mode) (See Figure 6 for an example). The attribute values were varied consistently around those reported for the target journey. Depending on the availability of a car to the person, the modes presented were public transport and car or public transport, bicycle and walk.

Table 1 lists the attributes. The experimental design was a random sample of the 2^{11} 3^{3} full factorial (44 situations, which were divided into four blocks with some overlap). The sample was checked for the extent of correlation between the attributes and the existence of factorial structures, in the factor analytical sense, and was found satisfactory in both respects. The tasks related to recorded work trips and shopping trips.

Figure 5 CA survey: Example of attribute & levels rating task (© Axhausen, Köll und Bader)

Wie wichtig ist für Sie die **Art des öffentlichen Verkehrsmittels**, das Sie benutzen ?

ganz unwichtig — sehr wichtig

0	1	2	3	4	5	6	7	8	9	10

Wie beurteilen Sie die folgenden Möglichkeiten ?

unattraktiv — attraktiv

	0	1	2	3	4	5	6	7	8	9	10
Bus											
O-Bus											
Straßenbahn ...											

Figure 6 CA survey: Example of a full profile rating task (© Axhausen, Köll und Bader)

Nr.: 3463-300

Sie haben uns den Weg zur Arbeit wie folgt geschildert:

Öffentlicher Verkehr:	Es fährt ein	Bus
	Bus fährt	alle 10 min
	Bus ist	in 0 von 10 Fällen unpünktlich
	Umsteigen	nein
	Fahrt dauert	insgesamt 8 min
	Fußwege von/zur Haltestelle dauern	insgesamt 3 min
	Fahrt mit dem Bus kostet	15 Schilling

Ihre Bewertung wäre:

unattraktiv — attraktiv

0	1	2	3	4	5	6	7	8	9	10

Table 1 Variables used in the CA/SP tasks

Attribute (Number of levels)

Public transport	Car	Bicycle	Walking
Means of transport (3)			
Access time (2) Headway (2) Waiting time[1] (2) Transfer (2)	Access time[2] (-)	Access time[1] (2)	
In-vehicle (inclusive of transfer times) (2)	In-vehicle (without search) (2)	Riding time (2)	Walking time (2)
	Parking search time (2)	Parking search time [2] (-)	
Egress time[2] (-)	Egress time[1] (2)	Egress time (2)	
	Type of parking (3)	Type of parking (2)	
Reliability (probability of lateness) (2)	Reliability (probability of congestion) (2)		
Fare (3)	Parking fee (2)		
		Share of bicycle paths (3)	

[1] Only for the CA compositional tasks
[2] Not varied for the CA full profiles/SP tasks

Stated Preference

The Stated Preference element of the survey was implemented as a *Stated Choice* experiment with respondents choosing between car, public transport, bicycling and walking, if a car was available and public transport, bicycle and walking, if no car was available. In the first case, bicycling and walking are described as "as today", while the other two modes are varied systematically. In the second case, the descriptions of all three modes are varied. In the case of public transport the access and egress walking times are presented as their sum, while the in-vehicle times include any transfer times. The in-vehicle time for the car excludes any parking search time. Access times to the car are assumed to be constant at current values.

The experiments were conducted for all three trip purposes (work, shopping and evening leisure). Each respondent received 11 choice tasks, plus a description of the reference journey (6 pages with 2 descriptions each) (see Figure 7 for an example).

Figure 7 SP experiments: example of a choice task (© Axhausen, Köll und Bader)

Nr.: 2918-401

Angenommen, die Situation wäre nun so:

Öffentlicher Verkehr:	Es fährt eine	Straßenbahn
	Straßenbahn fährt	alle 6 min
	Straßenbahn ist	in 0 von 10 Fällen unpünktlich
	Umsteigen	nein
	Fahrt dauert	insgesamt 20 min
	Fußwege von/zur Haltestelle dauern	insgesamt 7 min
	Fahrt mit der Straßenbahn kostet	12 Schilling
Rad:	Fußweg bis zum Rad	1 min
	Fahrzeit mit dem Rad ist	8 min
	Zum Abstellen des Rades gibt es	keinen Fahrradständer
	Fußweg vom abgestellten Rad zum Ziel	1 min
	Als Radweg ausgebaut sind	15 % der Strecke
zu Fuß:	Gehzeit ist	23 min

Ihre Entscheidung wäre: Straßenbahn ... ☐ Rad ... ☐ zu Fuß ... ☐

4 RESPONSE BEHAVIOUR

4.1 Socio-demographics of respondents

The telephone interview technique led to an overrepresentation of older and female respondents. The sample was therefore weighted to reproduce the known distribution of residents with regards to age (3 age categories), sex and season ticket ownership. Table 2 presents the distribution of the key socio-demographic variables for the weighted sample.

Table 2 Socio-demographics weighted sample (all telephone respondents)

Characteristic	Share [%]
Female	53.6
Age	
15-20	3.3
20-30	12.3
30-40	26.2
40-50	17.0
50-60	15.4
60-70	9.4
70+	15.4
Occupation	
White-collar employee + civil servant	41.3
Blue-collar employee	5.6
Self-employed	4.5
Housewife	9.5
Retired	25.4
Student	5.5
Other	2.8
N.A.	0.6
Highest level of education achieved	
Primary school (up to 15 years of age)	20.1
Apprentenceship	27.9
Vocational degree	8.7
Highschool diploma	25.2
University degree	13.3
Other	2.3
N.A.	2.5
Paid working hours	
Not working	43.5
1-13 hours	4.8
14-34 hours	12.5
35 and more hours	39.1
Season tickets (weekly, monthly, annual)	
Females	13.6
Males	7.5
Car driving licence	82.9
Car availability	70.4

4.2 Analysis of response behaviour

Table 3 summarizes the overall response behaviour. The share of unreachables is typical for the City of Innsbruck, reflecting the substantial share of second homes in the City. The share of those reached, who completed the interview was satisfactory with 66%, of which nearly all had a suitable target trip to report.

The response rate to the SP/CA- experiments was identical in the aggregate with a satisfactory 65%. The response behaviour was analyzed using probit models of response probability using the available set of socio-demographic variables (See Table 4 for the detailed results) contrasting those who had participated in the telephone interview, but not returned the forms with those, who did. The equations estimated were not significant overall and only a small set of variables had a significant impact, but there was no overlap between those significant in the CA response model and those in the SP response model. The high share of correct classifications overstates the quality of the model, as it misclassified nearly all of the non-respondents as respondents. The willingness to participate in this task seems therefore unrelated to the socio-demographic description of the respondents. The commitment comes from other sources, which cannot be described with the socio-demographic variables available here.

Table 3 Response behaviour

Response							Share of all
Unreachable	391			(18%)			18%
Reached	1832			(82%)			
Interview refused		487			(27%)		22%
Interview aborted		130			(7%)		6%
Full interview		1215			(66%)		
With trip			1161			(96%)	52%
Without trip			54			(4%)	2%
Sum	2223	1832	1215				2223

Table 4 Probit model of response probability

Variable	Participation in SP task		CA task	
	Parameter	Significance	Parameter	Significance
Purpose: Shopping	0.024		0.005	
Purpose: Leisure	0.062		-	
Male	0.083		-0.054	
Owner of driving licence	-0.026		-0.112	
Car owner	0.147		0.469	*
Working	-0.322	*	0.223	
In education	0.076		-0.094	
Primarily public transport user	-0.028		-0.027	
Primarily bicycle user	0.181		-0.095	
Highschool diploma	0.047		0.354	**
Born in the 1930's	0.581	**	0.175	
Born in the 1940's	0.678	**	-0.060	
Born in the 1950's	0.774	**	0.057	
Born in the 1960's	0.501	*	-0.280	
Born in the 1970's	0.214		-0.273	
Annual season ticket holder	0.413		0.073	
Weekly/monthly season	0.104		-0.189	
Surveyed before Christmas	-0.260	*	-0.067	
$\mathcal{L}(C)$	-452.2		-291.5	
$\mathcal{L}(\beta)$	-444.9		-283.1	
χ^2, Significance level	14.5	0.63	17.7	0.40
N	710		451	
Share predicted correctly	67%		67%	

* = Significance < 0.05; ** = Significance < 0.01

5 DESCRIPTIVE ANALYSIS OF THE CHOICES

This section provides a descriptive presentation of the observed choice behaviour in the RP and SP/CA contexts to set the frame of the later analysis.

5.1 Mode generally chosen

The respondents were asked as the first question of the interview, which mode they chose in general for trips in Innsbruck. This is a very soft question, which was intended more to relax the respondent than to retrieve hard information. Still, it gives an idea of the perception of the respondents of their trip making. Within these limitations it can be used to highlight some longer term limit to changing mode choice behaviour.

Table 5 crosstabulates this preferred mode against car availability and ownership of a season ticket. The shares of the preferred mode over all respondents do indicate a public transport friendly sample. The shares of all trips made in Innsbruck in 1993 was 16% public transport, 36% car, 33% walking and 15% cycling (Sozialdata, 1994). The largest differences are for walking and public transport (16% vs. 40% and 10% vs 33%), while the differences for cycling and the car are not large. The differences for public transport and walking can be understood as a result of respondents, who gave public transport as their preferred mode, ignoring their substantial walking in the aggregation process leading to the overall preference judgement.

Table 5 Preferred mode against car availability and season ticket ownership

Car availability	Season ticket ownership	In general preferred mode [%] Car	PT	Walking	Bike	Share of all respondents [%]
No	No	3.6	58.1	13.6	24.7	22.3
	Yes	-	88.9	2.8	8.4	6.9
Yes	No	44.9	23.4	11.3	20.4	63.2
	Yes	8.6	83.1	2.3	6.0	7.7
Share of all respondents [%]		29.9	40.2	10.5	19.4	100.0

The effect of the season ticket in comparison to car availability on the preferred mode is striking. The owners of a season ticket are strongly selfselected and are strongly bound to their preferred mode. Car availability, admittedly a weak behavioural concept, does not bind the persons so strongly, although one should point out, that the share of persons, who have a car available and a season ticket is relatively small (only about 10% of persons with a car available). Further tabulations show, that it is, in particular, the working males, who are committed to the car, although the share of females, who prefer the car, also increases with the increasing number of hours worked, if not as strongly as for males.

5.2 Description of reported trips

The respondents were asked to describe a trip they recently performed to get to work, to go shopping or to get to a leisure activity. The trips are well spread across the city, but with the bulk of the trips having their destinations in the core of the city (See Table 6 for the work trips, for which the distribution is roughly comparable to the other two purposes).

Table 6 OD-pattern for the reported trips

Origin	Destination [% of originating trips] Core	NW	NE	S	Share of trips
Core	63	28	4	5	*4*
NW	47	13	27	12	*31*
NE	47	10	19	22	*31*
S	51	12	20	17	*34*
Share of all originating work trips	49	12	21	17	*100*

Core = Functional core of the city (traffic zones 1-10, 16)
NW = North of the Inn and west of the Innsteg
NE = North of the core and Pradl/Amras and east of the Innsteg
S = South of the Inn and the core, Pradl and Amras

Excluding 1% of trips ending outside the city limits

The shares of the chosen modes for the reported trips are shown in Table 7. The results show a preference for the motorized modes reflecting the larger then average distances of the trips reported. The origin-destination specific modal splits follow the expected patterns and reflect the good public transport accessibility of the core and of the corridors served by the trolley bus lines.

Table 8, Table 9 and Table 10 summarize the characteristics of reported trips aggregating across the chosen mode and the available alternatives, as reported by the respondents.

Table 7 Modes chosen for the reported trips

Purpose	Mode chosen [% of purpose] Public transport	Car	Bicycle	Walking
Work	33	42	17	8
Shopping	40	46	6	8
Leisure	35	47	7	10

Table 8 Public transport: characteristics of the trips and their alternatives, as reported

Characteristic	Purpose (Means and *standard deviations*/Shares) Work		Shopping		Leisure	
Public transport						
Type of vehicle [%]						
Bus	35.0		30.3		29.3	
Trolley bus	38.8		44.8		44.8	
Street car	26.2		24.9		26.0	
Access time [min]	3.44	*2.85*	3.80	*3.80*	3.86	*4.76*
In-vehicle time [min]	20.19	*13.27*	18.85	*13.14*	18.95	*13.15*
Egress time [min]	4.15	*3.31*	4.04	*3.15*	5.32	*3.93*
Without transfer [%]	66.9		65.6		74.3	
Headway [min]	11.79	*10.10*	11.17	*8.37*	14.68	*11.37*
Reliability [][1]	0.78	*1.63*	0.68	*1.43*	1.05	*2.17*
Fare [Schilling/trip][2]	12.28	*6.84*	13.82	*5.28*	15.05	*5.64*

[1] Measured as being 5 minutes late x times of out 10 trips
[2] The fare per single trip was calculated using the following assumptions for season tickets: weekly ticket = 11 trips, monthly and longer seasons = 50 trips for seniors and 66 for adults

Table 9 Car: characteristics of the trips and their alternatives, as reported

Characteristic	Purpose (Means and *standard deviations*/Shares) Work		Shopping		Leisure	
Car						
Access time [min]	1.41	*1.15*	1.48	*1.13*	1.48	*1.41*
In-vehicle time [min]	10.06	*4.48*	10.11	*5.42*	10.58	*4.49*
Egress time [min]	2.49	*2.92*	2.03	*2.02*	4.25	*3.86*
Search time [min]	2.40	*3.93*	2.17	*3.45*	3.87	*4.24*
Type of parking [%]						
Missing	21.0		33.3		30.1	
On street	28.4		11.9		43.0	
Parking lot	35.0		39.7		19.9	
Multi-storey	15.6		15.1		7.0	
Reliability [][1]	1.02	*2.60*	0.61	*1.85*	0.42	*1.50*
Parking costs [Schilling/trip][2]	28.41	*48.39*	4.85	*12.90*	6.45	*18.83*

[1] Measured as being 5 minutes of congestions x times of out 10 trips
[2] The fees were based on reported values

The values reported in general do not vary substantially by purpose, as one would expect. There are two exceptions, the perception of reliability of public transport and leisure and the car and work, but which can be explained with the usual timing of those trips and the associated unreliability of the road system in the morning and of public transport in the evening.

Aggregating the reported origins and destinations into 12 larger areas the absolute values for the reported time elements are reasonably consistent with those of network models available at the City of Innsbruck for private vehicular traffic[8]and the IVB for public transport[9], if one considers the different sources of error in both kinds of data (rounding error, misperception, definition of centroid and their connection times, precision of intersection modelling, aggregation errors etc.).

[8] Private communication with Dr. Fischer (Stadtmagistrat Innsbruck)

[9] Private communication with Dipl.-Ing. Rauch of BVR, which maintains the model for the IVB.

Table 10 Cycling and walking: characteristics of the trips and their alternatives, as reported

Characteristic	Purpose (Means and *standard deviations*/Shares)					
	Work		Shopping		Leisure	
Cycling						
Access time [min]	1.11	*0.32*	1.16	*0.37*	1.33	*0.70*
In-vehicle time [min]	12.39	*7.99*	14.31	*8.42*	15.81	*9.56*
Egress time [min]	1.11	*0.35*	1.42	*0.91*	1.28	*0.65*
Search time [min]	0.68	*0.57*	1.08	*1.44*	0.95	*0.71*
Bicycle stand [%]						
N.A.	79.0		66.7		69.9	
No	3.5		10.9		14.6	
Yes	17.6		22.4		15.5	
Walking						
Walking time [min]	32.07	*20.24*	32.63	*17.72*	31.52	*13.88*

The relative values for the driving, riding, in-vehicle plus waiting and walking times as roughly 1 : 1.5 : 2 : 3 are consistent with expectations, although the walking speeds are high. Interesting to note is the high share of travellers, who would need to change given that actual public transport users only change in about 15% of their journeys. The access, egress and search times have the right magnitudes in absolute and relative terms.

5.3 RP choice behaviour

This section has the task to provide a descriptive analysis of the RP data, while the formal modelling of the data will be reported in the next chapter. The focus of the analysis will be on the modal choice behaviour, i.e. the share of trips undertaken by any one mode for particular values of one or two attributes. Given the policy interest the analysis will stress the shares of private vehicular transport and of public transport.

Figure 8 and Figure 9 compare the shares of public transport and car travel by the door-to-door travel times of the two modes[10]. For low public transport travel times both public transport and car travel have small shares as both the bicycle and walking are still competitive. Both modes show a linear decrease (constant elasticity) with regards to their own travel time. This linearity of effects is also visible in Figure 10 and Figure 11, which show how the shares of public transport and of car travel depend on both of their travel times.

The effects of the respective out-of-pocket costs are also linear in the case of public transport (See Figure 12), while slight non-linearities can be seen in the case of car travel. The strong effects of parking fees on mode choice are reconfirmed with these results (See Figure 13).

Also substantial is the effect of a transfer on mode choice. Figure 14 shows a reduction of about 20% in the modal share of public transport for those relations, where a change is necessary.

5.4 SP choice behaviour

The SP data allow the performance of similar analyses to those above. When comparing one has to remember, that the total shares are not comparable given the systematic variation of the choice contexts and that one has to concentrate on the elasticities of the demand, i.e. the changes resulting from change in the attribute values.

The effects of their own travel times on their mode share are shown in Figure 16 for public transport and in Figure 17 for car travel. The overall pattern is comparable to the patterns revealed in the RP data, but the elasticities are not as strong overall, but Figure 18 and Figure 19 show that the effects are comparable, when we correct for the travel times of the competing mode. The same trends to weaker effects is visible for the impacts of the direct costs (Figure 20 for public transport and Figure 21 for car travel) and the need to transfer (Figure 15), while not correcting for the impact of competing modes.

[10] The door-to-door travel times were calculated as the sum of all time elements with an assumed waiting time of half the headway.

Figure 8 RP: Share of public transport and car travel by public transport travel times [min]

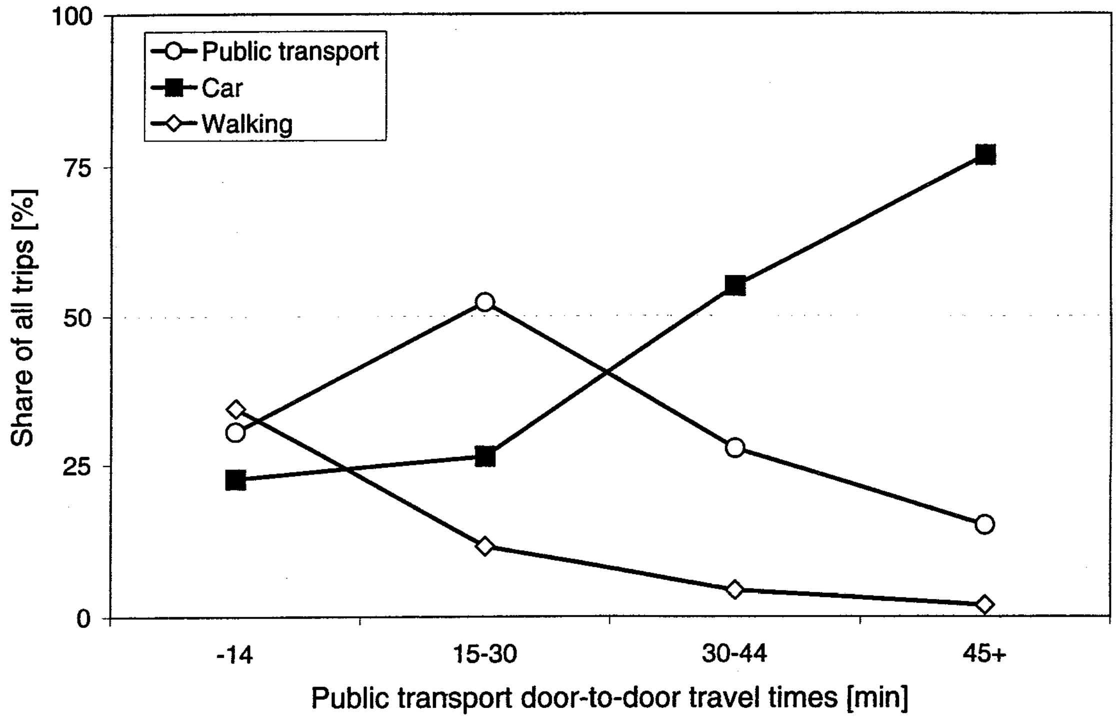


Figure 9 RP: Share of public transport and car travel by car travel times [min]

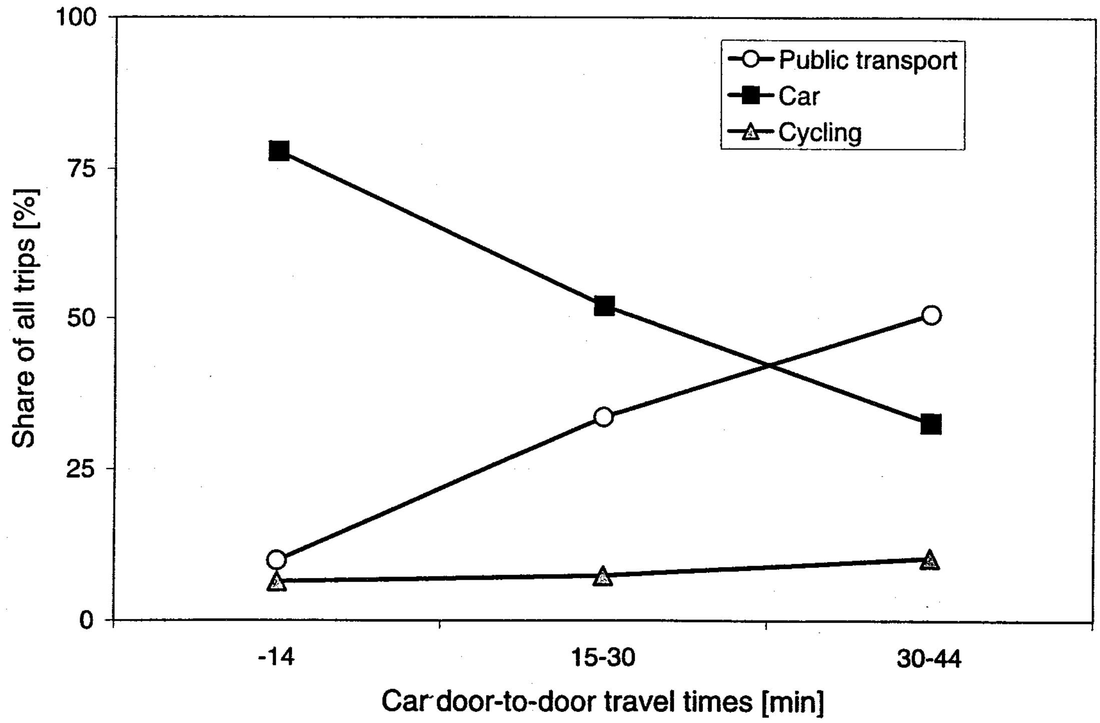


Figure 10 RP: Share of public transport by public transport and car travel times [min]

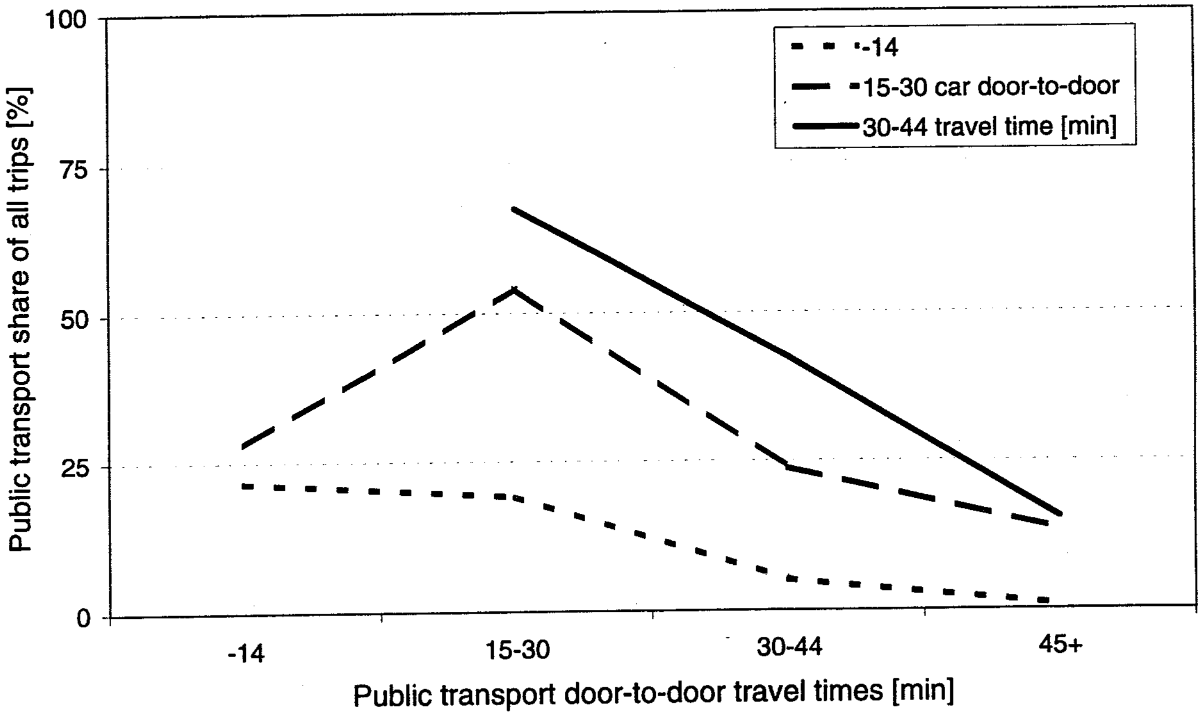


Figure 11 RP: Share of car travel by public transport and car travel times [min]

