SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY

Intermediary report - January 2003

DETERMINANTS OF MODAL CHOICE IN TRIP CHAINS
CP-42

LV – KULeuven - FUNDP

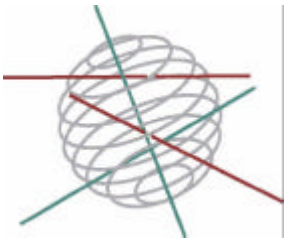
SPSD II

PART 1
SUSTAINABLE PRODUCTION AND CONSUMPTION PATTERNS

- GENERAL ISSUES
- AGRO-FOOD
- ENERGY
- TRANSPORT

This research project is realised within the framework of the Scientific support plan for a sustainable developmentpolicy (SPSD II)

Part I "Sustainable production and consumption patterns"



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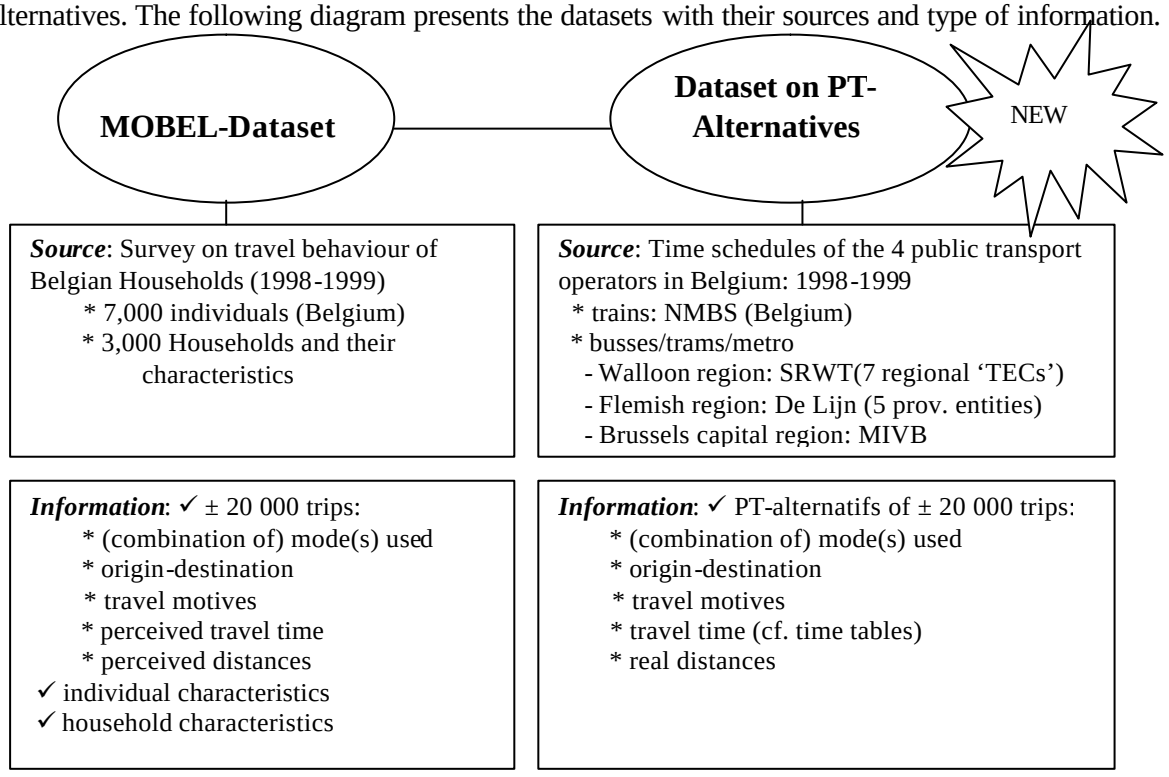
1. Determinants of mode Choice in Trips & Trip chains

2. Introduction

2.1 Context and summary

The main objective of this study is to gain insight into the observed modal split in trips and in trip chains. This is extremely important for the government in order to improve its public transport policy and in order to increase its public transport commuters. To this end, a literature study is combined with statistical analyses on an existing cross-sectional database, with statistical analyses executed on a subset of this database, completed with additional information.

The **literature review** aims at giving an overview of the knowledge on all factors determining the choice of mode in trips and trip chains. The international literature extensively covers the determinants of the choice of mode in trips. In this respect, one of the objectives therefore is to find out whether these findings also apply to the Belgian situation. Much less is known however about the determinants of the choice of mode in trip chains. A first task here is to further investigate how this concept of trip chains can be made operational. Once this is done, the link between these trip chains and the mode choice can be investigated with statistical analyses. In order to conduct the analyses, the network project makes use of two datasets: the MOBEL-database and a new database on public transport (PT-) alternatives. The following diagram presents the datasets with their sources and type of information.



MOBEL-dataset. The project network can dispose of the database of the National Survey on Travel Behavior organized in the period 1998-1999 (called MOBEL). This survey was realised within a network project of the former SPSD I-program. The database describes the travel patterns of more than 7 000 Belgian individuals of about 3 000 households. It also includes information on socio-economic characteristics of households and individuals. More than 20 000 trips are documented in this database with their modes used, origin-destination, travel time, etc. Therefore it contains a wealth of information to study trips, trip chains and the role of individual and households characteristics[1].

[1] Some study work on trip chains and modal choice started already within the earlier SPSD I-network project and will be further elaborated within this project. The same dataset is also used within another network project of the current SPSD-II-program called SAMBA.

In the new **dataset on public transport alternatives**, the information of the 7000 individuals and their 20 000 trips in MOBEL will be completed with information on the available public transport supply at the time of the survey (1998-1999). More concretely, for every trip made (irrespective of the mode used), a public transport alternative is explored. The information is taken from the timetables of the PT-supply of all Belgian public transport providers at that time. For this PT-alternative, information on travel time, travel distance, number of transfers, etc. is stored. In this way, an idea of the percentage of the current private car users that ideally also could have chosen the public transport for a specific trip, is attained. For the trips actually made by public transport, we get information on the 'perceived' travel time and distance (information from the survey) versus the 'objective' time and distance (information from the PT-time tables).

The statistical analyses on both datasets focus on the link between household characteristics and choice of mode, on the link between the spatial structure and choice of mode and furthermore on the link between the characteristics of the public transport supply and the choice of mode both in trips and trip chains.

The following table summarizes all research tasks and sub-tasks (cf. technical annex of the network project CP/B8/421). During the first year of this project, the emphasis lay on (1) conducting a literature review and fine-tuning research questions (task B1), (2) building the new dataset of PT-alternatives (tasks A2 and B2) (For these tasks, the role of the user group was crucial) and (3) the analyses with respect to trip chains and household characteristics on the available MOBEL-dataset have commenced (tasks C1 and C2). The methodology and results of these tasks will be elaborated in sections 3 and 4 below.

Research tasks (cf. technical annex of the network project)	**In this document**
A Introduction	
A1 Composition of user group	Sect. 3.1
A2 Data gathering of PT-alternatives & quality control	Sect. 3.3 & 4.2
B Preparation	
B1 Problem definition & state of affairs: literature study & research hypotheses	Sect. 3.2 & 4.1 + annex 6.3
B2 Technical preparation: input of data on PT-alternatives into a dataset	Sect. 3.3 & 4.2
C Data analysis	
C1 Description of trip chains and choice of mode in the MOBEL-database	Sect. 3.4 & 4.3
C2 Household barriers: impact of household characteristics on choice of mode	Sect. 3.4 & 4.3 + annex 6.3
C3 location: impact of location on choice of mode	Section 5
C4 Mode: impact of existing PT-supply on choice of mode	Section 5
D Synthesis	
D1 Exchange of methodologies and results on a permanent basis	in 2003
D2 Consultation with other project teams	
D3 Preparation of reports	in 2003
E Communication of results	
E1 Scientific final report	in 2004
E2 Policy report	in 2004
E3 Seminar	In 2004

2.2 Objectives

Cf. section 2.1

2.3 Expected outcomes

Knowledge on key indicators, such as:

- elasticities of mode choice with respect to. travel distance
- elasticities of PT-use with respect to travel time and its different components
- weight given to different time components for all PT-modes

- relation between trip distance and critical travel time ratio (PT/car)

Policy recommendations, such as:

- information for the PT-companies on how to measure the potential for planning new PT-lines: the size of the group of potential PT-users and their mean characteristics
- the market potential for PT within trip chains.

