Time and money allocation decisions in out-of-home leisure activity choices

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Introduction

1.1 Background

One of the important aspects when evaluating alternative urban plans from the perspective of sustainable development concerns their impact on travel and accessibility. Typically, travel demand models and traffic assignment models are used to evaluate travel and accessibility impacts. Since the mid 1990s, activity-based models have been developed to better represent the decision mechanisms of individuals and households that underlie their travel demand. Because travel demand is derived from the activities individuals conduct. There are operational activity-based models for large scale applications for planning and policy applications based on different modeling approaches. A main characteristic of activity-based models is their consideration of time expenditure on activities and travel for predicting activity-travel patterns in time and space.

Time-use studies in activity travel behavior context generally examine time allocation to in-home and out-of-home activities where they consider explanatory socio-demographic variables. In time allocation models, it is assumed that spending time on activities generate utility. These models can explain the influence of changes in urban structure and transportation by predicting the effects of these changes on activity participation and time allocation. Although many activities require money directly or indirectly, these models do not include monetary budgets as an explanatory variable. Moreover, monetary constraints shape the time use for activities (Kockelman, 2001). Since, there is a relation between time use and monetary expenditures, especially for out-of-home leisure activities. Furthermore, the allocation of monetary budgets is important to understand the occurrence of activities and their associated travel because monetary budget constraint determines the precedence of activities and travel.

People conduct their activities under budget constraints which involve time and money. It is important to understand those constraints as they shape the set of feasible configurations of activity-travel patterns. In this context, the impact of income and monetary budgets on activity participation and travel, in relation to the costs of activities, travel and goods should be examined in the urban planning literature and beyond. Since, on the longer run, both household incomes as well as prices of travel, goods and agricultural products may significantly change, due to economic developments, depletion of materials and changes in demand. These changing budget constraints and varying elasticities will have short-term and long-term effects on activity-travel patterns and may influence the (dis)functioning of the cities.

The importance of monetary constraints in activity participation and time use has been recognized in economic literature since 1965 by Becker. Later, De Serpa (1971) and Evans (1972) proposed improvements and modifications of this seminal model. According to these micro-economic theories of time allocation, utility is a function of time spent on different activities and the consumption of goods during the activities. Constraints are derived from limitations in time and money budgets available for activities so that trade-offs have to be made between these budgets.

These theories have provided the foundation for studies on time and money constraints and they have been extended in urban and travel studies. In most of the theoretical studies, both time and income limitations are considered. These theories address the trade-off between time and money resources which is significant to understand longer-term decisions. Nevertheless, they do not consider spatial organization of activities. Another drawback of these studies is that they consider allocation of budgets at the activity category level which strongly limits the relevance of these approaches to urban and transportation planning. Since, these frameworks cannot incorporate conditions and choice facets such as location and timing that may vary across episodes of an activity and hence influence duration and expenditure choices as well. Furthermore, due to lack of data, these studies use different data sets for time and monetary expenditures.

1.2 Research Objectives

As the inadequacy of the existing studies suggests, the aim of this research project is to develop and empirically test a new approach for modeling time and money allocation decisions of individuals under time and money budget constraints in the context of activity based models of transport demand. To achieve this aim, the following research questions are formulated.

Research Questions

1. How do time and money budgets relate to each other? Can monetary budget compensate for lack of time budget and vice versa?

2. How do households allocate their time and money to activities, travel and goods, and how do they re-organize their activities in time and space given limited budgets?

3. How are activity-episode level time and money expenditures allocated simultaneously to out-of-home leisure activities under time and money budget constraints? What is the role of frequency on the allocation of activity-episode time and money expenditures under budget constraints? And how can we model this?

4. How can we collect data regarding existing time and money expenditures of individuals and also regarding their budget adaptations?

5. How do people adapt their time and money expenditures to their activities? How do they change the allocation of time and money to activities in order to save time and money when there is a change in their budgets?

To answer those research questions, several activities are undertaken. First, based on the available literature, and adding to it, a broad theoretical framework is developed for analyzing and modeling time and monetary allocation decisions in response to changing land use and transport policies and to potential shifts in exogenous factors such as cost and income changes. This framework considers all activity categories. However, this thesis focuses on leisure activities because this is the most important category for the interface between expenditure and activity participation/travel. Therefore, a modeling framework is developed to empirically estimate the frequency, duration and expenditure decisions of individuals at activity-episode level on out-of-home leisure activities. Third, to empirically estimate the modeling framework and to understand how the budgets are re-allocated according to the changes on income and working hours, a new data collection instrument is developed and data collection is conducted. Data consists of current time and monetary budgets, frequency of activities and activity-episode time and money expenditures and also re-allocation of the budgets to activities under hypothetical scenarios, such as increase in working hours or decrease in income. Data collection is done by using the stated adaptation technique and it is used to empirically estimate the developed model and to understand the saving behavior.

1.3 Outline

This thesis reports the development of a comprehensive theoretical framework and also empirical validation of the modeling framework. The thesis is organized into eight chapters. Following this introductory chapter, Chapter 2 reviews the state-of-the-art in activity-based modeling, micro-economic consumer theories of time allocation, and studies of time and money allocation in activity travel behavior context. This chapter will briefly report the basic principles of these approaches, their advantages and limitations. Chapter 3 will give a detailed explanation of the development of theoretical model for allocation of time and money to activities and travel under time and money budgets. This theoretical framework allows evaluating budget changes and re-allocating of time and money budgets.

In Chapter 4, an activity-based modeling framework under time and money budget constraints is proposed in order to simultaneously estimate the allocation of time and money to out-of-home leisure activities. This chapter will report the results of simultaneous estimation of duration and expenditure. The empirical study in this chapter is done by using an existing data set obtained from a national survey, namely Continuous Leisure Time Use Study (CVTO). However, this data set has some limitations since it does not include information about frequency of activities, and income and working hours of individuals. Therefore, data regarding current time and monetary budgets, frequency of activities and activity-episode duration and expenditure is needed. Moreover, as the framework suggests re-allocation of budgets, data regarding allocation of savings to various objectives under hypothetical scenarios needs to be collected. Data collection is done by using stated adaptation technique. Chapter 5 will describe the stated adaptation data collection and the sample characteristics. Chapter 6 will improve the proposed modeling framework in Chapter 4 by incorporating the frequency decisions and it will report the estimation results of the model.

As stated adaptation data is collected considering the individuals' time and money savings, Chapter 7 will report the analysis based on savings. In this chapter three analyses are executed to analyze the savings. First, the distribution of total amount saved across activity categories is analyzed by using multinomial logit model. Second, individuals are clustered according to their saving behavior and then a multinomial logit analysis is applied on clusters to understand the effect of individual-level variables on the membership of a cluster. Finally, a multinomial logit analysis is applied on the indicated ways of time/money saving such as reducing activity frequency, reducing the episode duration/expenditure of activity, choosing a faster/cheaper transport mode, choosing a closer activity location and multiple options.

Finally, Chapter 8 concludes this thesis by discussing the main findings of this research and the possible directions of future research.

2

Literature Review

2.1 Introduction

As indicated in the introduction chapter, the time constraint is a significant concept in activity-based models, since individuals' activity-travel patterns are the result of their time-use decisions. However, time spent on activities is also affected by monetary constraints and vice versa. There are few existing utility-maximizing frameworks subject to time and monetary constraints where time and money are allocated to activities however; these frameworks have shortcomings that limit the relevance of these approaches for urban and transportation planning. This chapter will discuss previous researches and their shortcomings that are relevant to the problems addressed in this thesis.

The chapter is organized as follows. First, background information will be given on activity-based modeling and some operational activity-based models will be discussed. Next section will focus on the micro-economic consumer theories where the study of monetary constraints and time use on activity participation started. Next, the studies of activity-time and money allocation will be reviewed. In the fifth section, a brief review of the daily activity scheduling studies will be given. The chapter will end with an evaluation of discussed literature and some conclusions.

2.2 History of activity-based modeling

Since 1960s, models have been developed to understand how activity-travel patterns are organized in time and space. The first type of travel demand model, which is called trip-based model, was developed as a result of rapid increase in car ownership in US and Western Europe and it is still dominant in planning practice.

In a trip-based model, the study area is divided into zones. In this approach, a trip flow is assumed to be the result of four subsequent decisions in each zone. This aggregate approach is called four-step model and these steps are trip generation, trip distribution, mode choice and route choice. The model measures the number of trips that leave and are attracted to each zone, distributes the destination of trips between zones, reflects the relative proportions of trips by alternative modes and assigns the vehicle trips to routes in the network, which are taken from origin to destination of trips. This model is used to predict flows on the road network to determine capacity needs of future roads.

Trip-based modeling approach has limitations because four decisions are modeled independently. Thus, the interdependencies between those choices are ignored. Moreover, it does not consider the time-use and monetary context for travel decisions. Finally, it does not take into account the spatial and temporal limitations such as opening hours of shops, the effects of activity locations, available transport modes for all trips and activities.

The trip-based approach is aggregate in nature and it is most similar to the standard economic analysis of consumer demand. Since the focus of policies shifted to short-term decisions from long term investments, an alternative approach which is known as behavioral travel demand modeling became the subject of intense research in the 1970s. This approach explains behavior of individuals or households as decision making units by improving data collection and model estimation techniques (Small, 1992).

Disaggregate models are more directly based on micro-economic theory of demand and individual choice behavior (e.g. McFadden, 1981; Ben-Akiva and Lerman, 1985). However, these models do not try to understand the relation between travel and non-travel aspects. Moreover, the changes in social life as a result of technological improvements caused more complex behavioral patterns and new policy focuses. Thus, a need to develop activity-based models occurred, leading to innovative work from the mid 1990s onwards.

The seminal works by Hägerstrand (1970), Chapin (1974) and Fried et al. (1977) have been accepted as the intellectual foundations of activity-based modeling. Hägerstrand (1970) introduced the temporal and spatial considerations in activity participation. According to Hägerstrand, individuals' activity participation in time and space is influenced by three types of constraints: capability constraints, coupling constraints and authority constraints. Biological needs such as eating, sleeping and/or resources such as income and limitations in travel speeds cause capability constraints. Coupling constraints occur while conducting activities with other individuals who have other resources. Finally, authority constraints come from institutional restrictions such as opening hours, public transport schedules.

Chapin (1974) proposed a framework to understand what motivates individuals to participate in an activity. He examined the time use of people to different activities in weekdays and weekends. In his framework, activity participation is influenced by personal characteristics, commitments and motivations in social life.

Fried et al. (1977)'s theory suggests that individual activity time allocation behavior is affected by adaptation and changes. The adaptation behavior is modified by psychological, social and economic influences to determine activity participation in space.

In the light of these studies, activity-based models have been developed to better represent the decision mechanisms of individuals and households by predicting which activities are conducted where, when, with whom, the duration of activities and the transport mode used. This approach assumes that individuals obtain utility by participating in activities and the travel is a derived demand from activity participation. Therefore, the activity itself is the core of this approach instead of trips. Activity-based approaches consider behavioral patterns; household and other social structures; constraints as spatial, temporal; transportation and interpersonal interdependencies; and the scheduling of activities in time and space. Methods and models generally reflect one or more of these themes above (McNally, 2000). Activity based models include more decision mechanisms which indicates that these models can be used for a larger range of different policies.

Activity-based travel analysis has received much attention and seen considerable progress in the past decade. It has enabled to understand the complexity and variability in the activities that an individual undertakes during any given period. There are several models which are operational for large scale applications. For example, CEMDAP (Bhat et al., 2004) is an activity-travel modeling system based on econometric models. It predicts daily activity-travel patterns of each individual in each household by given socio-demographics, land-use and activity-transport attributes. FAMOS (Pendyala et al., 2005) is another micro-simulation model that predicts activity-travel patterns of individuals. It consists of two main modules as Household Attributes Generation System (HAGS) and the Prism-Constrained Activity Travel Simulator (PCATS). There are also rule-based models such as ALBATROSS and TASHA. ALBATROSS (Arentze and Timmermans, 2004) is an advanced computational model, which simulates every Dutch individual subject to a set of spatial, temporal, spatial-temporal and institutional constraints. It works with IF-THEN rules, which are derived from activity diary data using a decision-tree induction method. These rules provide information for the constraints and also for the activity scheduling engine to predict activity-travel choices at the individual and household level. Furthermore, TASHA (Roorda et al., 2008) is another operational model for activity scheduling and mode choice. The activity scheduling model uses a rule-based method which generates activity episodes by using random draws from observed probability distribution of start time, frequency and duration. Moreover, the mode choice model uses a random utility model, which incorporates mode choice for joint activities, vehicle allocation and rideshare opportunities in the household.

A distinctive feature of activity based models is their consideration of time use on activities and travel as their aim is to understand the allocation of time to activities and how this affects the timing and duration of trips. While trip-based approaches consider time as a cost of making trip, activity-based models considers time also as a resource within which individuals conduct their activity and travel. Therefore, individuals' activity travel patterns are a result of their time-allocation decisions (Bhat and Koppelman, 1999).

Time allocation to activities is studied in micro-economics as well. In these studies, time allocation and consumption of goods are related by using utility-maximization approach. As mentioned in the introduction chapter, this thesis addresses time and money allocation to activities subject to time and money budgets. Therefore, it is important to understand micro-economic consumer theories of time allocation and their relevance to activity-based modeling. In the next section, the micro-economic consumer theories of time allocation and empirical studies of activity-time and, time and money allocation in transportation field will be discussed.

2.3 Micro-economic consumer theories of time allocation

Micro-economic theory typically concentrates on answering how individuals decide about which and how much goods to consume for gaining the highest utility while allocating their available budget. Nevertheless, micro-economic theory can also be used for answering how other sources, such as time and money, are allocated to activities. In economic literature, the role of time and money started to be discussed from 1965 by Becker. Since then, several modifications of this time allocation model have been proposed.

According to Becker, utility is maximized by the time spent on activities and the goods consumed during the activities. He pointed out that market goods are not consumed when they are bought but they need to be converted into basic products and this conversion needs time. In his model, income is an endogenous variable as individuals can decide how many hours to work. Therefore, there are two constraints which are money and time and he combined these constraints by suggesting that time can be converted into goods. For instance, by working more hours, you can earn more money to buy goods. After Becker, Johnson (1966) and Oort (1969) used the time constraint to understand the effect of travel time when modeling trip generation. However, they applied a limited formulation by including work time in the utility function.

In De Serpa’s model (1971), time and goods are included in the utility function as by Becker, but consumption of each good is considered as an activity. Utility depends on time needed for consumption of goods and the amount of goods consumed. In this model, constraints are derived from available income, available time and time needed for consumption of a good. Time and income constraints are represented as independent equations. He also points out that saving time from an activity creates more time for other activities to increase the utility.

According to Evans (1972), utility is derived from the time spent on activities subject to time and income constraints. In his formulation, activities are the central subject, which makes it the first micro-economic model dealing with activities. Type of activity is the main source of utility and the utility can be measured by the amount of time assigned to that activity within a given period. Activities cost money as they need the input of goods to be conducted. In his formulation, cost constraints stem from the amount of goods per unit time, which are needed for an activity and the price of one unit of a good. Moreover, expenses and income also depend on time spent on consumption and work activities respectively. In addition, the time spent on one activity can be related to the time spent on another activity via the time constraint.