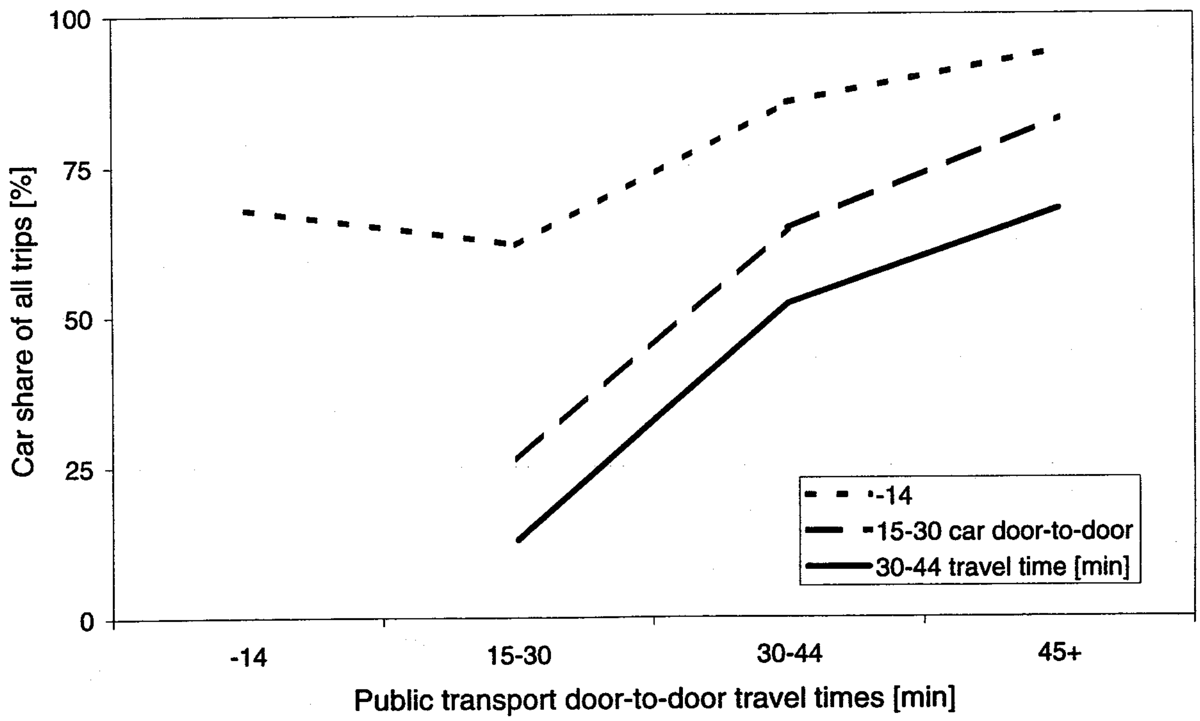


Figure 12 RP: Share of public transport and car travel by public transport fare [Schilling]

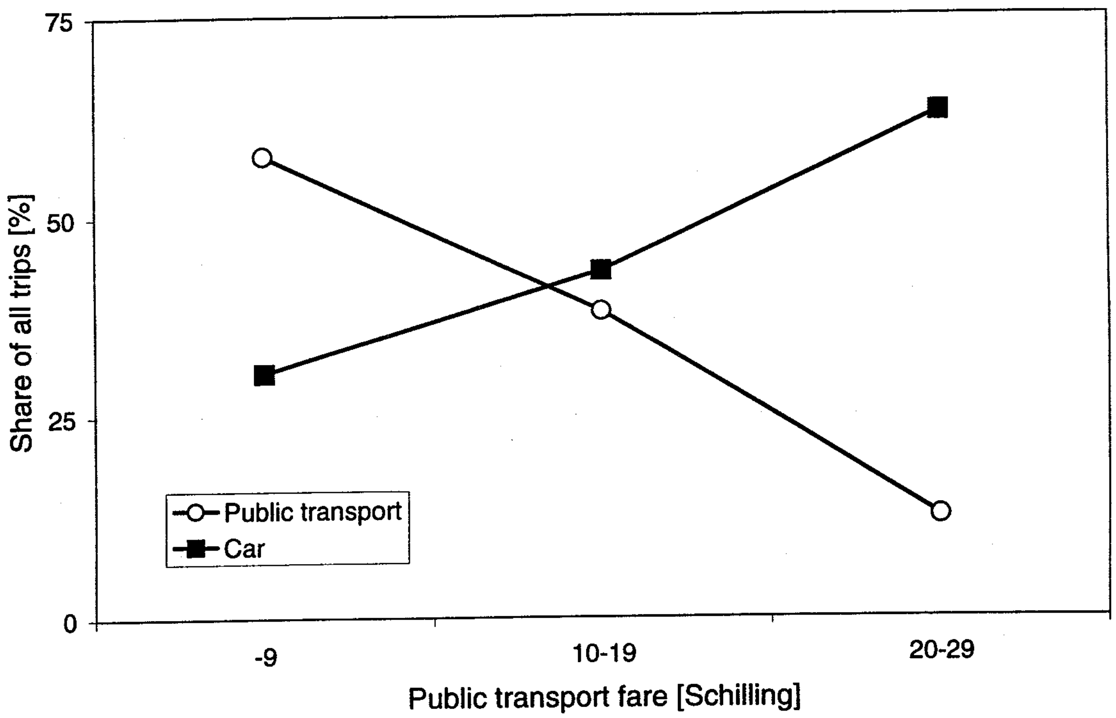


Figure 13 RP: Share of public transport and car travel by parking fee [Schilling]

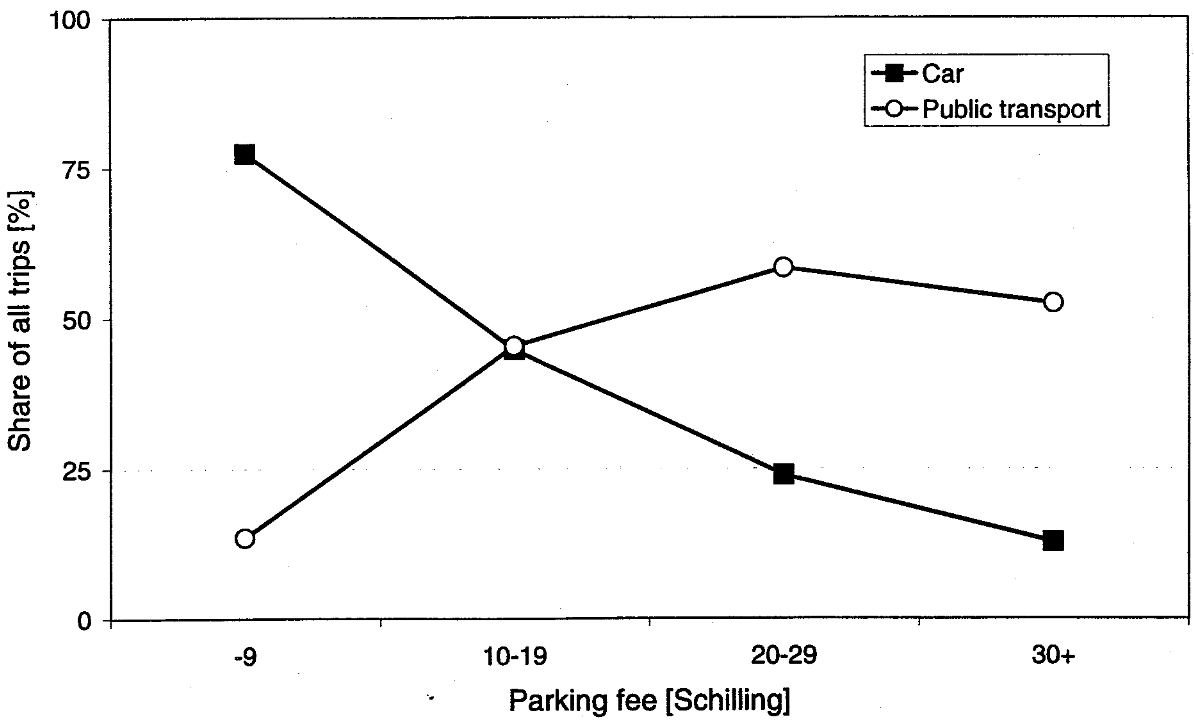


Figure 14 RP: Share of public transport by public transport travel times [min] and need to transfer

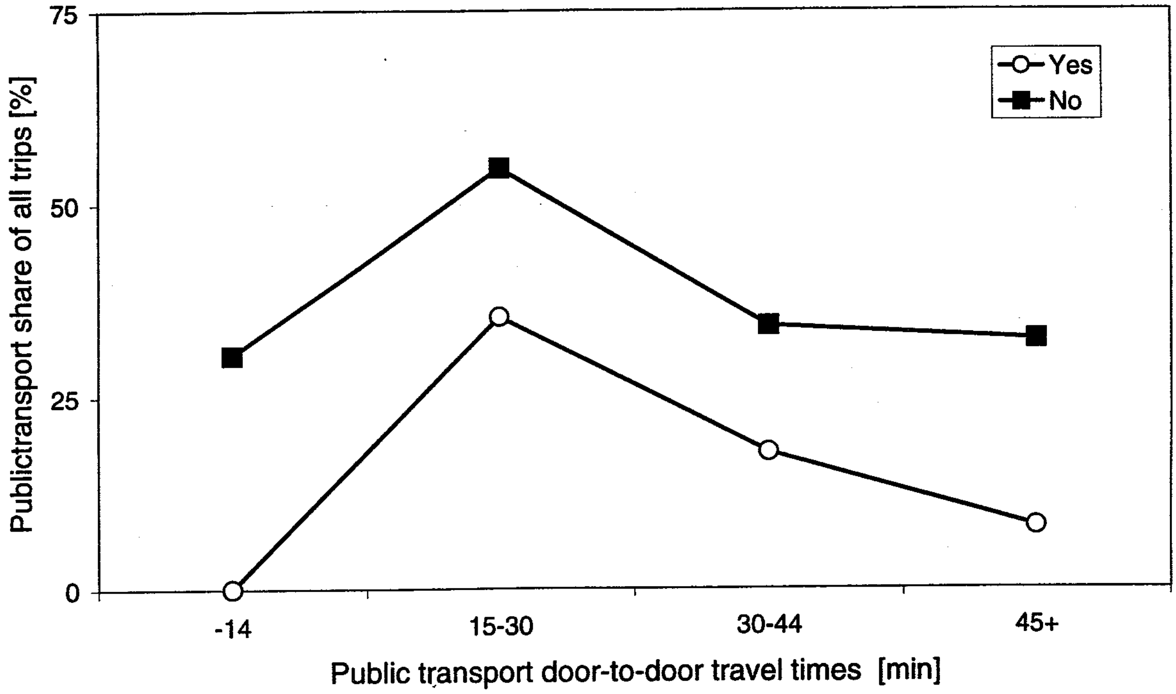


Figure 15 SP: Share of public transport by public transport travel times [min] and need to transfer

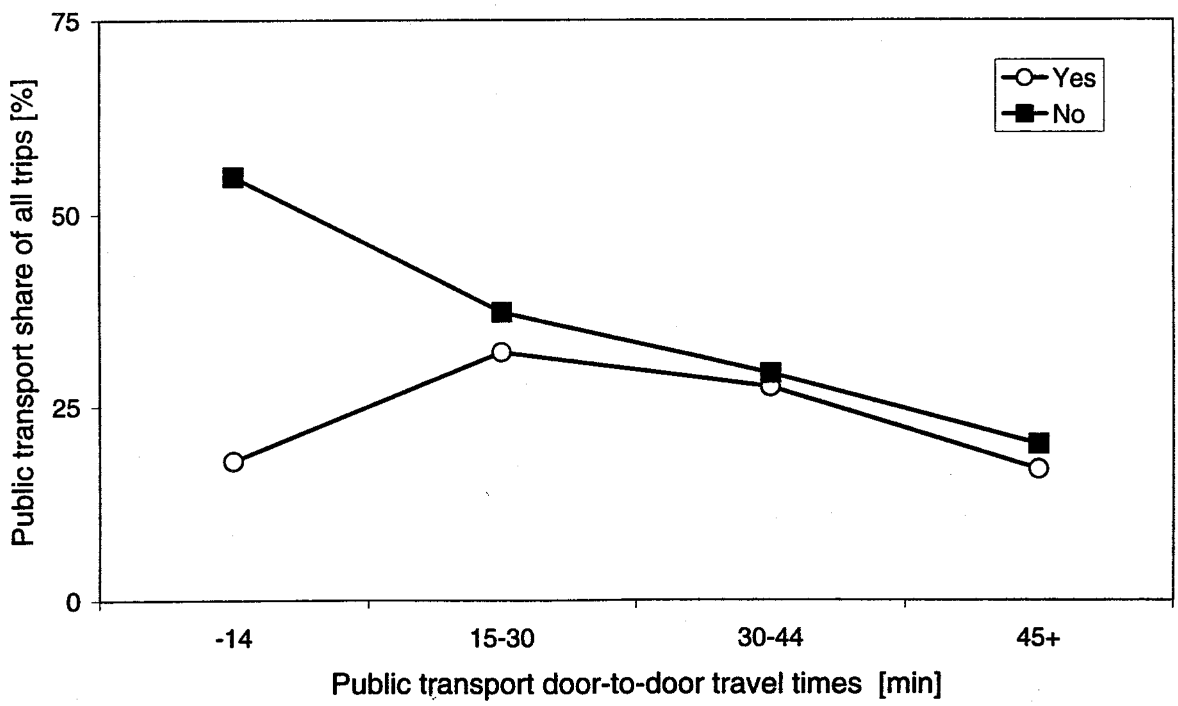


Figure 16 SP: Share of public transport and car travel by public transport travel times [min]

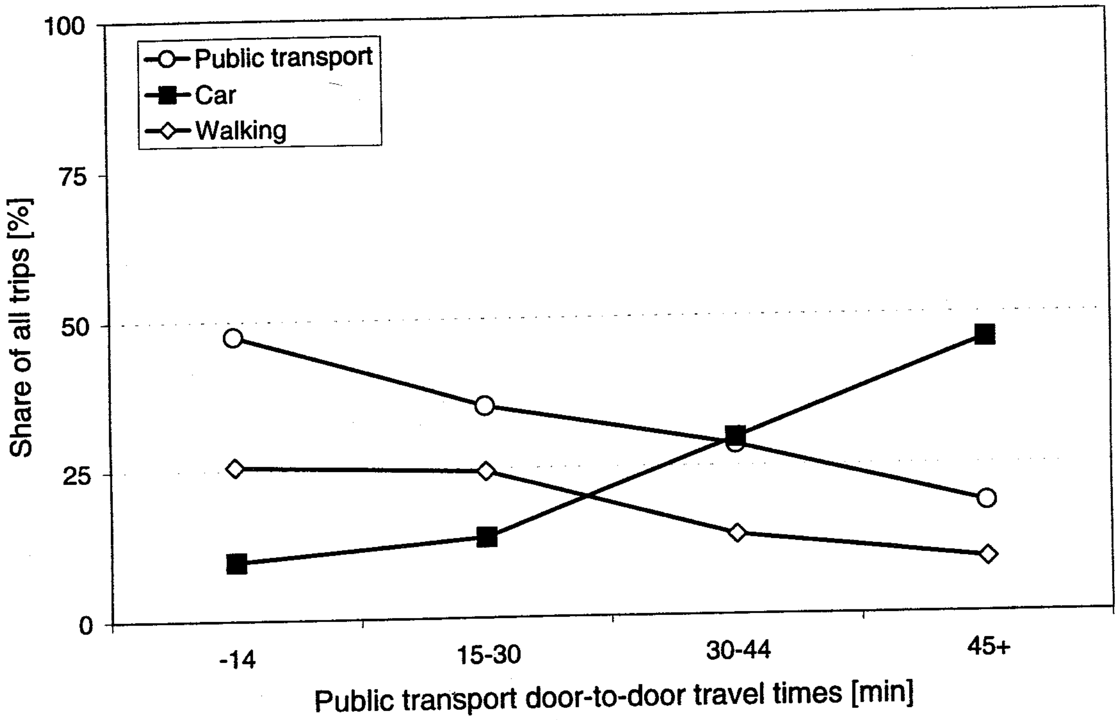


Figure 17 SP: Share of public transport and car travel by car travel times [min]

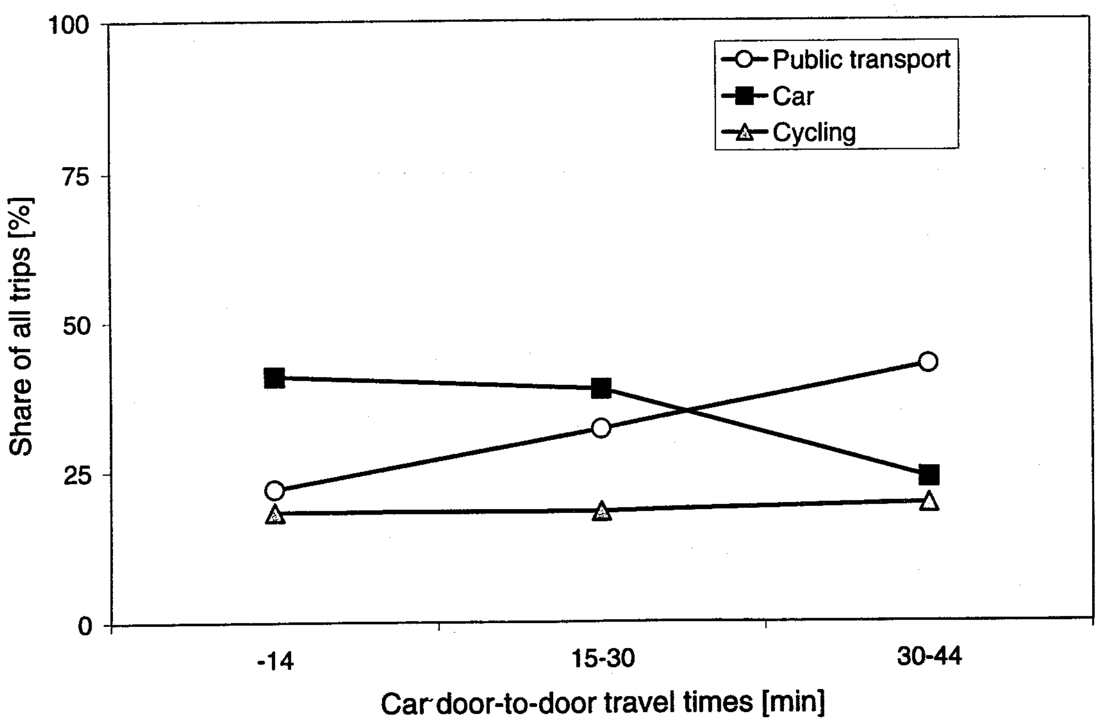


Figure 18 SP: Share of public transport by public transport and car travel times [min]

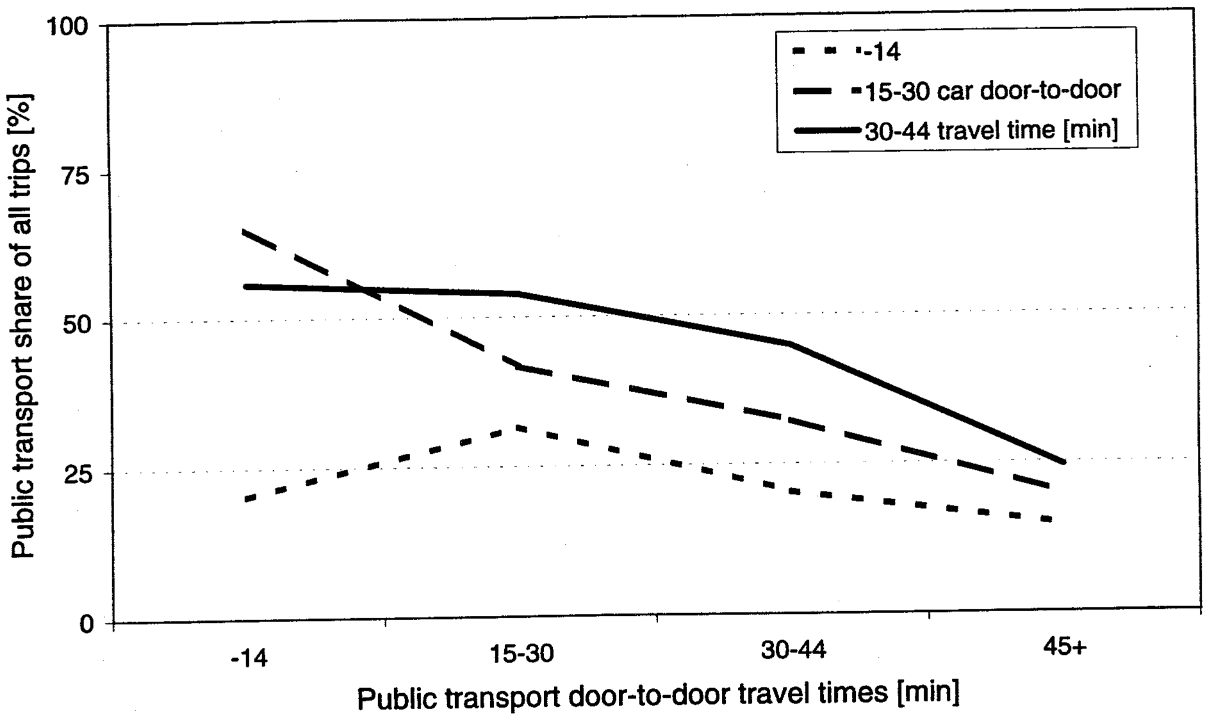


Figure 19 SP: Share of car travel by public transport and car travel times [min]

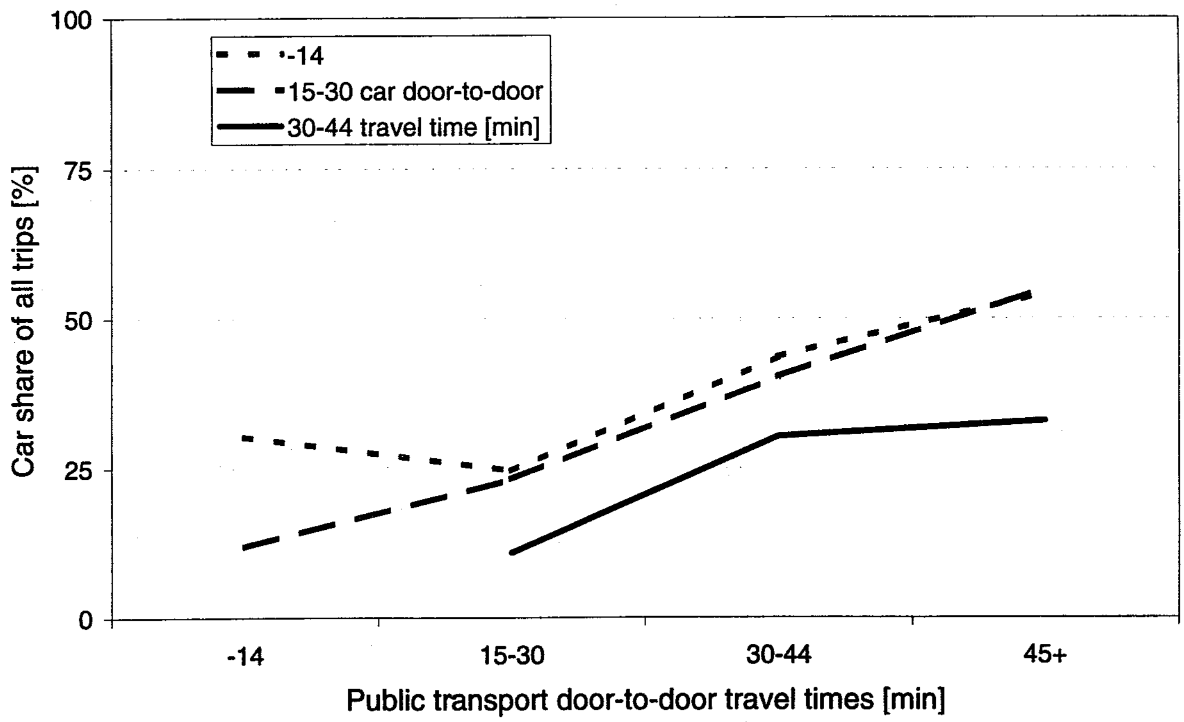


Figure 20 SP: Share of public transport and car travel by public transport fare [Schilling]

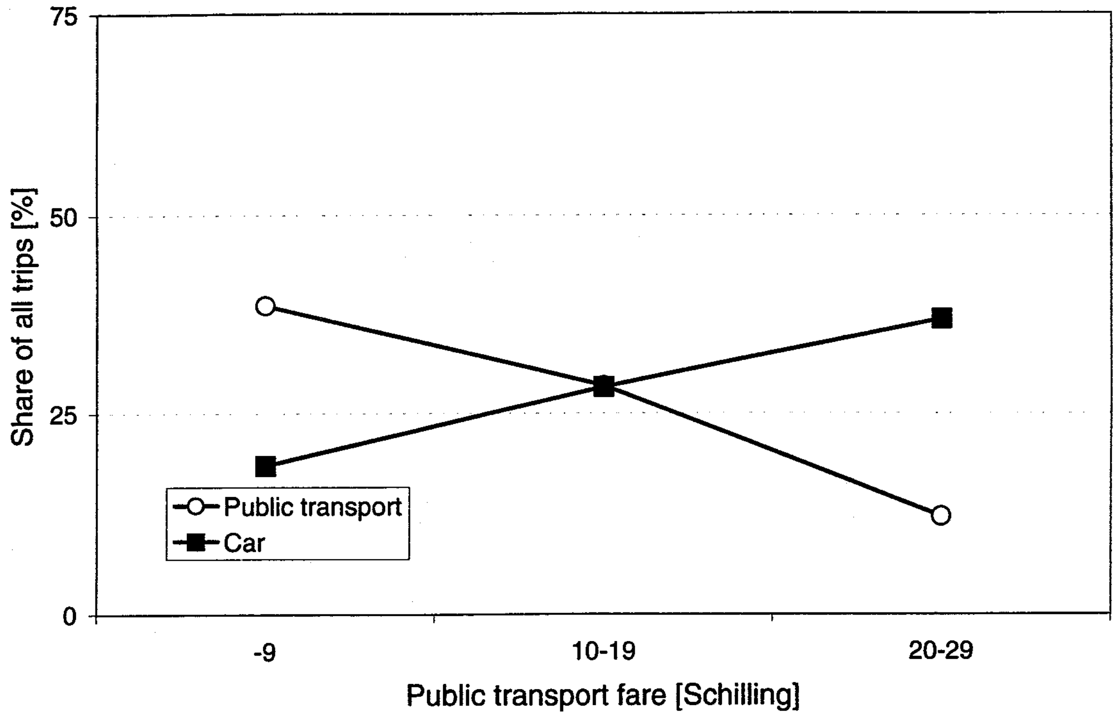
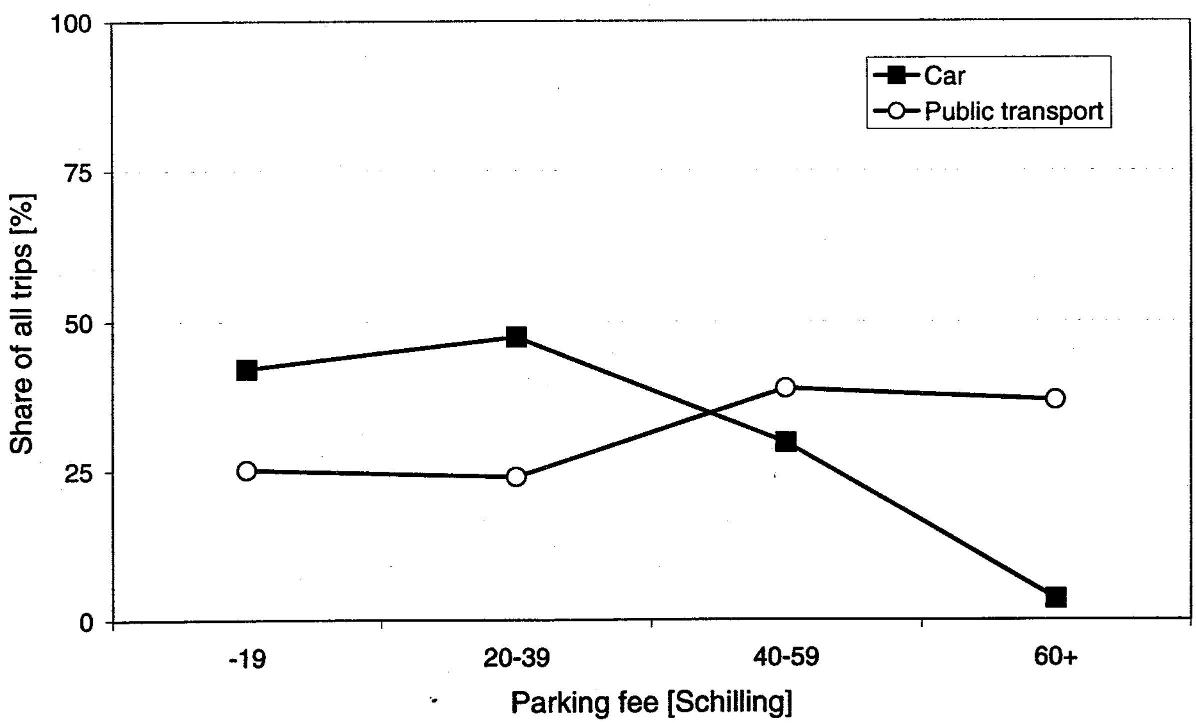


Figure 21 SP: Share of public transport and car travel by parking fee [Schilling]



The wider range of values in comparison with the RP data and the systematic exploration of possible combinations allows to study the role of unreliability better than with RP-data. Looking at the combined effect of public transport travel times and its own reliability (Figure 22) the substantial impact of unreliability on mode choice becomes visible: a 5% drop for each 3 cases of 10 more in lateness between 0-2 and 3-5 cases and a stronger impact for the next level of increase (the number of trips, on which the numbers for 6+ cases and 30+ minutes travel time are based, is too small to put too much weight on the observed trend reversal). A similar pattern and similar magnitudes are visible for car traffic (Figure 23).