3. Detailed description of the scientific methodology

During the first year of this project, mainly four (groups of) tasks have been performed within this project.

- Installation and initiation of a user group
- Building a conceptual framework and inventoring all the knowledge on the factors determining the choice of mode in trips and trip chains: a literature review + fine-tuning of the research questions. (technical annex, task B1)
- Development and implementation of a methodology to collect information on the public transport alternatives in 1998-1999 and to edit this information into the existing MOBEL database (technical annex, tasks A2 and B2)
- First data-analyses on the available MOBEL-database on trip chains and the link between household characteristics and the choice of mode (technical annex, tasks C1 and C2)

3.1 Installation and Initiation of the User Group (TA-task A1)

At the start of the project, a user group was installed with the following participants:

- the four public transport companies representing the supply of all public transport modes in Belgium (busses, trams, metro and trains);
- the regional and federal authorities in charge of mobility and transport;
- the association of PT-users of Flanders and the federal ministry of statistics.

Until now, three user group meetings have taken place. These meetings have been crucial in the course of the network project. First of all, the technical support of the public transport providers in gathering information on the PT-supply in 1998-1999 was crucial in setting up the database of PT-alternatives. For this purpose, there have been many bilateral contacts with each of the PT-providers in the first quarter of 2002. Secondly, with respect to the overall aim of the project, the user group members have delivered a substantial influence; based on their input, the research questions could be refined. The close collaboration with this user group is considered very important for guaranteeing the policy orientation of this project. It assists the network partners in focusing the data analyses on important policy matters.

3.2 Literature overview & refinement of research questions (TA-task B1)

As the choice of mode in trips and trip chains is a complex topic, it was important to clarify and structuralize its complexity in the beginning of the project. This warranted the literature study performed during the first year of the project that in turn aimed at resolving the following:

- A clarification of the terminology used in the literature and within this study, more specifically what do we mean by trip chains, simple trips, multi-modal trips, and how can they be investigated.
- An overview of all factors determining the choice of mode both in trips and trip chains. All these factors are brought together within a comprehensive conceptual framework. In a second stage a selection is made of the factors that will be studied in depth, based on the data availability for this study.
- Based on the literature review and on the input of the user group, the research questions of the network project were refined.

3.2.1 Terminology used within the network project

Definitions:

- A **trip chain** is defined as a loop between the departure from and then again the arrival back to the place of residence, and further more all trips with various destinations that have taken place between departure and arrival (e.g. home school – work - baby-day-care - home). Aside from these loops, also loops with departure from 'work' and arrival back to 'work' are taken up as separate trip chains (e.g. work-shopping-work).
- A trip chain constitutes individual **trips.** They all differ from one another with respect to their destination or travel motive (e.g. to go from A to B to bring someone at home, to do some shopping, to go to work, …etc.)
- These individual trips can be **uni-modal** or **multi-modal**. Uni-modal means that they are done with one mode of transport only (e.g. with the bike to school, with the car to work...). Multi-modal means that they use a combination of transport modes (e.g. go to school by going first on foot to the bus stop, take the bus, take the train, and go the last 100 meters on foot). The use of each separate transport mode within a trip is called a '**sub-trip'**.
- A **public transport alternative** for a stated trip is defined as a trip in which at least one mode of public transport is used to reach the stated destination.

3.2.2 Conceptual framework and literature review

The literature review has been performed jointly by all network partners during the first part of 2002 (Refer to the bibliography in annex 6.1). The conceptual framework and the completed literature study report have been presented and discussed in the user groups. Refer to annex A of section 6.3 for a draft of the literature study. This draft report will serve as a basis for the statistical analyses will be conducted within the framework of this study. All new results will be verified with the collected and available literature. A short summary of the literature review is given in section 4.1 below.

3.2.3 Refinement of the research questions

The following determinants of mode choice will be subject to the analyses performed during 2003: household and individual characteristics, spatial structure and public transport supply characteristics. The formulation and reformulation of these research questions is the result of a consultation process with the user group.

The relation between household characteristics and choice of mode in trips and trip chains

Three topics will be examined:

1. What household characteristics are important in the individual's choice of a mode of transport and what changes in the household are likely to change an individual's choice of mode.
2. Another topic is the car usage within the household context.
3. And finally, the household structure and the trip distances of the home-to-work trips of its members will be studied.

The following research questions are addressed more closely:

- What household characteristics have an impact on the choice of mode of a person?
- Is there a link between the number/proportion of working household members and the choice of mode?
- Does the combination of trips by different members of the household (e.g. parents driving their children to school and continue with doing shopping or going to work) have an impact on the choice of mode?
- Does the disposal of more than one car within the household have an influence on the frequency of using this car?
- In case there is only one car available in the household, is this one always used by the same person for his home-to-work travel or is the car usage shared by all or more than one household of the members and for other motives?

- What is the consequence of the utilization of the one car by different household members with respect to the different needs of the household members?
- What combinations of home-to-work distances do occur within households with two incomes (far-far/close-far/close-close)?

The relation between the spatial structure and the choice of mode in trips and trip chains
The aim is to specify the impact of the spatial structure (both distance and location patterns) on the choice of mode towards the characteristics of the public transport supply and towards the individual travelers and their travel motives.

Concrete research questions are:
- What is the elasticity of the choice of mode (and more specifically the use of public transport) with respect to travel distance?
- What is the relation between the travel time ratio and the choice of mode for different distance intervals?
- What is the connection between the critical travel time ratio (PT/car) and the trip distance?
- What is the connection between the trip distance and the occurrence of different types of trip chains? The hypothesis is that not the complete travel distance of the trip chain is of importance but the characteristics of the different composing trips, sub-trips and the amount of transfers.

The relation between characteristics of the public transport supply and choice of mode in trips and trip chains
In these analyses, a comparison will be made between the official travel time of the public transport (according to the PT-time tables) and the registered perceived travel time of the public transport (in the MOBEL-survey).

Furthermore, the following research question will be addressed:
- What is the elasticity of the use of public transport with respect to changes in travel time? A distinction will be made between the different travel time components.
- What is the weight given to the different travel time components (waiting time, transfer time, actual travel time, before and after transport time)?
- Which characteristics of the trips or trip chains have an influence on the travel time elasticity?
- How many trips can be made within 1,5 times the travel time of a car and with max. 1 transfer?
- What characteristics of trip chains have an impact on the choice of mode?
- What characteristics of the PT-supply have an impact on the choice of mode (the travel time, number of transfers, etc.)?

Confrontation between the actual and the potential mode choice in trips & trip chains
The following research questions are addressed:
- What is the profile of the individuals for whom a feasible public transport offer or biking offer was found (age, travel motive, socio-economic status)?
- What is the household context of these individuals (availability of bike/car, household income, role within the household, …)?
- Are there significant differences between the profile of car users with a feasible PT-alternative on the one hand and the profile of PT-bike users with a car available on the other hand?
- Are there significant differences between the profile of the car users with a PT-or bike alternative and the group without an alternative?