Regarding the theories above, time had a significant role in consumer theories. In general, these theories address the relation between goods, time and activity. Moreover, time and income constraints are introduced which enables the interrelations between activities. A limitation of these early works to adapt to activity-based models is that these theories are not at activity-episode level and do not consider the frequency. For instance, the utility derived from performing one activity for an hour in a week and for performing the activity three times in a week for 20 minutes is the same, which is not realistic. Moreover, the spatial organization of activities is not considered in these models although location is important to understand how the activity-travel patterns are organized in time and space.

2.4 Studies of activity time and money allocation

Based on these micro-economic consumer theories, time allocation model have been developed in activity-based modeling literature. This section will give an overview and review of these studies. These studies can be reviewed in two parts as time allocation studies and, time and money allocation studies.

2.4.1 Time Allocation Studies

As this thesis addresses the time and money allocation to activities, the time allocation studies can be considered as a transition to the modeling of time and money allocation to activities. Time allocation studies in activity-travel behavior context generally examine time allocation to in-home and out-of-home activities where it is assumed that spending time on activities brings utility. This utility is gained from an activity-travel pattern and can be explained with a concave function since utility increases with decreasing marginal utility. Moreover, in these models, time allocated to an activity is chosen to maximize the utility that is obtained subject to the time constraint.

In transportation, individuals' time allocation, subject to time budget, emphasizing the trade-off and relation between activities started with Kitamura (1984). His model integrates discrete activity choice and time allocation models in the context of random utility maximization. In his study, utility is a function of time allocated to specific activities and exogenous variables subject to total available time. It is assumed that utility increases with time with diminishing marginal utility. His study considers only two different activity types as working activity and out-of-home discretionary activities. The model deals with the time allocation of workers to work and out of home activities. The work trip duration and the work duration are included as explanatory variables in the activity choice and time allocation equations thus; the model gives explanation about the travel behavior of workers. However; it does not consider the location of activities.

Kitamura et al. (1996) extended the previous approach by using a Tobit model to study time allocation to in-home and out-of-home activities by using a weekly time-use data from The Netherlands. This study suggests that there is a correlation between different activity locations for generation of trips and it examines the substitution effect between in-home and out-of-home activities. In this study, income is added to the model as an explanatory variable but no impact of it was found on the allocation of discretionary time. Yamamoto and Kitamura (1999) extended the earlier works to examine time allocation on working days and non-working days over a multi-day period by applying a doubly-censored Tobit model. Meloni et al (2004) extended the work of Yamamoto and Kitamura by applying a nested Tobit model, which is a discrete continuous model with limited dependent variable. This study explains how individuals choose to allocate their discretionary time between in-home and out-of-home activities and between trips and activities by using a hierarchical sequence of two equations.

Bhat and Misra (1998) modeled the allocation of total weekly discretionary time of individuals between in-home and out-of-home locations and between weekdays and weekend. Their framework is based on Becker's theory since they used a resource allocation formulation to determine individual participation in an activity and duration of participation. This study combines time allocation studies with activity episode analysis by using fractional time splits instead of total weekly time allocation. Moreover, income is added as explanatory variable however, no effect of it was found on the allocation.

To sum up, by considering time constraint and activity episode concepts, activity-based models have been improved to be more realistic for the applications in urban planning and transportation. Since, these models can explain the influence of changes in urban structure and transportation by predicting the effects of these changes on activity participation and time allocation. Furthermore, these models also give insight to model how activities can be substituted by other activities when there are changes in the policy applications. Finally, these studies do not consider money allocation and monetary constraints in their frameworks.

2.4.2 Time and Money Allocation Studies

In addition to the time allocation studies, there are existing empirical studies of utility-maximizing frameworks subject to time and monetary constraints which extend the existing micro-economic consumer theories of time allocation. These theories and models point out individuals do not obtain utility from only one activity but they obtain it from an activity-travel pattern, which contains multiple activities. Moreover, these activities are interdependent due to time and money budgets since activities and travel needs time and money to be conducted. These approaches assume time and money spent for activities to be simultaneous decisions.

Kraan (1996) modeled time and money allocation to activities based on a utility maximization approach. Her model assumes that utility is derived from the total duration of all activities, the distance traveled, the frequency of activities and the amount of money spent on the purchase of goods, and utility is maximized subject to time and money budget constraints. However, there are limitations in her modeling approach. First of all, travel time is considered in the time constraint but not in the utility function. Second, decision of money spent on goods is not associated with activity participation, duration of activity and frequency. Furthermore, due to lack of data containing both time and money expenditures, the empirical study was done for only time allocation of individuals to in-home and out-of-home discretionary activities using a time budget survey data from Netherlands.

Jara-Diaz (1996), attempted to integrate mode choice models to time allocation models. In his framework, utility is derived from time allocated to activities, mode choices for each trip, amount and prices of goods to be bought at each zone, variable work hours and numbers of trips. This model builds on Evans' model. According to the model, time to activities and travel made by various modes are allocated in relation to the market services and goods at different zones. The utility maximization is constrained by time and income. Moreover, there are additional constraints, which are time needed for consumption of goods and a function of linking trips to the purchase of goods at zones. This framework includes spatial settings associated to each zone and its effect on time allocation since goods can be bought at different zones and for different prices.

This framework was further developed in a sequel of papers (Jara-Diaz, 1998a, 1998b, 1999, 2003, 2007). Jara-Diaz and Martinez (1999) developed a theoretical framework that describes the longer-term decision of individuals such as residential location choice by using a micro-economic approach to discrete choice analysis. The utility maximization is subject to time allocated to activities, frequency, goods, travel time and environmental characteristics subject to time, income and technical constraints and it is assumed that residential location and work location are chosen such as to maximize utility. Therefore, interrelation between time and money, and short-term and long-term decisions are considered. In this framework, income does not affect the residential location. However, price of dwelling and income are also related. This framework has not been empirically estimated.

The latest work of Jara-Diaz et al. (2008) empirically tests the proposed framework with data from 3 different cities from different countries to calculate the value of leisure and work time. The framework suggests utility is maximized with time assigned to each activity and amount of goods consumed and therefore a simultaneous equations approach is suggested. The utility maximization is subject to total income, total time and minimum time and minimum consumption requirements. A Cobb-Douglas specification is used for the model, which is not flexible but allows formulations of the utility function that have closed-form solutions. A further limitation of this approach is that it considers time use and consumption of goods as independent decisions in the sense that the goods consumed are not tied to specific activities. Furthermore, due to lack of data considering time and money expenditures, different data sets for time use and for monetary expenditures are combined to make the empirical estimation possible.

Kockelman (2001) conducted another empirical study. She proposed a simultaneous-equations approach in which, utility is maximized by participation in out-of-home activities, time spent on participating each activity, total time spent accessing all these activities and consumption of all other goods. Utility is subject to income and available time. She used a flexible trans-log cost function and a multivariate negative binomial specification for activity-participation rates to estimate household members' activity participation across trip purposes and across zones (Kockelman and Krishnamurthy, 2004). However, data used in her empirical study does not include expenditure or price information. Therefore, in her approach, time expenditures are fundamental since the indirect utility is derived from travel times instead of prices.

Zhang (2009) suggested a utility-maximizing approach in estimating a resource allocation model to describe pedestrian time use and expenditure simultaneously. By taking into account time-specific utilities, expenditure-specific utilities and inter-activity interactions, it is assumed that utility is maximized. A dedicated data was collected for this study. Data includes time and associated money expenditures during the activities that are conducted in the city center. Therefore, this study is different than the studies mentioned above in the sense that this framework considers the activities at the episode level rather than activity category level. However, data is collected only in the center thus spatial elements are ignored in this study. Moreover, activity participation cannot be represented in the modeling framework with consumption patterns. Finally, to simultaneously estimate the model system, the seemingly unrelated regression analysis is used. The seemingly unrelated regression analysis does not address the issue of endogeneity, which occurs due to the correlation of time and money variables.

The studies in this sub-section describe how time and monetary shifts lead to patterns of substitution within the activity-travel pattern. These models are also useful to understand how individuals allocate time and money to activities and goods. However, they have some limitations. First, these studies do not consider duration of activities and consumption during activities at episode level since they are generally at activity category level, except Zhang (2009). Although Zhang (2009)'s study is at activity episode level, it does not consider location effects and activity participation in the model. This strongly limits the relevance of these approaches for urban and transportation planning. Since, these frameworks cannot incorporate conditions and choice facets such as location and timing that may vary across episodes of an activity. Second, frequency of activity that influences duration and expenditure choices is ignored or not related to consumption of goods in these models. Third, theoretical frameworks of these works do not consider the longer-term changes such as purchase of durable goods or a house except Jara-Diaz (1999). Finally, another important issue is the lack of data considering time and associated money expenditures during the activity participation.

2.5 Daily activity scheduling

In the previous section, micro-economic theories of time allocation and empirical studies of them are discussed. As it is mentioned, those studies are generally conducted at activity category level. In this section, the models of activity scheduling at activity episode level are going to be discussed.

These studies assume that activity scheduling is a process in which individuals decide on daily basis which activity to conduct, in which sequence, with whom, where, what time and for how long while considering the limited time during the day. These studies are also based on micro-economic theories of time allocation due to the time budget consideration.

Habib (2011) proposed a framework that uses random utility maximization based discrete continuous modeling for daily activity scheduling within a time-budget constraint. After an activity is conducted, time budget decreases for other activities. Therefore the dynamics of scheduling are modeled by the change in time budget availability in a day and also by the history of activity participation. The model deals with activity scheduling process and uses the scheduled activity information for empirical estimation. For this model, only time expenditure and activity types are considered. For empirical application, a data set from Canada is used to model 24-h weekend activity scheduling.

In another study, Habib et al. (2012) proposed random utility maximization based activity-travel scheduling model under time-budget, which are used to investigate the relationship between transportation system performance and daily activity-travel scheduling process. In this study, both revealed preference and stated preference are used. The data is collected in Zurich, Switzerland by stated adaptation technique by means of four adaptation scenarios on increase and decrease of travel time in the context of 24-hour activity scheduling. The model can capture the effects of travel time changes on activity type choice, time of day choice and activity duration choice jointly.

Arentze et al. (2011) developed a different approach. They proposed a dynamic model based on needs-based theory for predicting daily activity agendas of individuals for a multi-day period of arbitrary length. The dynamic model predicts longitudinal activity patterns of individuals taking into account dynamic needs as well as day-varying preferences and time-budgets. A national travel survey from the Netherlands is used for estimation and prediction of the model.

In an earlier study by Arentze et al. (2010), the incorporation of income constraint to need-based models has also been showed where they propose a dynamic agent-based model of activity travel choice subject to time and money constraints. In this approach, agents make time and money allocation decisions on daily basis taking into account day-varying conditions and also the available budgets for longer time horizon. Due to lack of data, this approach has not been empirically estimated yet.

There is also a study from Bhat (2005) in which he proposed an econometric model called the multiple discrete-continuous extreme value (MDCEV) model. This is not a model at activity-episode level as the studies mentioned above however; it is different than existing time-allocation models since, this model allows for zero allocation of time to activities and reduces to a logit model under specific assumptions. The MDCEV model is based on utility maximization theory for discrete/continuous choice and it assumes that with increasing level of consumption of any alternative the marginal utility decreases. It considers activity participation and time allocation choices simultaneously within a given time-budget constraint. This model allows simultaneous estimation of multiple alternatives. In this paper, the model is applied empirically on a weekend day time use data to simultaneously estimate discretionary activities.

These represent a new stream of activity-based modeling, which is concerned with developing more comprehensive models of activity-rescheduling. As these are recent studies, they can still be improved and extended.

2.6 Evaluation and conclusion

This chapter briefly reviewed the existing literature on activity-based modeling and activity-time and money allocation studies. Although, activity-based models and applications have developed considerably, there are still some aspects to be improved.

Time is a significant concept in activity-based modeling. However, many activities require money directly or indirectly and the allocation of monetary budgets is also important to understand the occurrence of activities and their associated travel. In this context, there are several studies considering the impact of monetary budgets in addition to time budgets on activity participation and travel, in relation to the costs of activities, travel and goods but these studies are limited. Since, they consider duration of activities and consumption during activities at activity category level instead of at activity-episode level. Moreover, frequency of activity that influences duration and expenditure choices is ignored or not related to consumption of goods in these models.

In addition, these theoretical frameworks do not consider the longer-term decisions such as buying a house, changing work location. Another limitation is the lack of data considering time and associated money expenditures during the activity participation. Finally, these models lack a locational aspect.

With respect to the limitations mentioned in this chapter, the aim of this thesis is to develop a comprehensive theoretical and also modeling framework for allocation of time and money to activities and travel under time and money budgets. Moreover, dedicated data collection is needed for the empirical application of the developed framework.

3

Theoretical Framework

3.1 Introduction

As discussed in the previous chapter, activity-based models can still be improved. This chapter will discuss a comprehensive theoretical framework of time and money allocation on activities, goods and travel considering long-term and short-term decisions of households and individuals. This theoretical framework addresses various limitations in the existing literature.

The chapter is organized as follows. First, basic concepts will be introduced in order to build the theoretical framework. The next section will focus on the mathematical translation of the assumptions into a utility function. The following section addresses the activity choice behavior, which shows how an agent determines the activity agenda by taking into account the time and money budget constraints. The chapter will end with a discussion of the proposed theoretical framework and some conclusions.

3.2 Basic Concepts

This section discusses assumptions underlying the theoretical framework. These assumptions are based on the activity behavior and allocation of time and money to activities, goods and travel by considering short and long-term decisions.

Individuals make decisions for both long and short-term periods. The long-term decisions can be exemplified as the choice of dwelling, work location, employment, etc. These are not made so often but they are important because they determine the constraints for short-term decisions which are made on daily basis such as daily shopping, going out for dinner, etc. (Cullen, 1978). It is assumed that these constraints are temporal and monetary. The most important temporal constraint is the total amount of time that individuals can spend on their activities. During a day, the total available time for daily activity pattern is 24 hours. In addition, individuals have also a limited amount of money available, depending on their income and fixed expenditures.

The time spent on an activity can be defined simply as the duration of an activity plus travel time (if there is travel). If the activity duration is known for each activity episode, then frequency is required to obtain the total amount of time spent on the activity. Moreover, money is spent on activities as well as on the dwelling and durable goods which are used during the activities.

While conducting an activity, individuals obtain a certain amount of satisfaction or so called utility. The proposed model assumes that the utility of activities can be explained as the sum of *process utility* and *product utility* (Winston, 1987). Process utility is the utility derived from conducting the activity directly while product utility is the utility derived from postponed consumption of products produced by the activity. For instance, possible pleasure derived directly from cooking is the process utility while utility derived from consumption of the prepared food is the product utility. Thus, in this example an individual receives not only process utility but also product utility. However, some activities do not result in any product. For these activities, individuals only receive the process utility. For instance, one does not get any product at the end of going out activity (such as going to a café) and therefore the utility derived from this activity is only the process utility. For realizing both process and product utility, time and money are spent.