Concentrating on the reliabilities alone (Figure 24 and Figure 25) reenforces this conclusion. In the case of public transport the share of it is reduced by the increase in its own unreliability (about 15% between the highest and the lowest category on average). The effect of the unreliability of car travel is not linear, as only a substantially incident prone system leads to higher public transport usage. The share of car travel increases or decreases with the increase in the unreliability of public transport depending on its own reliability. The interaction is quite pronounced and shows how important it is for the public transport operator to run services to timetable.

Public transport is offered in Innsbruck with three different types of vehicles: diesel bus, trolley bus and street car. The SP data (Figure 26) do not indicate in this naive analysis, that the type of vehicle will have a substantial impact on mode choice, as is confirmed by the comparable result from the CA questionnaires (Figure 27).

5.5 CA desirabilities

The CA questionnaires asked first for the importance of the different attributes and for the desirability of the different levels of these attributes. In a second step, desirabilities were asked for full profiles of individual modal alternatives. The comparison of the results from the individual ratings of the levels with the marginal values from the profiles showed that the results were comparable. The report will therefore only show results derived from the profiles, as it is then possible to show interactions between different variables.

Figure 22 SP: Share of public transport by public transport travel times and reliability [%]

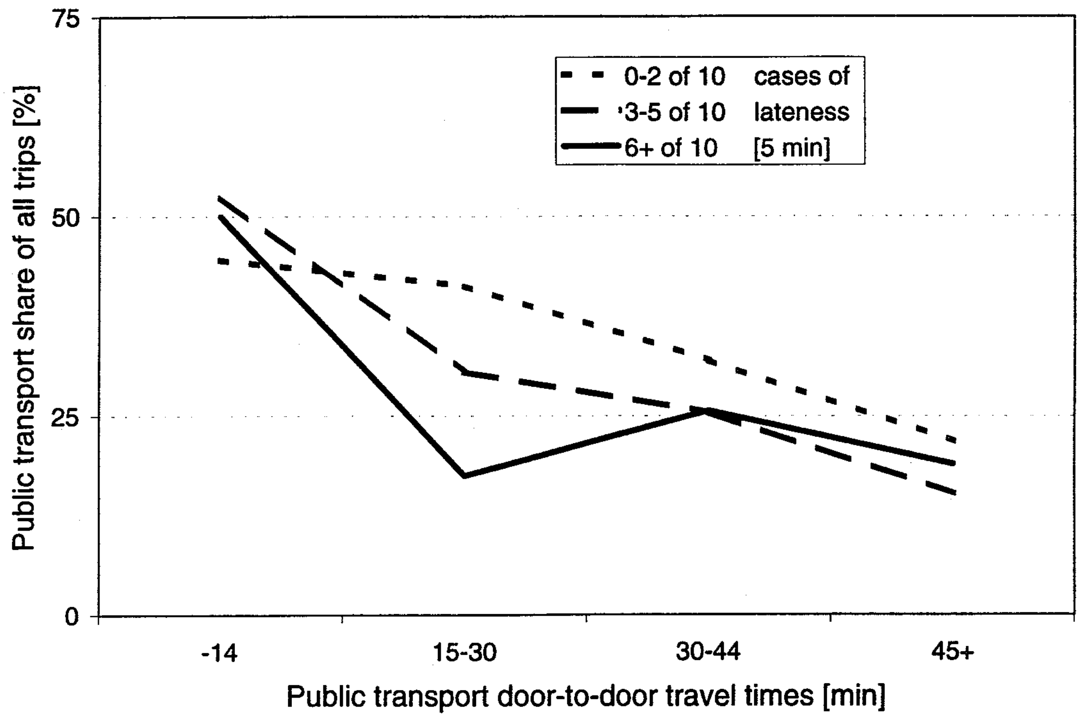


Figure 23 SP: Share of public transport by public transport travel times and reliability [%]

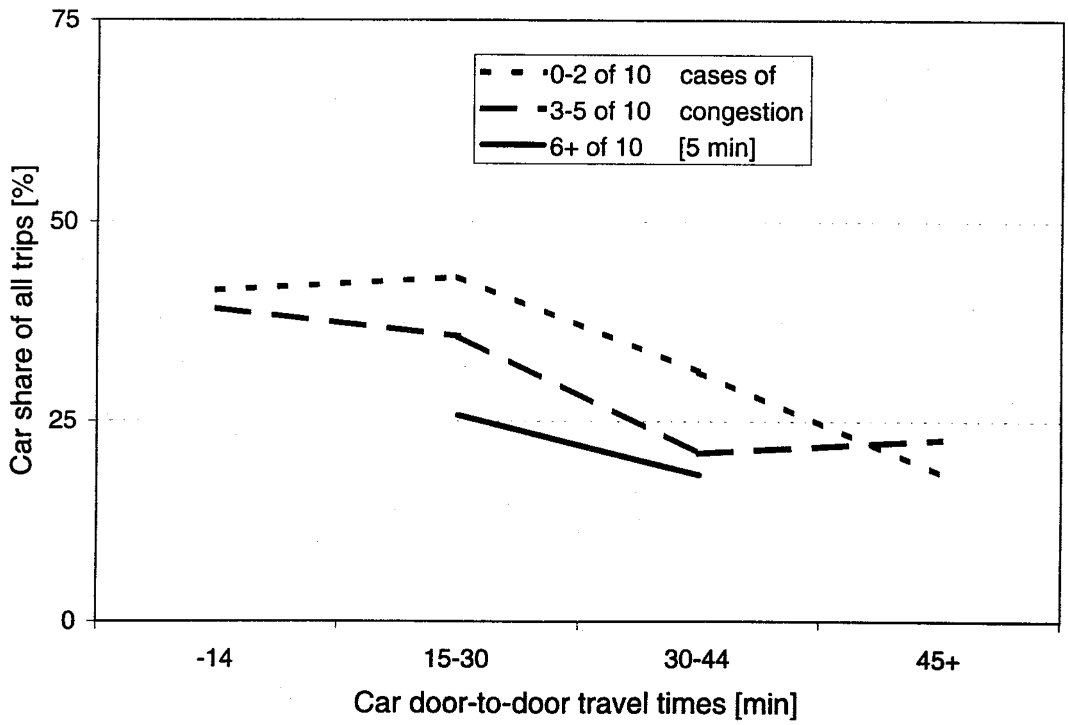


Figure 24 SP: Share of public transport by public transport and car travel reliability [min]

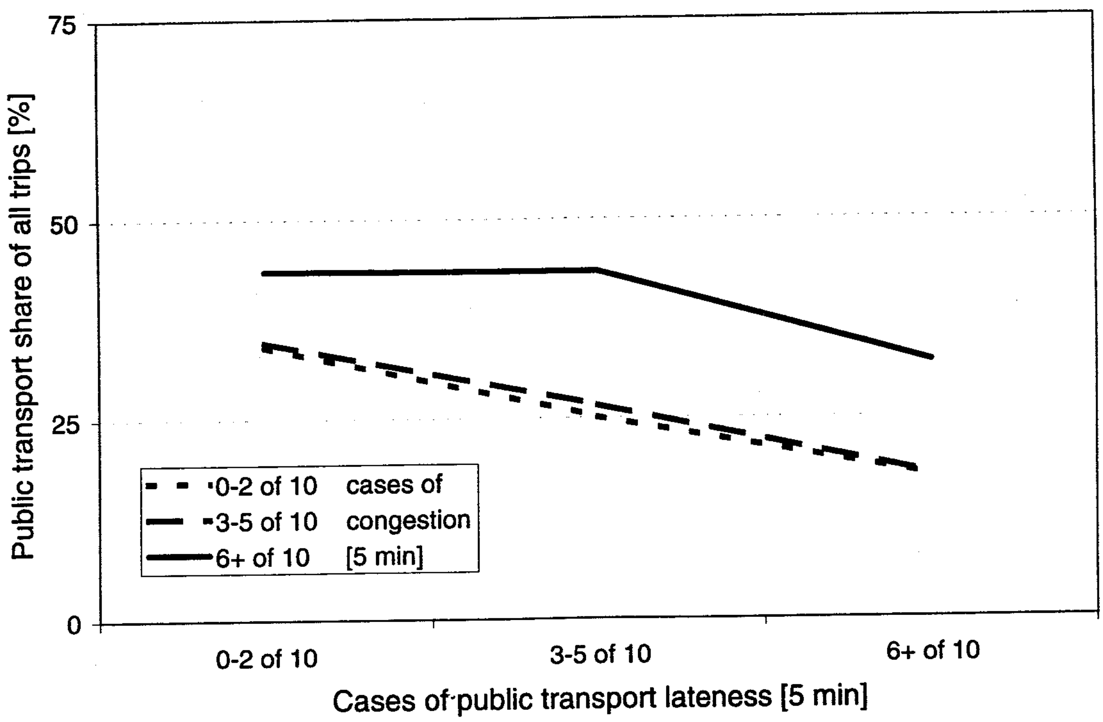


Figure 25 SP: Share of car travel by public transport and car travel reliability [min]

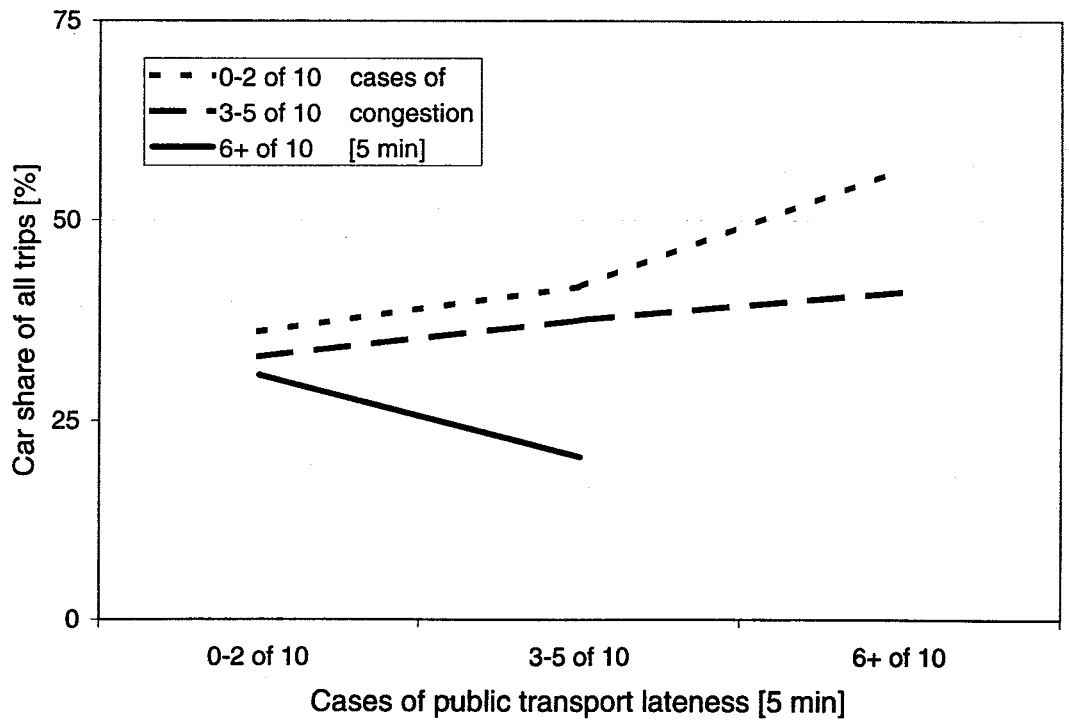


Figure 26 SP: Share of public transport by type of vehicle [%]

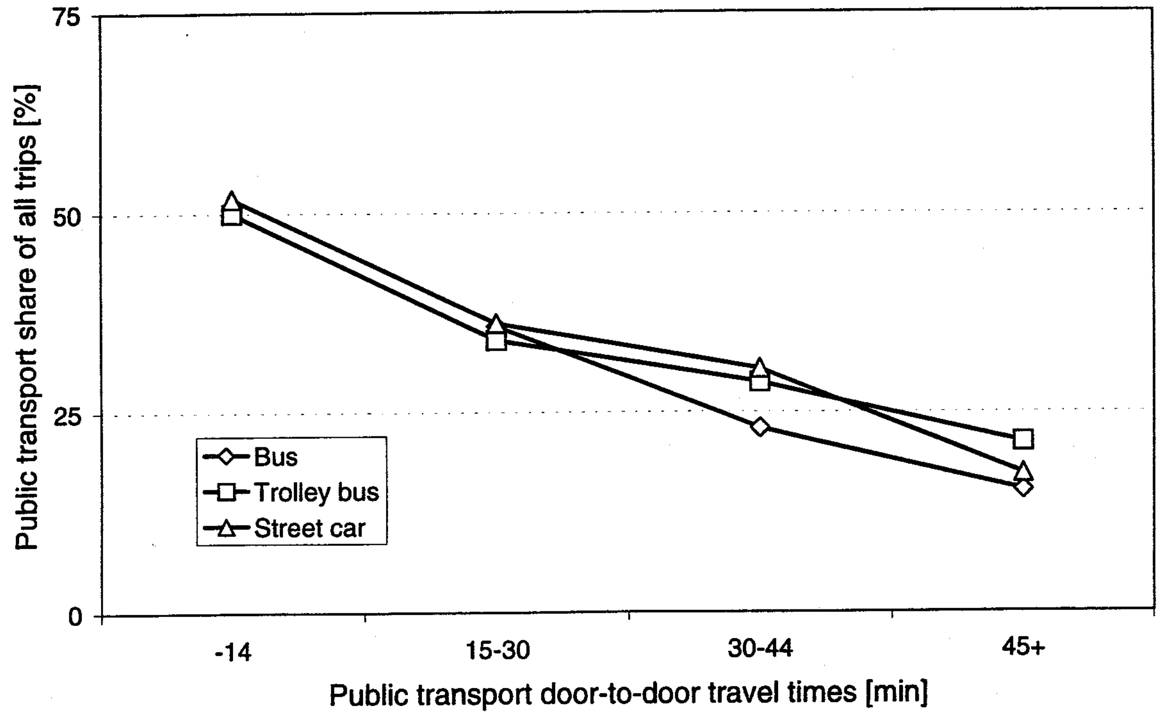


Figure 27 CA: Average desirability of public transport by type of vehicle []

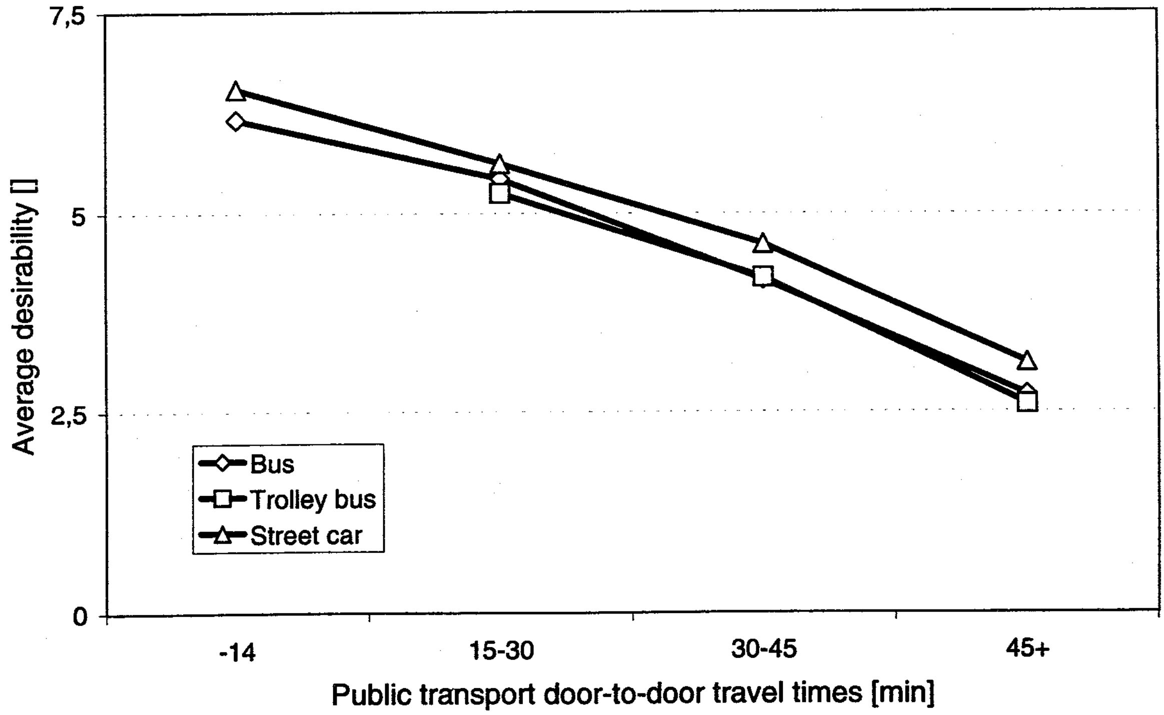


Figure 28 shows the attributes ranked by their average normalized importance[11]. Among the top six attributes are twice the difficult to anticipate egress time to the destination and twice elements subject to potentially large unforeseeable variations (parking search times and public transport headway) indicating the importance of reliability, although reliability as such only appears further down. The importance of the share of the bicycle paths is the result of the large amount of non-bicyclists among the sample, which are known to emphasize this.

Among the bottom five are surprisingly the car parking fee (see above) and the walking time and the bicycle riding time. The lack of importance of the parking fees is understandable given the relatively low rates in Innsbruck and because of the many car drivers who park for free and because of the non-car drivers, who can ignore this attribute.

An analysis of the importance ratings by the characteristics of the trip and by the characteristics of the respondents revealed no large variations and no surprising patterns.

The interactions between door-to-door travel times and the reliability of the mode was also analyzed with the CA data. The linear effects visible in the SP data for public transport were replicated for the CA data (Figure 29), while the CA data for car travel indicated an interaction pattern, in which reliability can balance increasing travel times for better reliabilities (Figure 30).

The interaction between public transport travel time and price, as revealed in the CA (Figure 31), seems to indicate, that prices in the current range have no impact on the rating, but that only higher prices lead to lower ratings. The evidence from a similar analysis of the car provides no clear evidence, other than that the parking fee has a very substantial impact on desirability (Figure 32).

5.6 Summary

The descriptive analyses have shown that most of the attributes considered have a visible impact on the mode choice behaviour and mostly in a linear additive fashion (with the exception of reliability in the case of the car). The three types of data show similar trends, although of sometimes different magnitudes. The consistent and reasonable SP and CA data show that the respondents considered their answers well.

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[11] Averaged over all respondents; normalized for each respondent by their respective mean importance over all attributes; multiplied by 10

Figure 28 CA: Attributes ranked by their average normalized importance [*10]

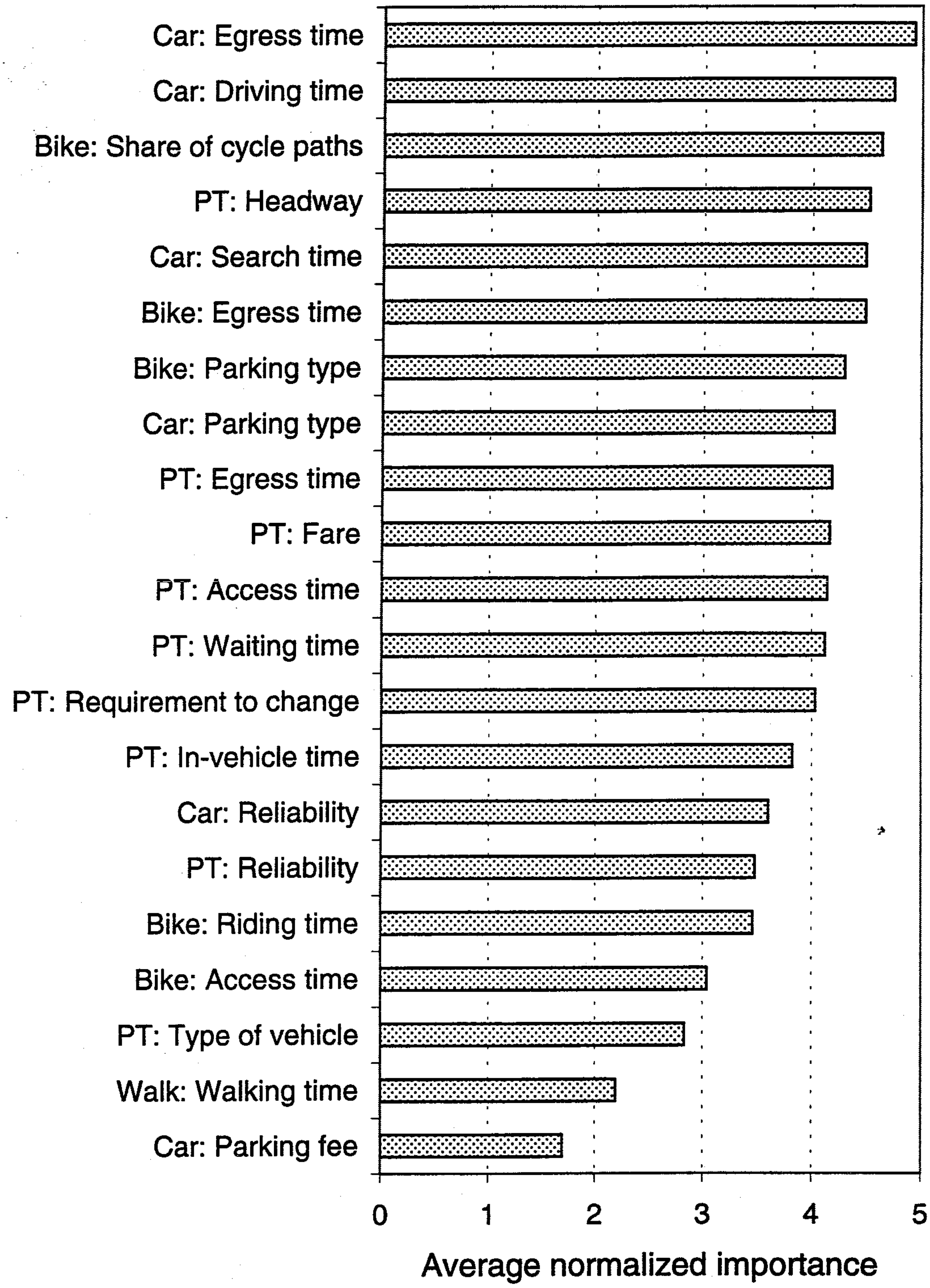


Figure 29 CA: Average desirability of public transport by public transport travel time and reliability

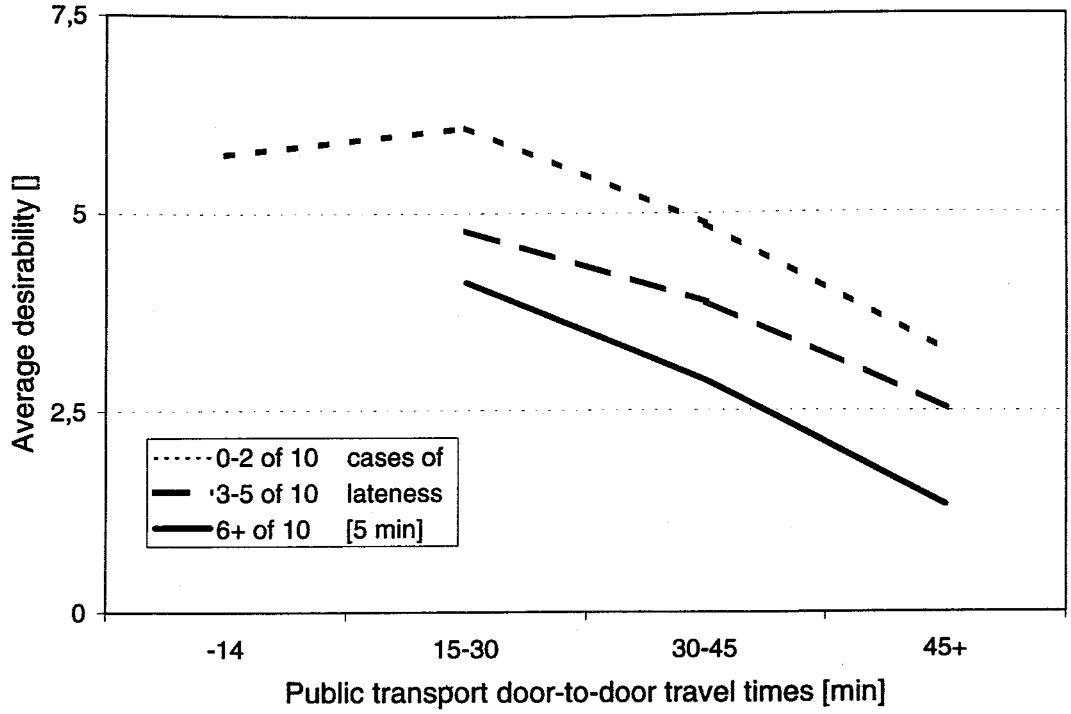


Figure 30 CA: Average desirability of car travel by car travel times and reliability