3.3 Building a database on PT-alternatives: methodology of data collection (TA-tasks A2 and B2)

The data needs for this research include the following:

- The national survey on mobility behaviour of households in Belgium (MOBEL), for the travel demand, and the public transport services for the offer.
- The survey data were available from the FUNDP network partner, provided that the confidentiality agreement was signed.
- The public transport data needed to be collected from the four public transport companies involved: the national railway company (NMBS), the Flemish Public Transport Company (De Lijn), the Walloon public transport company (SRWT), and the STIB/MIVB for Brussels.

Since the survey was carried out between December 1998 and November 1999, the objective was to collect public transport data from that period, if possible. For each trip in the database, public transport alternative(s) were explored. This section gives an overview of the different methodologies applied, the problems encountered, and the solutions found.

The data input process consisted of:

1. Collection of information from the public transport organisations;
2. Definition of a public transport alternative;
3. Correction of addresses;
4. Determination of decision rules related to the data input;
5. Calculation and input of public transport alternatives;
6. Correction of input errors and quality control;

3.3.1 Collection of information at the various public transport companies

The four public transport companies in Belgium were contacted and asked for information on their public transport services during the realisation period of the MOBEL questionnaire (1998-1999).

De Lijn (busses and trams)-Flemish region[2]

Data on the offer of public transport are stored in HASTUS (reference: GIRO, www.giro.ca), software specifically designed for public transport management. Passengers can query the public transport schedules using HASTINFO. Data from 1998 – 1999 are no longer available in the system of De Lijn. The public transport timetables and stops are kept up to date. Past timetables were archived in a number of (provincial) entities, but not consistently for the entire region. The company provided information on the changes of the offer during the last three years. Since the survey was conducted after a major reorganisation in early 1998, due to changes of the railway services, the current timetables are not fundamentally different from those of the survey period. The most fundamental changes occurred in the province of Limburg, and in a number of cities where the service was substantially increased.
It was decided to use present public transport data, and if necessary, to make corrections afterwards based on the printed 1998-1999 timetables.
The period of data collection coincided with the test period at De Lijn of the internet passenger information system. The web application was tested for 150 trip chains of the survey, and feedback was provided to the company. De Lijn offered to automate the search for alternatives.

MIVB (busses, trams, metro)- Brussels capital region.

As in Flanders, HASTUS is used and outdated timetables are not stored. Passenger information can be accessed from HASTINFO through the internet for the next week. The internet passenger information was used, and printed timetables were collected for the Brussels capital region for the time period of the MOBEL questionnaire.

SRWT (busses, trams) – Walloon region[3].

All the provincial entities (TECS) of the SRWT have the HASTUS system to store their data. However, they don't have HASTINFO, and the implementation of HASTUS is at an early stage in some TECS.

[2] De Lijn is subdivided in 5 entities, one for each province: Oost- & West-Vlaanderen, Vlaams brabant, Limburg & Antwerpen
[3] SRWT is subdivided into 7 entities or TECs: Hainaut, Charleroi, Tournai, La Louvière, Liège-Verviers, Namur-Luxembourg, Brabant-Wallon.

Timetables and route maps of past years are not systematically stored, neither in HASTUS, nor on paper. The availability of outdated timetables is dependent on individual initiatives. Notably, most entities and especially timetables in rural areas are very flexible. They are altered in cooperation with schools, markets, tourist activities etc. Finding a public transport alternative for a trip based on the HASTUS data was not considered feasible, as it is complex and requires considerable programming.
The TECS provided the coordinates of bus stops (for all provinces, except for Luxembourg, and the bus lines using these stops (for all provinces except for Hainaut, Liège and Charleroi, where only analogue maps are available).
For all entities the appropriate timetables and maps were collected.

NMBS (trains) – Belgium
The NMBS was already using an electronic passenger information system distributed on CD-ROM in 1998 (ARIDISC). For Flanders and Brussels, information concerning present railway timetables is integrated in their HASTINFO systems. For Walloon, the ARIDISC disks were collected for the 1998-1999 period.

3.3.2 Definition of a public transport alternative

Based on the definition of a public transport alternative (see section 3.2.1), four categories were encountered while searching for a public transport alternative for a trip:

- Trips with a public transport alternative;
- Short trips, where the best alternative is walking (the walking distance from origin to destination is shorter than the walking distance from origin to public transport (PT)-stop, and from PT-stop to destination);
- Trips where no alternative could be found due to the distance to the nearest PT-stop;
- Trips with missing or incomplete data.

Calculated trips were coded accordingly.

3.3.3 Correction of addresses

A first test on 150 records (trips) in the Flemish region indicated that only a small percentage of the addresses were recognized by the HASTINFO module (about 30%). The addresses used in HASTUS are based on the Streetnet nomenclature[4]. To improve matching with the addresses recorded in the survey, an initial correction phase was performed. The correction consisted of harmonizing the filled in addresses with the Streetnet nomenclature, used in HASTINFO, replacing small villages by their principal local authority, translating French addresses within Flanders into Dutch, completing if possible, gaps in origin or destination and replacing landmarks by their address (e.g. shopping centres, tourist attractions).

For the trips in the Flemish region and the trips between the Flemish region and the Brussels capital region, 92% of the origin and the destination addresses could be corrected amounting to 87% of the trips. The methodology used was based on Access query techniques.
In Brussels, the nomenclature is based on URBIS[5]. The system includes tools to correct addresses in accordance with the URBIS standards, using geocoding techniques. For the Brussels capital region 91% of the destination addresses and 93% of the origin addresses could be corrected, which constitutes a combined match of 86%. This percentage includes trips with incomplete or missing data but that could be filled in by approximation. Not included are a number of trips that can be corrected based on their position in the chain (e.g. destination first trip and origin second trip).
The Walloon trips were corrected within the framework of the OSTC project SAMBA[6]. In this case about 86% of all trips could be corrected, not taking into account additional corrections of landmarks and the filling up of chains. An exact geocoding could be done for 66% of all trips. This lower

[4] Nomenclature of Streetnet digital mapping vector databases. The version used was Streetnet 2001, www.teleatlas.com
[5] Brussels UrbIS Urban Information System, distributed by the Centre for Informatics of the Brussels Region (C.I.B.G.).
[6] SAMBA is a SPSDII research project for which the MOBEL data were geocoded.

percentage is due to a high number of missing house numbers. In these cases the middle of the street was taken as a proxy.

3.3.4 Decision rules

A sample of 150 trips (about 100 effective calculated alternatives) was used to determine a number of decision rules, related to the calculation of alternatives:

- The lower limit of a trip, in order to calculate an alternative, was fixed at 5 minutes, except if the trip is made by car. For these types of short trips, the assumption is made that the probability on a realistic alternative is very low.
- The time window wherein public transport alternatives are explored is limited to 30 minutes before and after the recorded departing time, regardless the motive of the trip. In a first test a window of 90 minutes before and after was used, but this resulted in a huge amount of alternatives. For Flanders, all alternatives within the window are calculated and a selection is made afterwards. In conclusion, only the fastest alternative is retained, except when for a given trip both a public transport alternative and an alternative on foot are found. In this case both alternatives are stored. For Brussels and Walloon only the fastest alternative is retained.
- The alternative with the fastest travel time was chosen, with a departure time as close as possible to the recorded time.
- There were no limitations brought forward regarding the number of changes, the maximum allowed walking time or the maximum travel time ratio (ratio between recorded travel time and calculated travel time). The only limitations at this stage were the limitations used by the public transport companies (confidential information).

3.3.5 Input correction and data quality control

The calculation of alternatives by public transport was divided into three stages, according to the data availability at the corresponding public transport authority.