Money that is spent can be either fixed or variable. Fixed expenditures are spent only once in a determined period of time such as rent of the dwelling. Moreover, some activities have fixed costs, which can be paid at each occurrence of the activity. For instance, if someone decides to do an activity, which has fixed cost, such as going to the cinema, there is no choice to pay less or more than the price of ticket as it is fixed. Variable expenditures vary from situation to situation and depend on a decision of the person, which may be influenced by the activity duration such as the case in going out. If the duration of activity is longer, the amount of expenditure made will be higher. Also, there are travel-related expenditures in the longer term such as the purchase of a car or purchase of a season train ticket and expenditures that are made in the shorter term such as the running costs of a car each time when one travels. In addition, individuals spend money to conduct activities by buying necessary input goods. These goods can be split into durable and non-durable goods. For instance, for a washing activity one needs to purchase a washing machine, which is a durable good and needs to purchase detergent for washing to get clean clothes which is a non-durable good. Or, in another example, one needs to purchase a stove to cook, which is a durable good and needs to purchase food to prepare the meal which is a non-durable good.

The important question is how the available amounts of time and money are allocated to activities. It should be noted that utility is affected by both the input of time and money, implying that at least for some activities time and money can be substitutes for each other. For example, people make trade-offs between time gained by using a washing machine for a washing activity and money saved by washing by hand instead of buying a washing machine. Thus, an important observation is that people make trade-offs between time and money budgets.

The trade-off between time and money is influenced by longer-term decisions. The dwelling and durable goods are the outcome of long-term decisions of individuals. They are used during the activities and affect both process and product utility for the activities that they are used for. Individuals do not buy these for each episode, but they have secondary effects as well as they put time and money constraints on activities. For instance, a washing machine is bought for once but used for every washing activity. Spending money on washing machine can reduce the available monetary budget for other activities and expenditures however, by using a washing machine, time will be gained and it will increase the time budget for other activities. Therefore, people make trade-offs between long term investments in facilities and daily time and money expenditures.

The effects of long-term investments are also seen on time and money expenditure at activity level. To deal with understanding these effects, a scenario-based approach can be used. For instance, if one considers moving, there will be two scenarios: a new house and a scenario of the existing house. The net utility of moving then is determined as the difference in utility between the scenarios under best time and money allocations to activities under each scenario. For instance; buying a more expensive house would cause more expenditure for the house. Thus, more expenditure for a house would increase the utility per unit time for at home activities which means that moving has an influence on the function for utility of time. For instance, a more expensive house may have a garden and one can enjoy spending time at the garden, which would increase the utility of time that is spent at-home. However, the increase in the money spent on a dwelling might involve a decrease in the expenditure to activities and to durable goods if budgets stay the same. Furthermore, location of the dwelling may change the activity pattern. If one moves to a house closer to the working place, less time will be spent for travel between home and work. Thus, time available for other activities will increase. Moreover, it would cause a decrease in travel expenditure so that more money can be allocated to other activities. In addition, choosing a house in a more attractive district would also cause an increase in utility of living. Therefore, the trade-offs between time and money can be used to examine the behavioral dimensions such as long-term and short-term decisions such as buying a car, choosing work location, etc. (Jara-Diaz and Martinez, 1999).

The location of an activity is also important to understand the expenditures of time and money allocated to activities. It has a two-way effect on activity-travel choices. First, by spending more time or money on traveling one could reach a more attractive location (process or product utility), where people are likely to spend more time and money. For instance, if a location is attractive such as going to a restaurant in an exclusive area then one might wish to spend more money and/or time there. Secondly, the location can influence time and money spent directly if locations differ in terms of price levels (e.g. an expensive shopping center) or speed of service (queues). In addition, the location of activity affects expenditures of time and money to travel.

There is also timing decisions such as start time of the activity which influence activity participation and expenditures because timing decisions are needed for scheduling activities. An activity needs appropriate timing to be conducted and this may depend on the commitments on other activities and time schedules of shops, institutions (banks, schools, etc.). It also depends on the activity start time itself. For instance, if one is going to a cinema, the movie starts at a certain time. Moreover, for discretionary activities, the utility can be affected by the preferences of start time of activity. For instance, one may get more satisfaction from going to a café in the evening rather than going in the morning.

Travel has indirect utility on activities. For instance, a faster transport mode allows one to reach a chosen location quicker. Therefore, the duration of the travel will decrease and time will be saved for spending on other activities. In turn, spending more time on other activities can bring process utility and product utility, because products are the function of time spent during the activity. In addition, one can go to further locations by car because a wider radius brings better locations in reach, which will make them gain more process and product utility. Travel may also have process utility itself. For instance one may like riding a bicycle and consequently derive process utility from it. It is assumed that people spend time and money to travel for the utility of activities that it brings within reach. On the other hand, it may have a negative effect on total utility of activities because these travel time and expenditures cannot be spent on other activities.

Another issue in the model is the role of shopping activity. A shopping activity has only process utility and indirect utility gained from other activities that use the goods bought during shopping. For these other activities, it is considered how much money is spent for the goods that are used. However, people buy the goods that are used in activities during the shopping activity. This might cause double counting for the money spent to buy goods. Therefore, it is assumed that what is spent on shopping is counted in the activity where it is used. Thus, shopping activity enables households to get the goods. In each good requiring activity, the stocks of goods are consumed and as a result utility is gained. For instance, soap used during the washing activity is bought at the shopping activity but it is counted as expenses during the washing activity. Moreover, for semi-durable goods, utility is gained from the activities where those durable goods are used. For instance, if one buys a nice dress for going out, the utility is not gained from the shopping activity but gained from the activities that are conducted while this dress is worn for going out. The expenditure that is spent on the dress is considered as "expenditure" made for the going out activity. If one wears the dress several times for going out then it affects the process utility of going out. Hence, the expenditure (i.e., costs) allocated to an activity episode can be defined in this case as the price of the dress and the number of times it is used.

3.3 Utility Function

This section translates the given assumptions in the previous section into modeling premises, describing how individuals allocate their total amount of time and money to activities, goods and travel.

Given the above considerations, it is assumed that total utility of an activity is the overall sum of utility across activities, as follows:

$$U_h^{TOT} = \sum\nolimits_{i \in J_h} U_i(f_i, t_i, l_i, m_i, T_i^A, E_i^A) \tag{3.1}$$

where

T^A is episode duration of activity

E^A is money spent during an activity episode

f is the interval time of activity

t is start time of the activity

l is location of the activity

m is mode of transport

h is person or household

and J_h is a set of activities in a month that contains either personal activities or household activities depending on *h*. Personal activities are conducted by individuals for personal needs while household activities can be conducted by a person or multiple persons and serve household needs (Arentze & Timmermans, 2009). Thus, *h* can be a person doing a personal activity from a set of personal activities J_h for personal needs and it can also be person(s) doing a household activity from a set of household activities J_h for household needs.

The total utility of activity per episode that individuals gain is the sum of the utility of travel and the utility of the activity as in the following equation:

$$U_i(f, t, l, m, T^A, E^A) = U_i^M(t, l, m) + U_i^A(f, t, l, T^A, E^A) \tag{3.2}$$

where U_i^A is the utility of activity episode *i* and U_i^M is the utility of travel per episode *i*. The utility of activity per episode is the sum of *process utility* and *product utility.* Process utility is derived from the activity episode duration (T^A), interval time of activity (*f*), the location of activity (*l*), start time of activity (*t*), and money spent at each episode for process utility (E^A). Product utility is derived from the amount of products obtained in each episode for product utility (G_i) and utility per unit good produced (u_i). Amount of products obtained in each episode depends on the episode duration of the activity (T^A).The following utility function captures these notions:

$$U_i^A(f,t,l,T^A,E^A) = \Big[[a(f,t,l) * ln(T^A) + b(f,t,l) * ln(E^A+1) + c(f,t,l) * ln(T^A) * ln(E^A+1)] + [u_i * ln(\mathrm{G_i}(T^A))]\ \Big] \quad (3.3)$$

where

a is a marginal utility of time

b is a marginal utility of expenditure

c is a marginal utility of the product of time and expenditure

u_i is a marginal utility of the products that are produced during the activity

The first three terms on the right-hand-side of this equation captures the process utility and the last term the product utility component. For process utility, the duration of the activity in each episode also determines the utility, given the levels of the other input variables. Over the range of activity episode duration, the utility one obtains increases but with decreasing marginal utility due to saturation. Thus, starting a new activity brings more utility than spending more time on an ongoing activity, but also requires that more time needs to be invested at least for the extra travel. The same holds also for the activity episode expenditure. As the activity episode expenditure increases, utility one gets increases with diminishing marginal utility. The logarithmic transformation of activity episode duration (T^A) and expenditure (E^A) is used to make sure that utility has decreasing returns with increasing values of duration and expenditure per episode. Unity is added to E^A to allow also zero values for expenditure, for instance activities where no costs are made such as walking for pleasure in a park.

There is also a relation between time and expenditure because spending more money increases the marginal utility of time and vice versa spending more time increases the marginal utility of expenditure. For instance, if one goes to a café, s/he gets more pleasant time for each unit of money that is spent. Therefore, the interaction between time and expenditure is assumed to be positively correlated however; it should be noted that it also depends on the time and money budgets. This interaction between duration and expenditure is also added to the process utility function in addition to the main effects of duration and expenditure.

a, b and c are attraction parameters; they indicate the marginal utility of duration, expenditure and an interaction between duration and expenditure for an activity. These parameters vary with location and timing characteristics of activity. Since, utility of an activity increases with the attractiveness of the location and timing preferences. These preferences also affect the duration and expenditure of the activity. For instance, one can spend the same amount of time and money for dinner at two different locations but the more attractive location will generate more utility. Moreover, the a, b and c terms depend also on the interval time, which is an indication of frequency of activity. Utility derived from activities depends on the frequency because individuals decide on frequency of activities to maximize utility. For instance, one can go to the beach every day. However; the same amount of utility will not be obtained every day. Consequently, one can derive more utility from each episode by reducing the frequency of the activity. Since the longer time ago an activity is conducted (the smaller the frequency), the higher the marginal utility terms (a, b and c) will be.

For product utility, the products obtained are the result of time spent on the activity ($G_i(T^A)$): the longer the activity episode duration, the more products are produced. With more products produced, the production increases but with diminishing marginal rate due to saturation. For instance, if one spends more time on cooking then the foods that are obtained increase or the foods have higher quality. After a while, one does not need more quantity of food or better quality food. This assumption is satisfied by using logarithmic functions for total products obtained of each activity. Moreover, there are some activities which have fixed durations as the time spent on the activity is not chosen on an episode such as dishwashing. These activities result in product within the fixed duration, thus, the amount of the produced product is also fixed. As a result of that, the product of such activities can be considered as constant in the function.

Utility per unit good produced (u_i) for an activity may be a function of several factors such as the location where the activity is conducted and the quality of the input goods (bought during a shopping activity). However, given the focus of this thesis this component will not be further elaborated here.

As mentioned above, individuals maximize the utility of their activity patterns under time and money constraints. The total expenditure of an activity and travel per episode (E_i^A) is sum of the expenditure that is spent for the process utility in each episode (E^A), the expenditure that is spent for the product utility which is the multiplication of a cost price (*p*) per unit good produced at each episode G_i and expenditure that is spent on travel (E^M) which is a function of mode, location and start time. This is defined as:

$$E_i^A(E^A, T^A, p, m, l, t) = E^A + p * G_i(T^A) + E^M(m_i, l_i, t_i) \tag{3.4}$$

Total expenditure that is spent on activity and travel (E_h^{TOT}) is the sum of total expenditure across activity and travel episodes from a set of personal activities J_h of person *h* in a month as follows:

$$E_h^{TOT} = \sum_{i \in J_h} E_i^A \tag{3.5}$$

The total duration of activity and travel per episode (T_i^A) is the sum of the time spent on an activity episode (T^A) and travel time (T^M) which is a function of mode, location and timing as follows:

$$T_i^A(T^A, m, l, t) = \sum_{i \in J_h} [T^A + T^M(m_i, l_i, t_i)] \tag{3.6}$$

The total time in a month that is spent on activity and travel (T_h^{TOT}) is an individual expenditure. It is the sum of total time spent across activity and travel episodes (T_i^A) from a set of personal activities J_h of person *h* and total time spent on working in a month (T_h^w):

$$T_h^{TOT} = T_h^w + \sum_{i \in J_h} T_i^A \tag{3.7}$$

Total time (T_h^{TOT}) should be less than or equal to the available time for each person: $T_h^{TOT} \leq$ available time. In equation 3.7, total time spent on working is considered as a component of the time constraint since work activity is assumed as a different activity from all other activities, i.e. it does not produce direct utility (only indirect through income) and is fixed in terms of time spent. It may generate process utility as someone likes or dislikes working, but this is disregarded in the model. Income is a function of the time spent on the work activity as seen in the following equation:

$$I = \sum_h (T_h^w * w_h) + I_h^o \tag{3.8}$$

As implied by equation 3.8, total income of the household is the sum of the individual incomes, which depend on total time spent on working (T_h^w) and wage rate of the workers (w_h) in the household and extra, not-work related income (I_h^o) for each of the workers in the household.

By definition, income should also be equal to the sum of budget constraints (B_h) of individuals sharing a household and total savings (S) as follows:

$$I = \sum_h B_h + S \tag{3.9}$$

Savings are added to the equation 3.9 because people may not spend all the income and can save some money at the end of the month, but they can also exceed the budget by spending from existing savings. In addition, individuals in one household spend the income to household/shared needs but also to their personal needs (Arentze et al, 2010). If there are two persons in the household then there will be three budgets which are personal budgets of each person as shown in equation 3.10 and the household budget as shown in equation 3.11.

$$B_h = E_h^{TOT} + E_h^{D} \quad \text{where } B_h \text{ is a personal budget} \tag{3.10}$$

$$B_h = E_h^{TOT} + E_h^{H} + E_h^{D} \quad \text{where } B_h \text{ is a household budget} \tag{3.11}$$

In equation 3.10, *h* stands for individual and the personal budget constraint is the sum of two components as total expenditure to activities and travel (E_h^{TOT}) and expenditure to durable goods (E_h^{D}). In equation 3.11, *h* stands for a household and the household budget constraint is the sum of three components as total expenditure to activities and travel (E_h^{TOT}), expenditure to dwelling (E_h^{H}) and expenditure to durable goods (E_h^{D}).

3.4 Activity Choice Behavior

Utility function and budget constraints are given in the section above. This section explains the mechanism of the described model in 3.3 by describing how an agent (individual or a household) decides to choose an activity to conduct and determines the activity agenda in a day considering the utility function and budget constraints under a utility maximization framework. The concept of activity choice behavior described in this section is based on the study Arentze et al. (2010).

Following Arentze et al. (2010), it is assumed that agents use a local decision rule where they decide how much time and money to spend on activities on a daily basis under given budget constraints. In existing allocation studies, time allocation is modeled to assign the available budget to maximize the utility for an entire period. However, the needs, demands and constraints may vary within days because physical and social environment change over time. Therefore, the agent make resource allocation decisions on a daily basis by considering conditions of the moment such as time of day, location and at the same time respect the available budgets over longer time horizon. To achieve this, a threshold parameter is used for each resource namely time and money, and these thresholds represents the scarcity of resource.

Assume the activity list for an agent is given as $A = \{A_1, A_2, \ldots., A_n\}$. This list states the activities that an agent can optionally conduct on a day. On each day of a given period, an agent is faced with the problem of determining which activities to conduct and how much time and money to spend on each activity under limited time and money budgets. There are mandatory activities such as work or school, which may be scheduled on agent's agenda. As these activities are given and fixed, they are not involved in the activity choice problem. Yet, mandatory activities decrease the available time for other activities. When mandatory activities and activities selected from the list are added to the agenda, there may still be time left for a day. This remaining time at the end of the day is assumed to be spent on at-home leisure activities. Therefore, this time spent on at-home leisure activities is a consequence of all other activity decisions.