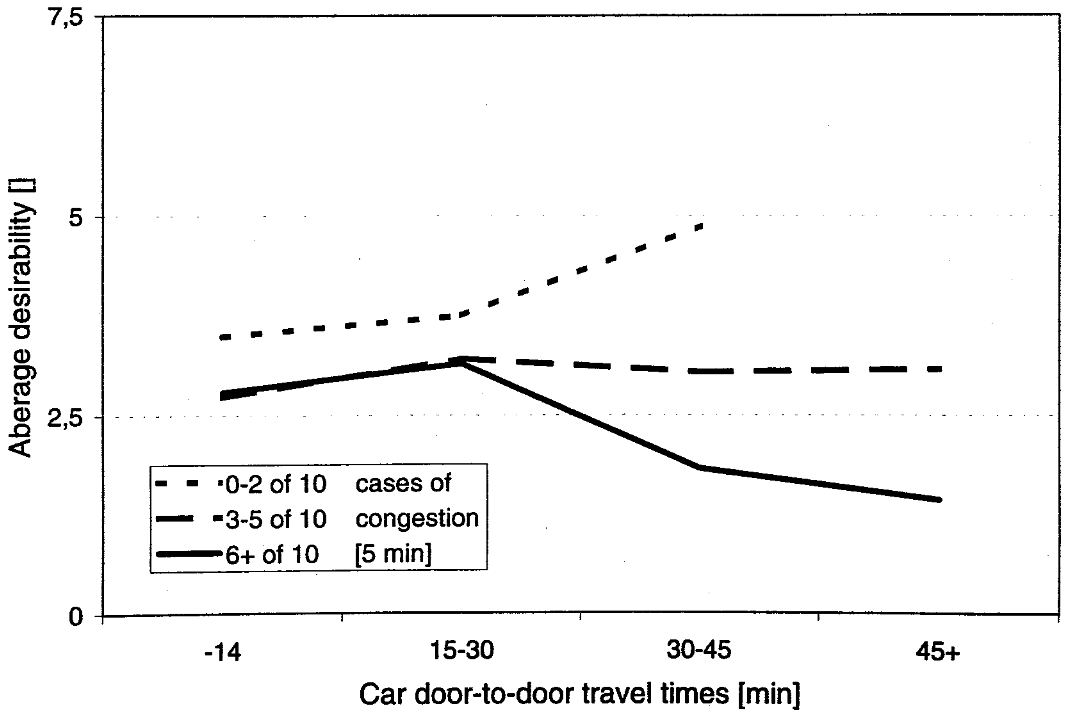


Figure 31 CA: Average desirability by public transport travel time and fare

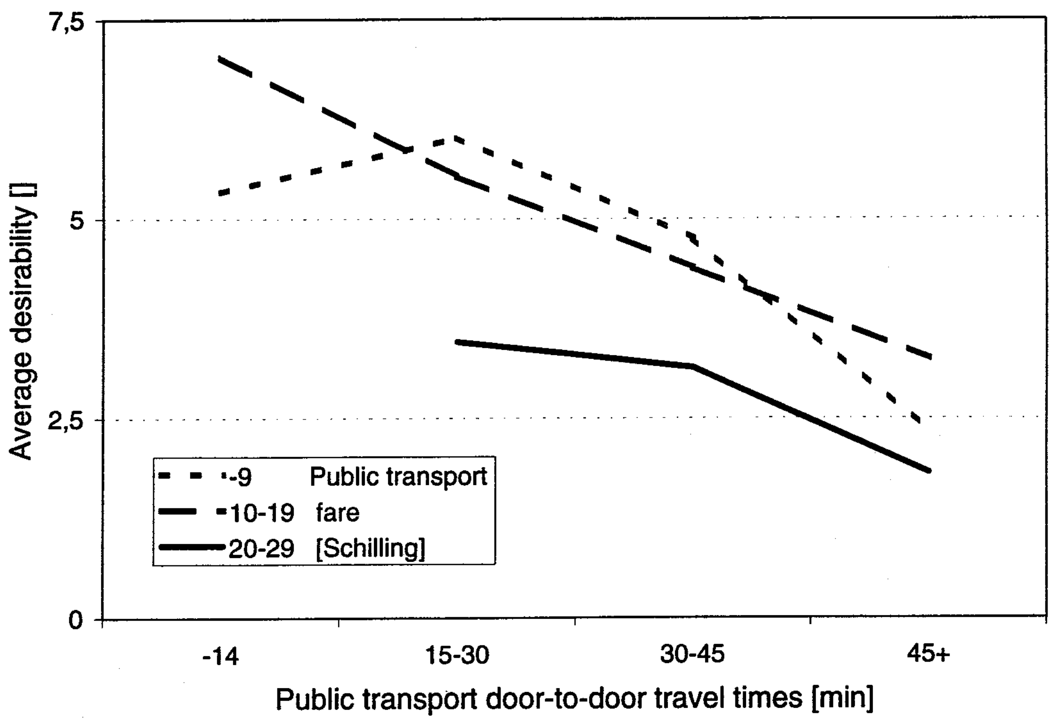
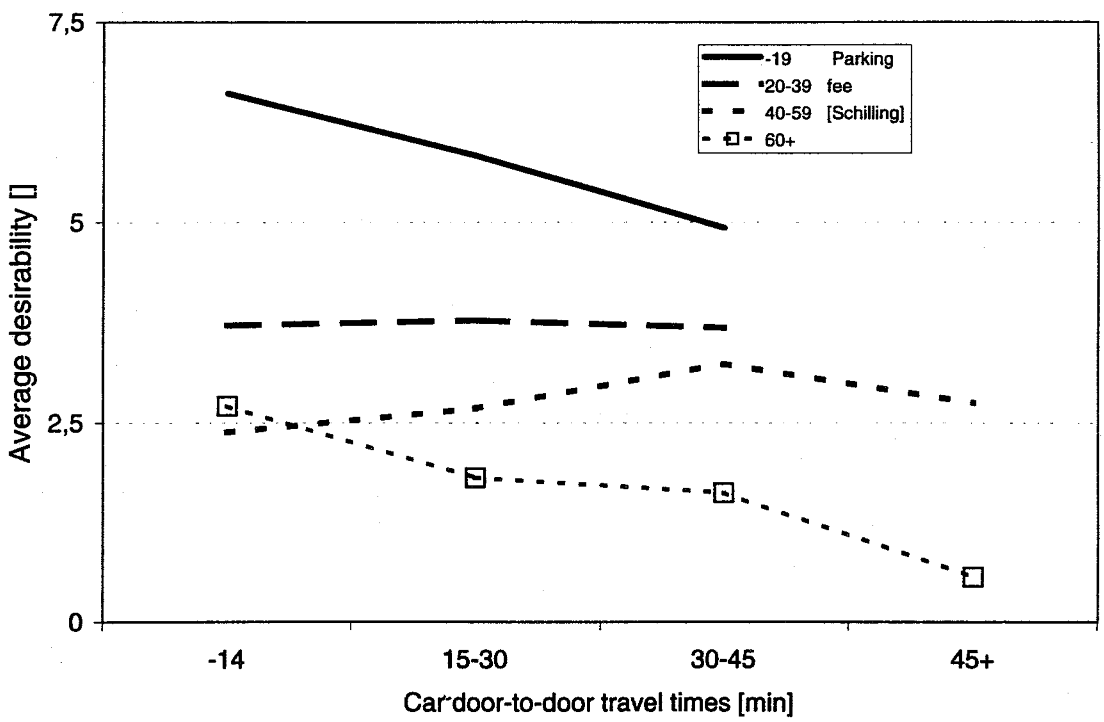


Figure 32 CA: Average desirability by car travel time and parking fee



6 REGRESSION AND CHOICE MODELLING

The descriptive analysis of the last chapter gave interesting insights into the choice behaviour of the respondents, but only a formal statistical analysis of the joint impact of all attributes simultaneously allows us to identify the strength of each of them. The next sections describe the analysis approaches used before the results are presented and compared.

6.1 Analysis approach for the Conjoint Analysis data

The hybrid approach chosen here requires that the compositional and the decompositional elements of the exercise are brought together in one uniform analysis framework. Adapting the procedure suggested Green and Krieger (1996) the following algorithm was implemented:

1. Calculate the ratings y_{ijk} for each level i of each attribute j for each person k from the compositional questions as:

$$y_{ijk} = d_{ijk} w_{jk}$$

$$with$$

$$\sum_{\forall j} w_{jk} = 1.0$$

using the desirability ratings d_{ijk} of the levels and the scaled importance rating w_{jk} of each attribute.

2. Calculate the scaled ratings y_{nk} for each full profile n for each person k from the decompositional tasks as:

$$y_{nk}^{i+1} = \frac{y_{nk}^{i} - \mu}{\tau}$$

using the rating r_{nk} as y^0_{nk}. In the first iteration assume the scaling parameters μ and τ to be zero and one.

3. Construct a joint data matrix from steps 1 and 2 as:

$$\begin{bmatrix} y_{ijk} \\ y_{nk} \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} + \begin{bmatrix} V_{jk} \\ V_{rk} \end{bmatrix}$$

with the vector y's of the ratings and a vector 0 of zeros, a vector 1 of ones and the vector V describing the values of the levels of the attributes. V_{jk} consists of zeros for the non-rated attributes j and of the rated value of the level of the attributed rated. V_{nk} consists of the values of levels of the attributes X_{jnk} in the full profile.

4. Estimate with multiple linear regression the ß's for the attributes:

$$\hat{y} = \beta_j X_j + \epsilon$$

5. Reestimate μ and τ as the intercept and slope of the simple linear regression of the model:

$$y^i_{nk} = \mu + \tau \hat{y}^i_{nk} + \epsilon$$

6. Repeat steps 2 to 4 until the sum of the squares of the errors of the regression in step 3 changes less then a predetermined amount between iterations.

This procedure, which essentially scales the ratings from the decompositional tasks to the mean and variance of the ratings from the compositional task, converged well in this application (3-5 iterations with a stopping criterion of 3% change between iterations). The calculations were performed with the linear regression procedure of SAS. They were performed for each mode and purpose separately.

6.2 Analysis approach for the Stated-Preference and Revealed Preference data

The data from the SP exercise and from the trips reported (RP) was analyzed using the procedure NLOGIT of LIMDEP 7.0 (Econometric Software, 1998), which implements both simple multinomial logit (MNL) and nested logit (NL) structures. The MNL model is based on the idea of utility maximisation, i.e. the choice observed reflects a reasoned judgement of the traveller about all available options. The model form is:

$$P_{jq} = \frac{e^{\beta V_{jq}}}{\sum_i e^{\beta V_{iq}}}$$

with $\beta = 1$ by definition. The systematic utility V_{jq} is a function of the (1 - n) attributes of alternative j for person q and of the (n+1 - k) socio-demographic variables describing person q:

$$V_{jq} = \sum_k \alpha_{kj} x_{kjq}$$

The parameters of the attributes and of the socio-demographic variables are estimated using the maximum likelihood approach (See also Ben-Akiva and Lerman, 1985 and the other reference cited above).

In the case of the SP-preference data persons, who chose only one mode across all eleven choice tasks, were removed from the estimation of the multinominal logit models reported below. The travel times of the "as is"-condition for the cyclists and pedestrians were estimated from the zone-to-zone car travel times from an available assignment model for the City of Innsbruck, which were scaled using the reported travel times.

The significance levels of the parameters were corrected by either the square root of the number of cases or the third root of the number of cases per person to account for the repeated measures problem in both the CA and the SP exercises (Bates and Terzis, 1997). The first correction (Columns marked 1/2) is deemed in general to be too conservative, while the second correction (Columns marked 1/3) is deemed to be more appropriate in the absence of a more rigorous estimation procedure (e.g. models allowing for taste variation and/or serial correlations between decisions).

6.3 Results

The discussion of the results is divided into the presentation of the results for the individual data sources, which is followed by a comparison across all sources. These initial discussions focus on the attributes of the different modes, ignoring the parameter estimates of socio-demographic variables for simplicity at this stage. Based on these discussions a model based on both the SP and RP data is estimated, which employs a set of generic parameters similar to those used in the modelling software employed by the City of Innsbruck.

6.3.1 CA: results for the modal attributes

The results of the analysis of the CA-data are presented[12] in Table 11 for the car attributes, in Table 12 for the public transport attributes and in Table 13 for the bicycle attributes. Certain results are not consistent with expectations, as for example in the case of the car the parameters for the walking and driving time are positive and in some cases even significant. Equally surprising are the extremely high values for transferring and reliability in the case of public transport, which seem unrealistic.

This initial analysis cannot do full justice to the CA data, but in the context of this study they will not be pursued further, as the results are not promising enough. See below for a discussion of possible further analyses.

[12] * = significant at alpha = 0,05; ** = significant at alpha = 0,01

Table 11 CA: Results for the car attributes by purpose

Attribute		Purpose Work Parameter	1/2 Sig	1/3 Sig	Shopping Parameter	1/2 Sig	1/3 Sig	Leisure Parameter	1/2 Sig	1/3 Sig
Walking times	[min]	0,108			0,213	*	*	Not available for CA		
Travel time	[min]	0,065		*	0,022					
Search time	[min]	-0,198		*	-0,181	*	*			
Reliability	[]	-0,166			-0,058	*	*			
Parking fee	[S]	-0,042	*	*	-0,229		*			
Parking lot	[y/n]	0,736			0,762					
Garage	[y/n]	0,892			0,484					
F		25,109			34,735					
adj. R^2		0,174			0,226					
N		2066			2075					
VOT	[S/min]	-1,548			-3,672					
Walking/travel	[]	1,662			9,682					
Search/travel	[]	-3,046			-8,227					
Reliability/travel	[]	-0,646			-10,409					

Table 12 CA: Results for the public transport attributes by purpose

Attribute		Purpose Work Parameter	1/2 Sig	1/3 Sig	Shopping Parameter	1/2 Sig	1/3 Sig	Leisure Parameter	1/2 Sig	1/3 Sig
Walking times	[min]	-0,064			-0,071		*	Not available for CA		
Travel time	[min]	-0,034		*	-0,009					
Headway	[min]	-0,027			-0,023					
Reliability	[]	-0,271		*	-0,233		*			
Fare	[S]	-0,004			-0,031					
Transfer	[y/n]	-2,341	*	*	-1,857	*	*			
Trolley bus	[y/n]	-0,301			0,043					
Street car	[y/n]	-0,121			-0,033					
F		24,222			29,750					
adj. R^2		0,125			0,135					
N		3242			3487					
VOT	[S/min]	8,500			0,287					
Walking/travel	[]	1,882			7,978					
Wait/travel	[]	1,588			5,169					
Transfer/travel	[]	68,853			208,652					
Reliability/travel	[]	7,971			26,180					

Table 13 CA: Results for the bicycle attributes by purpose

Attribute		Purpose Work Parameter	1/2 Sig	1/3 Sig	Shopping Parameter	1/2 Sig	1/3 Sig	Leisure Parameter	1/2 Sig	1/3 Sig
Walking times	[min]	-0,258			0,042					
Travel time	[min]	-0,020			0,023			Not available for CA		
Search time	[min]	1,511			-0,407					
Cycle paths	[%]	0,019			0,034	*	*			
Cycle stand	[y/n]	2,580	*	*	1,686		*			
F		13,356			15,331					
adj. R^2		0,305			0,263					
N		450			521					
Walking/travel	[]	12,900			1,826					
Search/travel	[]	-75,550			-17,696					
Cycle path/travel	[]	-0,950			1,478					
Stand/travel	[]	129,000			73,304					

6.3.2 *RP: results for the modal attributes*

The reported trips, even if they are not a representative sample of trip making in Innsbruck with regards to the modal shares prevailing in the city, they are representative for the way, in which the residents balance the modal attributes and for the constraints they face. The parameters for the modal attributes are therefore valid, while the alternative specific constants are not and will therefore not be reported.

Table 14, Table 15 and Table 16 present the results for the car, public transport and cycling attributes respectively. All three models, which were estimated with the reported values, show a good fit, as measured by ρ^2-statistic and the share of cases predicted correctly. The significance values do not need to be corrected as in the case of the CA and RP data, as only one record is used per person.

In nearly all cases the models have difficulties to identify the influence of reliability. The parameters are normally not significant, although they have both the wrong sign and are significant in some cases, which raises the questions of what unused covariates are picked up via the reliability (time of day, route ?). The main reason for these problems is the small range of the variable, as observed in the field. Also surprising are the very high relative valuations of the transfer in the case of work and leisure, which are beyond the range known from the literature.

The values of travel time savings (VOT) follow a consistent pattern with the understandable exception of public transport and work:

[S/min]	Car transport	Public
Work	3,500	-
Shopping	1,239	1,292
Leisure	0,078	0,197

The public transport VOT for work is not included as the fare parameter is not significant due to the impact of season ticket ownership, which gives zero marginal cost travel in the short run and therefore no price impact on behaviour in a short run context. The very low valuation of leisure travel is due to the willingness to travel to attractions even over longer distances.

Table 14 RP: Results for the car attributes by purpose

Attribute		Purpose Work Parameter	Significance	Shopping Parameter	Significance	Leisure Parameter	Significance
Walking times	[min]	0,021		-0,009		-0,074	**
Travel time	[min]	-0,091	**	-0,057	**	-0,004	
Search time	[min]	-0,179	**	-0,280	**	-0,165	**
Reliability	[]	-0,025		0,124	*	0,259	
Parking fee	[S]	-0,026	*	-0,046	**	-0,051	**
Parking lot	[y/n]	0,845	**	2,296	**	-0,583	*
Garage	[y/n]	0,710	**	1,078	**	-0,347	
Share predicted	[%]	69,6		72,1		66,8	
$\rho^2(0)$		0,551		0,626		0,546	
$\rho^2(C)$		0,438		0,355		0,301	
N		392		494		229	
VOT	[S/min]	3,500		1,239		0,078	
Walking/travel	[]	-0,231		0,158		18,500	
Search/travel	[]	1,967		4,912		41,250	
Reliability/travel	[]	0,275		-2,175		-64,750	

Table 15 RP: Results for the public transport attributes by purpose

Attribute		Purpose Work Parameter	Significance	Shopping Parameter	Significance	Leisure Parameter	Significance
Walking times	[min]	-0,140	**	-0,021		-0,070	**
Travel time	[min]	-0,018	**	-0,084	**	-0,014	
Headway	[min]	-0,014	*	-0,010		0,004	
Reliability	[]	0,132	**	0,007		0,057	*
Fare	[S]	0,006		-0,065	**	-0,071	**
Transfer	[y/n]	-0,766	**	0,023		-1,504	**
Trolley bus	[y/n]	0,116		0,493	**	0,052	
Street car	[y/n]	-0,323		0,695	**	0,451	*
Share predicted	[%]	69,6		72,1		66,8	
$\rho^2(0)$		0,552		0,626		0,546	
$\rho^2(C)$		0,438		0,355		0,301	
N		392		492		229	
VOT	[S/min]	-3,000		1,292		0,197	
Walking/travel	[]	7,778		0,250		5,000	
Wait/travel	[]	1,556		0,238		-0,571	
Transfer/travel	[]	42,556		-0,274		107,429	
Reliability/travel	[]	-7,333		-0,083		-4,071	

Table 16 RP: Results for the bicycle attributes by purpose

Attribute		Purpose Work Parameter	Significance	Shopping Parameter	Significance	Leisure Parameter	Significance
Walking times	[min]	0,405	*	-0,098		-1,155	**
Travel time	[min]	-0,141	**	-0,136	**	0,006	
Search time	[min]	0,056		-0,320	*	0,214	
Cycle paths	[%]	0,018	**	0,017	**	0,004	
Cycle stand	[y/n]	0,540	**	-0,066		-0,143	
Share predicted	[%]	69,6		72,1		66,8	
$\rho^2(0)$		0,551		0,626		0,546	
$\rho^2(C)$		0,438		0,355		0,301	
N		392		494		229	
Walking/travel	[]	-2,87		0,721		-192,50	
Search/travel	[]	-0,40		2,353		35,667	
Cycle path/travel	[]	-0,13		-0,125		0,667	
Stand/travel	[]	-3,83		0,485		-23,883	

The preferences for the types of parking vary between contexts: for work there is a significant, but not large preference for off-street parking, while in the shopping context there is a stronger preference for off-street parking, but with a much stronger preference for off-street parking lots in comparison with multi-storey garages. In the case of leisure these preferences reverse and the travellers prefer free off-street parking.

The preferences for the vehicle type in public transport also vary by context. While the commuters are indifferent, the shoppers show a significant preference for both trolley bus and street car over diesel busses, the leisure travellers only prefer the tram.

6.3.3 SP: results for the modal attributes

The SP experiments explore a wider range of values for the attributes and allow therefore a more precise estimates of the trade-offs the travellers make. Table 17, Table 18 and Table 19 present the results for the car, public transport and bicycle attributes.

The overall fit of the models is not exceptional with the shopping models having the worst fit of all the models estimated. Still, the fit is reasonable.

The result for the car and cycling underline the importance of the parking search times in the overall decision process. The walking times, in contrast, do not have a significant impact for these two modes, with the exception of car and work. This should reflect the relatively small total walking times encountered by the respondents in reality and in the SP by extension.

Reliability is always significant for public transport and for the car in the case of work. There is no doubt, that the public transport operator has to keep unreliability under control (each 10% increase in unreliability (= 0,5 min additional travel time on average) being worth 6,5 min for shopping and leisure and 2,5 min for work. The ratio is 3.2/0.5 in the case of work and car.

The SP results show the importance of the transfer by valuing it at 10 min for work and shopping and roughly 20 min for leisure. These values are smaller than the matching values of the RP estimation, but more in line with current expectations.

Table 17 SP: Results for the car attributes by purpose

Attribute	Purpose Work Parameter	1/2 Sig	1/3 Sig	Shopping Parameter	1/2 Sig	1/3 Sig	Leisure Parameter	1/2 Sig	1/3 Sig
Walking times [min]	-0,277	*	*	-0,003			0,002		
Travel time [min]	-0,033			-0,034	*	*	-0,074	*	*
Search time [min]	-0,023			-0,071	*	*	-0,092	*	*
Reliability []	-0,106		*	0,068		*	-0,002		
Parking fee [S]	-0,056	*	*	-0,017	*	*	-0,041	*	*
Parking lot [y/n]	0,317			-0,054			0,133		
Garage [y/n]	-0,176			0,176			0,253		
Share predicted [%]	51,6			38,5			41,7		
$\rho^2(0)$	0,398			0,205			0,255		
$\rho^2(C)$	0,344			0,105			0,155		
N	752			1253			1134		
VOT [S/min]	0,589			2,000			1,805		
Walking/travel []	8,394			0,088			-0,027		
Search/travel []	0,697			2,088			1,243		
Reliability/travel []	3,212			-2,000			0,027		

Table 18 SP: Results for the public transport attributes by purpose

Attribute	Purpose Work Parameter	1/2 Sig	1/3 Sig	Shopping Parameter	1/2 Sig	1/3 Sig	Leisure Parameter	1/2 Sig	1/3 Sig
Walking times [min]	-0,133	*	*	-0,050	*	*	-0,003		
Travel time [min]	-0,048	*	*	-0,027	*	*	-0,032	*	*
Headway [min]	-0,010			-0,041	*	*	-0,033	*	*
Reliability []	-0,108	*	*	-0,183	*	*	-0,129	*	*
Fare [S]	-0,019			-0,077	*	*	-0,052	*	*
Transfer [y/n]	-0,466	*	*	-0,271		*	-0,358	*	*
Trolley bus [y/n]	0,568		*	0,049			0,124		
Street car [y/n]	0,208			-0,127			0,073		
Share predicted [%]	51,6			37,4			41,7		
$\rho^2(0)$	0,398			0,205			0,255		
$\rho^2(C)$	0,344			0,105			0,155		
N	752			1253			1134		
VOT [S/min]	2,526			0,351			0,615		
Walking/travel []	2,771			1,852			0,094		
Wait/travel []	0,417			3,037			2,063		
Transfer/travel []	9,708			10,037			11,188		
Reliability/travel []	2,250			6,778			4,031		

Table 19 SP: Results for the bicycle attributes by purpose

Attribute		Purpose Work Parameter	1/2 Sig	1/3 Sig	Shopping Parameter	1/2 Sig	1/3 Sig	Leisure Parameter	1/2 Sig	1/3 Sig
Walking times	[min]	0,036			0,123			-0,074		
Travel time	[min]	-0,055	*	*	-0,060	*	*	-0,068	*	*
Search time	[min]	-1,794	*	*	-0,220		*	-0,668	*	*
Cycle paths	[%]	0,026	*	*	0,011	*	*	0,015	*	*
Cycle stand	[y/n]	0,523		*	0,133			-0,136		
Share predicted	[%]	51,6			38,5			41,7		
$\rho^2(0)$		0,398			0,205			0,255		
$\rho^2(C)$		0,344			0,105			0,155		
N		752			1253			1134		
Walking/travel	[]	-0,65			-2,050			1,088		
Search/travel	[]	32,62			3,667			9,824		
Cycle path/travel	[]	-0,47			-0,183			-0,221		
Stand/travel	[]	-9,51			-2,217			2,000		

The values of travel time savings (VOT) follow a pattern with the exception of car and work, which derives from the non-significant parameter for car travel time:

[S/min]	Car	Public transport
Work	-	2,526
Shopping	2,000	0,351
Leisure	1,805	0,615

The value for Public transport and work seems reasonable in relation to the the RP-values reported above, but the value for shopping is low. The value for car and leisure is high due to a high estimate of the travel time parameter.