De Lijn: automated processing in HASTINFO

In cooperation with De Lijn an optimal methodology was developed to allow automatic calculation of public transport alternatives and storage in an Access database. The first step is the automated run of the HASTINFO module. This implies an important reduction of time, since putting each trip in the web application and calculating an alternative one-by-one is no longer required. The second step is the transformation of the output data to a readable database format. To this end a procedure has been developed in VBA (Visual Basic for Applications). The best alternative was selected for each trip, by adding the travel time to the difference between the stated departure time and the calculated departure time.

MIVB: semi-automated processing in HASTINFO

For the trips in the Brussels Capital Area the alternatives were calculated using the HASTINFO travel guide on the MIVB website. Automated search for alternatives using HASTUS was not an option and the use of printed time tables is very time consuming and susceptible to errors in this urban environment with such a complex network. The major disadvantage of using the web application is the limited speed (about 60 trips a day).

Using HASTINFO, a public transport alternative was calculated for each trip and stored in an Access database. The total distance, waiting times and the number of train lines are not included in the output. Another limitation is that only the dates from the next week can be selected, a problem that can be partly solved by searching for days that are similar in the present as to the days in the survey (e.g. calculation of trips in holidays during holidays).

The effect of the use of present timetables instead of past timetables will be analysed on samples in Flanders and Brussels. Alternatives will be calculated using the two sets of timetables and compared. For Flanders (included Flanders – Brussels) a sample size of 150 (N = 6727) is proposed, equally distributed among the 5 provinces, for Brussels a sample size of 100 trips (N = 3009) is proposed. The

user group agreed with the suggestion to work with the present public transport data for Flanders and Brussels, and to document possible effects on the results.

SRWT: manual processing using booklets with timetables
In the Walloon Region all calculations needed to be done manually, since HASTINFO is not available. The manual calculations are based on public transport network maps and booklets with time tables from the period 1998-1999. The procedure of finding all the required booklets was immensely time-consuming, as the booklets were not categorized. The additional disadvantage of this method is its proneness to human errors, but it has the advantage that the timetables at the time of the questionnaire are used.

In order to address the disadvantages, an application was developed in VBA. Starting with the coordinates of bus stops and train stations on the one side and the coordinates of the origins and destinations of trips on the other side, a table with potential stops and stations within a radius from each origin and destination is calculated. A second step is to look for potential direct bus or train connections between these points of origin and destination. The result is a table with potential direct bus and train connections for each trip that can be used complementary to the work with the printed maps and timetables.

3.3.6 Data quality control and basic statistics

To ensure a maximum reliability of the created database, a number of data quality tests are performed on the created database:

1. Checking of input errors;
2. Analysis of extreme values (outliers) for selected variables;
3. Analysis of difference of methodologies;
4. Analysis of difference between revealed and calculated public transport trips;
5. Analysis of representativeness of the calculated database (effect of missing values on representativeness of sample);

1. Since for the Brussels capital region and the Walloon region, the input requires a manual contribution, the presence of input errors is likely. Some input errors were prevented by using an input form. Some input field ranges or sets of possible values were determined, and the corresponding input values were to lie within these ranges. For example, the line numbers of buses and trams, waiting times or the trip ID's. Other information could be derived from the database such as the code for a walking alternative, where the actual walking time is compared to the total travel time.

2. For the variables total travel time, number of changes and waiting and walking times, a distribution analysis is performed to detect extreme values. These extreme values are investigated extensively in order to find if they are due to field conditions or to input errors.

3. To calculate public transport alternatives for all trips in the MOBEL questionnaire, data from different public transport companies are used. Each public transport company applies different systems to store information and uses different decision rules in their route planners.
A first analysis compares the two HASTINFO systems used, of the De Lijn to that of the MIVB (Refer to summary of findings in appendix). A second analysis compares the use of the HASTINFO route planner to the manual method using maps and timetables.

4. The MOBEL survey provides information on real trips (revealed preferences). These are compared here with the public transport offer. Trips where there is a discrepancy between the use of public transport and the existence of an alternative (public transport was used in reality while no public transport alternative was found, or public transport was not used in reality while a public transport alternative was found), will be used for evaluation of the decision rules applied in the search for alternatives.

5. Analysis of representativeness of the calculated database
For a considerable part of the trips in MOBEL (about 25%) no alternative could be calculated due to missing or incomplete information. It is important to examine if and how this proportion of missing data causes distortions in the representativeness of the database. Especially the geographical spread (on regional level), the effect on the average travel time and the effect on the distribution of chains need to be elaborated.

3.4 Data-analyses on the MOBEL-database: trips/trip chains and mode choice and household restrictions (TA-tasks C1 and C2)

In the first Belgian National Travel Survey of 1999 (MOBEL), many analyses have already been undertaken to describe the behaviour of individuals to organize their mobility. Some describe an activity-based approach. However, these analyses were more undertaken within a descriptive approach and underlined the great complexity of mobility organization. The description of trip chains in particular, delivered a very diversified picture, suggesting that the household puts constraints on the composition of the activity framework of all its members, taking into account the use of time and common resources and the needs of each of its members. The very large number of different trip chains thus motivated us to continue to investigate the constraints within the household and to explore this point in more detail.

During the first year of the present network project, the first aim was to identify the different characteristics of a household (size, composition, age of members, etc.) which could influence the choice of mode. In order to do this, a new terminology was developed, defining a new concept next to the 'trip'-concept: namely the concept of 'journey'.

3.4.1 Trips versus journeys

The objective of this step was combine the mutual importance of on the one hand the trips made by several members of the household and the different patterns between these (combined) trips and on the other hand the trips made by single people.
A way to study the group effect done by families is indeed to construct a new 'journey'-variable within the MOBEL-database, which groups all the trips made at the same time, with several people of the same household, into one journey. By journey, all the trips inside a household, with the same characteristics, are considered: departure hour, arrival hour, origin and destination places. These journeys can be trips made by one person, if they correspond to only one trip of one person, or they can be collectives if they constitute several trips, done by individuals of the same household. As a consequence, all the trips are included in the journeys, and each journey corresponds to one or several trips. For each journey, only one mode can be used, but can constitute several activities, as much as the number of individuals taking part in the journey. This is one of the most important differences between trips and journeys, and it allows, among other things, to define principal and secondary motives for each journey. This was used in particular while observing the journeys made for a "taxi" purpose, when someone had picked up or dropped off someone else. The principal motive of such a journey was the "taxi" motive, but it was interesting to observe the repartition for the secondary motive. Finally, it was also noted that in using the concept of journey, people travelling with individuals outside of the household (and thus unknown in the survey) could nevertheless be included in the individual journeys (principally considering carpoolers).

3.4.2 Individual versus collective journeys

Using this concept of journey, we then defined a new classification of journeys, which distinguished individual and collective journeys. Nine categories were distinguished: five for '*individual journeys*' and four for '*collective journeys*'. The journeys were also separated in function of the 'nature' of the participants, since they were made by people from differently structured households and with or without children. The following table shows these categories and explains what each category includes. In particular, the categories concerning the families are: "1Par", "1Ad","1Enf","1Pacc","nPar","2Par".

The term "Adult" was used to indicate an individual coming of age (+ 18 years old) who is neither the husband, nor the wife, but usually a child of the household.

	Abbreviation	Nature of participants
Individual journeys	Isol	One person living alone
	1Cpl	One single adult belonging to a household of two adults
	1Par	One single parent belonging to a household with children
	1Ad	One single adult, except parents belonging to a household with children
	1Enf	One child (of age unknown) belonging to a household with children
Collective journeys	1Pacc	One single parent and one other member of a household with children
	nPar	Several members of a household with children, except the parents
	2Cpl	The two adults of a household containing only two adults
	2Par	At least the two parents from a household with children

Using this classification, the distribution of journeys was investigated according to the age structure of the household, to the day-type (working and school days, working but not school days, public holiday) and to the time of the day. In addition, the repartition of the different motives was analyzed using the classification in nine classes, given in the MOBEL-survey. The "taxi" motive with the analysis of the principal and secondary motives received particular attention. Thereafter, the modal split of the journeys was investigated, with particular attention to the "car" mode, which included the "taxi" motive just analyzed before. The link between the motive and the mode repartition was done by this particular case of family mobility, concerning in first instance the school transport.