An activity produces utility and requires time and money, which are scarce resources. Thus, an activity is added to the agenda of an agent when utility is maximized subjecting to the time and money budget constraints. To take into account budget constraints regarding both time and money, the following conditions should be met before a discretionary activity is added to the agenda. The best possible specification of the activity is the specification that maximizes the utility within these constraints (Arentze et al., 2010).

$$max_{t,m,l,T^A,E^A}[U_i(t,m,l,T^A,E^A)] \tag{3.12}$$

subject to

$$U_i(t,m,l,T^A,E^A) > q^T_{dh} * T^A_i(t,m,l,T^A) \qquad i \in J_h \tag{3.13}$$

$$U_i(t,m,l,T^A,E^A) > q^E_{B_h} * E^A_i(t,m,l,E^A,T^A,p) \qquad i \in J_h \tag{3.14}$$

where

d is the day when activity is conducted

q^T_{dh} is the utility per unit time of person *h* on a day *d* when spent on leisure at the end of the day (opportunity costs for time)

$q^E_{B_h}$ is the utility per unit money from budget *B* of person *h* when spent in another way (opportunity costs for money)

J_h is the set of activities *J* that are conducted by person *h*

q^T and q^E are thresholds in terms of the utility that an activity should produce per unit of the resource (time or money) spent. Arentze et al. (2010) argues that in the context of activity choice, marginal utility is assumed to be equal to the marginal utility of the leisure time at home at the end of the day. Furthermore, a well-known optimal condition is that the marginal utility should be equal across selected activities. If this is not the case, utility can be maximized by substituting a selected activity with lower q^T by a non-selected activity with higher q^T. The same holds for the money resource. Agents also determine and adjust the threshold value by a mechanism. This mechanism suggests that if the utility of the leisure time (or money) at home at the end of the day is higher than the utility of time (or money) of another activity then the threshold for time (or money) should be adjusted upwards and vice versa.

As mentioned in basic concepts section, long-term decisions such as residential location, working hours have impact on the amounts of time and money available for daily activities such as recreational activities. Therefore, long-term decisions affect the activity agendas of agents on daily basis. The integration of long-term decisions in the model is possible with thresholds q^T and q^E. For instance, if the expenditure for dwelling increases, this will decrease the available money budget for discretionary activities. If the budget for activities is smaller due to spending more on dwelling, then q^E should be increased or vice versa. The same holds for long-term decisions on time budgets.

It should be noted that there is an asymmetry here: the threshold for time, generally, is dependent on day *d*, whereas the threshold for money does not vary across days. The reason is that mandatory activity time and hence available time for discretionary activities may vary from time to time, whereas a money budget is defined for a longer period (e.g., a month or a year). An activity is put on the agenda when there is a possible specification of the activity where both thresholds are met. The best possible specification of the activity is the specification that maximizes the utility within these constraints.

3.5 Discussion and Conclusion

Due to economic developments, depletion of materials or changes in demand, household incomes as well as prices of petrol, goods and agricultural products may significantly change. These changes will have an effect on the activity patterns, travel decisions and household expenditures. The anticipated changes have triggered the need to elaborate current activity-based models of transport demand by including explicitly budget allocation. Although theories on budget and time allocation are not new as summarized in previous chapter, they are limited in scope and therefore need further elaboration.

In this chapter, how time and money budgets can be integrated in an episode based activity-based model of travel demand was described. The proposed model enables exchange between time and money budget of individuals and households within their activities. The framework also includes the savings and the expenditure to durable goods and housing. A distinctive characteristic of the model is that it can evaluate policy scenarios in terms of time and monetary budget effects, thus it allows better understanding the impact of income and cost changes on activities and travel. A crucial element of the model to achieve this is the distinction between process and product utility of activities, which allows for an intuitively and theoretically plausible linkage between expenditures, investments, activity engagement and utility.

A complex description of activity patterns is obtained by putting all these assumptions on time and money expenditures together. This thesis will focus only on the leisure out-of-home activities as this is the most important category for the interface between expenditure and activity participation/travel. Conducting leisure out-of-home activities result in process utility. Since the utility is gained directly from conducting these activities and these activities do not result in product. Thus, the product utility component is discarded in the context of this thesis.

The next chapter will propose an activity-based modeling framework under time and money budget constraints in order to simultaneously estimate the allocation of time and money to out-of-home leisure activities. In this thesis, only duration, expenditure and frequency decisions are modelled while location, mode and timing decisions are left to be modelled in a future work.

4

Simultaneous Modeling of Individuals' Duration and Expenditure Decisions

4.1 Introduction

Chapter 3 reported the theory of an activity based model on episode level that enables exchange between time and money expenditures of individuals and households within their activities constrained by their budgets. This theory is derived from well-established utility-based economic theories of resource allocation and needs to be empirically tested. Based on that, this chapter develops an operational model of time and money allocation decisions of individuals on their out-of-home leisure activities which represents the first step for developing the suggested framework in Chapter 3.

The aim of this chapter, therefore, is to propose an activity-based model under time and money budget constraints to simultaneously predict the allocation of time and money on out-of-home leisure activities. The framework, in this chapter, does not include activity timing decisions in a long-term time frame decision as suggested in the theoretical framework, since frequency decisions are not included in the data set that is used. A comprehensive model including activity timing decisions will be presented in Chapter 6, based on a new data collection procedure.

The framework, in this chapter, considers the activity-episode level, given the activity is scheduled. Thus, the model considers the decision of the quantities for duration and expenditure spent during the activity. For this approach, a flexible utility function is used. Since, it allows an empirical estimation of the theory that is described in Chapter 3 which is needed to be operationalized. A structural equations model (SEM) estimation technique is used to handle the endogeneity problem for the simultaneous equations. The estimation results are based on Continuous Leisure Time Use (CVTO) data set which is a large national leisure diary data set collected in 2008 in the Netherlands, and provides detailed information about time and money spent as well as timing and location attributes at the activity episode level.

The organization of the chapter is straightforward. First, the model development is introduced. Next, the proposed estimation method is presented. This is followed by explanation of the data and the results of the estimation on the activity-diary data set. Finally, the chapter is concluded with a summary of results and discussion of main findings.

4.2 Methodology

In this section, decision problem model for out-of-home leisure activities under time and money budget constraints and the utility function derived from the decision problem will be presented.

4.2.1 Decision problem model

In Chapter 3, a utility maximization framework under time and money budget constraints for determining activity agenda of an individual was described (eqs 3.12, 3.13 and 3.14) where utility maximization depends on start time of the day, location of activity, mode of transport, activity episode duration and activity episode expenditure decisions. In this chapter, this model is followed however by considering only activity episode duration and activity episode expenditure decisions. Therefore, it is assumed that given a schedule of out-of-home leisure activities for a given time period (e.g., a day, a week or a month) and limited time and money budgets, an individual is faced with the problem of determining how much time and money to spend on each activity such that the budgets are respected and utility is maximized. Formally, this problem is defined as:

$$maxU = \sum_i U_i(T_i, C_i) \tag{4.1}$$

subject to

$$\sum_i T_i < T^I - \sum_i T_i^0 \tag{4.2}$$

$$\sum_i p_i C_i < E^I - \sum_i p_i^0 \tag{4.3}$$

where i is an index of scheduled leisure activities, T_i is the duration of activity i, T_i^0 is the travel time required for activity i, T^I is a time budget for leisure activities, E^I is a money budget for leisure activities, p_i^0 is a fixed cost such as entrance fee, p_i is a price of consumption and C_i is the amount of consumption during the activity.

Lagrange transformation results in the following function:

$$Z = \sum_i U_i(T_i, C_i) + \mu(T^I - \sum_i T_i^0 - \sum_i T_i) + \lambda(\mathrm{E^I} - \sum_\mathrm{i} \mathrm{p_i^0} - \sum_i p_i C_i) \tag{4.4}$$

where μ and λ are Lagrange multipliers representing the marginal utility of time and marginal utility of money. The variables μ and λ reflect the time budget- and money budget constraints of the person, respectively. For instance; if λ is high (e.g., low income level), this means that the monetary constraint is strongly restrictive since an individual with a small monetary budget will get more satisfaction from a similar amount of money spent conducting an activity. This relates to the threshold terms in the previous chapter (eqs 3.13 and 3.14) as concept since they also reflect the marginal utility of time and marginal utility of money and are used to obtain the optimum amount of time and money to spend on activities under budget constraints. As these variables are characteristics of budgets not of the activity, they are the same for all activities of a same person. In sum, the so-called thresholds μ and λ reflect the individual's notion of his/her utility of time and utility of money given his/her available budgets (Arentze et al., 2010).

The first-order conditions are:

$$\frac{\partial Z}{\partial T_i} = 0, \qquad \frac{\partial Z}{\partial C_i} = 0 \qquad \forall_i \tag{4.5}$$

Solving gives the following well-known optimality condition:

$$\frac{\partial U_i}{\partial T_i} - \mu = 0, \qquad \frac{\partial U_i}{\partial C_i} - \lambda p_i = 0 \qquad \forall_i \tag{4.6}$$

So, in terms of expenditure, the marginal utility of consumption should be equal to the price multiplied by a budget-constraint factor.

In the following, price are normalized by assuming that they are fixed to an amount and given for the time frame considered. Then it is convenient to reformulate the decision of how much to consume as a decision of how much to spend. Thus, the decision variable collapses to:

$$E_i = p_i C_i \tag{4.7}$$

Replacing (4.7) in the above equations, eventually gives the following reduced-form first-order condition regarding expenditure:

$$\frac{\partial U_i}{\partial E_i} - \lambda = 0 \qquad \forall_i \tag{4.8}$$

4.2.2 Utility function

Utility function that is used in this chapter relates to the process utility component of the function 3.3 which was described in the previous chapter. The following utility function is proposed for each activity *i*:

$$U_i = a_i \times ln(T_i) + b_i \times ln(E_i + 1) + c_i \times ln(T_i) \times \ln(E_i + 1) \tag{4.9}$$

where *a, b* and *c* are the coefficients of duration, expenditure and, duration and expenditure interaction for an observed activity *i*. As mentioned in the previous chapter, these coefficients depend also on the interval time shown in equation 3.3. However, the data used in this chapter does not include that information. Thus, the interval time of activity is disregarded in this chapter. The logarithmic transformation of *duration (T)* and *expenditure (E)* is used to make sure that utility has decreasing returns with increasing values of *T* and *E*. Unity is added to *E* to allow also zero values for *E*, i.e. activities where no costs are made. This function is more flexible than a Cobb-Douglas function which is the most often assumed function in existing approaches. In addition to an interaction between duration and expenditure, it also allows for their main effects on utility. A similar function was proposed by Zhang (2009).

Applying the first order condition for time (Eq. 4.6) and expenditure (Eq. 4.8) gives the following solutions for *T* and *E*:

$$T_i^* = (\mu)^{-1}[a_i + c_i \ln(E_i^* + 1)] \tag{4.10}$$

$$E_i^* = (\lambda)^{-1}[b_i + c_i \ln(T_i^*)] \tag{4.11}$$

where T^* and E^* are optimal values. Clearly, the optimum of *T* depends on *E* and, vice versa, the optimum of *E* depends on *T*. Therefore, there is no closed form solution for *T* and *E*.

4.3 Estimation Method

In this section the estimation method of the model is presented. First, the empirical model and the problem of endogeneity are described. Next, the parameterization and identification of the model are explained.

4.3.1 Empirical model and the problem of endogeneity

Using the model (Eqs 4.10-4.11), observations can be described by the following equations.

$$T_{in} = (\mu_n)^{-1}[a_{in} + c_{in} \ln(E_{in} + 1)] + \varepsilon_{in}^T \tag{4.12}$$

$$E_{in} = (\lambda_n)^{-1}[b_{in} + c_{in} \ln(T_{in})] + \varepsilon_{in}^E \tag{4.13}$$

where T_{in} and E_{in} are observed duration and expenditure for an observed activity *i* of individual *n* and $\varepsilon_{ni}^{\mathrm{T}}$ and $\varepsilon_{ni}^{\mathrm{E}}$ are error terms. μ and λ are Lagrange multipliers representing the marginal utility of time and marginal utility of money. These multipliers cannot be observed therefore they should be estimated. Thus, in equation 4.12 and 4.13, these multipliers are used as parameters as it is done in the earlier studies such as Zhang (2009) and Habib (2011).

Equation 4.12 and 4.13 are linear-in-parameters functions. If the multiplication of μ, λ and the coefficients are omitted, linear regression analysis can be used to estimate the parameters. There is however also an issue of endogeneity. This endogeneity is a result of simultaneity between equations 4.12 and 4.13 because there is causality between the independent and dependent variables of the two equations. Therefore, *E* and *T* are correlated even after controlling for explanatory variables *(X)*, so that the *E* and *T* cannot readily be used as an independent variable for the other.

Figure 4.1 shows schematically the assumed relationships in the simultaneous equations for duration and expenditure (Eqs. 4.10 and 4.11). The connections shown by dashed lines (Figure 4.1) are crucial. When omitted, the model reduces to separate models for

T and *E*. When included, the dependent variables are interconnected. In an Ordinary Least Squares (OLS), these connections would be ignored so that estimated coefficients for the exogenous variables (*X*) will represent both indirect and direct influences of these variables.

The extent to which this leads to bias is indicated by a correlation analysis of residuals in OLS regression. Positive correlations indicate that mutual information between *E* and *T* is left in the residuals, whereas negative correlations mean that unique information of *E* and *T* is extracted from the error terms and erroneously assigned to the dependent variables. In a consistent estimation of the two functions for *T* and *E*, the resulting error terms should be uncorrelated. To achieve this, a simultaneous modeling approach is required. Hence, a structural equation model is proposed here as a framework to estimate the involved parameters.

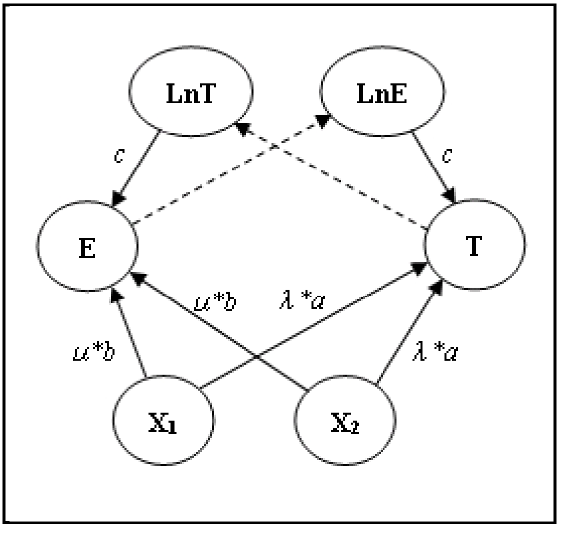

Figure 4.1 Causal structures of the duration and expenditure relationships (X1 and X2 stand for sets of explanatory variables)

4.3.2 Functions and Parameters

The coefficients *a, b* and *c* and threshold parameters μ and λ are all unobserved and should be estimated. They have the following behavioral interpretation:

- *a*, *b* and *c* are attraction parameters; they indicate the marginal utility of duration, expenditure and an interaction between duration and expenditure for an activity.