6.4 Comparison of results

Initial models were estimated for both the CA and the SP data employing linear models of the levels of the relevant variables and of the available socio-demographic variables for each person (sex, age in decades (set of dummy variables), season ticket ownership, employment status, participation in education, ownership of a highschool diploma). More complex forms (logistic transformation of the desirabilities for the CA or quadratic terms of the independent variables) did not increase the explanatory value of the models.

The CA models produce fewer significant parameter estimates and more estimates, which seem unrealistic in comparison with prior knowledge. The signs of the estimates are in general the same and the rank order of the sizes is also normally identical, but the relative sizes can vary considerably raising doubts about the consistency of either set of results.

The goodness of fit for the shopping models is worse than for the models for work. The SP and CA estimates of the value of time for in-vehicle time are low, but not unreasonable. It is interesting to note, that for work the estimates for the public transport fare are not significantly different from zero, reflecting on the one hand the long-term commitment of a season ticket and on the other the necessity to use public transport for the other users. The parking fee estimates are consistently significant for work (CA, SP and RP models).

The relative valuations for the different time elements vary considerably, but for the SP and RP case they do not deviate massively from prior expectations, but for walking time relative to travel time, which in a number of cases seems too low reflecting the lack of variability in the data. The CA estimates are in a fair number of cases excessive.

It is difficult to judge to what extent this unexpected patterns are due to the presence of the reliability variable, which does not produce convincing results. For the RP models is has twice the wrong sign and is significant and twice it is insignificant. This might be due to the lack of range and variability in the rather non-congested Innsbruck. For the CA and SP car models the estimates are either not significant or only marginally so, maybe again reflecting either too little variability in the data or a lack of understanding of the description of the variable, which might have been misunderstood by the respondents (Some respondents might have included the congested time with the travel time specified for the CA/SP description). The reliability estimates for the SP public transport models are significant and have the right signs (less significant for the CA models) reflecting an easier to understand formulation of reliability (x of out 10 late for 5 minutes) and more range in the observed data.

Both methods agree, that there is no difference between offering a bus, trolley bus or tram to the traveller, if modelling the data separately.

6.5 Joint SP/RP model

The SP and the RP data provide views of the decision processes of the traveller from different angles, also representing different constraints, in particular in the case of the RP data, and as a result different trade-offs, in particular in the case of the SP data, where all relevant information is provided to the respondent. The data sources complement each other.

The analysis so far has shown that the parameter estimates are in many cases rather similar across the modes. Given this fact and the fact, that the choice model used by the City of Innsbruck for its traffic modelling uses generic parameters, a joint SP/RP model was estimated using LIDEMP based primarily on generic parameters. This formulation should help the City in its efforts.

The estimation used the methodology suggested by Bradley and Daly (1993) following Ben-Akiva and Morikawa (1990). The method scales the error variances of the SP-alternatives relative to the error variances of the RP-alternatives, while assuming that the parameters are the same in the SP and RP dataset. The scaling parameter λ indicates the strength of the scaling required.

The estimation of the impacts of reliability proved problematic due to the RP data, which are unsatisfactory in their description of reliability (see above). The parameters were therefore fixed a priori using the earlier SP-results.

Table 20 presents the results of modal attributes and the summary statistics. The full results including the estimates for the socio-demographic variables are shown in Appendix D. The fits of the models are good. The highly significant scaling parameters λ indicate the necessity of the estimation method used.

The core modal attributes are all significant, with the exception of headway/waiting time, which is only (weakly) significant in the case of work. The introduction of the reliability variable has to be the reason for this, as the headway variable normally captures both aspects of the wait (waiting time and the unreliability of the service). The transfer variable captures the inconvenience of the transfer plus the chance for additional unreliability.

The importance of cycle paths is again visible in the joint estimation.

Table 20 SP/RP: Results for the modal attributes

Attribute		Purpose Work Parameter	1/2 Sig	1/3 Sig	Shopping Parameter	1/2 Sig	1/3 Sig	Leisure Parameter	1/2 Sig	1/3 Sig
Walking time	[min]	-0,090	*	*	-0,070	*	*	-0,101	*	*
Travel time	[min]	-0,054	*	*	-0,062	*	*	-0,032	*	*
Headway	[min]	-0,015		*	-0,004			-0,007		
Search time (car)	[min]	-0,091	*	*	-0,197	*	*	-0,106	*	*
Search time (cycle)		-0,111			-0,307			-0,931		*
Transfer	[y,n]	-0,775	*	*	-0,562	*	*	-0,711	*	*
Fare/Fee	[Schilling]	-0,021	*	*	-0,026	*	*	-0,048	*	*
Reliability (PT)	[x/10]	**-0,540**			**-0,360**			**-0,270**		
Reliability (Car)		**-0,400**								
Cycle paths	[%]	-0,004			0,013	*	*	-0,005		
Trolley bus	[y,n]	0,785	*	*	0,534	*	*	-0,257		
Street car	[y,n]	-0,316			0,560	*	*	0,730	*	*
Parking lot	[y,n]	0,572	*	*	2,533	*	*	-0,005		
Multi-storey	[y,n]	0,609	*	*	1,256	*	*	0,822		*
Cycle rail	[y,n]	0,213			-0,596			0,648		
Summary statistics										
λ		0,956	*	*	0,312	*	*	0,384	*	*
$\rho^2(0)$		0,725			0,759			0,684		
$\rho^2(C)$		0,279			0,223			0,162		
N		1095			1692			1312		

The parameters in bold were fixed based on the earlier SP-results.

The significance levels are based on 1,96*Square root(2) (=1/2 Sig) and 1.96*Third root(2) (1/3 sig), as there are 2 observations per person given the weighting of the SP observations.

The relative valuations and the values of time are shown in Table 21. The values of travel time savings are in a realistic range of about 2,0-2,5 Schilling/min for work and shopping, while the value is considerable lower, as expected, for leisure. The relative valuations for walking show a reasonable pattern, although the value for shopping seems low in comparison with many other studies. The separate estimation of waiting time and unreliability results in by comparison low valuations for waiting time, which are in turn balanced by substantial valuations for unreliability, especially for the work trip. The search time valuations for car travel are in the expected range, while the valuations for cycling seem high, but which have to be accepted in the absence of comparable results as the expression of the ardent wish to park one's bicycle in front of the destination, in particular during shopping and at night. The transfer penalty of about 10-15 minutes during the day (work and shopping) is within the range of earlier studies, while the value for leisure (22 minutes) seems reasonable given the associated loss of comfort, especially during the evening and night.

Table 21 SP/RP: Relative valuations

Relation	Purpose Work				Shopping				Leisure			
	All modes	PT	Car	Bike	All modes	PT	Car	Bike	All modes	PT	Car	Bike
VOT [Schilling/min]	2,57				2,38				0,67			
Walking/Travel []	1,67				1,13				3,16			
Waiting/Travel []		0,56				*0,13*				*0,44*		
Searching/Travel []			1,69	2,06			3,18	4,95			3,31	29,09
Transfer/Travel [min]		14,35				9,06				22,22		
Reliability/travel []		**10,00**	**7,41**			**5,81**				**8,44**		
Cycle path/Travel [min/%]				*-0,07*				*-0,21*				*0,16*

Bold values were determined a priori from the SP-results
Italizied values are based on non-significant parameter estimates

The results for the vehicle types are more conclusive for the joint estimation indicating in comparison with the normal bus a preference for the trolley bus to work, the trolley bus and the street car to shopping and for the street car to a leisure activity. Similarly, there are significant preferences for off-street parking during work and shopping.

7 CONCLUSIONS

The study reported above has used a number of different survey methods to shed light on the modal choice behaviour of the residents of Innsbruck. Next to reports on trips actually undertaken (revealed preference (RP) data), data was collected on choices and assessments in hypothetical situations (stated preference (SP) data and conjoint analysis (CA) data).

The CA data, while consistent with the other two types of data in broad terms, was less reliable giving rise to less realistic valuations of the attributes. The results of the RP and the SP experiments were rather similar, although particular problems arose due to the way, in which the data had been collected, e.g. how reliability had been presented to the respondents.

The joint estimation of the SP and the RP-data gave consistent results, which are credible for a city of the size of Innsbruck and are within the range of expectations. The value of travel time savings across all modes range from 2.0-2.5 Schilling/Minute for work and shopping trips. The savings for evening leisure trips are valued considerably less.

The relative valuations show, that Innsbruckers put in comparison with travellers elsewhere relatively less value on walking then one would expect, but that they put more value on parking search. The separate estimation of the effects of waiting times and reliability showed that in Innsbruck a high value is put on reliability, while waiting seems less of a problem. Transfers are a substantial disbenefit equal to about 10-15 min additional travel time during the day and even 22 minutes during the evening (for leisure trips at least).

The price elasticities for public transport are relatively low due to the low fares in the case of work and due to low market share in the case of the other two trip purposes.

The results reported here do not exhaust the data set. In particular, more work could be applied to the CA data. Here it would be interesting to see, if choice rules derived from the CA results produce choices similar to those observed in the SP experiments. The SP/RP could be analyzed further to see, if other market segmentations then by trip purpose are necessary, e.g. by the available socio-demographic variables.

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The responsibility for the contents of this report rests with the authors alone.

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[16] Obtained as http://www.sawtoothsoftware.com/TechPap.htm/CBCTchWp.zip

[17] Obtained as http://www.sawtoothsoftware.com/TechPap.htm/ACATchWp.zip

APPENDIX A REVIEW OF SEASON TICKET USAGE INTENSITIES[18]

The consumer can choose the shares of the fixed and of the variable costs for any one journey through his long-term resource allocation: the acquisition of an annual season ticket buys zero-marginal cost travel for the year, the purchase of one of the many railroad discount cards entails a 20, 30 or even 50% fare reduction for a year (e.g. *Umweltticket* in Austria, *Halbpreispass* in Germany or *Halbtaxabo* in Switzerland), the type of car selected determines the amount of variable costs in comparison with the fixed costs of travel. For public transport operators the pricing of these ticket types and their detailed design is of crucial importance for their success. The elements of the design are the price, the duration (number of days), the type of period (e.g. 24 hours vs day, seven days vs week), the temporal validity during the period (e.g. peak included or excluded), the excluded types of services (e.g. express services or first class), the amount of price reduction, the persons eligible (e.g. young persons, families, retired persons etc.), the transferability, the benefits to accompanying persons (their number, the amount of price reduction granted to them, the types of persons covered (e.g. children only)), the extra benefits given (e.g. newsletters, price reductions with other operators etc.). The operator has to strike the right balance between the cost of operating the service for the usage made of the tickets given their design and the price charged for them.

The usage made of those prepaid tickets, which give the right to unlimited free travel during their period of validity, is therefore one of the key variables for a public transport operator. Without it the operator cannot properly assess the balance between usage and revenue, in particular, if the total ridership (in number of stages or trips (unlinked or linked trips)) is estimated by the number of these tickets sold and not from independent counts or surveys. Table A.1 list the current assumptions of a number of the larger Austrian operators, which have not been checked against actual behaviour for some time, although the recent innovations in ticketing (transferable tickets, Verkehrsverbünde etc) suggest changes in behaviour.

There are two main methods to estimate the number of trips[19] made by each type of ticket:

- counts of ticket type usage in the vehicle combined with sales statistics
- surveys of usage and ticket ownership

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[18] This appendix is taken from Axhausen, Köll and Bader (1998a)

[19] The following terminology is used throughout:

- stage: movement with one means of transport (unlinked trip, *Etappe*)
- trip: sequence of stages between two activities (linked trip, *Fahrt*)
- journey: sequence of trips starting and ending at home (*Reise, Ausgang*)

Table A.1 Current assumptions of Austrian operators about the usage intensity of different ticket types (1998)

City	Type of ticket [Trips/period] Day ticket	24h-ticket	Weekly ticket	Monthly ticket	Annual ticket	Education ticket
Graz	-	5	30	130	1440	110
Innsbruck	4	4	25	100	1200	100
Klagenfurt	-	6	25	100	1200	-
Linz	5	-	20	90	1080	960
Salzburg[1]	3	3	25	100	1080	900
Wien	-	4	19	90	960	960

[1] Salzburg also conducts regular counts using automatic counters at the doors of selected buses, which are rotated around all lines.

While the first method was used extensively in the past, the recent changes brought by large-scale regional joint ticketing (*Tarifverbünde*) have made the application of this technique infeasible in Germany or Austria, unless the whole of the regional area is surveyed, which is generally too expensive. The currently preferred method is therefore to survey users at home about their ticket usage. Typical for recent studies is the survey carried out in 1995 for the Münchner Verkehrsverbund by EMNID (EMNID, 1995). The survey firm telephoned households from a sample frame including known owners of season tickets. The firm phoned up to five times at different times of the day to reach a person at the address. The respondents were asked about the number of trips to work/education during the last three days, the number of other trips during the last three days and the type of ticket owned.

To gain an understanding of the range of possible values a number of operators were contacted, of which a small number provided the relevant information, which is summarized in Table A.2. It is clear, that tickets of a shorter temporal validity tend to have higher usage intensities. The differences between weekly and other longer duration seasons are small in comparison[20]. Across the longer duration ticket types the number of public transport trips/month ranges from (31) 42 to 78 with a median of 52,1. There is a clear tendency for the values to fall in line with the current real reductions in prices and the increases in sales.

[20] The factors used for conversion to monthly figures are: (365/12) for daily tickets; (365/12)/7 for weekly tickets, 1/12 for annual tickets.

Table A.2 Usage intensities of season tickets (converted to public transport trips/month)

Year	City/Region	Market segment/ Validity	Ticket type				
			Daily	24-hours	Weekly	Monthly	Annual
1987	Freiburg[1]	Full price				70,00	
		In education				65,00	
1991	London[2]	LT area	102,50		67,48		
		Heavy rail within	109,50		66,96		
		Heavy rail without	119,54		66,70		
1992	Essen[9]	Full price				68,13	
		In education				74,98	
1992	Paris[2]	Centre only			54,19		
		All zones			49,23		
1993	Germany[3]	Full price	106,46	136,88	59,75	58,50	54,58
		In Education			65,18	64,50	48,00
1993	VOR[10]	Rural areas				52,32	
	VOR[10]	Suburban				50,15	
	VOR[10]	Urban				53,20	
1994	Victoria[4]	Full price	69,65		70,87	78,32	71,88
1995	München[5]	Full price			44,84	47,65	45,39
		Transferable				58,73	
1996	RMV[9]	All monthlies				42,00	
1996	Berlin[9]	Full price				48,38	49,73
	Berlin[9]	Seniors				31,03	32,09
1996	VRN[11]	Full price		98,85	52,14	52,00	50,83
		In education			53,01	51,00	
1997	Chicago MetraRail[6]	Full price				38,11	
1998	Bregenz[7]	Full price	91,25		69,52	49,00	49,58
1998	Welser[8]	Full price	60,83		43,45	43,00	43,33
1998	Karlsruhe[12]	Full price			56,97	52,16	49,58
		In education				59,80	

[1] IVV, 1987; [2] Private communication; [3] VDV, 1993 - Midpoint of the recommendations; [4] Private communication; [5] EMNID, 1995 - The value for the transferable ticket includes trips made by others and accompanying persons; [6] Personal communication; mean of annual values for 1991-1997; [8] Values developed on the basis of the numbers suggested by the public transport operator Welser; see below; [8] Values used by the public transport operator Welser (Traun, OÖ) and other operators in the *Verkehrsverbund Oberösterreich* (outside Linz) based on recent counts; [9] Personal communication with Target Group, Nürnberg, midpoint of the range given; [10] Herry, Rittler and Snizek, 1994 - values include an average of 8.1 weekend trips per month; [11] PTV System, Karlsruhe, private communication; [12] Verkehrsbetriebe Karlsruhe GmbH, private communication

This trend becomes even clearer, if one includes substantially earlier data into the consideration. White (1981) reviewed usage intensities for the late 1970's (See), which are generally about ten trips higher per months. shows the trend over time.

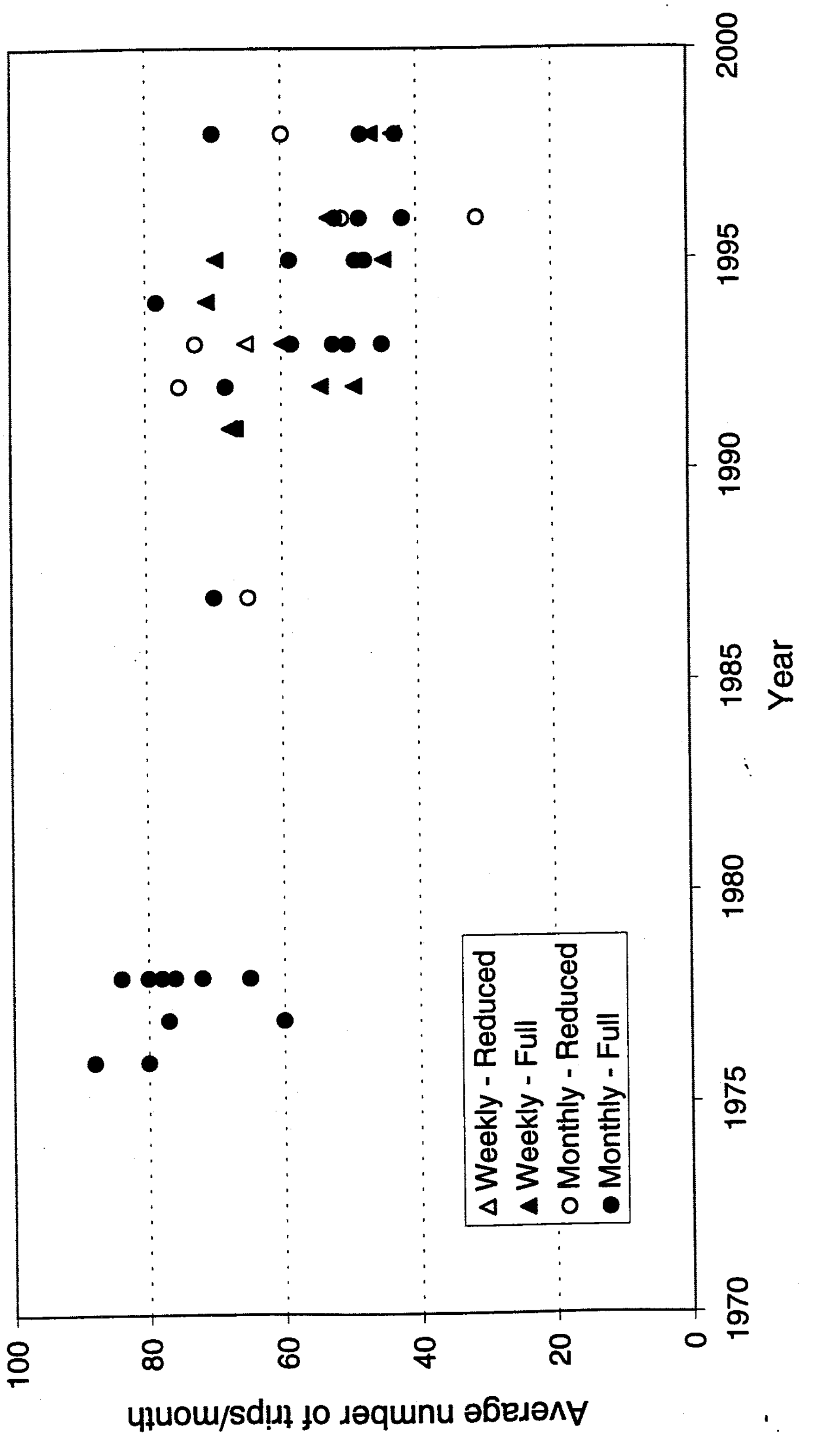
Table A.3 Summary detail of some principal "travelcards"

System/Card Title	*Date Introduced*	*Date of Data*	*Number on issue* (000)	*% of all trips*	*Trips per holder per month*[a]
Brussels/mtb	Dec. 1970	1978		37	76
Göteborg/70-kort, etc.	Jan. 1973	1977	68	52.5	60
Hamburg/Monatskarten, etc.	1966	1976	325	66.4	80
Stockholm/70-kort etc.	Oct. 1971	1978	448	61[b]	65
Paris/Carte Orange	Aug. 1975	1978	1300[c]	48	80
Oslo/Manedskort	1976	1977	50	59	77
Bremen		1977		42.6	
West Midlands/Travelcard	Oct. 1972	1978	125	29[d]	78
Tyne & Wear/Travelcard	May 1975	1976/77	17	7	88
Greater Manchester/Saver Seven	Nov. 1975	1978	60	20	84
Glasgow/Transcard	Sep. 1974	1978/79	37[e]	16	72
London/Red Bus Pass, etc.	June 1972	1977	52	7	90
Lothian/Ridercard	1957	1979	20	12–15	
West Yorkshire/Metrocard	1972	1978/79	28[f]	7.2	

[a] Or per four weeks for four-weekly cards. The lower averages for Stockholm and Göteborg result from inclusion of pensioners' reduced-rate travelcards within the total.
[b] As percentage of revenue.
[c] Excluding summer holiday period.
[d] As percentage of all adult fare-paying trips.
[e] Average for last quarter of 1979.
[f] Average for April–Nov. 1979.

Source: White (1981), 23

Figure 33 Development of usage intensities



APPENDIX B TELEPHONE INTERVIEW: CONTENT

The telephone interview was divided into eight sections. All respondents had to provide answers to the same questions during sections 1 to 4 and 7. The questions related to the target trip in Section 5 were dependent on the availability of a motor vehicle. The questions about public transport usage in section 6 were allocated by interview number. Section 8 was used to announce the dispatch of the SP/CA survey.

The question in section 1 was for the mode generally used for trips in Innsbruck. It was intended as an opening questions to ease the way into the interview:

For my trips in Innsbruck I use

- ☐ principally the following *mode*
- ☐ depending *on* the following *modes*

The section acted also a screener. If respondents indicated that they did not live in Innsbruck or were immobile, the interview was terminated.

Section 2 investigated the availability of public transport to the respondent using the distance to the most frequently used public transport stop at home and at work as indicators.

How far are the following stops away:

The IVB-stop, you most frequently use from home:	The IVB-stop, you most frequently use at work/school/university:
☐ Don't know/never use one	☐ Don't know/never use one
.... Minutes walk	.... Minutes walk
.... Meter	.... Meter
Name:	Name: ....
Using line(s):	Using line(s): ....

Section 3 concerns availability of a car/motor vehicle:

Do you own a driving licence ? ☐ yes, of type ...... ☐, no

..... cars are always available to me in my household

☐ I share a car with other household members

☐ I have no car available

The availability of parking at home and, if relevant, at work/university, was the subject of section 4:

If a car is available

When you drive home, do you park the car (practically) always in the same place ?

- □ Yes,
  - □ Garage (level + roof)
  - □ Below ground (+ roof)
  - □ Above ground (+ roof)
  - □ Yard (level, no roof, private)
  - □ Lot (level, no roof, public)
  - □ Curb

  Rent/Month: .....

- □ No

  Walking distance to home: ....

If working/studying in Innsbruck

When you drive to work/university, do you park the car (practically) always in the same place ?

- □ Yes,
  - □ Garage
  - □ Below ground
  - □ Above ground
  - □ Yard
  - □ Lot
  - □ Curb

  Rent/Month: .....

- □ No

  Walking distance to work/university: ....

Section 5 establishes the details of the target trip to work/shopping or leisure, as allocated during the interview. Depending on the availability of a car to the respondent, he or she is asked about the details of the trip as undertaken with a car, or as undertaken with a bike or on foot. The other questions remain the same.

Start:	Starting location of the trip:	....		
	Departed at	.... [Time]		
PT:	Travelling by	□ Bus	□ Trolley-bus	□ Streetcar
	Walking time to stop	.... [min]		
	The ... comes every	.... [min]		
	The ... is not on time in	.... of ten cases		
	Transfer	□ Yes	□ No	
	Riding time (inc. transfer) is	.... [min]		
	Walking time to destination	.... [min]		
	Trips with the ... costs	.... [Schilling]		
Car:	Walking time to parked car	.... [min]		
	Driving time with the car is	.... [min]		
	Jam of 5 min and more on	.... of ten days		
	Parking search takes usually	.... [min]		
	Type of parking	....		
	Parking costs	.... [Schilling] (per working day)		
	Walking time to destination	.... [min]		
Cycle:	Walking time to parked bike	.... [min]		
	Riding time with bike	.... [min]		
	Parking search takes usually	.... [min]		
	Type of parking	....		
	Walking time to destination	.... [min]		
	Share of cycle paths is	.... [% of total route]		
Foot:	Walking time is/would be	.... [min]		

Destination: ....

Arrived at .... [Time]

Duration of stay .... [h]

You were □ Alone With .... persons

You took □ PT □ Bike □ Foot or

□ PT □ Car □ Bike □ Foot

Additional details, if public transport was used:

At which stop did you board ? ....

At which stop did you alight ? ....

Did you have a seat ? □ Yes □ No

How many times did you transfer ? .... times at ....

at ....

What type of ticket did you use ?

□ Single □ 4-trip ticket □ Day ticket

□ 24h-ticket □ Weekly □ Monthly

□ 6-monthly □ Annual □ Student

The following set of questions (Section 6) enquired about the number of trips undertaken by public transport during the last week:

Minimum (even household (interview) number):

How many trips did you make with the IVB during the last calendar week ? ....

Which ticket types did you use ? (for list see above, multiple answers permitted)

If owner of a longer-term transferable season ?

Did somebody else use your ticket ? □ Yes □ No

Maximum (odd household numbers)

How many trips did you make with the IVB on each of the seven days of the last calendar week ? Which ticket types did you use on each of the days ?

Matrix (day of week, date, number of trips, ticket type)

If owner of a longer-term transferable season ?

Did somebody else use your ticket ? □ Yes □ No

(List of ticket prices for information)

Section 7 covered the socio-demographic details of the respondent:

You are:

□ Employed (White collar)	□ Employed (Blue collar)
□ Selfemployed	□ Housewife
□ Retired	□ Unemployed
□ University student	□ On maternity leave/unpaid leave
□ Civil servant	□ Other

How many paid hours per week do you work ? ....

What is your highest educational qualification ?

□ Compulsory schooling	□ Apprentenceship
□ Baccalaureate	□ University degree

Year of birth: ....

Sex (inferred from the voice) □ Male □ Female

Figure B.1 Telephone interview guide: Contact details, sections 1 and 2

ÖV-Befragung

HH.Nr.: 3343

Name: ....

c/o: Horst Weniger

Tel.: 589724

Straße: Leopoldstr. 13

Wohnort: A-6020 Innsbruck

Zweck: ....

Interview am: .... durch: ....