Finally, another point of interest in 2002 was the availability of cars and drivers inside the household. The repartition of transport modes between the members of the household suggests a competition to satisfy the mobility needs of each of them. And it's also a way to understand which part of the non-car users are captive users (they make the choice of another mode but they could do it with an available car), or are restricted users (they don't have the choice, as no car is available). To follow the use of the available vehicles inside the household, we began to build a new database based on the journeys. Each vehicle and each driver was considered. To use the car as transport mode, each person has to find in this household an available car and an available driver (or is a driver himself) at the moment he/she leaves. Based on this principle, a new table is now being built with each departure time and each arrival time with a car, corresponding each time at a modification of the availability of the "car" mode. In other words, when one or several persons of the household used a car for any motive, these car and driver(s) were considered unavailable for the time they were leaving the household. This part of the analysis must be continued in 2003.

4. Detailed description of the intermediary results, preliminary conclusions and recommendations

4.1 Conclusions from the literature review (task B1)

4.1.1 Conceptual framework

In the figure on the next page, the whole range of factors determining the choice of mode in trips and trip chains are presented in a supply-demand framework. The demand for trips and trip chains takes place in a market where all different transport systems are supplied, all having their own characteristics.

Demand-side factors: The demand for trips and trip chains (on the left hand side) and the preferences towards mode choice are determined by

(1) the spatial context in which they take place,
(2) the person who wants to make the trip, and his
(3) travel motive.

(1) Two aspects of the spatial context are important when it comes to deciding on the choice of mode, namely the travel distance and the spread or location patterns between origin and destination. The literature review mentions, aside from the direct impact of the travel distance on the choice of mode, an even more important indirect impact. That is that the relative distance between private car use and public transport is crucial, especially when the distance is related to the travel time for both transport modes. Also, the relation between travel distance and trip frequency (negative) on the one hand and perception of transfers (undetermined) on the other hand needs an in depth investigation.
Two aspects are important about the location patterns and the choice of mode: one is the geographical location and the urban character of both working place and residence, and the other is the position of all kinds of facilities (shopping, social and cultural) towards both residence and working place.

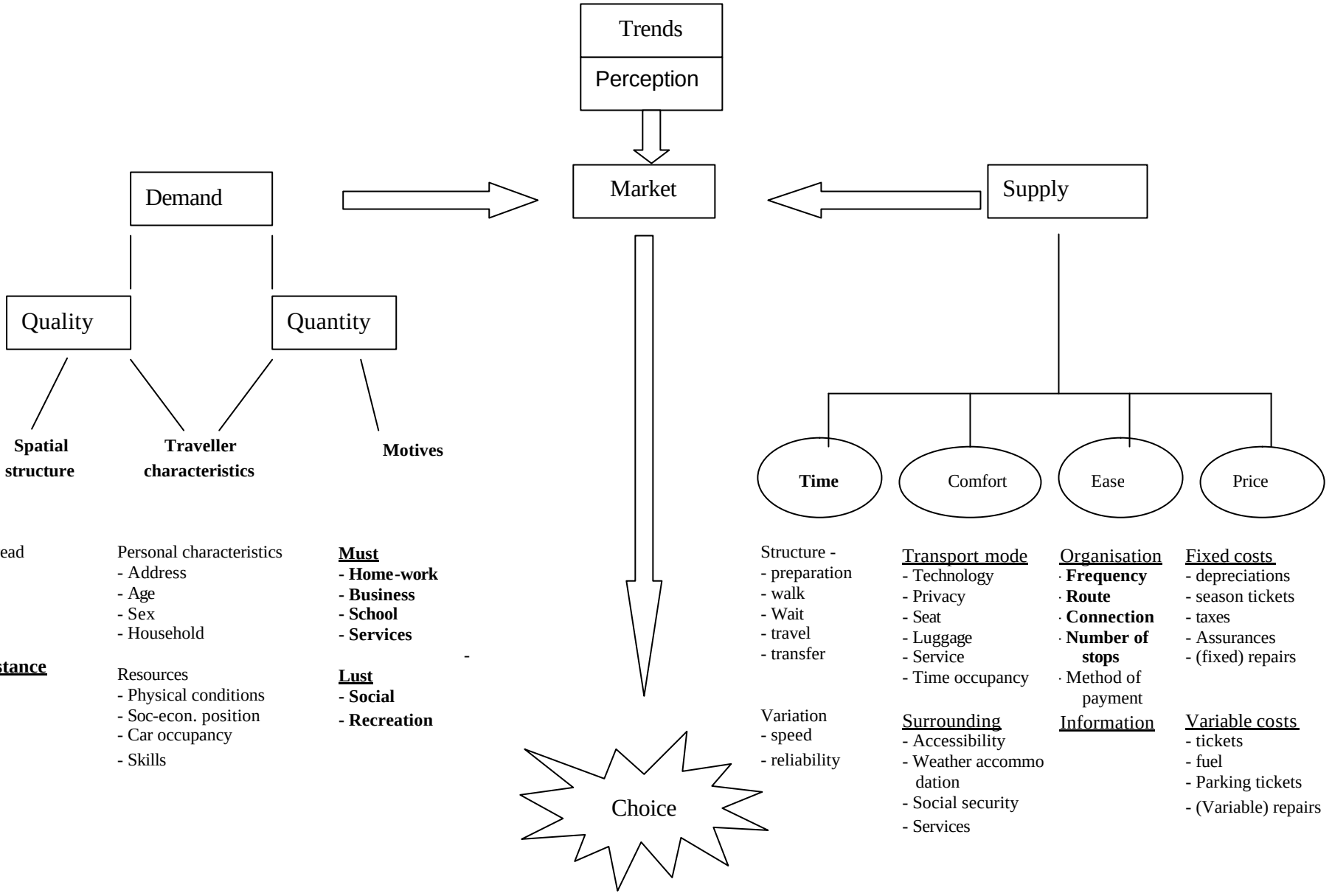
(2) Travellers' characteristics and (3) travel motives are intertwined factors on the demand side. Previous research on the MOBEL-database has already shown that differences exist between the group of working and school going people on the one hand and others on the other hand, no differences occur between these two groups, in the number of trip chains, but they do appear in the time periods they take place. For both groups, one observes more car use in complex trip chains. However, the first group is relatively more car driver than car passenger.

Supply-side factors: The characteristics of the different transport systems that are important for the trip and trip chains and its mode choice are subdivided into four main categories: (1) time, (2) comfort, (3) ease and (4) price.

(1) Time has to be split up in different components that all have their own relation to mode choice. In the literature review, distinction is made between five different time components and their differences in appraisal: preparation time (routing, ticket buying, etc.), waiting time (at traffic lights, at the bus stop, ..), the actual travel time, transfer time (needed to change modes, e.g to change platform), before and after the transport (often the walking time). All these components are weighted in a negative way, but the extent to which transport modes differ, depends on personal, household and travel motive characteristics.
Apart from the time components, also the reliability of the travel time is an important determinant in choice of mode: studies point out that a longer but reliable time is preferred above a short but unreliable.
An important indicator for time is the ratio between travel time of PT and car. Different values are found in the literature, highly depending for example on socio-economic, on spatial factors, on travel motives, on global travel time, on amount of transfers, on waiting time, on comfort, and on others. They also differ between PT-modes (buses, train).
The same differences can be found in travel time elasticities (the sensitivity of the demand for one travel mode with respect to a travel time variation). The literature review gives an overview of the differences and reasons for these differences.