Hence, it is expected that these parameters vary with location and timing attractiveness characteristics.

- μ and λ are budget-threshold parameters; they indicate the extent to which time and money are scarce resources for the individual. Hence, it is expected that these parameters co-vary with available time and money budgets.

Based on these notions the following parameterization is proposed:

$$b_{in} = b_{i0} + \sum_j b_{ij} X_{ijn}, \quad a_{in} = a_{i0} + \sum_j a_{ij} X_{ijn}, \quad c_{in} = c_{i0}$$

$$\mu_n = \mu_0 + \sum_k \mu_k X_{kn}, \qquad \lambda_n = \lambda_0 + \sum_\ell \lambda_\ell X_{\ell n} \tag{4.14}$$

where i is an index of activity, n is an index of individual, j is an index of attraction variables (e.g., time and location attributes), k is an index of time-budget variables (e.g., working hours) and ℓ is an index of money-budget variables (e.g., income). In sum, it is assumed that attractiveness parameters are a function of the activity and budget-parameters are a function of the individual (or household) and, in case of time, the day when the activity is conducted (available time).

Socio-demographic variables may co-vary with preferences (tastes) and, for that reason, they are included as attraction variables. Although in theory these variables may have an effect on the coefficient for the interaction term as well (c-parameter), a constant is assumed for the latter parameter as such effects are expected to be smaller and hard to identify on the level of the interactions. Moreover, due to lack of explanatory variables for time and monetary budget-threshold parameters in the data set, the effects of these variables cannot be estimated. Therefore, only the constants μ_0 and λ_0 can be estimated in this analysis.

There is a further issue of identification of the model. It is obvious that μ_0 and λ_0 cannot be estimated both at the same time. At the point where X_k's are zero, μ_0 defines a scale for a and c. Similarly, at the point where X_ℓ's are zero, λ_0 defines a scale for b and c. Setting for example $\lambda_0 = 1$ the scale of c (and b) is determined and, hence, μ_0 can be estimated. So, if one is preset, the other can be estimated based on the common factor c in the two equations.

Thus, in terms of the threshold parameters only the time-budget threshold parameter (μ_0) needs to be estimated (as the money-budget threshold (λ_0) is set to 1). Although the budget parameter is identifiable for the reason mentioned above, standard estimation methods of regression models cannot handle a form where the effects of an independent variable is given by a multiplication of two parameters (such as μ and *a* in the present model). Therefore, a two-step approach is used. In the first step, the model (Eq. 4.12 and 4.13) is estimated using maximum likelihood estimation of joint *T* and *E* observations. The maximum likelihood function of joint *T* and *E* is shown in equation 4.15 where likelihood of *T* and *E* are multiplied. Equations 4.16 and 4.17 show the likelihood functions of E and T respectively. The likelihood of expenditure is calculated by using normal distribution of observed expenditure, predicted expenditure and standard deviation of expenditure which is calculated by using OLS results. The same is done also for duration. Overall, for this estimation, a Newton-type optimization algorithm is applied (NLM routine in R).

$$\mathcal{L} = \prod_{in} \mathcal{L}(T_{in}) \times \mathcal{L}(E_{in}) \tag{4.15}$$

$$\mathcal{L}(E_{in}) = \emptyset(E_{in}, E^{*}_{in}, \sigma_E) \tag{4.16}$$

$$\mathcal{L}(T_{in}) = \emptyset(T_{in}, T^{*}_{in}, \sigma_T) \tag{4.17}$$

In the second step, the estimated value of μ is fixed and all remaining parameters are re-estimated using SEM estimation. The latter step should result in a refinement of the parameter estimates as the SEM estimation is able to deal with endogeneity in the observations of *T* and *E*.

4.4 Application

In this section, first the explanation of data set will be given. Next, the results of estimation are presented.

4.4.1 Data set

The data used for the empirical analysis in the paper is obtained from a national survey, namely Continuous Leisure Time Use Study (CVTO), representative of the Dutch population, conducted between May 2008 and May 2009. This survey collects information on leisure activity episodes of individuals over the course of a random week. Every week around 350 respondents answered an online questionnaire about their weekly leisure activities and some personal characteristics. Only the activities that are conducted for one hour or more are included in the data set. This is a restriction for the current analysis. As some leisure activities can be conducted in less than an hour, the data does not allow estimating effects of time and money allocation on such activities.

The data set has a panel structure because respondents usually have multiple responses since they do more than one leisure activity in a week. To eliminate the panel structure, one activity of each person is randomly sampled. This is feasible, since this analysis considers allocation of time and money on an activity of an individual and does not consider interrelation between activities. Several types of variables were considered in the model specification. These included duration of the activity, money spent during the activity, individual and household socio-demographics (gender, age, social class, household composition), with whom the activity is conducted and, timing and location variables (day of the week, starting time of activity and distance to the activity). The money spent during the activity includes information of direct costs of activities such as consumptions during the activity, money spent in the shops, etc. The data do not include entrance fee, subscription, contribution, membership and travel costs. As the activity has already been scheduled, the constant costs of the activity are already known to the individuals and they do not vary with the duration of the activity.

As mentioned above, the data does not contain information about explanatory variables for time and monetary budget-threshold parameters, the effects of these variables cannot be estimated. Social class variable in the data set is based on income and education level however; it does not contain information about the associated income values. Therefore, only the constants of time and monetary budget-thresholds, μ_0 and λ_0 (where the latter is pre-set and fixed as explained) can be estimated.

Six activity categories are considered for estimation which are as below:

- Outdoor recreation such as walking for pleasure, recreation in park or forest or near sea, fishing, swimming;
- Event visits such as exhibition, fairs, shows, festivals
- Culture such as concert, musical,
- Attraction visit such as attraction parks, zoo;
- Going out such as bar, café, disco visits, eating out and
- Wellness and beauty such as beauty treatment, spa and sauna visits.

The data includes activities of 4607 individuals. Table 4.1 gives an overview of the key sample characteristics. The sample is fairly equally distributed across gender classes. Moreover, 16.6% of the sample is younger than 18 years old, 23.9% of the sample is between 18 and 35 years, 45.2% of the sample is between 36 and 64 years, finally 14.3% of the sample is 65 years and older. Middle social class is overly represented in the sample as it is 58.2% of the sample. Furthermore, half of the sample is families with children. The activities are conducted mostly with partner or with others (such as friends, colleagues) as the percentages are 42.2 and 30.5, respectively. The sample is fairly equally distributed across starting time of activity. Weekends and weekdays are also equally distributed in the sample.

Table 4.1 Sample characteristics (N=4607)

Variables		Frequency	%
Gender			
	Female	2316	50.3
	Male	2291	49.7
Age			
	<18 years	765	16.6
	18-35 years	1100	23.9
	36-64 years	2081	45.2
	>65 years	661	14.3
Social Class			
	High	855	18.5
	Middle	2679	58.2
	Low	1073	23.3
Household Composition			
	Single	846	18.4
	Family without children	1374	29.8
	Family with children	2387	51.8
With Whom			
	Alone	606	13.2
	With Partner	1942	42.2
	With Children	880	19.1
	With Family	908	19.7
	With Others	1405	30.5
Start Time			
	Morning	1431	31.0
	Afternoon	1796	39.0
	Evening and Night	1380	30.0
Day of the Week			
	Weekdays	2479	53.8
	Weekend	2128	46.2

Table 4.2 Sample Characteristics per Activity Category (%)

	Outside Recreation	Wellness and Beauty	Attraction Visit	Event Visit	Culture	Going Out
Gender						
Female	595	166	290	185	223	857
Male	607	62	276	159	213	974
Age						
<18 years	265	10	167	41	60	222
18-35 years	202	61	107	83	113	534
36-64 years	510	134	225	171	185	856
>65 years	225	23	67	49	78	219
Social Class						
High	207	43	85	67	91	362
Middle	676	142	325	205	274	1057
Low	319	43	156	72	71	412
Household Composition						
Single	173	62	61	57	94	399
Family without children	412	67	130	103	137	525
Family with children	617	99	375	184	205	907
With Whom						
Alone	528	105	257	139	208	718
With Partner	534	28	238	142	206	794
With Children	252	8	213	68	61	278
With Family	230	9	182	59	82	346
With Others	266	38	115	112	133	741
Start Time						
Morning	547	76	299	126	79	304
Afternoon	512	81	211	132	127	733
Evening and Night	143	71	56	86	230	794
Day of the Week						
Weekdays	554	51	288	207	163	865
Weekend	648	177	278	137	273	966
Sample Size	1202	228	566	344	436	1831

Table 4.3 Mean Values of Travel Distance, Activity Episode Expenditure and Activity Episode Duration per Activity Category (Standard deviation between brackets)

	Outside Recreation	Wellness and Beauty	Attraction Visit	Event Visit	Culture	Going Out
Distance (km)	1.05 (0.62)	0.88 (0.51)	1.17 (0.56)	1.29 (0.61)	1.08 (0.53)	0.96 (0.54)
Episode Expenditure (in Euro's)	10.12 (17.39)	32.05 (31.37)	12.91 (14.78)	23.79 (28.68)	18.44 (21.76)	20.88 (20.33)
Episode Duration (in minutes)	221.06 (175.37)	207.36 (196.17)	266.90 (191.13)	313.02 (217.83)	244.06 (156.38)	205.47 (176.93)

Table 4.2 gives information about the sample characteristics for each activity category. It is seen that going out is the most conducted activity category. It is followed by outside recreation, attraction visit, culture, event visit and wellness and beauty activity categories.

Table 4.3 shows the mean values of travel distance, activity episode expenditure and activity episode duration per activity category where the standard deviations are shown in brackets. It is seen that mean travel distance is highest for visiting events and it is followed by visiting attractions, culture, outside recreation, going out and wellness and beauty activities. Mean activity episode expenditure is highest for wellness and beauty, followed by event visit, going out, culture, attraction visit and outside recreation. The results also indicate that activity episode duration is highest for event visit, followed by attraction visit, culture, outside recreation, wellness and beauty, and finally going out.

4.4.2 Estimation Results

In this section, the estimation results of the proposed model are presented. The estimation is done by using the two-step approach and structural equations model (SEM) techniques based on a classification of leisure activities into six activity categories. Note that in the second SEM step, all remaining parameters to be estimated are activity-specific. Therefore, in the SEM step the model is estimated separately for each activity category. Furthermore, an OLS estimation of the separate models for T and E is conducted. The OLS estimation provides an indication of the relevance of the endogeneity problem. Therefore, the results of correlation coefficients between the residuals for T and E in OLS estimation are shown in Table 4.4.

Table 4.4 Correlation Coefficients of Residuals of OLS Estimation of Duration and Expenditure Models When Endogenous Variable is Included

	Outside Recreation	Wellness and Beauty	Attraction Visit	Event Visit	Culture	Going Out
Correlation	-0.16	-0.21	-0.13	-0.23	-0.17	-0.22

In the OLS case, the models for time and expenditure (Eqs 4.10 and 4.11) where endogenous variables $ln(E)$ and $ln(T)$ are included in the equations are estimated separately. When the endogenous variable is included in each equation, the correlation between time and money error terms are found to be negative as shown in Table 4.4 and when excluded the correlations are found to be positive. This holds for all 6 activity categories for which this analysis was conducted. However, in a consistent estimation, the correlations should be close to 0 and this is successfully solved in the SEM estimation as shown in Table 4.5. Moreover, the result of log-likelihood proves the improvement of the model. An overall log-likelihood can be calculated across the 6 activity categories. The overall log-likelihood of the null model is -72737.65 and it increases to -56747.76 by using the SEM method estimation resulting in an Rho-squared (McFadden) of 0.22. Moreover, high R-squared values for each activity in the SEM estimation (Table 4.6) show that the independent variables are strongly related with the duration and expenditure.

Table 4.5 Correlation Coefficients of Residuals of SEM Estimation of Duration and Expenditure Models

	Outside Recreation	Wellness and Beauty	Attraction Visit	Event Visit	Culture	Going Out
Correlation	-0.02	-0.01	0.02	0.00	-0.03	-0.02

The parameter estimate for μ is 0.168 with a t-value of 23.042 ($p < 0.001$). As explained, the estimation result of μ is used in the SEM estimation by multiplying the attributes with this factor. Table 4.6 shows the results of the SEM estimation. In terms of interpretation of the results, a warning is in order. Since time-budget and money-budget variables (such variables are missing in CVTO dataset) cannot be controlled for, there may be a confounding of preference and budget effects of socio-demographic variables. Thus, in principle, when effects of a socio-demographic variable on *a* and *b* parameters are uniform across activities it cannot be told whether they are budget or attractiveness effects. Keeping this in mind the results can be interpreted as follows.

Being female has a positive effect on utility of expenditure for the wellness and beauty activity category. Regarding the age category, being younger than 18 has a negative effect on utility of expenditure for outside recreation, attraction visits, event visits, culture and going out activities. As this effect can be seen for all activity types, it can be said that this is a plausible result due to the restrictive budget of these people. Moreover, the utility of duration and also of expenditure for event visits is lower for people aged between 36 and 64. In addition, utility of expenditure for attraction visit and going out is higher for this age group. Being older than 65 has a positive effect on the utility of duration on outside recreation. This can be explained by the preference of this age group because when people grow older they appreciate outside recreation activities more. Moreover, being older than 65 has a negative effect on the utility of expenditure for visiting events while this group has a positive effect on the utility of expenditure for going out.

Regarding social class, the utility of duration for outside recreation activities is lower for high social class. This suggests that this segment prefers to spend less time on this activity. Moreover, the utility of expenditure for going out activities is higher for high social class. Middle social class has a negative effect on the utility of duration for outside recreation and attraction visit. In addition, being from a middle social class is found to have a negative effect on the utility of duration while it is found to have a positive effect on the utility of expenditure for wellness and beauty. Furthermore, it has a negative effect on the utility of duration for going out activities while it has a positive effect on the utility of expenditure for this activity. This shows that middle social class people trade-off between duration and expenditure for going out activities. Regarding household composition, being single has a positive effect on the utility of expenditure for wellness and beauty activities. Being a family without children has a negative effect on the utility of duration for attraction visit. Moreover, the utility of expenditure for event visit is higher for family without children category.

Looking at travel party categories, conducting outside recreation with a partner has a positive effect on the utility of duration while it has a negative effect on the utility of expenditure. Conducting wellness and beauty activity with a partner has a positive effect on the utility of duration. Moreover, the utility of expenditure is lower for conducting outside recreation, attraction visit and event visit with children. The utility of duration is also lower for conducting a culture activity with children. In addition, both the utility of duration and expenditure is lower for conducting a going out activity with children. This is expected because spending less time on an activity will also decrease the expenditure for that activity. Although not all effects are significant, conducting activities with children has a negative effect on the utility of duration across activities.

Conducting the wellness and beauty activity with family has a positive effect on the utility of duration. It is found that utility of duration is lower for conducting going out activity with family. Furthermore, the utility of expenditure is lower for conducting event visit activity with family. In addition, conducting outside recreation activities with others has a positive effect on the utility of duration for this activity. Conducting wellness and beauty with others has a positive effect on the utility of duration while it has a negative effect on the utility of expenditure. This is plausible because conducting such an activity with others can make the activity more pleasant and the costs of the activity such as entrance fee can be shared which reduces the expenses. In addition, the utility of duration is higher for conducting event visit, culture and going out activities with others.