Erinnert am: .... durch: ....

Versuch(en) am: von:

...5..3..98... ..RS.

....

....

....

....

unerreichbar ☐

interviewt ☐

verweigert ☐

abgebrochen ☐

1. Allgemein benutztes Verkehrsmittel:

Für meine Wege / Fahrten in IBK verwende ich:

☐ grundsätzlich ....

☐ abhängig von .... entweder .... oder ....

Habe meinen gewöhnlichen Aufenthaltsort nicht Innsbruck: ☐ (Wenn eines davon

Bin nicht mobil: ☐ zutrifft: abbrechen)

2. ÖV-Verfügbarkeit:

Können Sie uns für Ihren Fall sagen, wie weit die folgenden Haltestellen entfernt sind ?

die IVB-Haltestelle, die Sie von Ihrer Wohnung aus am häufigsten-benutzen:

☐ weiß / benutze keine

.... Gehminuten

.... Meter

Bez.: ....

Fahre von dort aus mit Linie(n): ....

die IVB-Haltestelle, die Sie von Ihrem Arbeitsplatz /der UNI aus am häufigsten benutzen:

☐ weiß / benutze keine

☐ arbeite nicht / nicht in IBK

.... Gehminuten

.... Meter

Bez.: ....

Fahre von dort aus mit Linie(n): ....

Figure B.2 Telephone interview guide: Sections 3, 4, 7 and 8

3. PKW-Verfügbarkeit (notfalls Motorrad):

Besitzen Sie einen Führerschein ? ☐ ja, vom Typ .... ☐ nein

.... PKW in unserem Haushalt stehen mir uneingeschränkt zur Verfügung

☐ Ich teile einen PKW mit anderen Mitgliedern in unserem Haushalt

☐ Mir steht kein PKW (zum Selberfahren) zur Verfügung

4. Parkplatz-Verfügbarkeit:

Falls ein Fahrzeug verfügbar:

Wenn Sie nach Hause fahren, parken Sie (praktisch) immer am gleichen Ort ?

- ☐ ja, nämlich:
  - ☐ Garage/Box (eben+Dach)
  - ☐ Tiefgarage (unten+Dach)
  - ☐ Parkhaus (oben+Dach)
  - ☐ im Hof (eben+offen+privat)
  - ☐ am Parkplatz (eben+offen+öffentlich)
  - ☐ am Straßenrand
  - regelm. Kosten / Monat: ....
- ☐ nein

Fußweg zur Wohnung: ....

Falls Arbeitsplatz / Studium in IBK:

Wenn Sie zur Arbeit/UNI fahren, parken Sie (praktisch) immer am gleichen Ort ?

- ☐ ja, nämlich:
  - ☐ Garage/Box
  - ☐ Tiefgarage
  - ☐ Parkhaus
  - ☐ im Hof
  - ☐ am Parkplatz
  - ☐ am Straßenrand
  - regelm. Kosten / Monat: ....
- ☐ nein

Fußweg zum Arbeitsplatz: ....

5. Beschreibung der letzten Fahrt in Innsbruck zur Arbeit / zum Einkaufen / in der Freizeit:

Eigenes Protokollblatt in Abhängigkeit von PKW-Verfügbarkeit

6. Zeitkartenbesitz und Fahrtenhäufigkeit:

Rückseite des Protokollblattes mit Angaben zur letzten Fahrt

7. Abschließende Fragen :

Sie sind:	☐ angestellt	☐ Arbeiter(in)	☐ selbständig	☐ Hausfrau
	☐ Pensionist	☐ arbeitslos	☐ Student(in)	☐ in Karenz
	☐ Beamter	☐ sonstige		

Wieviele Stunden arbeiten Sie in der Woche (bezahlt) ? ....

Ihr höchster Schulabschluß ? ☐ VS/HS ☐ Lehre ☐ Matura ☐ UNI /Akad.

Geburtsjahr : ....

Geschlecht (aus Stimme): ☐ männlich ☐ weiblich **NAME !!!**

8. Ankündigung und Motivation für ergänzende schriftliche Befragung

Figure B.3 Telephone interview guide: Section 5 (Car available)

Weg zur/zum:	☐ **Arbeit** ☐ **Einkauf**	☐ **Freizeit am Abend**
Start:	Ausgangspunkt der Fahrt/des Weges____	....
	Weggegangen / weggefahren um_______	.... Uhr
ÖV:	Es fährt ein/e ____________________	☐ Bus ☐ O-Bus ☐ Straßenb.
	Fußweg bis zur Haltestelle ___________	.... min
	xxx fährt alle ______________________	.... min
	xxx ist in _________________________	.... von 10 Fällen unpünktlich
	Umsteigen ________________________	☐ ja ☐ nein
	Fahrtzeit (inkl. Umsteigen) ist insgesamt _	.... min
	Fußweg von der Endhaltestelle zum Ziel _	.... min
	Fahrt mit xxx kostet _______________	.... Schilling
Auto:	Fußweg bis zum geparkten Auto ist _____	.... min
	Fahrzeit mit dem Auto ist ____________	.... min
	Stau von 5 Minuten oder länger an _____	..... von 10 Tagen
	Parkplatzsuche dauert gewöhnlich ______	.... min
	Parkmöglichkeit am Ziel ______________	....
	Parkplatz kostet ___________________	.... Schilling (pro Arbeitstag)
	Fußweg vom geparkten Auto zum Ziel ___	.... min
Ziel:	Ziel der Fahrt/des Weges ____________	....
	angekommen um ___________________	.... Uhr
	Aufenthaltsdauer am Ziel ____________	.... Stunden
	Sind Sie alleine gefahren ____________	☐ ja .... Personen insgesamt
Ihre Entscheidung war:	☐ ÖV ☐ Auto	☐ Rad ☐ zu Fuß

Zusätzliche Details falls tatsächlich ein öffentliches Verkehrsmittel benutzt wurde:

Bei welcher Haltestelle sind Sie eingestiegen: ....

Bei welcher Haltestelle sind Sie ausgestiegen: ....

Hatten Sie einen Sitzplatz: ☐ ja ☐ nein

Welche Linie(n) haben Sie benutzt: ....

Wieoft und wo sind Sie umgestiegen: ...... mal bei ....

bei ....

Welchen Fahrschein haben Sie benutzt:

EK	4FK	TK	24H	WK	MK	HK	JK	STK		

Figure B.4 Telephone interview guide: Section 5 (Car not available)

Weg zur/zum:	☐ **Arbeit**	☐ **Einkauf**	☐ **Freizeit am Abend**
Start:	Ausgangspunkt der Fahrt/des Weges	....	
	Weggegangen / weggefahren um	.... Uhr	
ÖV:	Es fährt ein/e	☐ Bus ☐ O-Bus ☐ Straßenb.	
	Fußweg bis zur Haltestelle	.... min	
	xxx fährt alle	.... min	
	xxx ist in	.... von 10 Fällen unpünktlich	
	Umsteigen	☐ ja ☐ nein	
	Fahrtzeit (inkl. Umsteigen) ist insgesamt	.... min	
	Fußweg von der Endhaltestelle zum Ziel	.... min	
	Fahrt mit xxx kostet	.... Schilling	
Rad:	Fußweg bis zum abgestellten Rad ist	.... min	
	Fahrzeit mit dem Rad ist	.... min	
	Stellplatzsuche dauert gewöhnlich	.... min	
	Parkmöglichkeit am Ziel	....	
	Fußweg vom abgestellten Rad zum Ziel	.... min	
	Als Radweg ausgebaut sind	.... % der gesamten Strecke	
zu Fuß:	Gehzeit ist / wäre	.... min	
Ziel:	Ziel der Fahrt/des Weges	....	
	angekommen um	.... Uhr	
	Aufenthaltsdauer am Ziel	.... Stunden	
	Sind Sie alleine gefahren /gegangen	☐ ja .... Personen insgesamt	
Ihre Entscheidung war:	☐ ÖV	☐ Rad	☐ zu Fuß

Zusätzliche Details falls tatsächlich ein öffentliches Verkehrsmittel benutzt wurde:

Bei welcher Haltestelle sind Sie eingestiegen: ....

Bei welcher Haltestelle sind Sie ausgestiegen: ....

Hatten Sie einen Sitzplatz: ☐ ja ☐ nein

Welche Linie(n) haben Sie benutzt: ....

Wieoft und wo sind Sie umgestiegen: ...... mal bei ....

bei ....

Welchen Fahrschein haben Sie benutzt:

EK	4FK	TK	24H	WK	MK	HK	JK	STK		

Figure B.5 Telephone interview guide: Section 6

6. Zeitkartenbesitz und Fahrtenhäufigkeit:

Minimum (bei **gerader** Haushaltsnummer):

Wie oft sind Sie letzte Kalenderwoche mit der IVB gefahren ? .... mal

Welche Arten von Fahrkarten haben Sie dabei verwendet ? (auch Mehrfachangaben)

EK	4FK	TK	24H	WK	MK	HK	JK	STK		

Bei Besitz einer Zeitkarte:
Haben Sie Ihre Wochen-/Monats-/Halbjahres-/Jahreskarte mit jemandem geteilt ?

☐ ja ☐ nein

Maximum (bei **ungerader** Haushaltsnummer):

Wie oft sind Sie an den einzelnen Tagen der letzten Kalenderwoche mit der IVB gefahren und welche Fahrkarten haben Sie dabei verwendet ?

Tag	Datum	Fahrten	EK	4FK	TK	24H	WK	MK	HK	JK	STK
Mo											
Di											
Mi											
Do											
Fr											
Sa											
So											

Bei Besitz einer Zeitkarte:
Haben Sie Ihre Wochen-/Monats-/Halbjahres-/Jahreskarte mit jemandem geteilt ?

☐ ja ☐ nein

Annahmen für die Kosten einer Einzelfahrt (normal und ermäßigt):

EK	21,-	12,-	Einzelkarte (Ermäßigung bis 15, Studenten mit HP, Senioren ,...)
4FK	15,-	12,-	Vierfahrtenkarte (normal 58,- ermäßigt 46,-)
TK	10,-	7,-	Tageskarte (normal 32,- ermäßigt 20,-)
24H	15,-	11,-	24-Stundenkarte (normal 45,- ermäßigt 34,-)
WK	10,-		Wochenkarte (normal 110,-)
MK	6,-		Monatskarte (normal 400,- ermäßigt 300,- [Senioren])
HK	5,-		Halbjahreskarte (normal 2.000,- ermäßigt 1.500,- [Senioren])
JK	5,-		Jahreskarte (normal 4.000,- ermäßigt 3.000,- [Senioren])
STK	5,-		Semesterticket (950,- pro Semester)

(Tief-)Garagenpreise für das Stadtgebiet:

tageweise Benutzung: 28,- pro (begonnene) Stunde, max. 196,- pro Tag
monatliche Benutzung: 1.200,- bis 1.900,- pro Monat, dh. 60,- bis 95,- pro Arbeitstag

APPENDIX C SURVEY FORMS: SP AND CA

C.1 Cover letter

Both the SP and CA survey were introduced by the cover letters shown in Figure C.1 and Figure C.2.

C.2 SP forms

The SP survey included the current situation and eleven new situations, which the respondents had to evaluate. Two formats were used depending on the car availability (Figure C.3 and Figure C.4).

C.3 CA forms

The CA survey consisted out of the measurement of the attribute importance and desirabilities of the levels (See Figure C.5 for an exable page) and full profile, which presented a modal alternative each (see Figure C.6, Figure C.7, Figure C.8 and Figure C.9 for examples).

Figure C.1 SP: cover letter

ARBEITSGEMEINSCHAFT
o.UNIV.PROF. DR.-ING. K. AXHAUSEN
INGENIEURBÜRO DIPL.-ING. H. KÖLL

POSTFACH 6
A - 6029 INNSBRUCK

TEL.: 0512 / 36 59 69
DVR.: 0839043

An Herrn
Serienbrief Nr 1

Reichenauerstr. 91
A-6020 Innsbruck

Innsbruck, 12.03.1998

Sehr geehrter Herr Nr 1!

Zuerst einmal möchten wir uns für die wertvollen Informationen, die Sie uns gestern beim Telefongespräch gegeben haben, sehr herzlich bedanken. Wie bereits angekündigt folgt nun die schriftliche Ergänzung der Befragung. Im wesentlichen geht es darum, jene Eigenschaften der Verkehrsmittel herauszufinden, die im Interesse der Benutzer am vordringlichsten verbessert werden sollen. Wir bitten Sie deshalb, die vollständig ausgefüllten Unterlagen im beigelegten frankierten Umschlag bis Montag, den 16.3.1998 an uns zurückzusenden.

Sie haben uns am Telefon einen Weg in Ihrer Freizeit am Abend geschildert, welche Verkehrsmittel Ihnen dafür zur Verfügung stehen und wofür Sie sich entschieden haben. Stellen Sie sich vor, für denselben Weg hätte sich nun einiges geändert, z.B. kommt der Bus nun alle 10 Minuten anstatt alle 15 Minuten oder die Parkgebühren werden von 25 Schilling auf 40 Schilling erhöht. Für welches Verkehrsmittel würden Sie sich dann entscheiden? Auf den folgenden Seiten finden Sie eine Reihe von solchen Situationen, bei denen Sie sich jeweils für ein öffentliches Verkehrsmittel, den Pkw, das Fahrrad oder fürs zu Fuß gehen entscheiden sollen.

Wie Sie sicher bemerken werden, ist jede Entscheidungssituation mit einer Nummer versehen, die zur Verknüpfung Ihrer telefonischen und schriftlichen Angaben dient. Nach dem Zusammenführen der Daten erfolgen die statistischen Auswertungen ohne jeden Bezug zu Ihrer Person. Wir möchten noch einmal betonen, daß alle Ihre Angaben selbstverständlich vertraulich behandelt werden.

Für alle Fragen, Wünsche und Anregungen stehen wir Ihnen gerne zur Verfügung:
Montag bis Freitag von 15:00 bis 20:00 unter Tel. 0512 / 36 59 69

Mit freundlichen Grüßen und bestem Dank für Ihre Mithilfe

Figure C.2 CA: cover letter

ARBEITSGEMEINSCHAFT
o.UNIV.PROF. DR.-ING. K. AXHAUSEN
INGENIEURBÜRO DIPL.-ING. H. KÖLL

POSTFACH 6
A - 6029 INNSBRUCK

TEL.: 0512 / 36 59 69
DVR.: 0839043

An Frau
Serienbrief Nr 3

Ing. Sigl Str. 41
A-6020 Innsbruck

Innsbruck, 12.03.1998

Sehr geehrte Frau Nr 3!

Zuerst einmal möchten wir uns für die wertvollen Informationen, die Sie uns gestern beim Telefongespräch gegeben haben, sehr herzlich bedanken. Wie bereits angekündigt folgt nun die schriftliche Ergänzung der Befragung. Im wesentlichen geht es darum, jene Eigenschaften der Verkehrsmittel herauszufinden, die im Interesse der Benutzer am vordringlichsten verbessert werden sollen. Wir bitten Sie deshalb, die vollständig ausgefüllten Unterlagen im beigelegten frankierten Umschlag bis Montag, den 16.3.1998 an uns zurückzusenden.

Auf den ersten Blättern kreuzen Sie bitte an, wie wichtig Ihnen einzelne Eigenschaften eines Verkehrsmittels sind und wie Sie einzelne Alternativen beurteilen. Im Anschluß daran beziehen wir uns auf den Weg zur Arbeit, den Sie uns am Telefon geschildert haben. Stellen Sie sich vor, für denselben Weg hätte sich nun einiges geändert, z.B. kommt der Bus alle 10 Minuten anstatt alle 15 Minuten und Sie haben nun eine Haltestelle in unmittelbarer Nähe zu Ihrer Wohnung. Wie attraktiv erscheint Ihnen unter diesen Bedingungen das beschriebene Verkehrsmittel? Auf den folgenden Seiten finden Sie eine Reihe von solchen Situationen und wir bitten Sie, Ihre persönliche Einschätzung auf einer Skala einzutragen.

Wie Sie sicher bemerken werden, ist jede Entscheidungssituation mit einer Nummer versehen, die zur Verknüpfung Ihrer telefonischen und schriftlichen Angaben dient. Nach dem Zusammenführen der Daten erfolgen die statistischen Auswertungen ohne jeden Bezug zu Ihrer Person. Wir möchten noch einmal betonen, daß alle Ihre Angaben selbstverständlich vertraulich behandelt werden.

Für alle Fragen, Wünsche und Anregungen stehen wir Ihnen gerne zur Verfügung:
Montag bis Freitag von 15:00 bis 20:00 unter Tel. 0512 / 36 59 69

Mit freundlichen Grüßen und bestem Dank für Ihre Mithilfe

Figure C.3 SP: Example form (car available) (© Axhausen, Köll und Bader)

Nr.: 3004-100

Sie haben uns einen Weg in Ihrer Freizeit am Abend wie folgt geschildert:

Öffentlicher Verkehr:	Es fährt ein	O-Bus
	O-Bus fährt	alle 15 min
	O-Bus ist	in 0 von 10 Fällen unpünktlich
	Umsteigen	nein
	Fahrt dauert	insgesamt 15 min
	Fußwege von/zur Haltestelle dauern	insgesamt 10 min
	Fahrt mit dem O-Bus kostet	21 Schilling
Auto:	Fahrzeit mit dem Auto ist	10 min (ohne Parkplatzsuche)
	Stau von 5 Minuten oder länger	an 0 von 10 Tagen
	Parkplatzsuche dauert gewöhnlich	10 min
	Parkmöglichkeit am Ziel	am Straßenrand
	Parkplatz kostet	nichts
Rad:	Wie derzeit	
zu Fuß:	Wie derzeit	

Ihre Entscheidung war: O-Bus .... ☒ Auto ... ☐ Rad ... ☐ zu Fuß ... ☐

Figure C.4 SP: Example form (car not avaiable) (© Axhausen, Köll und Bader)

Nr.: 2918-406

Angenommen, die Situation wäre nun so:

Öffentlicher Verkehr:	Es fährt ein	O-Bus
	O-Bus fährt	alle 15 min
	O-Bus ist	in 0 von 10 Fällen unpünktlich
	Umsteigen	ja
	Fahrt mit Umsteigen dauert	insgesamt 23 min
	Fußwege von/zur Haltestelle dauern	insgesamt 7 min
	Fahrt mit dem O-Bus kostet	14 Schilling
Rad:	Fußweg bis zum Rad	1 min
	Fahrzeit mit dem Rad ist	8 min
	Zum Abstellen des Rades gibt es	keinen Fahrradständer
	Fußweg vom abgestellten Rad zum Ziel	3 min
	Als Radweg ausgebaut sind	15 % der Strecke
zu Fuß:	Gehzeit ist	23 min

Ihre Entscheidung wäre: O-Bus .... ☐ Rad ... ☐ zu Fuß ... ☐

Figure C.5 CA: Example page for attribute importance and level desirability

Wie wichtig ist für Sie die **Art des öffentlichen Verkehrsmittels,** das Sie benutzen ?

ganz unwichtig … sehr wichtig

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Wie beurteilen Sie die folgenden Möglichkeiten ?

unattraktiv … attraktiv

	0	1	2	3	4	5	6	7	8	9	10
Bus	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
O-Bus	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Straßenbahn ...	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Wie wichtig ist für Sie bei der Fahrt zur Arbeit die **Verläßlichkeit des öffentlichen Verkehrsmittels,** das Sie benutzen ?

ganz unwichtig … sehr wichtig

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Wie beurteilen Sie ein Zuspätkommen:

unattraktiv … attraktiv

	0	1	2	3	4	5	6	7	8	9	10
in 3 von 10 Fällen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
in 0 von 10 Fällen	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Wie wichtig ist für Sie der **Takt in dem ein öffentliches Verkehrsmittel fährt,** also der zeitliche Abstand zwischen zwei Bussen derselben Linie?

ganz unwichtig … sehr wichtig

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Wie beurteilen Sie die folgenden Angebote ?

unattraktiv … attraktiv

	0	1	2	3	4	5	6	7	8	9	10
alle 10 min	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
alle 6 min	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure C.6 CA: Example for a full profile - public transport (© Axhausen, Köll und Bader)

Nr.: 2726-102

Angenommen, es gäbe die folgende Möglichkeit:

Öffentlicher Verkehr:	Es fährt ein	O-Bus
	O-Bus fährt	alle 6 min
	O-Bus ist	in 3 von 10 Fällen unpünktlich
	Umsteigen	nein
	Fahrt dauert	insgesamt 13 min
	Fußwege von/zur Haltestelle dauern	insgesamt 8 min
	Fahrt mit dem O-Bus kostet	6 Schilling

Ihre Bewertung wäre:

unattraktiv — attraktiv

0	1	2	3	4	5	6	7	8	9	10

Figure C.7 CA: Example for a full profile - car (© Axhausen, Köll und Bader)

Nr.: 2726-107

Angenommen, es gäbe die folgende Möglichkeit:

Auto:	Fahrzeit mit dem Auto ist	15 min
	Stau von 5 Minuten oder länger	an 6 von 10 Tagen
	Parkplatzsuche dauert gewöhnlich	5 min
	Parkmöglichkeit am Ziel	Parkplatz
	Parkplatz kostet	100 Schilling pro Tag

Ihre Bewertung wäre:

unattraktiv — attraktiv

0	1	2	3	4	5	6	7	8	9	10

Figure C.8 CA: Example for a full profile - bicycle (© Axhausen, Köll und Bader)

Nr.: 3141-205

Angenommen, es gäbe die folgende Möglichkeit:

Rad:	Fußweg bis zum Rad	1 min
	Fahrzeit mit dem Rad ist	6 min
	Zum Abstellen des Rades gibt es	einen Fahrradständer
	Fußweg vom abgestellten Rad zum Ziel	1 min
	Als Radweg ausgebaut sind	15 % der Strecke

Ihre Bewertung wäre:

unattraktiv — attraktiv

0	1	2	3	4	5	6	7	8	9	10

Figure C.9 CA: Example for a full profile - walking (© Axhausen, Köll und Bader)

Nr.: 3141-200

Sie haben uns den Weg zur Arbeit wie folgt geschildert:

zu Fuß:	Gehzeit ist	7 min

Ihre Bewertung wäre:

unattraktiv — attraktiv

0	1	2	3	4	5	6	7	8	9	10

APPENDIX D RESULTS OF THE SP/RP ESTIMATION

D.1 Variable definitions

The variables are specific to a mode, when preceded by:

O_	Public transport
P_	Car
R_	Bicycle
F_	Walking

Variable name	Unit	Definition
P	[Schilling]	Out-of-pocket costs (fare, parking fee)
GZ	[min]	Walking time (access plus egress time in the case of public transport, car and cycle)
FZ	[min]	Driving time/In-vehicle time
SZ	[min]	Search time
TKT	[min]	Headway
UM	[y,n]	Necessity to transfer
ZUV	[x of 10]	Reliability
O_OBUS	[y,n]	Trip with trolley bus
O_STRAB	[y,n]	Trip with street car
P_PP1	[y,n]	Parking on off-street parking lot
P_PP2	[y,n]	Parking in multi-storey garage
R_PP	[y,n]	Bicycle parking rail available
R_WEGE	[%]	Share of cycling paths
KERN	[y,n]	Trip within the centre of Innsbruck
OTICKET	[y,n]	Ownership of a season ticket
MALE	[y,n]	Male
TAETIG	[y,n]	Working
AUSB	[y,n]	In education
MATURA	[y,n]	Highschool diploma
D30	[y,n]	Born in the 1930's
D40	[y,n]	Born in the 1940's
D50	[y,n]	Born in the 1950's
D60	[y,n]	Born in the 1960's
CRPKW		Constant RP car
CRRAD		Constant RP bicycle
CRFUSS		Constant RP walking

D.2 Joint SP/RP estimation results: Work

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]
	Attributes in the Utility Functions			
P	-.24197620E-01	.201055E-02	-12.035	.00000
GZ	-.90329511E-01	.585610E-02	-15.425	.00000
FZ	-.54109897E-01	.746878E-02	-7.245	.00000
TKT	-.15116473E-01	.596014E-02	-2.536	.01120
UM	-.77524245	.190578	-4.068	.00005
O_ZUV	-.540000	........(Fixed Parameter)........		
O_OBUS	.78534861	.164752	4.767	.00000
O_STRAB	-.31994414	.190475	-1.680	.09301
OTICKET	4.6333094	.201053	23.045	.00000
CRPKW	.42065057	.432166	.973	.33038
P_SZ	-.91299062E-01	.265014E-01	-3.445	.00057
P_ZUV	-.400000	........(Fixed Parameter)........		
P_PP1	.57193166	.170203	3.360	.00078
P_PP2	.60910953	.196192	3.105	.00191
P_MALE	-.44728962	.157685	-2.837	.00456
P_TAETIG	.88141065	.275878	3.195	.00140
P_AUSB	-3.4211692	.490315	-6.977	.00000
P_MATURA	.65950585	.155390	4.244	.00002
P_D30	.74123631	.466098	1.590	.11177
P_D40	1.2217901	.271966	4.492	.00001
P_D50	.19303250	.269364	.717	.47361
P_D60	.12545815	.254175	.494	.62160
CRRAD	-8.0726576	.617872	-13.065	.00000
R_SZ	.11162107	.212101	.526	.59871
R_PP	.21321101	.198180	1.076	.28200
R_WEGE	.43279726E-02	.351853E-02	1.230	.21868
R_KERN	-23.363892	6.71592	-3.479	.00050
R_MALE	1.0657224	.163953	6.500	.00000
R_TAETIG	2.1038578	.345647	6.087	.00000
R_AUSB	2.3150927	.449706	5.148	.00000
R_MATURA	.91962626	.165271	5.564	.00000
R_D30	5.9297366	.574893	10.315	.00000
R_D40	5.4068036	.416936	12.968	.00000
R_D50	4.8558100	.406900	11.934	.00000
R_D60	3.8810279	.398161	9.747	.00000
CRFUSS	.94969687	.428617	2.216	.02671
F_KERN	-15.926582	8.49709	-1.874	.06088
F_MALE	.23209873	.196903	1.179	.23850
F_TAETIG	-.35661211E-01	.286326	-.125	.90088
F_AUSB	-1.8338478	.479942	-3.821	.00013
F_MATURA	-.49968360	.220400	-2.267	.02338
F_D30	.76096536	.545311	1.395	.16287
F_D40	1.0189448	.340166	2.995	.00274
F_D50	-.40589097	.334293	-1.214	.22468
F_D60	-.97044187	.330266	-2.938	.00330