(2) With regard to comfort, distinction can be made between comfort of the vehicle and of the transport system as a whole and its environment. Concerning the vehicle the technical characteristics (e.g. speed, safety), privacy, the possibility to load freight are taken into consideration. Concerning the transport systems, the waiting accommodation, information availability, the parking facilities and the social safety are important.

(3) The ease is strongly linked to the accessibility of the transport modes but also to the accessibility of the travel information for different groups in society.



Spread

Personal characteristics
- Address
- Age
- Sex
- Household

Distance

Resources
- Physical conditions
- Soc-econ. position
- Car occupancy
- Skills

Must
- **Home-work**
- **Business**
- **School**
- **Services**

Lust
- **Social**
- **Recreation**

Structure -
- preparation
- walk
- Wait
- travel
- transfer

Variation
- speed
- reliability

Transport mode
- Technology
- Privacy
- Seat
- Luggage
- Service
- Time occupancy

Surrounding
- Accessibility
- Weather accommodation
- Social security
- Services

Organisation
- **Frequency**
- **Route**
- **Connection**
- **Number of stops**
- Method of payment

Information

Fixed costs
- depreciations
- season tickets
- taxes
- Assurances
- (fixed) repairs

Variable costs
- tickets
- fuel
- Parking tickets
- (Variable) repairs

(4) Two price components might be distinguished to have an influence on the choice of mode: the fixed and the variable costs of the transport system. Studies show that in general people give a higher weight to the variable cost component in their appraisal of the different transport modes. In comparing relative costs of different transport modes, the fixed costs are often ignored. Next, studies show large differences in the importance of prices and costs and choice of mode.

Both determinants on the demand side and on the supply side are liable to a **number of trends**. On the demand side, these may be: the increase in scale, the growing number of smaller households, the growing participation on the labour market, changes in activity patterns. On the supply side, the most important trend is the technologic evolution with its consequences on the vehicle speed, comfort of travel modes, accurate information systems, etc.
And last but not least, the literature review points at the fact that the actual choice of mode people made, is not the outcome of the confrontation of the actual demand and supply, but more of the **perceived demand and supply factors**. In this way, it is wrong to talk about a 'rational choice' like the one we see in the traditional economic demand and supply schemes. In fact it is not the actual travel distance, travel time or price of travel that are crucial in the decision-making process of individuals and households but the perceived distance, time and price.

4.1.2 Factors investigated in depth within this study

In the figure on the previous page, all factors that can be taken up in the analyses of our study are marked in bold. As you can see, on the demand side, we can dispose of very good information available within MOBEL. On the supply side, information is especially lacking with respect to the factors 'comfort' and 'price'. Both are not available within MOBEL. In theory, information on prices can be traced but the effort would be enormous and asks for a separate research.

Another handicap is the lack of information in MOBEL, on the perception of many supply side characteristics of the transport systems. Only the perceived travel time and distance can be taken up in the analyses. For other perceived characteristics such as comfort and ease, we can only rely on what we find in the literature (e.g. studies reporting about the needs and satisfaction of different mode users). However, in interpreting results of our own analyses, we will have to take these findings into account.

4.2 Findings w.r.t. the quality of extra data collected (TA-tasks A2, B2)

In section 3.3 the process of data collection was described as well as the necessary steps to ensure a good data quality. A first step is the comparison of the applied methodologies in the HASTINFO systems in Flanders and Brussels. Differences in the geographical context and the characteristics of the public transport network are reflected in the use of different parameters for selection of a public transport route in HASTINFO. A second step is the comparison between the HASTINFO method and the manual method used in Walloon. The results of the first step are presented.

A random sample of 100 trips in Brussels was selected. For these trips, public transport alternatives were calculated with both systems. The results were compared in terms of:

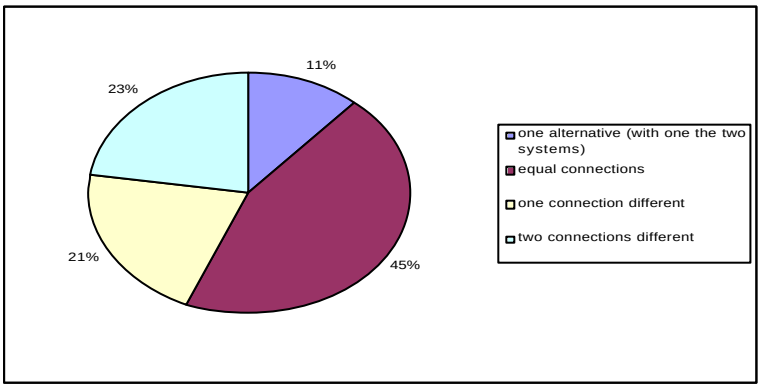
1. For how many trips an alternative was found;
2. The difference in total travel time;
3. The indicated travel route;
4. The number of transfers;
5. The total walking time.

1. On this issue the differences between the systems are rather limited (Refer to table on next page). Only for a small number of, in particular short trips, a difference was found, because the one system finds an alternative on foot and in the other, the walking time is somewhat reduced by a short public transport trip. No alternative could be calculated for about 20% of the trips, a percentage that corresponds to the total dataset.

	MIVB/STIB	De Lijn	Number of trips with a different result
Valid public transport alternative	66	68	8
Alternative = walking	9	10	5
No alternative due to missing or wrong data	20	20	0
No alternative found in HASTINFO	5	2	3

2. The figure below presents the distribution of the difference in travel time. At-test for paired observations is performed on the difference (most appropriate variable according to chi square test). The resulting p-value (0, 70) indicates no significant difference. This is visually supported by the histogram that indicates that for 60% of the trips the difference is less than 5 minutes.

3. For a considerable share of trips a different travel route is presented in the two systems. In almost half of the cases at least one line is different (trips without public transport alternative not taken into account). One explanation is the fact that the MIVB Hastinfo does not include the offer of De Lijn in Brussels. Others are the very dense public transport offer in Brussels and differences in the user defined parameter values of the HASTINFO system. With the system of De Lijn, more bus connections are recorded; due to the inclusion of the bus offer from De Lijn, the MIVB system records more tram and metro connections.



4. For nine trips an unequal number of transfers were recorded (13 % of the trips with an alternative). In all cases more transfers were recorded with the MIVB system, probably due to different parameter values.

5. A last element of comparison was the total walking time. The table shows a higher average walking time for the trips calculated with the system of De Lijn, which seems to correspond with the lower number of transfers. However, the standard deviation is quite high, whereby the differences are not significant ($p = 0,16$) at a 95% confidence interval.