With respect to time variables, a positive effect was found on the utility of duration for starting outside recreation activity in the morning while a negative effect is found on the utility of expenditure. Moreover, morning has a positive effect on the utility of expenditure for the wellness and beauty activity. The utility of duration is higher for starting culture activity in the morning. Furthermore, the utility of duration is higher for starting going out activities in the morning while the utility of expenditure is lower. This shows that there is a trade-off between duration and expenditure for conducting a going out activity in the morning.

The utility of expenditure is lower for starting outside recreation activity in the afternoon. Besides, utility of expenditure is higher for starting wellness and beauty activity in the afternoon. Visiting an attraction or event in the afternoon has a negative effect on the utility of duration for these activities. These activities generally take long time and therefore starting these activities in the afternoon would shorten the duration of these activities. In addition, the utility of expenditure is lower for starting attraction visit activity in the afternoon. Starting culture activity in the afternoon has a positive effect on the utility of duration. It is also found that the afternoon category has a negative effect on the utility of expenditure for going out activities, probably because people tend to spend more money for going out in the evening and night which is the baseline category.

Table 4.6 Results of SEM Estimation

	Outside Recreation				Wellness and Beauty			
	Duration		Expenditure		Duration		Expenditure	
	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Female	-0.60	0.70	-0.83	0.38	-4.91	0.15	12.81	0.00
< 18 years	1.41	0.44	-4.50	0.00	14.18	0.06	-14.95	0.09
36-64 years	2.21	0.15	0.48	0.62	3.98	0.20	2.90	0.43
>65 years	5.65	0.00	-1.06	0.39	8.19	0.11	-1.60	0.79
High Social Class	-5.38	0.01	-0.19	0.88	-5.86	0.13	5.70	0.22
Middle Social Class	-5.61	0.00	0.50	0.60	-6.26	0.05	9.98	0.01
Single	0.64	0.77	-1.09	0.42	1.10	0.75	10.59	0.01
Family without children	-1.12	0.48	-0.04	0.97	-4.89	0.15	-2.40	0.55
With Partner	4.96	0.00	-1.96	0.04	19.37	0.00	-1.80	0.75
With Children	1.44	0.44	-2.95	0.01	-8.41	0.31	1.42	0.89
With Family	1.53	0.43	-1.30	0.29	27.20	0.00	-17.51	0.06
With Others	7.74	0.00	1.68	0.15	18.98	0.00	-11.93	0.02
Morning	5.98	0.00	-2.15	0.03	3.61	0.27	10.74	0.01
Afternoon	-2.19	0.16	-2.59	0.01	-5.83	0.07	7.57	0.05
Weekend	3.47	0.02	0.40	0.67	3.32	0.37	4.42	0.31
Distance	12.86	0.00	4.59	0.00	27.46	0.00	10.37	0.00
		Estimate	p-value			Estimate	p-value	
c-parameter		3.49	0.00			6.17	0.00	
R-squared		0.75				0.73		

Table 4.6 Results of SEM Estimation (continue)

	Attraction Visit				Event Visit			
	Duration		Expenditure		Duration		Expenditure	
	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Female	-0.01	1.00	-1.40	0.21	-3.07	0.36	1.53	0.57
< 18 years	1.25	0.58	-4.64	0.00	-9.62	0.06	-11.52	0.01
36-64 years	1.56	0.46	2.36	0.04	-10.42	0.00	-8.25	0.00
>65 years	-2.74	0.39	-0.25	0.88	-7.28	0.13	-16.58	0.00
High Social Class	-3.03	0.30	-1.11	0.47	3.90	0.35	-0.75	0.83
Middle Social Class	-4.32	0.04	-1.52	0.18	-1.27	0.71	4.22	0.12
Single	-6.17	0.07	0.87	0.63	-2.25	0.61	1.72	0.63
Family without children	-5.23	0.03	-0.89	0.50	-0.76	0.83	5.93	0.04
With Partner	0.09	0.96	-1.28	0.25	0.10	0.98	-1.86	0.50
With Children	-2.14	0.32	-2.39	0.04	-5.52	0.19	-6.68	0.05
With Family	-0.92	0.68	0.07	0.96	-0.49	0.91	-7.78	0.03
With Others	4.91	0.06	-0.31	0.82	8.37	0.02	2.05	0.48
Morning	0.35	0.87	-0.79	0.47	-1.02	0.77	-4.40	0.11
Afternoon	-9.37	0.00	-3.81	0.00	-8.42	0.01	-4.23	0.13
Weekend	-4.17	0.04	0.49	0.66	5.89	0.08	4.11	0.13
Distance	28.75	0.00	6.58	0.00	15.25	0.00	12.03	0.00
		Estimate	p-value			Estimate	p-value	
c-parameter		3.05	0.00			7.33	0.00	
R-squared		0.74				0.76		

Table 4.6 Results of SEM Estimation (continue)

	Culture				Going Out			
	Duration		Expenditure		Duration		Expenditure	
	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Female	0.01	1.00	0.39	0.84	-2.08	0.11	-0.50	0.56
< 18 years	-0.17	0.96	-10.05	0.00	-1.13	0.58	-6.14	0.00
36-64 years	0.67	0.78	-1.79	0.36	-1.39	0.29	2.55	0.00
>65 years	2.02	0.50	2.87	0.26	-0.45	0.82	2.57	0.05
High Social Class	-1.53	0.59	-2.50	0.30	-1.56	0.35	6.59	0.00
Middle Social Class	-0.20	0.93	-2.16	0.28	-3.21	0.02	3.31	0.00
Single	-4.25	0.13	1.47	0.53	-1.84	0.25	-1.41	0.18
Family without children	-2.93	0.24	-0.21	0.92	-1.25	0.39	-1.57	0.10
With Partner	1.39	0.55	2.29	0.24	-1.38	0.30	1.54	0.08
With Children	-7.56	0.02	-2.97	0.29	-4.14	0.02	-5.54	0.00
With Family	-1.89	0.52	1.62	0.52	-3.32	0.05	0.41	0.71
With Others	5.70	0.02	-1.03	0.62	7.37	0.00	-0.89	0.31
Morning	6.26	0.04	-0.11	0.96	5.75	0.00	-8.60	0.00
Afternoon	5.32	0.04	0.87	0.68	-0.75	0.58	-3.86	0.00
Weekend	-4.20	0.08	0.34	0.86	2.12	0.11	2.02	0.02
Distance	12.02	0.00	9.93	0.00	5.69	0.00	5.87	0.00
		Estimate	p-value			Estimate	p-value	
c-parameter		3.95	0.00			5.74	0.00	
R-squared	0.76				0.80			

Considering the weekend category, a positive effect was found on the utility of duration for outside recreation activities while a negative effect was estimated on the utility of duration for visiting an attraction. Moreover, conducting going out activity in the weekend has a positive effect on the utility of expenditure.

Distance has a positive effect both on the utility of duration and expenditure for all activity categories. This shows that increasing distance increases the duration and expenditure for all activity categories. The likely explanation is that traveling more brings more attractive locations in reach. The c-parameter determines the relation between spending money and time. In line with theoretical prediction, the c-parameter is found to have a positive effect on the interaction of duration and expenditure for all activity categories which means the utility of expenditure increases with increasing duration and vice versa.

4.5 Conclusion

In this chapter, an activity model under time and money budget constraints was developed to simultaneously predict the allocation of time and money to out-of-home leisure activities. The proposed model is derived from the theory outlined in the previous chapter. Moreover, the proposed framework considers the activity episode level, given that the activity is scheduled. Thus, the model considers the decision of the quantities duration and expenditure spent during an activity simultaneously. A flexible utility function is introduced which has no closed form solution. It is showed how the more complex model can be estimated by using structural equations model (SEM) estimation techniques in order to see the effects of duration and expenditure on activities simultaneously and to solve the endogeneity problem. The estimation results are based on a large national continuous leisure diary data set collected in 2008 in the Netherlands, which provides detailed information about time and money spent as well as timing and location attributes at the activity episode level. The analysis reveals that socio-demographics, travel party, timing and location variables influence the duration and expenditure of activities at the episode level. The analysis provides plausible results and the log likelihood of the model shows that the model has significant explanatory value. However, time-budget and money-budget variables cannot be controlled for as they are missing in the data set. Therefore, if there is an effect of a socio-demographic variable on *a* and *b* parameters, it cannot be told whether they are budget or attractiveness effects.

As a simultaneous estimation is conducted, the effect of the variables on duration and expenditure together can be seen which can also capture the trade-off between duration and expenditure for an activity. People from middle social class make trade-offs between duration and expenditure of going out and wellness. Conducting outside recreation with a partner gives information about a trade-off between duration and expenditure. In addition, conducting the wellness and beauty activity with family and with others provides information about a trade-off between expenditure and duration. Moreover, starting outside recreation, going out in the morning make people trade-off between duration and expenditure.

Another significant result is the effect of distance on duration and expenditure. For all activity categories, distance has a positive effect on both duration and expenditure, suggesting that individuals generally can find more attractive locations for out-of-home leisure activities by traveling further and this affects the amount of time and expenditure for the activities. Overall, the results show that this time and money allocation study can provide relevant information for policy formulation and planning.

As mentioned in theoretical framework, frequency is significant since it influences the duration and expenditure choices. Therefore, frequency of activities should also be considered in the estimation of the model. However, data used in this chapter does not include information about frequency and also information about income and working hours. Thus, it is not possible to estimate the effect of those variables on the time and money budget thresholds. Due to the lack of information in the data set, a new data collection is required. Next chapter describes the data collection which provides the data needed in order to simultaneously estimate individuals' duration, expenditure and frequency decisions on out-of-home leisure activities.

5

Data Collection

5.1 Introduction

The previous chapter focused on the simultaneous prediction of duration of and expenditure on out-of-home leisure activities. To our knowledge, the only existing data consisting of duration and expenditure on activities at activity episode level is the Continuous Leisure Time Use (CVTO) data set which is a national level survey conducted in 2008 by the Dutch Board of Tourism and Conventions, TNS-NIPO. However, this data does not include information about activity frequency, time and money budgets such as income and working hours. Incorporating activity frequency into modeling the duration and expenditure decisions at activity episode level is important. Since, if the activity duration and expenditure are known for each activity episode, then the total amount of time and money spent on the activity follows from the frequency of the episodes. Moreover, one can obtain higher utility by conducting an activity with higher or lower frequency. Given that the aim is to simultaneously estimate the activity duration, expenditure and frequency decisions under time and money budget constraints, there is a need for data that includes frequency of the activity in a month apart from activity episode duration and expenditure and in addition to that time and money budget attributes.

Another aspect is, as mentioned in the theoretical framework chapter, the need to understand how individuals reallocate their budgets in response to possible changes in budgets and how the changes in policies or exogenous factors impact overall activity-travel and expenditure patterns. Therefore, data regarding current time and monetary budgets and expenditures in which individuals re-allocate their budgets to various objectives under hypothetical scenarios, such as decrease in income or increase in working hours needs to be collected. For this aim, a stated adaptation experiment was developed and applied in a survey.

This chapter reports the development and application of a stated adaptation experiment for individuals' time and money budget allocation decisions focusing on out-of-home leisure activities and the descriptive results of this approach. The structure of this chapter is as follows. First, a brief description of the survey design is given. This is followed by the sample characteristics. Next section gives explanation of reported changes of behavior. Finally the chapter ends with summary and conclusions.

5.2 Design of the Survey

The questionnaire was developed and conducted online through a platform that is developed in Design and Decision Support Systems (DDSS) group at Technical University of Eindhoven to generate web-based questionnaires. The questionnaire consists of three parts as socio-demographic attributes, current time and money expenditure and stated adaptation which is further explained below.

5.2.1 Socio-demographic Attributes

The first part consists of questions about socio-economic attributes at individual and household level such as gender, age, income, household size, education, car availability, and number of cars. Since, personal and household attributes are essential for the development of activity-based models. In addition to that, more detailed questions about fixed time and money expenditures are added to the first part. These attributes are important to understand the constraints of individuals for out-of-home leisure expenditures. Therefore, respondents are asked the questions below;

- How many hours do you work in a general work-week?
- How much money does your household spend on housing per month? These costs are rent/mortgage, service costs, taxes, gas/electricity/water.
- Does your household make use of household help? If yes, how much does your household pay on it per month?
- What is your net income per month?
- What is your partner's net income per month?

5.2.2 Current Time and Money Expenditures

In the second part, respondents are given a list of out-of-home leisure activities. The following classification of out-of-home leisure activities is used in the survey which is consistent with the CVTO data set.

- Recreation such as walking in a park, cycling for pleasure, recreation near water or in a park,
- Sport Event Visit such as going to a football match
- Sporting
- Wellness, beauty and relaxation such as beauty treatments, sauna and spa visits
- Attraction Visit such as attraction park, zoo
- Event Visit such as exhibition, fairs, festival
- Culture such as going to cinema, concert, musical, museum
- Going Out such as bar, café, disco visits, eating out
- Hobbies, Courses and Others such as club activities, courses for hobbies

Respondents are asked to report their average current time and money expenditure per episode on each out-of-home leisure activity and associated travel separately, and also how frequent each activity is conducted on average in a month. The questionnaire platform allowed adding constraints to the questionnaire to avoid respondents writing unrealistic amounts.

5.2.3 Stated Adaptation Survey

In the third part, a stated adaptation experiment was conducted in which respondents are asked to save money or time from their out-of-home leisure activities, thus creating two scenarios (time saving or money saving). Each respondent had to answer a time saving and a money saving scenario, separately.

Stated adaptation is an experiment technique in which respondents are asked to indicate if and how they would change their behavior in response to hypothetical scenarios. In transport research, the use of stated adaptation experiments has recently increased as this approach can capture behavioral responses state dependently. This can improve policy impact analysis by collecting behavior change responses to new transport policy scenarios (Arentze et al, 2004, 2007; Nijland et al, 2011). Recently, Weis et al. (2010) applied a stated adaptation experiment in which scenarios are based on travel time changes affecting the time budget of respondents.

For the application of the stated adaptation experiment, first the monthly time and money expenditure on an activity are calculated by multiplication of frequency with episode duration and expenditure, respectively. This is done by using the reported current time and money expenditure per episode on each out-of-home leisure activity and associated travel separately and also indicated frequency of each activity in a month. Time and money expenditure on out-of-home leisure activities are then obtained by totaling across the categories. After that, hypothetical scenarios are shown to the respondents based on their reported time and money expenditures. The hypothetical scenarios for saving time and saving money are shown separately. For each respondent, these two scenarios state that 30% of the overall duration and 30% of the overall expenditure are the amounts to be saved, respectively. Then respondents are asked to save this amount across the activity categories. A built-in calculator is added to the questionnaire which allowed the system and also respondents to check if their savings add up to the stated amounts of savings. If the amounts were unrealistic such as negative amounts, extreme amounts or they did not add up to the total amounts, respondents received a warning and could not continue to the next page. Moreover, respondents are also asked to indicate how they would save time and money. This indication is made possible by giving options which respondents could choose. Below are the structures of scenarios.

5.2.3.1 Time saving scenario

The text of the time saving scenario in the question is shown as below.