D.3 Joint SP/RP estimation results: Shopping

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]
	Attributes in the Utility Functions			
P	-.25817403E-01	.563464E-02	-4.582	.00000
GZ	-.70404629E-01	.531206E-02	-13.254	.00000
FZ	-.61845694E-01	.708327E-02	-8.731	.00000
TKT	.41124990E-02	.801202E-02	.513	.60775
UM	-.56248523	.142769	-3.940	.00008
O_ZUV	-.360000	........(Fixed Parameter)........		
O_OBUS	.53402688	.158386	3.372	.00075
O_STRAB	.55989046	.164025	3.413	.00064
OTICKET	1.7829600	.194505	9.167	.00000
CRPKW	.28926532	.306190	.945	.34480
P_SZ	-.19754396	.304266E-01	-6.492	.00000
P_PP1	2.5337081	.175786	14.414	.00000
P_PP2	1.2559649	.169403	7.414	.00000
P_MALE	.20140231	.144603	1.393	.16368
P_TAETIG	.30036123	.178035	1.687	.09159
P_AUSB	-.32045276	.841803	-.381	.70344
P_MATURA	-.88856513E-02	.157278	-.056	.95495
P_D30	-1.0271326	.293615	-3.498	.00047
P_D40	-.28849726	.314557	-.917	.35906
P_D50	-.91885590	.360621	-2.548	.01083
P_D60	-.16774371	.325233	-.516	.60602
CRRAD	-1.1017433	.267340	-4.121	.00004
R_SZ	-.30735000	.225959	-1.360	.17377
R_PP	-.59596865	.279566	-2.132	.03303
R_WEGE	.12859570E-01	.340410E-02	3.778	.00016
R_KERN	-1.5877133	.698384	-2.273	.02300
R_MALE	.40847378	.177159	2.306	.02113
R_TAETIG	-.69780395	.241273	-2.892	.00383
R_AUSB	-1.3736975	.470811	-2.918	.00353
R_MATURA	.42084163	.205520	2.048	.04059
R_D30	-1.1667488	.265687	-4.391	.00001
R_D40	-.67153579	.301034	-2.231	.02570
R_D50	-1.0175811	.379685	-2.680	.00736
R_D60	-1.1896790	.360174	-3.303	.00096
CRFUSS	.24398019	.295206	.826	.40853
F_KERN	-.38860029E-01	.677251	-.057	.95424
F_MALE	-.48658591	.213001	-2.284	.02235
F_TAETIG	.63693743	.258242	2.466	.01365
F_AUSB	-6.2689632	3.77469	-1.661	.09676
F_MATURA	-.68336549E-01	.228525	-.299	.76491
F_D30	-.71945822	.276134	-2.605	.00917
F_D40	-.53968535	.298402	-1.809	.07052
F_D50	-.72729149	.351742	-2.068	.03867
F_D60	-3.4886763	.688019	-5.071	.00000

D.4 Joint SP/RP estimation results: Leisure

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]
	Attributes in the Utility Functions			
P	-.47810692E-01	.781879E-02	-6.115	.00000
GZ	-.10068338	.984685E-02	-10.225	.00000
FZ	-.31854237E-01	.105082E-01	-3.031	.00243
TKT	-.69887645E-02	.857254E-02	-.815	.41493
UM	-.71196248	.233172	-3.053	.00226
O_ZUV	-.270000	........(Fixed Parameter)........		
O_OBUS	-.25722834	.190775	-1.348	.17755
O_STRAB	.73063285	.197567	3.698	.00022
OTICKET	.82434537	.217718	3.786	.00015
CRPKW	-.58613799	.331608	-1.768	.07713
P_SZ	-.10648107	.204754E-01	-5.200	.00000
P_PP1	-.50754100E-02	.237927	-.021	.98298
P_PP2	.82212906	.312557	2.630	.00853
P_MALE	1.3098965	.226593	5.781	.00000
P_TAETIG	.32274565	.234192	1.378	.16816
P_AUSB	-.74358340	.426079	-1.745	.08095
P_MATURA	1.8054750	.228319	7.908	.00000
P_D30	-.56593261E-01	.362812	-.156	.87604
P_D40	-.50198706	.343042	-1.463	.14337
P_D50	.35340251	.296920	1.190	.23396
P_D60	.14190215	.288295	.492	.62257
CRRAD	-1.5246926	.309999	-4.918	.00000
R_SZ	-.93171568	.337937	-2.757	.00583
R_PP	.64815738	.456934	1.418	.15605
R_WEGE	-.46455417E-02	.512255E-02	-.907	.36447
R_KERN	1.5325247	.556469	2.754	.00589
R_MALE	1.6647315	.324213	5.135	.00000
R_TAETIG	-.99942099	.419282	-2.384	.01714
R_AUSB	-1.3063761	.641640	-2.036	.04175
R_MATURA	.72734067	.339315	2.144	.03207
R_D30	-2.5092781	.507838	-4.941	.00000
R_D40	-1.3212726	.391703	-3.373	.00074
R_D50	-5.7616759	1.12296	-5.131	.00000
R_D60	-2.8983352	.550871	-5.261	.00000
CRFUSS	.41316748	.342022	1.208	.22704
F_KERN	1.9281125	.665049	2.899	.00374
F_MALE	2.2922431	.264276	8.674	.00000
F_TAETIG	-1.0939669	.275411	-3.972	.00007
F_AUSB	-.82164780	.503756	-1.631	.10288
F_MATURA	.32845095	.292971	1.121	.26224
F_D30	-2.6345278	.435567	-6.048	.00000
F_D40	-.21644008	.333503	-.649	.51635
F_D50	.33098907	.403149	.821	.41164
F_D60	-1.8883357	.420806	-4.487	.00001

APPENDIX E DESCRIPTION OF THE DATA

All the file names for the data set as listed in Table .

E.1 Original format

The data were coded at the Ingenieurbüro Köll and Bader and stored in a MS-Access data base. The following tables are included:

Name	Content
Haushalte	Information related to the households as a whole
Kontakte	Contact history with the sample households
Allgemein benutztes Verkehrsmittel	Generally used mode of transport
ÖV-Verfügbarkeit	Public transport availability
PKW-Verfügbarkeit	Car availability
Parkplatz-Verfügbarkeit	Availability of a parking space
Beschriebene Fahrt	Additional information about the reported trip
Fahrten pro Woche	Public transport trips by week
Fahrten pro Tag	Public transport trips by day
Personen-Daten	Person data
Wege	Reported trips and SP/CA trips
Bewertung Wege	Ratings/choices for the trips under Wege
Bewertung Eigenschaften	Importance ratings and desirabilities

The detailed description of these tables is given in the figures below (in German).

The data collected during the additional survey of annual season ticket holders are held in the MS-access data base *additional.mdb* containing the following three tables structued like their name sakes in original.mdb:

Name	Content
PKW-Verfügbarkeit	Car availability
Fahrten pro Tag	Public transport trips by day
Personen-Daten	Person data

Table E.1 Overview of the data files

Kind	Name	Records	Content
\Orginal MS-Access			
	\original.mdb		Original data base containing individual data sets (See above)
	\additional.mdb		Data from the additional survey of season ticket holders
\ASCII			
	\kontakte.dat	7098	Contakt history
	\fahrten.dat	945	Public transport trips reported during the additional survey
	\f_p_t.dat	949	Public transport trips (by day format)
	\f_p_w.dat	1214	Public transport trips for all respondents (by week format and summary from other format)
	\personen.dat	135	Personal details (additional survey)
	\p.dat	1214	Personal details
	\hh.dat	2471	Household details (including households not reached)
	\vm.dat	1214	Modal detail
	\oev.dat	1214	Public transport availability
	\parken.dat	1214	Availability of parking at home and work
	\pkw.dat	1214	Car availability
	\wege.dat	12128	Details of SP and CA exercises
	\ca.dat	2408	Ratings of CA full profiles
	\sp.dat	5688	Choices for SP exercises
	\eigenschaft.dat	4515	Importance ratings and desirabilities for CA
\Additional information			
	\gewichte.xls		Excel 97 spreadsheet deriving the weights used from residential statistics and the known distribution of season ticekt holders by age and sex
	\qz.dat	1161	Origin-destination codes for RP trips
	\rz_iv.dat	481	Assignment-based car travel times
	\rz_oev.dat	1387	Assignment-based public transport travel times

Figure E.1 Description of *original.mdb*

Haushalte:

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Zwk:** befragter Zweck (0 = Arbeit, 1 = Einkauf, 2 = Freizeit am Abend)
- **Art:** Befragungsart (0 = SP, 1 = CA)
- **Blk:** Block im Versuchsplan (1..4)
- **Interview:** Verlauf des Interviews mit folgenden Werten:
  - unerreichbar (Telefonnummer ungültig oder fünfmal niemand zu Hause)
  - verweigert (von Zielperson)
  - abgebrochen (von Zielperson oder Interviewer)
  - ohne Weg (wenn erst im Verlauf des Interviews erkennbar, daß kein für uns interessanter Weg angegeben werden kann)
  - mit Weg (nur in diesem Fall erfolgt eine Versendung)
  - uninteressant (nur bei Interviews nach Unterbrechung; kein anwesender Erwachsener im Haushalt arbeitet in Innsbruck oder geht am Abend aus)
  - leer (noch kein Interview, dh. Anrufversuche laufen noch)
- **Fragebogen:** Schicksal des Fragebogens für Rücklaufstatistik mit folgenden Werten:
  - nicht erhalten (weil kein Interview mit Weg erfolgt)
  - unzustellbar (weil Adressat unter dieser Adresse unbekannt oder verzogen)
  - Annahme verweigert
  - nicht zurückgeschickt
  - leer zurückgeschickt (dh. es wurde nichts angekreuzt, also die Fragebögen sind leer; fallsweise wurden aber Wünsche, Anregungen oder Beschwerden auf dem Zusatzblatt angegeben)
  - zurückgeschickt (Fragebögen teilweise oder vollständig angekreuzt)
  - leer (noch kein Interview oder Rücklauf ungewiß)
- **Erinnerung:** Verlauf der Erinnerung mit folgenden Werten:
  - nicht notwendig (weil Rücklauf unmöglich, auszuschließen oder innerhalb der vorgesehenen Frist erfolgt; Bem.: unmöglich z.B. weil keine Versendung erfolgte oder Fragebogen unzustellbar; auszuschließen z.B. weil Zielperson telefonisch Verweigerung ankündigt)
  - offen (weil Versendung erfolgt, aber Frist noch nicht abgelaufen)
  - durchgeführt
  - nicht erreicht (Erinnerung versucht, aber niemanden erreicht)
  - leer (noch kein Versand)

Figure E.1 Description of *original.mdb* (continued)

Kontakte:

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Datum:** Datum des Kontakt(versuch)es; bei SRL Datum der Abholung aus Postfach
- **Art:** Art des Kontakt(versuch)es mit folgenden Werten:
  - TIV = Telefoninterview versucht (Nummer ungültig oder niemand daheim)
  - TIE = jemanden zum Telefoninterview erreicht (unabhängig vom Verlauf desselben, also Verweigerung, Abbruch, mit Weg, ohne Weg)
  - SVS = schriftlicher Versand der Fragebögen
  - SRL = schriftliche Rücksendung der Fragebögen (unabhängig von Verwertbarkeit derselben)
  - TEV = telefonische Erinnerung versucht (niemand daheim)
  - TEE = jemanden für telefonische Erinnerung erreicht (fallweise auch nur Ehepartner, Eltern oder Kinder)
  - TAN = Telefonanruf von Haushalt an uns (z.B. Fragen zum Ausfüllen oder Beschwerde und Ankündigung, daß kein Rücklauf erfolgt)
- **von:** Absender / Anrufer (HH = Haushalt)
- **mit:** Empfänger / Angerufener (HH = Haushalt)
- **Bem:** Bemerkungen zum Kontakt(versuch)

Allgemein benutztes Verkehrsmittel:

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Bedingung:** für Verkehrsmittelwahl mit folgenden Werten:
  - leer = grundsätzlich, dh. ohne Bedingung
  - nicht leer = abhängig von angegebener Bedingung
- **Alt1:** Alternative 1 für Verkehrsmittel
- **Alt2:** Alternative 2 für Verkehrsmittel

Figure E.1 Description of *original.mdb* (continued)

ÖV-Verfügbarkeit:

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **HS-Wohnen:** Bezeichnung der Haltestelle mit folgenden Werten:
  - leer = verweigert
  - „weiß/benutze keine"
  - einheitliche Bezeichnung entsprechend Linienplan der IVB
- **Lin-Wohnen:** benutzte Linien (mit Komma getrennt)
- **FW-Wohnen:** Länge des Fußweges zur Wohnung (leer oder > 0)
- **FW-W-Einh:** Einheit des Fußweges zur Wohnung (leer oder m oder min)
- **HS-Arbeit:** Bezeichnung der Haltestelle mit folgenden Werten:
  - leer = verweigert
  - „weiß/benutze keine"
  - „arbeite nicht/nicht in IBK
  - einheitliche Bezeichnung entsprechend Linienplan der IVB
- **Lin-Arbeit:** benutzte Linien (mit Komma getrennt)
- **FW-Arbeit:** Länge des Fußweges zum Arbeitsplatz (leer oder > 0)
- **FW-A-Einh:** Einheit des Fußweges zum Arbeitsplatz (leer oder m oder min)

PKW-Verfügbarkeit:

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **FS:** Führerschein (leer = verweigert, „nein", Kombination aus „A".."G")
- **PKWs:** verfügbare PKWs (leer = ohne Angabe [verweigert; nicht gefragt, weil kein Führerschein], 0 = keiner, 1..8 = uneingeschränkt, 9 = geteilt)
- **Zeitkarte:** Zeitkartenbesitz (leer = keine Info, sonst WK, MK, HK, JK oder STK) Bem.: FK = Freikarte (Schülerfreifahrt oder Angehörige von IVB)
- **geteilt:** (leer = keine Info, j = ja, n = nein)

Figure E.1 Description of *original.mdb* (continued)

Beschriebene Fahrt:

Zusatzinformationen über den Verlauf der beim Telefoninterview geschilderten Fahrt.

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **AbOrt:** Ausgangspunkt des Weges (Whg = Wohnung)
- **AbTim:** weggefahren/weggegangen um hh:mm
- **AnOrt:** Zielpunkt des Weges
- **AnTim:** angekommen um hh:mm
- **Aufent:** Aufenthalt am Zielort hh:mm
- **Personen:** Anzahl Personen insgesamt (1 = alleine)
- **HS-Ein:** Einstiegshaltestelle mit folgenden Werten:
  - leer = ohne Angabe (verweigert oder nicht mit ÖV gefahren)
  - einheitliche Bezeichnung entsprechend Linienplan der IVB
- **HS-Aus:** Ausstiegshaltestelle mit folgenden Werten:
  - leer = ohne Angabe (verweigert oder nicht mit ÖV gefahrten)
  - einheitliche Bezeichnung entsprechend Linienplan der IVB
- **Sitzplatz:** Sitzplatz (leer oder j = ja oder n = nein)
- **Lin-Fahrt:** benutzte Linien (mit Komma getrennt)
- **Anz-Um:** Anzahl der Umsteigevorgänge (leer oder >= 0)
- **HS-Um1:** Umstiegshaltestelle 1 mit folgenden Werten:
  - leer = ohne Angabe (verweigert oder nicht umgestiegen)
  - einheitliche Bezeichnung entsprechend Linienplan der IVB
- **HS-Um2:** Umstiegshaltestelle 2 mit folgenden Werten:
  - leer = ohne Angabe (verweigert oder höchstens einmal umgestiegen)
  - einheitliche Bezeichnung entsprechend Linienplan der IVB
- **Karte:** verwendete Fahrkarte (EK, 4FK, TK, 24H, WK, MK, HK, JK, STK, ??)

Figure E.1 Description of *original.mdb* (continued)

Fahrten pro Woche:

Wie oft wurde in einer Woche gefahrten und welche Fahrkarte(n) verwendet? Die Tabelle enthält nur die Anzahl Fahrten, nicht aber die Anzahl Karten! Die Information, ob eine Zeitkarte verwendet wird und mit anderen geteilt wurde, ist aus organisatorischen Gründen in der Tabelle „PKW-Verfügbarkeit" untergebracht.

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Woche:** Kalenderwoche (1..52)
- **EK:** Einzelkarte(n) verwendet? (leer = nein, nicht leer = ja)
- **4FK:** Vierfahrtenkarte(n) verwendet? (leer = nein, nicht leer = ja)
- **TK:** Tageskarte(n) verwendet? (leer = nein, nicht leer = ja)
- **24H:** 24-Stunden-Karte(n) verwendet? (leer = nein, nicht leer = ja)
- **WK:** Wochenkarte verwendet? (leer = nein, nicht leer = ja)
- **MK:** Monatskarte verwendet? (leer = nein, nicht leer = ja)
- **HK:** Halbjahreskarte verwendet? (leer = nein, nicht leer = ja)
- **JK:** Jahreskarte verwendet? (leer = nein, nicht leer = ja)
- **STK:** Semesterticket verwendet? (leer = nein, nicht leer = ja)
- **??:** andere oder überhaupt keine Fahrkarte(n) verwendet? (leer = nein, nicht leer = ja)
- **Anz:** Anzahl Fahrten in der gesamten Woche (leer = verweigert oder >= 0!)

Fahrten pro Tag:

An welchem Tag wurde mit welchem Ticket wie oft gefahren?

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Karte:** verwendete Fahrkarte (EK, 4FK, TK, 24H, WK, MK, HK, JK, STK, ??)
- **Tag:** Wochentag (Mo, Di, Mi, Do, Fr, Sa, So)
- **Woche:** Kalenderwoche (1..52)
- **Anz:** Anzahl Fahrten (> 0!)

Figure E.1 Description of *original.mdb* (continued)

Personen-Daten:

sozio-demographische Informationen zu angeschriebenen Personen für Auswertung.

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Beruf:** folgende Werte sind möglich:
  - leer = verweigert
  - 1 = Angestellte(r)
  - 2 = Arbeiter(in)
  - 3 = Selbständige(r)
  - 4 = Hausfrau, -mann
  - 5 = Pensionist(in)
  - 6 = Beamter, Beamtin
  - 7 = Student(in)
  - 8 = Karenz, Krankenstand
  - 9 = arbeitslos
  - 0 = sonstiger
- **WoAzt:** bezahlte Wochenarbeitszeit in Stunden (0..144 oder leer = verweigert)
- **HöchsAb:** höchster Schulabschluß mit folgenden Werten:
  - leer = verweigert
  - 1 = VS/HS/Polytechnischer Lehrgang
  - 2 = Lehre
  - 3 = berufsbildende Schule ohne Matura (z.B. Handelsschule)
  - 4 = Matura
  - 5 = UNI/Akademie
  - 0 = sonstiger
- **Geb:** Geburtsjahr (1900..1980 oder leer = verweigert)
- **Sex:** m(ännlich) oder w(eiblich)

Figure E.1 Description of *original.mdb* (continued)

Wege:

Am Telefon beschriebene und nach Versuchsplan variierte Wege zu Arbeit, Einkaufen oder Freizeit am Abend. In den Feldbezeichnungen steht Suffix „B“ für „**B**us (ÖV)“, Suffix „A“ für „**A**uto“, Suffix „R“ für „**R**ad“ und Suffix „F“ für „zu **F**uß“. Die Tabelle enthält alle Wege, die in den Versendungen vorkommen (unabhängig vom Rücklauf).

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Blk:** Block im Versuchsplan (1..4)
- **Rec:** Numerierung der Datensätze eines Haushalts (0..11 bei SP, 0..7 bei CA; am Telefon beschriebener Weg hat immer die Datensatznummer 0); Schlüsselfeld
- **Ser:** Nummer des verwendeten Serienbriefes (1..9)
- **Zwk:** Zweck der Fahrt (0 = Arbeit, 1 = Einkauf, 2 = Freizeit am Abend)
- **Hdr:** Zusatzinfo für Ausdruck (0..1)
- **TypB:** Wagentyp für ÖV (0 = Bus, 1 = O-Bus, 2 = Straßenbahn)
- **ZztB:** Zugangszeit zu ÖV (1..60 min)
- **TktB:** Takt für ÖV (4..60 min)
- **ZuvB:** Zuverlässigkeit für ÖV (in 0..10 von 10 Fällen unpünktlich)
- **UstB:** Umsteigen (0 = ja, 1 = nein)
- **GztB:** Gesamte Fußwege von/zur Haltestelle (ZztB+AztB) (2..120 min)
- **FztB:** gesamte Fahrzeit mit ÖV inkl. Umsteigen (5..60 min)
- **AztB:** Abgangszeit von ÖV (1..60 min)
- **FprB:** Fahrpreis mit ÖV (0 = frei oder 4..100 ÖS)
- **ZztA:** Zugangszeit zum geparkten Auto (leer oder 1..60 min)
- **FztA:** Fahrzeit mit dem Auto ohne Parkplatzsuche (leer oder 3..60)
- **ZuvA:** Zuverlässigkeit für Auto (leer oder an 0..10 von 10 Tagen Stau >= 5 min)
- **SztA:** Parksuchzeit für Auto (leer oder 0..60 min)
- **PkmA:** Parkmöglichkeit für Auto (leer oder 0 = schlechteste Mögl. [Straßenrand], 1 = bessere Möglichkeit [Parkplatz], 2 = beste Möglichkeit [Tiefgarage, Parkhaus])
- **PkgA:** Parkgebühr für Aufenthalt am Ziel (leer oder 0..200 ÖS) Bem.: bei Zweck „Arbeit“ pro Tag, sonst pro Fahrt
- **AztA:** Abgangszeit vom Auto (leer oder 1..60 min)
- **ZztR:** Zugangszeit zum abgestellten Rad (leer oder 1..60 min)
- **FztR:** Fahrzeit mit dem Rad (leer oder 1..60 min)
- **SztR:** Parksuchzeit für Rad (leer oder 0..60 min)
- **PkmR:** Fahrradständer vorhanden (leer oder 0 = nein, 1 = ja)
- **AztR:** Abgangszeit vom Rad (leer oder 1..60 min)
- **RwaR:** Radweganteil am Gesamtweg in Prozent (0..100)
- **GztF:** Gehzeit zu Fuß (leer oder 1..30 min)

Figure E.1 Description of *original.mdb* (continued)

- **Tab:** Zusatzinfo für Ausdruck (0..2)
- **Trl:** Zusatzinfo für Ausdruck (0..1)
- **Art:** Befragungsart (0 = SP, 1 = CA)
- **BewB:** Bewertung für ÖV (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **BewA:** Bewertung für Auto (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **BewR:** Bewertung für Rad (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **BewF:** Bewertung für zu Fuß (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **Ent:** Entscheidung (nur bei beschriebenem Weg steht hier ein gültiger Wert ungleich Null, nämlich 1 = ÖV, 2 = Auto, 3 = Rad, 4 = zu Fuß)

Bewertung Eigenschaften:

Bewertung der Einflußgrößen auf die Verkehrsmittelwahl aus dem Rücklauf der CA-Fragebögen. Die Merkmalsausprägungen, die zur Bewertung vorgelegt wurden, entsprechen bis auf eine Ausnahme dem Versuchsplan: bei der Fahrzeit mit einem öffentlichen Verkehrsmittel wurde immer nur die reine Fahrzeit, also ohne Umsteigezuschlag von 3 Minuten genommen.

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Eigenschaft:** Einflußgröße in derselben Bezeichnung wie für Wege verwendet Schlüsselfeld
- **Allgemein:** Allgemeine Bewertung der Wichtigkeit (leer, Skalenwert 0..10)
- **Aus1:** Ausprägung 1 wie im Versuchsplan beschrieben
- **Bew1:** Bewertung für Ausprägung 1 (leer, Skalenwert 0..10)
- **Aus2:** Ausprägung 2 wie im Versuchsplan beschrieben
- **Bew2:** Bewertung für Ausprägung 2 (leer, Skalenwert 0..10)
- **Aus3:** Ausprägung 3 wie im Versuchsplan beschrieben (falls vorhanden)
- **Bew3:** Bewertung für Ausprägung 3 (leer, Skalenwert 0..10)

Figure E.1 Description of *original.mdb* (continued)

Bewertung Wege:

Bewertung der Wege aus dem Rücklauf, also entweder durch Entscheidung für eine Alternative durch Ankreuzen (SP) oder Bewertung verschiedener Alternativen auf einer Skala von 0 bis 10 (CA). Die Tabelle enthält alle Wege von denjenigen Personen, die den Fragebogen teilweise oder vollständig ausgefüllt an uns zurückgeschickt haben, also mindestens ein Feld selber angekreuzt haben.

Bei SP beschreibt jeder Datensatz einen Weg mit den Alternativen ÖV-Auto bzw. ÖV-Rad-zu Fuß, weshalb nur eine Alternative ausgewählt sein sollte (im Rücklauf traten allerdings Mehrfachauswahlen auf: wenn z.B. das Wetter die Hauptrolle spielt, werden oft Bus und Rad angekreuzt).

Bei CA beschreibt mit Ausnahme von Datensatz 0 jeder Datensatz zwei zur Bewertung vorgelegte Alternativen (ÖV-Auto bzw. ÖV-Rad bzw. ÖV-zu Fuß), weshalb jeweils zwei Alternativen bewertet sein sollten. Bei Datensatz 0 sollte nur für die tatsächliche Entscheidung die Attraktivität bewertet sein.

Zur Auswahl der teilweise ausgefüllten Fragebögen enthält das Feld Info Angaben darüber, ob für den Weg eine Bewertung vorliegt oder nicht.

- **HHNr:** vierstellige Haushaltsnummer; Schlüsselfeld
- **Rec:** Numerierung der Datensätze eines Haushalts (0..11 bei SP, 0..7 bei CA; Schlüsselfeld
- **BewB:** Bewertung für ÖV (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **BewA:** Bewertung für Auto (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **BewR:** Bewertung für Rad (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **BewF:** Bewertung für zu Fuß (leer, 0..10 = Skalenwert bei CA, 11 = Kreuz bei SP)
- **Info:** Bewertung erfolgt? (0 = keine, 5 = mindestens eine)

E.2 ASCII-Data files

The MS-access tables were saved as ASCII data files and matching SAS programm written to read the data and to format them. Based on the basic files a series of further data sets was derived (See Table E.5 and Table E.6).

The structure of the estimation data sets rp.dat, sp.dat and joint.dat and the codings are given in Table E.7).

E.3 Estimation programs

Table E.5 lists the estimation programs.

E.4 Zoning system and derived codings

The trips were coded according to the zoning system developed by the City of Innsbruck for its transport planning (Figure E.2). Based on this system the zones were grouped into larger units for certain OD-based analyses (Figure E.3). For the choice modelling the reported trips were allocated to corridors, which were defined as all zones through which the respective public transport line crossed (Figure E.4 to Figure E.7).