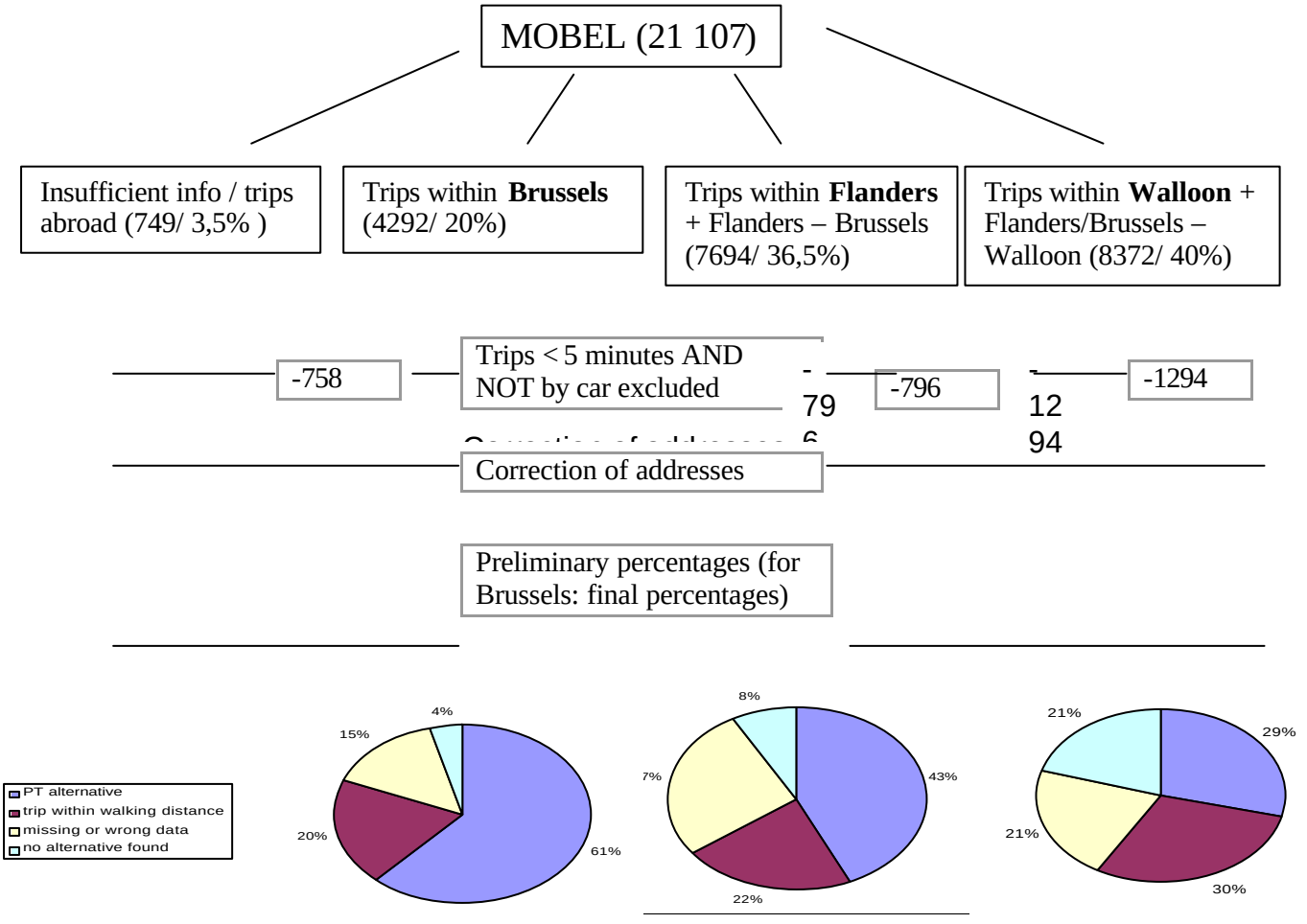
This comparison showed that out of a sample of 100 trips in the Brussels capital region, no significant differences (at a 95% confidence interval) could be found between the results from both HASTINFO systems. The analysis of the number of transfers and the total walking time gives an indication for a tendency towards higher walking times with the HASTINFO system from De Lijn, whereas the MIVB system will look for an extra connection. Although differences are not significant, it is desirable to keep these findings in mind during further analysis. The differences found are due to different user defined parameters in HASTINFO, the differences in the service integrated in the system and the very dense net in Brussels, in particular during peak hours and on the metro net.

Statistics walking times		
	DE LIJN	MIVB/ STIB
Count	75	75
Mean	10,12	9,48
Median	9	9
Standard deviation	5,21	3,85
Minimum	2	3
Maximum	26	19

Test of mean=0 versus two-tailed alternative	
Hypothesized mean	0,00
Sample mean	0,64
Std error of mean	0,45
Degrees of freedom	74
t-test statistic	1,44
p-value	0,16

4.3 Intermediary results of the calculation of public transport alternatives for the MOBEL trips

As stated before, an important part of the research activity during the first year consisted of calculating public transport alternatives for each trip in the MOBEL database. The scheme below presents the intermediary results. The diagrams show for each region, the percentage of trips for which a public transport alternative has been found, the percentage of trips for which the best alternative was a walk, and the percentages of trips for which no alternative has been found, due to missing data or a too high distance from a public transport stop.



4.4 First results of the MOBEL-data analyses (TA-tasks C1 and C2)

In section 3.4, we described the context of the analyses done on the existing MOBEL-database. Some analyses were also done on complementary datasets built from these existing data. The first results for 2002 were collected in a paper presented to the user group of the project: "*Les déplacements faits en famille dans l'enquête sur la mobilité des ménages Belges*" (Hubert, Luyckx, Toint, 2002). This paper (Annex 6.3.3) reflects all the preliminary results and an interpretation is also given. These results need to be completed in 2003, by additional analyses and by further evaluating some elements that are yet unexplored.

4.4.1 Description of journeys

Considering journeys instead of trips brings about notable differences in mobility indicators. The ratio between the number of trips and the number of journeys is an indicator of the mobility of several persons inside the household. Another indicator for the mobility of several persons is the percentage of journeys, in which two or more than two persons travel together. These figures are presented in the tables A and B below.

Table A: Number of journeys and trips during a day, following type of day, in Belgium (Data: Mobel)

Day :	Working & school days			Working & not school days			Public holidays			Mean		
x 1000	journey	trips	tr/jour	journ.	trips	tr/jour	journ.	trips	tr/jour	journ.	Trips	tr/jour
Belgium	24.940	29.172	1,17	20.745	23.604	1,14	17.794	23.734	1,33	22.240	26.763	1,20

Table B: Distribution of the number of participants from a same household to a journey, according to region and type of day (Data: Mobel)

	Working and school days			Working but not school days			Public holidays		
	1 pers.	2 pers.	> 2 pers.	1 pers.	2 pers.	> 2 pers.	1 pers.	2 pers.	> 2 pers.
Flanders	87 %	11 %	2 %	91 %	9 %	0 %	76 %	21 %	3 %
Brussels	90 %	9 %	1 %	85 %	12 %	2 %	79 %	17 %	4 %
Walloon	85 %	13 %	2 %	86 %	11 %	3 %	69 %	25 %	6 %
Belgium	87 %	11 %	2 %	89 %	10 %	1 %	74 %	22 %	4 %

Both indicators prove that the mobility of several people is lower during working and school days, than during public holidays, and also lower in Brussels than in Flanders and Walloon. Moreover the journeys with more than two people are much fewer during a working day. The percentage of collective journeys in Belgium reaches 13% during the working and school days, 11% during working but non school days and 26% during public holidays. The collective journeys are also higher in Walloon than in the two other regions.

Table C below shows that families have a greater weight in the total amount of journeys during the week than during the weekend, because of individual mobility of their members.