We have summarized your data from the previous page where you indicated your time expenditure and we calculated how much time you spend in total per month to each activity. We now ask you to imagine that you should save Y minutes in total from the activity categories below. For example, you can think of a situation that your working hours increased and you decided to save this amount only from your leisure activities. Please specify how you would like to do this by clicking the options below. You can *choose multiple options. You can also calculate by using the calculate button to check whether the sum of your savings are equal to Y minutes.*

The list of activities (see above) is again shown to the respondent with the calculated totals of time. The following choice options are included for respondents to state their behavior of changing for time saving. Respondents could choose multiple options.

1. I would conduct this activity less frequently
2. I would spend less amount of time per episode of this activity
3. I would choose a faster transport mode
4. I would choose a closer location to conduct this activity
5. I would not change anything

After clicking option(s), respondents specify the exact amount of time that they want to save. This is done for each activity category.

5.2.3.2 Money saving scenario

The text of the money saving scenario in the question is shown as below.

We have summarized your data from the previous page where you indicated your expenditure and we calculated how much money you spend in total per month to each activity. We now ask you to imagine that you should save X Euro in total from the activity categories below. For example, you can think of a situation that your income decreased as a result of the economic crisis and you decided to save this decreased amount only from your leisure activities. Please specify how you would like to do this by clicking the options below. You can choose multiple options. You can also calculate by using the calculate button to check whether the sum of your savings are equal to X Euro.

The list of activities (see above) is again shown to the respondent with the calculated totals of money. The following choice options are included for respondents to state their behavior of changing for money saving. Respondents could choose multiple options.

1. I would conduct this activity less frequently
2. I would spend less amount of money per episode of this activity
3. I would choose a cheaper transport mode
4. I would choose a closer location to conduct this activity
5. I would not change anything

After clicking option(s), respondents specify the exact amount of money that they want to save. This is done for each activity category.

5.2.3.3 Reporting Saving Amount

After respondents indicated, in the way described above, how they would save and how much time and money they would save, it is also asked how much of the given amounts of time and money they would save on their *out-of-home leisure activities* in real life given the stated changes in budgets (note: they could also save the resources in other categories of activities). This is asked for saving time by the following structure:

In the previous page, we asked you to imagine that you have to save Y minutes from your out-of-home leisure activities. Would you do this in reality too? Please indicate how much time in reality you would save from your out-of-home leisure activities if your working hours would increase Y minutes.

And it is asked for saving money by the following structure:

In the previous page, we asked you to imagine that you have to save X Euros from your out-of-home leisure activities. Would you do this in reality too? Please indicate how much money in reality you would save from your out-of-home leisure activities if your income would decrease X Euros.

5.3 Sample Descriptive

The questionnaire was conducted in the Netherlands in June 2012 by sending the web link to a respondent panel of a research bureau in the Netherlands. The panel includes individuals from all over the Netherlands. As a result of the data collection, completed responses from 500 respondents were obtained and after cleaning the data 423 of them were useful for the analysis. The data is cleaned by omitting the responses including outliers and the inconsistent responses.

Table 5.1 gives an overview of the key sample characteristics. The sample is fairly evenly distributed across gender classes where 50.4% of the sample is male while 49.6% of the sample is female. 32.4 % of the sample is between 18 and 35 years old, 31.9% of the sample is between 36 and 50 years old, 27.2% of the sample is between 51 and 65 years old. There are fewer respondents from the elderly category compared to the population (65 years and older). This might be due to the online survey, since older people are more difficult to be reached through internet. Moreover, regarding household composition, couples without children is the largest category and followed by single or couples with children, single without children and multiple person households.

Table 5.1 Sample Descriptive Statistics of Socio-demographic Characteristics

		Value	Percent (%)
Gender	Male	213	50.4
	Female	210	49.6
Age	18-35	137	32.4
	36-50	135	31.9
	51-65	115	27.2
	65+	35	8.3
Household Composition	Single, no children	68	16.0
	Couple, no children	170	40.2
	Single or Couple, with children	147	34.8
	Multiple Persons	38	9.0
Income	<625	85	20.1
	625-1250	78	18.4
	1251-1875	112	26.5
	1876-2500	88	20.8
	2501-3125	36	8.5
	3125+	24	5.7
Partners Income	<625	68	16.1
	625-1250	58	13.7
	1251-1875	82	19.4
	1876-2500	60	14.2
	2501-3124	18	4.3
	3125+	16	3.8
Working Hours	No work (0 hour)	97	23.0
	Part time work (1-32 hours)	156	36.9
	Full time work (>32hours)	170	40.1
Dwelling Expenditures	<500	70	16.5
	500-1000	250	59.1
	>1000	103	24.3
Number of Auto in Household	1	47	11.1
	2	248	58.6
	3+	128	30.3

According to the monthly net income distribution, it is seen that between 1251 and 1875 Euro is the largest category, followed by 1876-2500 Euro, less than 625 Euro, 625-1250 Euro, 2501-3125 Euro and more than 3125 Euro. 302 respondents indicated that they have a partner and reported their partner's income category as well. A similar income distribution is also reported for partners. Furthermore, 40.1% of the sample works full time and 36.9% of the sample works part time while 23% of the sample does not work. In addition, 59.1% of the sample spends between 500 and 1000 Euros to their dwellings. Finally, 58.6% of the sample has 2 cars in the household.

Mean values monthly duration and money expenditure figures are shown in Table 5.2 which consist of average amounts of time and money spent on out-of-home leisure activities and travel and standard deviations between brackets. The results show that monthly time spent on outside recreation is highest on average across the activities with 511 minutes. It is followed by going out, sporting, hobbies and courses, attraction visit, culture, event visit, sport event visit, and finally wellness, beauty and relaxation activity. Moreover, most expenses in a month are made on the going out activity with mean of 150 Euro. It is followed by culture, outside recreation, attraction visit, sporting, hobbies and courses, event visit, sport event visit and finally wellness, beauty and relaxation.

Table 5.3 shows the mean values of frequency, activity episode duration and expenditure, and expenditure per unit time for out-of-home leisure activities. The results indicate that outside recreation is the most frequently conducted activity in a month followed by sporting, going out, hobbies and courses, and cultural activities. Wellness, beauty and relaxation is the least frequently conducted activity. Moreover, mean episode duration is highest for attraction visit followed by going out, culture, outside recreation and event visit while it is lowest for wellness, beauty and relaxation. Furthermore, the results show that mean episode expenditure is highest for going out followed by attraction visit, culture and event visit while it is lowest for sport event visit. Finally, table 5.3 reports the expenditure per unit time which is highest for going out and lowest for outside recreation activity.

Table 5.4 gives the mean values of one-way travel duration and expenditure for the out-of-home leisure activities. Travel expenditure is highest for attraction visit followed by going out, event visit, culture, outside recreation, sport event visit, hobbies and courses, wellness, beauty and relaxation, and finally sporting. Turning to duration, the results indicate that one-way travel duration is also highest for attraction visit which suggests that this activity is generally conducted at more distant locations. This is followed by going out, event visit, culture, outside recreation, sport event visit, hobbies and courses, sporting and finally wellness, beauty and relaxation.

Table 5.2 Mean values of monthly duration and expenditure

Activity	Monthly Duration (in minutes)	Monthly Expenditure (in Euro's)
Outside Recreation	511.81 (831.842)	44.95 (122.34)
Sport Event Visit	109.21 (329.22)	15.91 (54.27)
Sporting	392.83 (790.49)	37.38 (114.97)
Wellness, Beauty and Relaxation	43.70 (144.95)	11.29 (34.27)
Attraction Visit	216.08 (379.02)	44.33 (87.43)
Event Visit	138.26 (392.56)	30.69 (119.75)
Culture	198.13 (576.93)	58.48 (311.16)
Going Out	487.07 (980.41)	150.85 (427.09)
Hobbies, Courses and Others	225.65 (630.52)	36.93 (155.98)
p-value	0.00	0.00

Table 5.3 Mean Values of Frequency, Activity Episode Duration, Activity Episode Expenditure, and Expenditure per Unit Time

Activity	Frequency in a month	Episode Duration (in minutes)	Episode Expenditure (in Euro's)	Expenditure per unit time (Euro/min)
Outside Recreation	5.78 (9.24)	73.70 (70.39)	5.06 (9.22)	0.069
Sport Event Visit	.57 (1.67)	31.49 (70.92)	3.89 (10.14)	0.124
Sporting	3.55 (5.31)	45.27 (71.62)	3.93 (10.13)	0.087
Wellness, Beauty and Relaxation	.20 (.58)	29.47 (96.49)	7.03 (20.29)	0.239
Attraction Visit	.52 (.87)	126.94 (190.64)	21.42 (37.37)	0.169
Event Visit	.48 (1.11)	62.86 (125.68)	10.14 (24.71)	0.161
Culture	1.00 (2.26)	76.11 (94.14)	15.71 (33.26)	0.206
Going Out	2.38 (3.07)	109.68 (113.54)	34.34 (44.21)	0.313
Hobbies, Courses and Others	1.43 (4.13)	43.80 (105.22)	5.11 (13.68)	0.117
p-value	0.00	0.00	0.00	

Table 5.4 Mean Values of One-way Travel Expenditure and Duration

Activity	One-way travel duration (in minutes)	One-way travel expenditure (in Euro's)
Outside Recreation	10.88 (19.06)	3.69 (24.77)
Sport Event Visit	7.84 (26.97)	2.00 (12.78)
Sporting	5.51 (10.847)	1.04 (3.96)
Wellness, Beauty and Relaxation	4.23 (12.83)	1.45 (6.24)
Attraction Visit	21.72 (37.77)	6.50 (11.04)
Event Visit	12.73 (26.95)	4.25 (10.71)
Culture	12.43 (18.57)	3.76 (8.04)
Going Out	13.48 (19.28)	4.31 (12.70)
Hobbies, Courses and Others	5.80 (15.81)	1.59 (6.57)
p-value	0.00	0.00

5.4 Reported Changes

For each respondent, the two scenarios state that 30% of the overall duration and expenditure are the amounts to be saved, respectively. According to that, the mean value of amount to be saved for money is 129 Euro (standard deviation=249.62). In addition, the mean value of amount to be saved for time is 696 min (standard deviation=686.16).

The mean values of savings for time and money, and also relative comparison of savings to the amounts to be saved of each out-of-home leisure activity and travel are shown in Table 5.5.

The results show that respondents tend to save most time on outside recreation while they tend to save least time from wellness, beauty and relaxation activity. After outside recreation, respondents on average save most time in decreasing order on going out, sporting, attraction visit, culture, hobbies and courses, event visit, sport event visit, and wellness, beauty and relaxation activities. Furthermore, the results indicate that respondents tend to save most money on going out while they tend to save least money from wellness, beauty and relaxation activity. After going out, respondents tend to save most money in decreasing order on attraction visit, culture, outside recreation, sporting, event visit, hobbies and courses, sport event visit and wellness, beauty and relaxation activities. In addition, the relative comparison of savings to the amounts to be saved shows the mean percentages for each activity category.

Table 5.5 Savings of Money and Time

Activity	Mean Amounts of Savings		Relative Comparison of Savings to the Amounts to be Saved	
	Duration	Expenditure	Duration	Expenditure
Outside Recreation	159.17 (294.10)	15.18 (54.16)	0.228	0.117
Sport Event Visit	31.90 (119.56)	4.45 (14.96)	0.046	0.034
Sporting	109.55 (309.25)	11.95 (55.42)	0.157	0.092
Wellness, Beauty and Relaxation	15.62 (71.42)	4.05 (15.80)	0.022	0.031
Attraction Visit	78.62 (161.11)	16.70 (34.59)	0.113	0.129
Event Visit	51.17 (167.56)	9.86 (39.56)	0.073	0.076
Culture	70.67 (300.60)	16.17 (106.95)	0.101	0.125
Going Out	155.63 (310.44)	51.75 (145.22)	0.223	0.400
Hobbies, Courses and Others	60.72 (192.72)	6.58 (29.81)	0.087	0.050
p-value	0.00	0.00		

The results indicate that respondents tend to save most time relatively to the total amount to be saved from outside recreation followed by going out, sporting and attraction visit. The results also indicate that respondents tend to save most money relatively to the total amount to be saved from going out followed by attraction visit, culture and outside recreation.

As mentioned above, respondents are asked to indicate how they would realize the savings indicated. Note that choosing multiple options was possible. Table 5.6 represents the percentages of individuals who indicated the ways to realize time savings for each activity category. Respondents who did not spend time on the activity are shown in NA category. Change nothing option has the highest percentage compared to other options for sporting, wellness and culture categories. If respondents are saving time, this is indicated to be done generally by conducting the activity less frequently or spending less time per episode. Moreover, conducting the activity less frequently is the option chosen most often for going out followed by outside recreation and it is chosen least often for wellness followed by sport event visit. Spending less time per episode is chosen most frequently for outside recreation followed by going out and it is chosen least often for wellness and sport event visit. Furthermore, using a faster transport mode is chosen most often for outside recreation, followed by culture, attraction visit and going out. Conducting the activity at a closer location is chosen most often for outside recreation, followed by going out, attraction visit, culture and event visit. Finally, results indicate that the change nothing option is chosen most often for outside recreation followed by going out, sporting, culture, hobbies and courses, event visit, attraction visit, sport event visit and wellness.

Table 5.6 Percentages for Time Saving Behavior Related to Out-of-home Leisure Activities

	Time Saving Behavior (Percentage)					
Activity	Less frequent	Less time per episode	Faster transport mode	Closer location	Change nothing	NA
Outside Recreation	29.30	28.80	3.10	6.10	28.80	15.80
Sport Event Visit	7.60	6.10	1.70	2.10	7.60	77.30
Sporting	14.20	18.20	0.90	3.10	19.90	49.60
Wellness	4.50	5.20	0.70	1.20	5.40	84.20
Attraction Visit	16.50	12.10	2.60	4.00	8.30	61.50
Event Visit	12.30	8.50	0.90	3.80	9.90	69.30
Culture	18.40	14.70	2.80	3.80	19.40	47.80
Going Out	31.70	25.30	2.40	4.50	24.60	23.20
Hobbies, Courses and Others	10.60	10.20	1.40%	2.40%	9.90	70.40

Table 5.7 Percentages for Money Saving Behavior Related to Out-of-home Leisure Activities

	Money Saving Behavior (Percentage)					
Activity	Less frequent	Less money per episode	Cheaper transport mode	Closer location	Change nothing	NA
Outside Recreation	10.60	14.20	5.70	7.30	21.00	52.70
Sport Event Visit	7.10	6.10	2.10	1.70	7.30	79.40
Sporting	8.70	11.80	5.70	3.30	19.60	61.00
Wellness	6.10	3.80	1.20	1.40	5.00	84.40
Attraction Visit	18.20	13.90	2.80	4.70	10.40	59.60
Event Visit	10.60	9.00	3.10	4.50	9.90	69.70
Culture	13.00	14.90	3.80	1.70	28.40	47.30
Going Out	32.40	32.20	4.70	6.10	24.30	21.50
Hobbies, Courses and Others	5.90	8.00	2.10	3.10	15.60	72.60

In Table 5.7 percentages of individuals who indicated the ways of money saving are shown per activity category. Respondents who did not spend money on the activity are shown in the NA category. Change nothing option has the highest percentage compared to other options for outside recreation, sport event visit, sporting, culture and, hobbies and courses categories. It is also seen that respondents tend to save money mostly by conducting the activity less frequently and/or spending less money per episode rather than choosing a cheaper transport mode or closer activity location. Conducting the activity less frequently to save money is the mostly chosen option for going out activity, followed by attraction visit, culture, outside recreation and event visit, sporting, sport event visit, wellness and, hobbies and courses. Spending less money per episode is chosen most often for going out and least often for wellness, beauty and relaxation activity. On the other hand, choosing a cheaper transport mode is chosen most often for sporting and outside recreation followed by going out. Respondents tend to choose closer location for saving money most often for outside recreation followed by going out. Finally, change nothing option is chosen most often for outside recreation followed by sporting, culture and going out while it is chosen least for wellness and beauty.