Table E.2 Generation of SAS files

SAS programme name (*.sas)	Input files	Output files	Number of records	Comments
PREPARING DATA FOR ANALYSIS OF USAGE INTENSITIES				
read_t	*fahrten.dat*	nutzung	945	Each day a record
		kette	135	weekly chain of trips
read_f_p_t	*f_p_t.dat*	f_p_t	949	Each day a record
		chain	297	weekly chains
read_f_p_w	*f_p_w.dat*	f_p_w	1214	All persons interviewed
read_p	*personen.dat*	dummy_1	135	Additional survey
	p.dat	dummy_2	1215	Main survey
create_p	dummy_1, dummy_2, f_p_w kette, chain,	p	1349	First version of person file (person details and public transport trip information)
CONTACT HISTORY				
read_kontakte	*kontakte.dat*	kontakte	7098	Contact history
		wer	1941	Name of person conducting the interview
		erfolg	1941	Analysis of interview
PREPARING COMPLETE PERSON/HOUSEHOLD DATA SET				
read_hh	*hh.dat*	dummy_2	1214	Household details
read_vm	*vm.dat*	dummy_3	1214	Modal details
read_oev	*oev.dat*	dummy_4	1214	Public transport availability
read_parken	*parken.dat*	dummy_5	1214	Parking availability
read_pkw	*pkw.dat*	dummy_6	1214	Car availability
create_px	dummy_2-_6 p	px	1349	Second version of person file
apply	px	px	1349	Adding weights
READ ADDITIONAL INFORMATION				
read_od	*qz.dat*	od	1125	OD codes of RP trips
read_rz_iv	*rz_iv.dat*	rz_iv	9216	Assignment-based car travel times
read_rz_oev	*rz_oev.dat*	rz_oev	6743	Assignment-based public transport travel times
create_odx	od, rz_iv, rz_oev	odx	1125	Model based information for RP trips

Table E.3 Generation of estimation files

SAS programme name (*.sas)	Input files	Output files	Number of records	Comments
PREPARING CA, RP, SP AND SP/RP DATA SETS				
read_wege	wege.dat	wege	12128	Read all trips
read_survey	hh.dat	survey	1161	Extract survey description from household data
read_ca	ca.dat	b_ca	2408	CA full profile ratings
read_sp	sp.dat	b_sp	5688	SP choices
create_sp_and_ca	wege, survey	ca	2001	CA full profiles rated with person details
	b_ca, b_sp	sp	4901	SP choice situations decided with person details
find_captive	sp	captive	473	Identification of non-choosers
read_eigen	eigenschaft.dat	eigen	4268	Importance and their levels rated (one record)
		bew	9933	One record per level rated
create_green	eigen, bew, ca	px		
	px	green	12611	Estimation data following Green and Krieger
create_rpx	wege, px, odx	rpx	1115	RP trips supplemented
write_rpx	rpx	*rpx.dat*	4125	LIMDEP estimation format
create_and_write_sp	captive, sp, odx, rpx	spx	4790	Supplement sp and write to disk in LIMDEP format
		spx.dat	17752	
write_joint	spx, rpx	*joint.dat*	21877	LIMDEP format
NON-RESPONSE ANALYSIS				
create_nr	kontakte, wer, erfolg, captive, px, ca	nr	1161	Data set of non-response analysis
write_nr	nr	*nr.dat*	1161	LIDEMP data set

Table E.4 Content of the SP, RP and SP/RP data files

Variable	Format	Content
hh_nr	4.0	Household/person number
sw	1.0	Variability of choices in SP (sw = 0 is a non-chooser)
mw	1.0	Choice of non-chooser (mw = 0 is a chooser)
rp	1.0	Dummy, if alternative was chosen in reported trip (0 = no; 1 = yes) (not included in rpx.dat)
gew_ohne	4.0	Weight of respondent
block	1.0	Block of SP experimental design
n_o_s	1.0	Number of situation (n_o_s = 0 is the reported trip)
zweck	1.0	Context of SP exercise (0 = Work; 1 = Shopping; 2 = Leisure)
xwahl	1.0	Dummy for choice of alternative (0 = no; 1 = yes) (See alt_ij)
n_ij	1.0	Number of available alternatives (4 for car available; 3 otherwise)
alt_ij	1.0	Number of alternative described (1,5 = public transport; 2,6 = car; 3,7 = bicycle; 4,8 = walking)
p	6.2	Fare or parking fee; zero otherwise
zz	6.2	Access time (if car available, then 1.2 for bicycle and 0 for walking)
fz	6.2	Driving time or in vehicle time or walking time for walking (if car available, then equals rz_mod for bicycle and for walking)
az	6.2	Egress time (if car available, then 1.2 for bicycle and 0 for walking)
tkt	6.2	Headway (zero for all modes but public transport)
um	1.0	Transfer necessity (0 = yes; 1 = no)
sz	6.2	Search time (zero for public transport and walking) (if car available, then 0.8 for bicycle)
rz_mod	6.2	Travel time as modelled by the assignment models for public transport and car; for bicycle = 1.5 car travel time; walk = 4.5 car travel time for the same OD-pair)
zuv	2.0	Reliability (zero for bicycle and walking)
bus	1.0	Dummy, if public transport vehicle is a diesel bus (0 = no; 1 = yes)
obus	1.0	Dummy, if public transport vehicle is a trolley bus (0 = no; 1 = yes)
strab	1.0	Dummy, if public transport vehicle is a street car (0 = no; 1 = yes)
pp0	1.0	Dummy, if type of parking is off-street (0 = no; 1 = yes)
pp1	1.0	Dummy, if type of parking is a parking lot (0 = no; 1 = yes)
pp2	1.0	Dummy, if type of parking is a garage (0 = no; 1 = yes)
wege	3.0	Share of route, which is a cycle path

Table E.4 Content of the SP, RP and SP/RP data files

Variable	Format	Content
sex	1.0	Dummy (1 = male; 0 = female)
w_hour	4.1	Working hours
taetig	1.0	Dummy (1 = working; 0 = not working)
ausb	1.0	Dummy (1 = in education; 0 = not in education)
n_oev	1.0	Dummy for public transport as the preferred mode (0 = no; 1 = yes)
n_rad	1.0	Dummy for cycling as the preferred mode (0 = no; 1 = yes)
matura	1.0	Dummy (1 = high school diploma; 0 = none)
ticket	1.0	Dummy (1 = season ticket, at least weekly ticket; 0 = none)
fs	1.0	Dummy (1 = driving licence; 0 = none)
pkw	1.0	Dummy (1 = car available; 0 = none)
d30	1.0	Dummy (1 = born in the 1930's; 0 = not)
d40	1.0	Dummy (1 = born in the 1940's; 0 = not)
d50	1.0	Dummy (1 = born in the 1950's; 0 = not)
d60	1.0	Dummy (1 = born in the 1960's; 0 = not)
mean	1.0	Type of public transport vehicle available for the reported trip (1 = trolley bus; 2 = street car; 3 = diesel bus; 4 = All)
tra	1.0	Reported trip in corridor (0 = in none; 1 = "O"; 2 = "R"; 3 = "O and R"; 4 = "1/6"; 5 = "3"; 6 = Core of city)

Table E.5 Estimation programs

Name	Task
RP DATA	
read_rpx.lim	Read ASCII-data file
rp_01.lim	MNL with alternative specific parameters without corridor variables
rp_02.lim	MNL with alternative specific parameters with corridor variables
rp_03.lim	MNL with alternative specific parameters for model derived travel times without corridor variables
rp_04.lim	MNL with alternative specific parameters for model derived travel times with corridor variables
SP DATA	
read_spx.lim	Read ASCII-data file
sp_01.lim	MNL with alternative specific parameters without corridor variables
sp_02.lim	MNL with alternative specific parameters with corridor variables
JOINT SP/RP DATA	
read_joint.lim	Read ASCII-data file
joint_01.lim	NL with alternative specific parameters without corridor variables
joint_03.lim	NL with (mostly) generic parameters without corridor variables
joint_03c.lim	NL with (mostly) generic parameters without corridor variables; parameters for reliability fixed a priori
NON-RESPONSE	
read_nr.lim	Read ASCII-0data file
nr.lim	Probit model of participation
GREEN AND KRIEGER FOR CA	
g3_osl1.sas	Example: 1. iteration (o = Public transport; s = shopping; l = linear)
g3_osl2.sas	Example: 2. iteration (o = Public transport; s = shopping; l = linear)
g3_osl3.sas	Example: 3. iteration (o = Public transport; s = shopping; l = linear)

Figure E.2 Zoning system

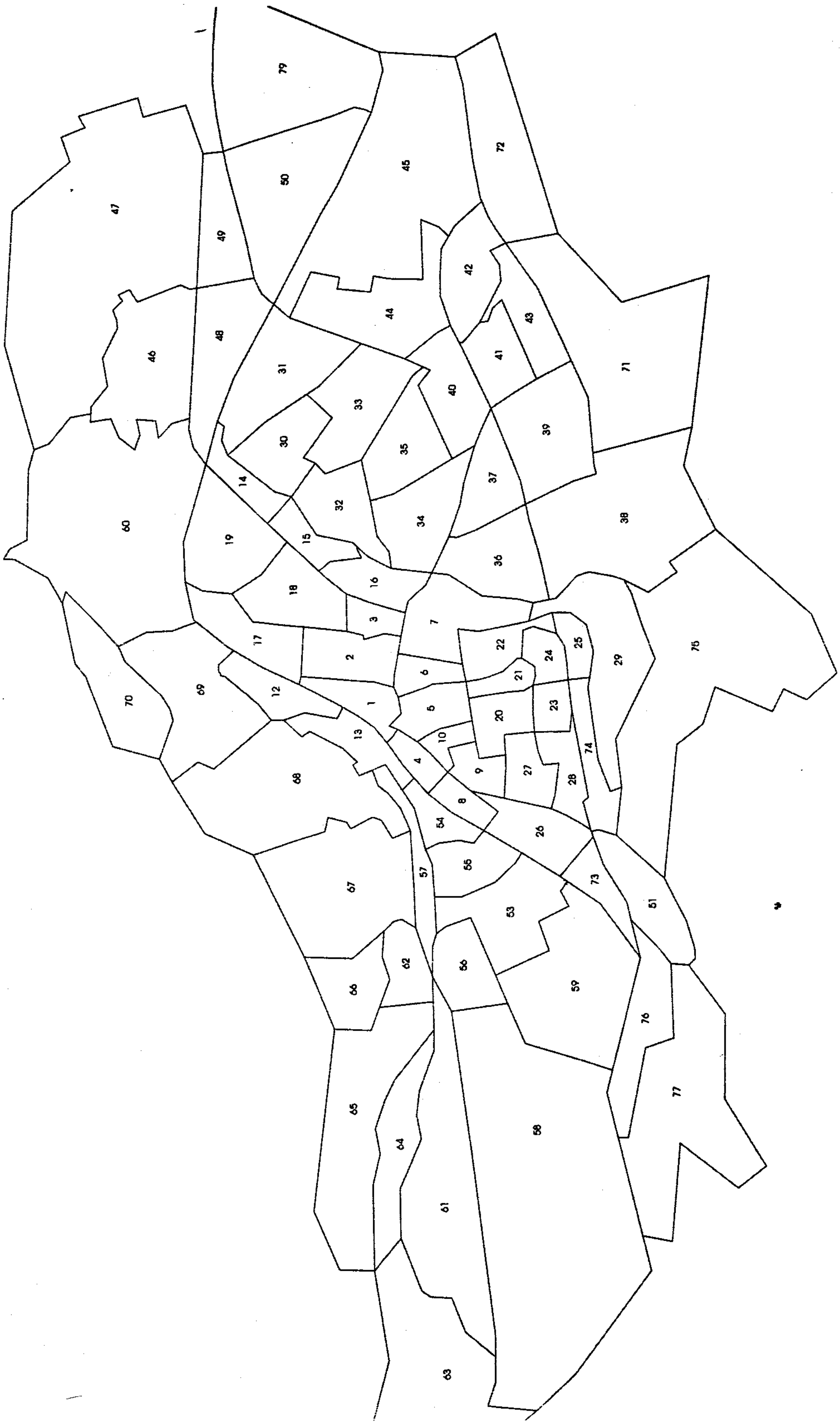


Figure E.3 Super zones

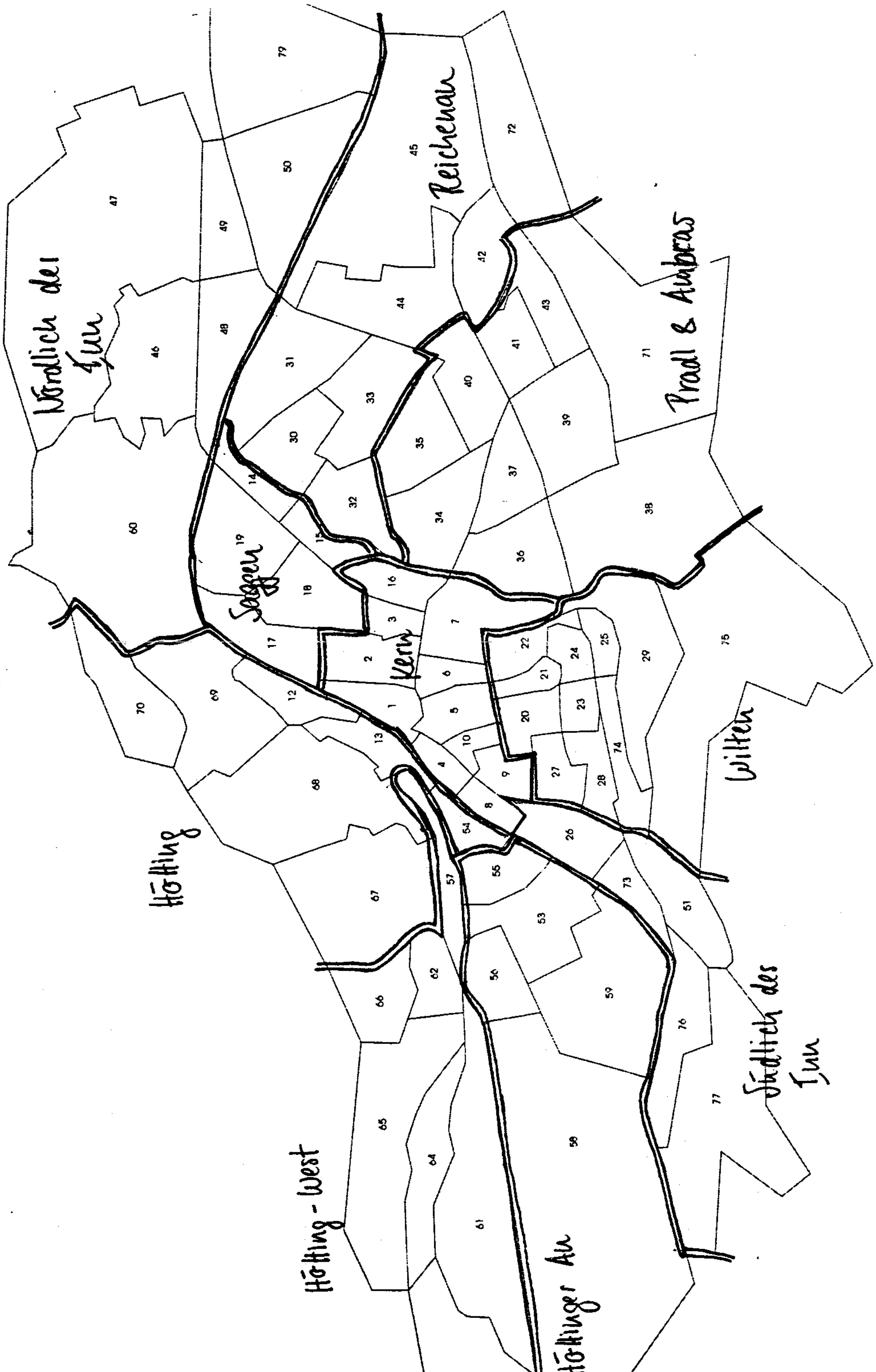


Figure E.4 Corridor: Line O

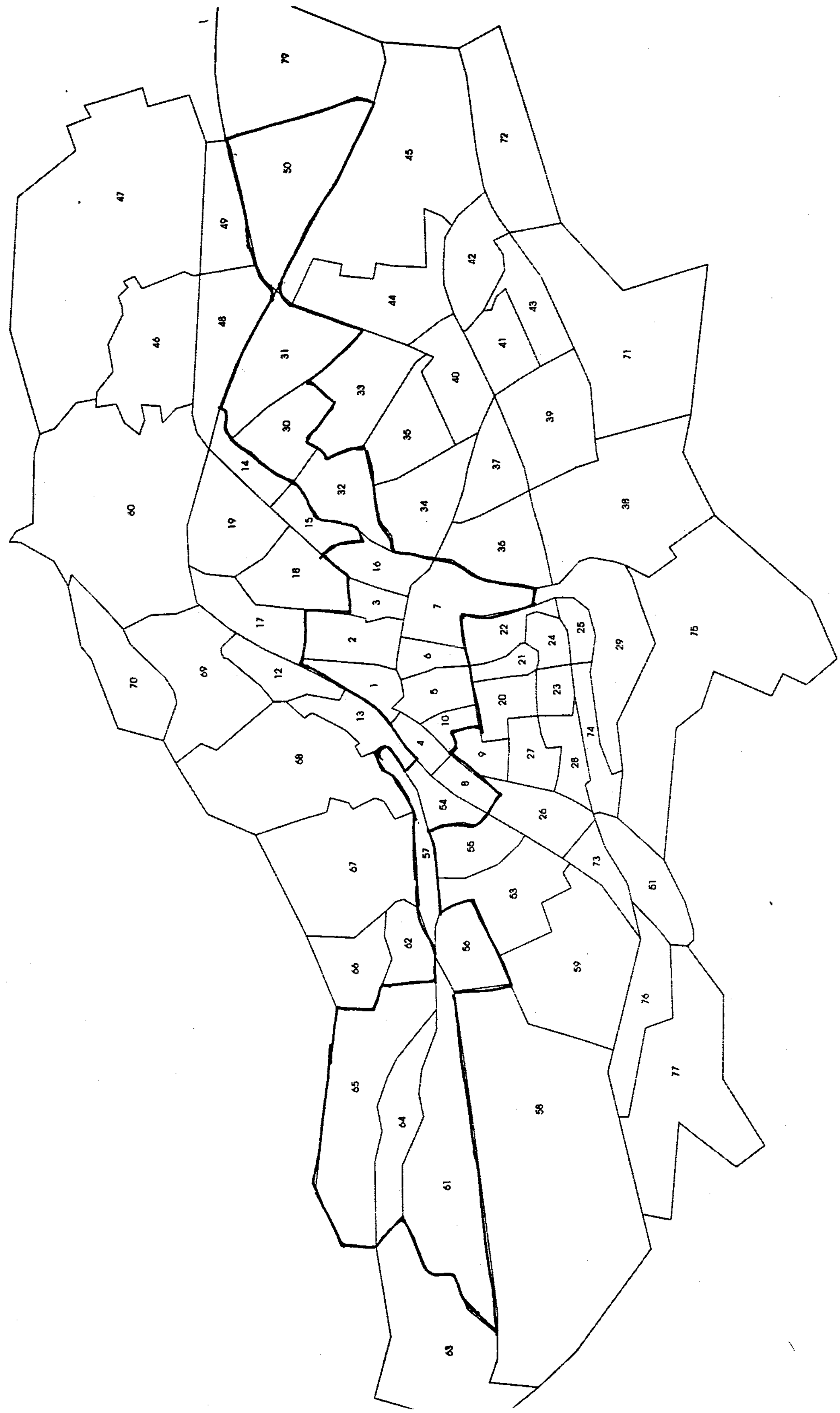


Figure E.5 Corridor: Line R

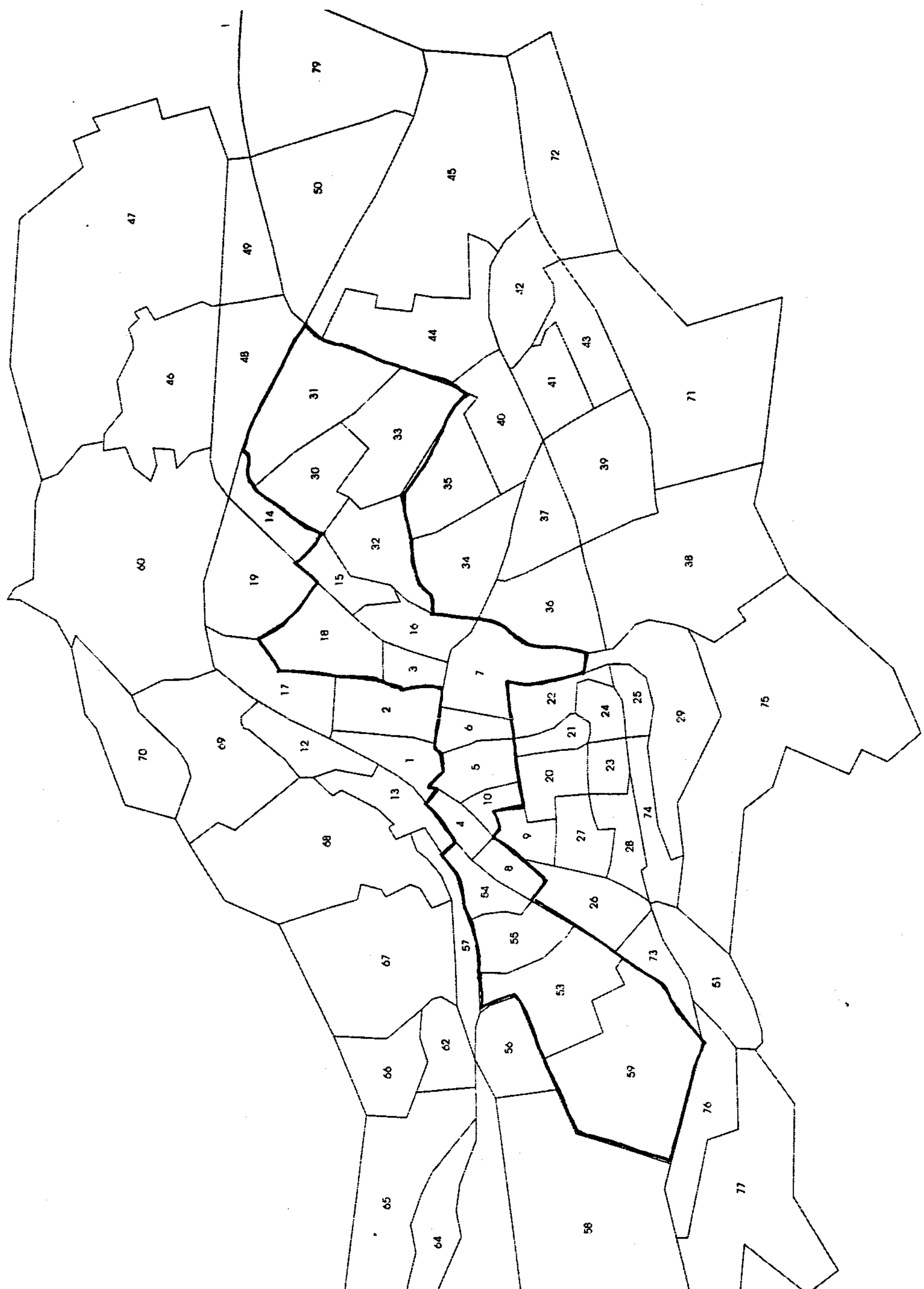


Figure E.6 Corridor: Line 1/6

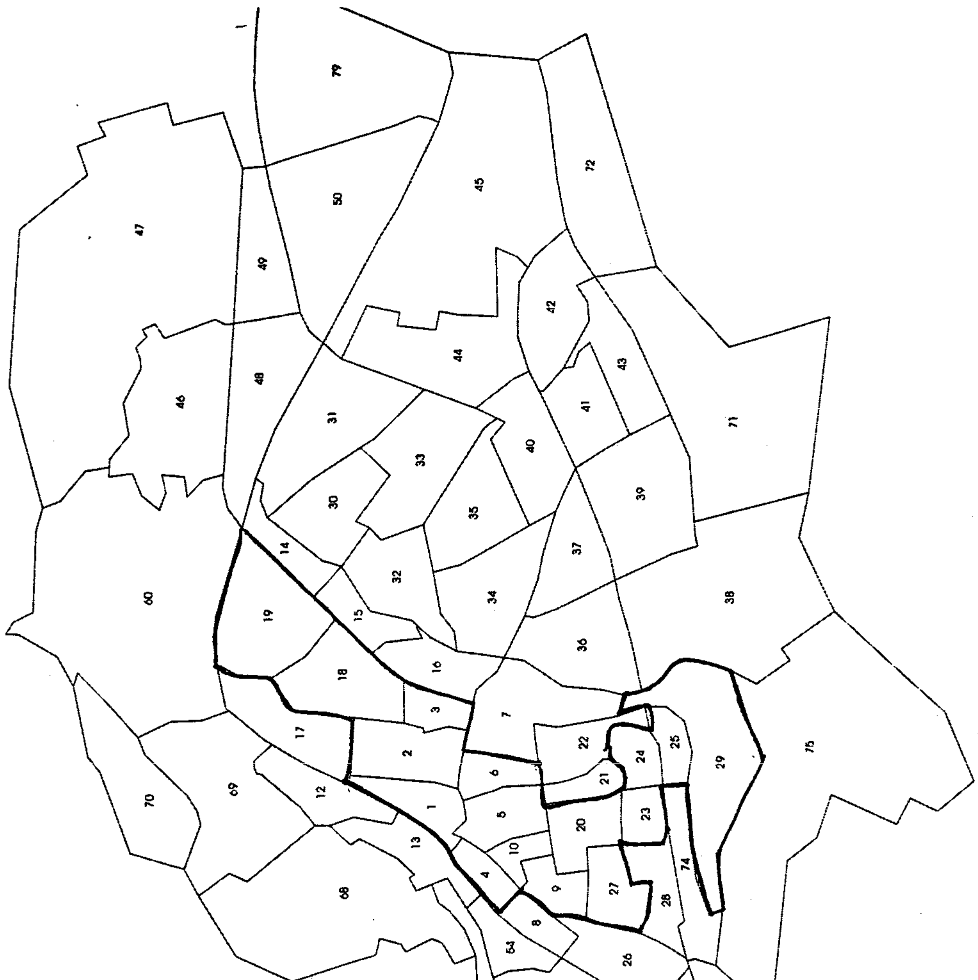


Figure E.7 Corridor: Line 3