Table C: Distribution of journeys and trips according to journey's categories & type of day Belgium (data:mobel)

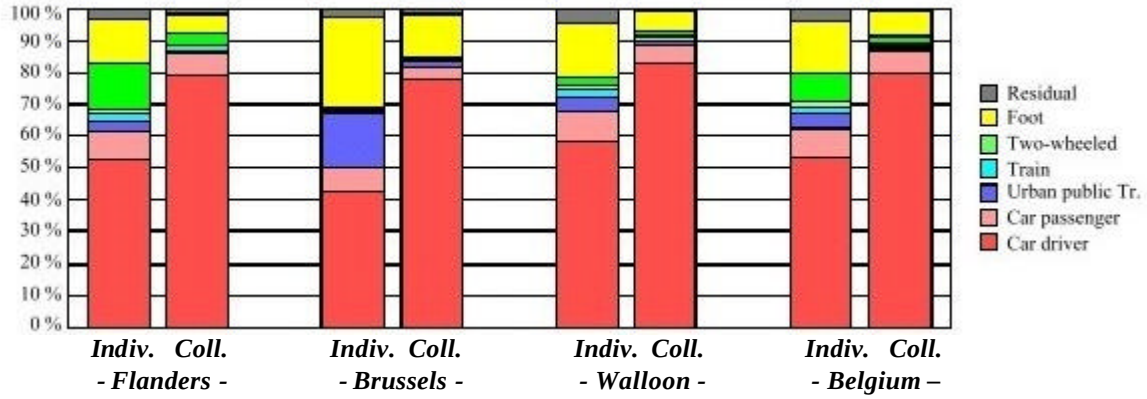
	Working and school days		Working but not school days		Public holidays	
	% journeys	% trips	% journeys	% trips	% journeys	% trips
Individual journeys						
Isol	12 %	10 %	17 %	15 %	17 %	13 %
1Cpl	28 %	24 %	30 %	27 %	20 %	16 %
1Par	27 %	24 %	25 %	22 %	20 %	15 %
1Ad	10 %	9 %	12 %	10 %	10 %	7 %
1Enf	9 %	8 %	5 %	4 %	7 %	6 %
Collective journeys						
1Pacc	6 %	11 %	5 %	10 %	6 %	9 %
nPar	1 %	2 %	1 %	1 %	1 %	2 %
2Cpl	5 %	8 %	4 %	8 %	11 %	17 %
2Par	2 %	4 %	1 %	3 %	8 %	15 %
Total (individual & collective journeys) = 100%						

The peak of family mobility is during the weekend or the holidays: the percentage of trips with several persons is then approaching the percentage of individual trips. The same applies to couples without children: they represent 33% of all trips during the holidays, with 16% of single trips and 17% in couple.
Finally, concerning the distances and the duration of the journeys, we saw that in general, both are lower for collective journeys than for individual journeys, irrespective of the type of day.

4.4.2 Modal repartition

Concerning the modal repartition, the question is whether the mobility of several people is more determined by car than the individual mobility. The modal split represented in the figure below for an average day in the different regions of the country, reflects a particularly high value for trips on foot or by public transport (except train) in Brussels. Apart from Brussels, the majority of individual trips are made by car (passenger or driver). For the collective journeys, this part reaches 85%. In each region, the share of car use increases at least by 30% between individual and collective mobility. Other collective journeys are made on foot, some with public transport (in Brussels) and some by bicycle (in Flanders). Thus, the journeys made with several people of the household are mostly done by car, and for very small distances. This is highly influenced by two types of travel patterns: on the one hand, short journeys made for the "taxi" motive (during peak hours during week days and also during the weekend) and on the other hand, longer journeys made during the weekend with all the members of the family (or at least the two parents).

Figure: Modal split of individual and collective journeys, according to the region, for a average day.



5. Future prospects and planning

In 2002, as planned in the technical annex, the main accent was on building the conceptual framework, gathering the data on public transport alternatives and editing this information into the existing MOBEL-database. In 2003, the main accent will be on the data analyses of the extented MOBEL database. In the first months of 2003, the data input will have to be finalized. Moreover, some steps in the quality control of these data are still to be undertaken.

The rest of this section presents an overview of the techniques and methods that are planned to analyze the effects of time and space related variables on the choice of mode. The two important data sources are the MOBEL database and the newly constructed database, which contains a calculated public transport alternative for each trip from the MOBEL. For the analyses, the statistical package **Statistica** will be used.

Calculation of elasticities

An elasticity indicates a change in terms of percentage in the chance on success for an independent variable, having a change of one percent of a dependent variable. For a number of time and space related determinants of the choice of mode, the demand elasticity will be calculated. The calculation

method is dependent on the model that is chosen to describe the relation between dependent (e.g. the demand for public transport) and independent variables. Where possible, simple linear or log-linear models will be used, since elasticities are easy to derive for such models.
Elasticities will be calculated to quantify the relation between modal choice and the ratio of travel times (by car versus by public transport). General values will be further analyzed taking into account trip and person related variables such as total travel time, car ownership, region and length of trip chain. The calculated elasticities will be compared to values cited in international literature.

Logistic regression (Logit model)

The logistic regression model (or **logit model**) is an extension of the simple linear regression model. It is in particular developed for models with discrete dependent variables that cannot be fitted into the classic regression model that requires a continuous dependent variable. The discrete variables are transformed into a proportion of chances (odds), which is a continuous variable. Then a logistic transformation is executed in order to get a linear relationship.
Using logistic regression, one can model the probability that public transport is used for a certain trip. Various characteristics of the trip (travel time, number of transfers,…) can be combined into a multiple logistic regression model. In fact there are two possibilities to include mode choice in such a model. A first possibility is to compare one mode with all other modes (e.g. car versus all other modes). This model enables a prediction, when the car will be used and when another mode will be used, without specification of which specific mode. The advantage is that the whole dataset can be used. The other possibility is to select two modes (e.g. car versus public transport), which makes it possible to analyze in detail when people switch between car and public transport. The disadvantage is that not all data are used. A variant of this technique is the **multinomial logit model**. This technique allows for all data to be used in the model and the possibility to analyze when switching from one model to another. This method is cited quite often in literature. However, in the "Onderzoek Verplaatsingsgedrag Vlaanderen" the results with this technique were disappointing (Zwerts & Nuyts, 2002a). This technique will be tested and compared with others.

Multiple regression

One of the disadvantages of the logistic regression model is that the obtained coefficients cannot be interpreted directly. Unlike with linear regression, the slope coefficient is not an index for the relation between dependent and independent variable, and the intercept is neither a coefficient for the unexplained variance. Since multiple regressions require a continuous dependent variable, frequencies of trips could be used. This technique has been used in the previous project on the MOBEL database (Toint, Cornelis et al., 2001) and will also be tested and compared with other regression models.
Before going to a multiple regression it is advisable to have an idea of the importance of each variable in the explanation of the variance in the choice of mode. An exploratory statistical technique such as **principal component analysis** could be an interesting tool to gain insight in the available variables.

Structural equation modelling (SEM)

Structural equation modelling grows out and serves similar purposes to multiple regression, but in a more powerful way, which takes into account the modelling of interactions, nonlinearities, correlated independents, measurement error and latent dependents, measured by multiple indicators. In fact, SEM is an extension of the general linear model (GLM) of which multiple and logistic regression are also parts. SEM is also related to path analysis. It takes the form of a set of simultaneous equations specified by links between latent variables and observed variables or indicators.
The technique has been derived rather recently and has been applied quite often in behavioural sciences. It allows for testing a theoretical model, not only by testing the correlations between the individual variables, but by testing the model as a whole. The model that is being tested is based on literature research or previous research findings.
Within the framework of this project SEM could be applied to examine the influence of a set of space, time and household related variable on travel behaviour variables such as modal choice, car ownership and trip chaining. It could be an interesting tool to integrate the analyses of the different partners.

6. Annexes

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6.2 Publications

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6.3 Detailed results

Annex 6.3.1: DWTC-PODO II, Determinanten van modale keuze, hfdstk. 1, literatuurstudie (voorlopig), (*Determinants of choice of mode, chapter 1, literature survey-draft version),* SADL, GRT, LV (red.), 14 nov. 2002.

Annex 6.3.2: DWTC-PODO II, Determinanten van modale keuze, hfdstk. 2, Onderzoeksvragen, (*Determinants of choice of mode, chapter 1, research questions),* SADL, GRT, LV (red.), 14 nov. 2002.

Annex 6.3.3: SSTC-PODO II, Determinants du choix modal: "Les déplacements faits en famille dans l'enquête sur la mobilité des ménages belges", GRT (Hubert, Luyckx, Toint, 2002. (*Trips made by households in the survey on Mobility behaviour of Belgian Households*).