If the NA categories of Table 5.6 and Table 5.7 are compared, it is seen that there is a high difference between percentages for outside recreation and sporting activities. This shows that some respondents spend time on these activities without spending money.

Finally, as we asked respondents how much of the given amounts of time and money they would save on their out-of-home leisure activities in real life given the stated changes in budgets, the results show that respondents tend to save mean value of 303 minutes (standard deviation=426.86) and mean value of 89 Euro (standard deviation=187.817). These mean values are less than the mean value of stated amounts to be saved which are 696 min (standard deviation=686.16) and 129 Euro (standard deviation=249.62). This result shows that if respondents are asked to save time and money from all activity categories, the savings would not be only from their out-of-home leisure activities.

5.5 Evaluation and Conclusion

In this chapter, the design and application of a stated adaptation experiment was presented. This experiment aimed at collecting data on individuals' activity-travel time and money allocation in a baseline situation and under budget-reduction scenarios focusing on out-of-home leisure activities. The data collection was conducted online through a platform that was developed in the DDSS group at TUE to generate web-based questionnaires. The data was collected in the Netherlands in June 2012 by sending the web link to a respondent panel of a research bureau in the Netherlands. The panel includes individuals from all over the Netherlands.

The results for monthly mean total duration and money expenditures are different than activity episode mean duration and expenditures. This indicates that frequencies of activities differ between individuals. It should also be noted that there is a high variation in time and money expenditures. Based on reported time and money expenditures, respondents are faced with changing budget conditions and are asked to state their likely behaviors in response to these hypothetical situations such as saving time due to increase in work hours or saving money due to decrease in income. It is found that respondents tend to save more time and money from the activities where they spend more time and money in a month. Another important finding is that time and money is saved mostly by reducing the frequency of the activity or by spending less time or money per episode. Changes of location and transport mode are also mentioned as ways to save time or money but less frequently. Finally, it is found that if respondents have to save time and money from all activity categories, they would save on average 43.5% less time and 69% less money from their out-of-home leisure activities.

Next chapter will present the estimation of activity based model under time and money budget constraints based on the collected data in order to see the effects of duration, expenditure and frequency on out-of-home leisure activities.

6

Modeling Individuals' Frequency, Duration and Expenditure Decisions

6.1 Introduction

Chapter 4 proposed and reported the results of an activity-based model under time and money budget constraints to simultaneously predict the allocation of time and money on out-of-home leisure activities. This framework did not include activity timing decisions in a long-term time frame as suggested in the theoretical framework as the data set that is used did not include this information. In this chapter, relative activity timing decisions (i.e., frequency) will be considered because this is provided by the new data collection. Therefore, this chapter develops the modeling framework that is suggested in Chapter 4 and makes it more comprehensive. Moreover, the new data set has information about income and working hours. Thus, the effect of those variables on the time and money budget thresholds is examined.

The framework in this chapter extends the utility function and therefore estimation method in Chapter 4. Thus, the model considers the decision of the quantities for duration and expenditure spent during the activity episode and also the frequency of activity in a month. This model is estimated by using maximum likelihood estimation based on joint frequency, duration and expenditure observations. The estimation results are based on the activity-episode level data set which is described in Chapter 5. This data includes current situation data and adaptation data. In this chapter, only the current situation data is used. Moreover, including the frequency of activities in the utility function allows estimating both of the budget-threshold parameters at the same time.

The organization of the chapter is straightforward. First, the methodology, which is based on Chapter 4, is described. Next, the proposed estimation method is presented. This is followed by the results of the maximum likelihood estimation on the data set. Finally, the chapter is concluded with a summary of conclusions and discussion of future works.

6.2 Methodology

In this section, decision problem model for out-of-home leisure activities under time and money budget constraints and the utility function derived from the decision problem will be presented. This section extends the decision problem model and utility function of Chapter 4 by adding individuals' activity timing decisions on their out-of-home leisure activities.

6.2.1 Decision Problem Model

In Chapter 3, utility maximization framework under time and money budget constraints for determining activity agenda of an individual is given where utility maximization depends on start time of the day, location of activity, mode of transport, activity episode duration and activity episode expenditure decisions. In Chapter 4, this model is followed by considering that a decision to conduct activity is made and the activity episode duration and activity episode expenditure decisions are modeled. Still, there is also activity timing decisions of individuals which affect the marginal utility of time and money expenditures on an activity as shown in equation 3.3. In this chapter, the frequency decision of individuals is added to the modeling framework as a relative activity timing decision.

Therefore, it is assumed that for a given time period (e.g., a day, a week or a month) and limited time and money budgets, an individual is faced with the problem of determining how much time and money to spend on each activity and how many times to conduct the activity in the given time period such that the budgets are respected and utility is maximized. Formally, this problem is defined as:

$$maxU = \sum_i U_i(T_i, E_i, t_i) \tag{6.1}$$

where *i* is an index of scheduled leisure activities, T_i is the duration of activity *i*, E_i is the amount of consumption during the activity and t_i is the interval time between two episodes of activity *i* which indicates frequency.

The utility maximization is assumed to be done under limited time and money budget. Therefore the optimality conditions which are shown by equations from 4.6 and 4.8 also hold for this chapter. These are shown here as equations 6.2 and 6.3 where μ and λ reflect the time budget- and money budget constraints of the person, respectively. According to equation 6.2 and 6.3, the marginal utility of T is equal to μ and the marginal utility of E is equal to λ.

The choice of frequency (interval time) is considered as endogenous. Therefore an additional requirement holds for the optimum. Adding the frequency (interval time) decision to the utility function brings two more additional constraints as shown in equations 6.4 and 6.5. This requirement follows from the notion that an activity should be conducted at the earliest moment when the utility exceeds opportunity costs of the time spent (spending time in another way) and opportunity costs of the money spent (spending time in another way) as shown in equations 3.13 and 3.14.

$$\frac{\partial U_i}{\partial T_i} - \mu = 0 \qquad \forall_i \tag{6.2}$$

$$\frac{\partial U_i}{\partial E_i} - \lambda = 0 \qquad \forall_i \tag{6.3}$$

$$U_i - \mu \times T_i = 0 \qquad \forall_i \tag{6.4}$$

$$U_i - \lambda \times E_i = 0 \qquad \forall_i \tag{6.5}$$

6.2.2 Utility Function

The following utility function is proposed for each activity *i*, by including the frequency (interval time) decisions to equation 4.9. This follows the equation 3.3 shown in the theoretical chapter.

$$U_i = a_i \times t_i \times ln(T_i) + b_i \times t_i \times ln(E_i + 1) + c_i \times t_i \times ln(T_i) \times \ln(E_i + 1) \quad (6.6)$$

where *i* is an index of scheduled leisure activities, T_i is the duration of activity *i*, E_i is the expenditure of activity *i* and t_i is an interval time between two episodes of activity *i*. *t* is proportional to $1/f$, where f is frequency. Moreover, *a, b* and *c* are the coefficients of interaction between duration and interval time, interaction between expenditure and interval time, and interaction between duration, expenditure and interval time for an observed activity *i*. This formulation assumes that the utility derived from duration and expenditure increases with the longer time ago the activity was conducted.

Applying the first order condition for time (Eq. 6.2) and expenditure (Eq. 6.3) to equation 6.6 gives the following solutions for *T* and *E*:

$$T_i^* = (\mu)^{-1}[a_i \times t_i + c_i \times t_i \times \ln(E_i^* + 1)] \quad (6.7)$$

$$E_i^* = (\lambda)^{-1}[b_i \times t_i + c_i \times t_i \times \ln(T_i^*)] \quad (6.8)$$

The additional constraint for time budget constraint is as below:

$$a_i \times t_i \times ln(T_i) + b_i \times t_i \times ln(E_i + 1) + c_i \times t_i \times ln(T_i) \times \ln(E_i + 1) - \mu \times T_i = 0 \quad (6.9)$$

where μ reflects the time budget constraint of a person. Moreover, solving equation 6.9 for t results in equation 6.10. There are two solutions for t due to two budget constraints namely time and money budgets. Superscript 1 shows that *t* is solved for time budget constraint.

$$\left(t_i^{1*}\right)^{-1} = (\mu)^{-1} \begin{bmatrix} a_i \times ln(T_i) \times (T_i)^{-1} + b_i \times ln(E_i + 1) \times (T_i)^{-1} + \\ c_i \times ln(T_i) \times \ln(E_i + 1) \times (T_i)^{-1} \end{bmatrix} \quad (6.10)$$

The additional money budget constraint is as below:

$$a_i \times t_i \times ln(T_i) + b_i \times t_i \times ln(E_i + 1) + c_i \times t_i \times ln(T_i) \times \ln(E_i + 1) - \lambda \times E_i = 0 \quad (6.11)$$

where λ reflects the money budget constraint of a person and solving 6.11 for *t* gives:

$$\left(t_i^{2*}\right)^{-1} = (\lambda)^{-1} \begin{bmatrix} a_i \times ln(T_i) \times (E_i)^{-1} + b_i \times ln(E_i + 1) \times (E_i)^{-1} + \\ c_i \times ln(T_i) \times \ln(E_i + 1) \times (E_i)^{-1} \end{bmatrix} \quad (6.12)$$

Superscript 2 shows that t is solved for money budget. Equation 6.10 gives the optimum time-interval with respect to T and equation 6.12 with respect to E. However, there should not be two solutions for a single variable. In fact, conditions 6.4 and 6.5 are not accurate. In reality, one of the two resources might be the limiting factor and hence, it should be defined as:

$$\min(U_i - \mu \times T_i, U_i - \lambda \times E_i) = 0 \qquad (6.13)$$

This means that the optimality condition for interval time is defined as:

$$t_i^* = \max\left(t_i^{1*}, t_i^{2*}\right) \qquad (6.14)$$

However, this form is difficult in terms of estimation. Therefore, only 6.10 will be used for the estimation because duration is assumed to be more determining than expenditure decisions.

6.3 Estimation Method

In this section the estimation method of the model is presented. First, the empirical model and then the parameterization and identification of the model are explained.

6.3.1 Empirical model

Using the model (Equations 6.7, 6.8 and 6.10), observations can be described by the following equations.

$$T_{in} = (\mu_n)^{-1}[a_{in} \times t_{in} + c_{in} \times t_{in} \times \ln(E_{in} + 1)] + \varepsilon_{in}^T \qquad (6.15)$$

$$E_{in} = (\lambda_n)^{-1}[b_{in} \times t_{in} + c_{in} \times t_{in} \times \ln(T_{in})] + \varepsilon_{in}^E \qquad (6.16)$$

$$(t_{in})^{-1} = (\mu_n)^{-1}\begin{bmatrix} a_{in} \times ln(T_{in}) \times (T_{in})^{-1} + b_{in} \times ln(E_{in} + 1) \times (T_{in})^{-1} + \\ c_{in} \times ln(T_{in}) \times \ln(E_{in} + 1) \times (T_{in})^{-1} \end{bmatrix} + \varepsilon_{in}^t \qquad (6.17)$$

where T_{in}, E_{in} and t_{in} are observed duration, expenditure and interval time for an observed activity i of individual n and ε_{in}^T , ε_{in}^E and ε_{in}^t are error terms.

It should be noted that only the activities that are conducted by the respondents are used in the estimation. Although it is possible to consider the activities of a respondent that are not conducted (where frequency is 0), it is difficult for the system to estimate.

6.3.2 Functions and Parameters

In Chapter 4, the functions and parameters are given by section 4.3.2 and by equation 4.14. In this chapter, the same functions and parameters are used for estimating the model. However, with addition of interval time, income and working hours variables, the coefficients *a, b* and *c* and threshold parameters μ and λ have the following behavioral interpretation:

a, *b* and *c* are attraction parameters indicating the marginal utility of interaction between

- duration and interval time,
- expenditure and interval time,
- duration, expenditure and interval time for an activity.

μ and λ are budget-threshold parameters; they indicate the extent to which time and money is a scarce resource for the individual. Therefore, it is expected that these parameters co-vary with available time and money budgets.

Based on these notions the following parameterization is proposed which is the same as equation 4.14 in Chapter 4:

$$b_{in} = b_{i0} + \sum_j b_{ij} X_{ijn}, \quad a_{in} = a_{i0} + \sum_j a_{ij} X_{ijn}, \quad c_{in} = c_{i0}$$

$$\mu_n = \mu_0 + \sum_k \mu_k X_{kn}, \qquad \lambda_n = \lambda_0 + \sum_\ell \lambda_\ell X_{\ell n} \tag{6.18}$$

where i is an index of activity, n is an index of individual, j is an index of attraction variables, k is an index of time-budget variables (working hours) and ℓ is an index of money-budget variables (income). In sum, it is assumed that attractiveness parameters are a function of the activity and budget-parameters are a function of the individual (or household). As explained in Chapter 4, socio-demographic variables may co-vary with preferences (tastes) and, for that reason; they are included as attraction variables. Moreover, the new data set has information about the explanatory variables for time and monetary budget-threshold parameters namely working hours and income, thus the effects of these variables can be estimated in this chapter.

As noted in Chapter 4, the constants μ_0 and λ_0 could not be estimated both at the same time. Therefore, one of the parameters had to be set to one and the other parameter could be estimated based on the common factor *c* in the two equations. In this chapter, the equation for interval time (eq. 6.17) is also added to estimation. This equation allows estimating μ_0 and λ_0 and also the time and money budget variables μ_k, λ_ℓ at the same time.

As standard estimation methods of regression models cannot handle a form where the effects of an independent variable is given by a multiplication of two parameters (such as μ and a in the present model). The model (Eqs. 6.15, 6.16 and 6.17) is estimated using maximum likelihood estimation of joint T, E and t observations. The maximum likelihood function of joint T, E and t is shown in equation 6.19 where likelihood of T, E and t are multiplied. Equations 6.20, 6.21 and 6.22 show the likelihood functions of E, T and t respectively. The likelihood of expenditure is calculated by using normal distribution of observed expenditure, predicted expenditure and standard deviation of expenditure which is calculated by using OLS results. The same is done also for duration and interval time.

$$\mathcal{L} = \prod_{in} \mathcal{L}(T_{in}) \times \mathcal{L}(E_{in}) \times \mathcal{L}(t_{in}) \tag{6.19}$$

$$\mathcal{L}(E_{in}) = \emptyset(E_{in}, E_{in}^{*}, \sigma_E) \tag{6.20}$$

$$\mathcal{L}(T_{in}) = \emptyset(T_{in}, T_{in}^{*}, \sigma_T) \tag{6.21}$$

$$\mathcal{L}(t_{in}) = \emptyset(t_{in}, t_{in}^{*}, \sigma_t) \tag{6.22}$$

For this estimation, as suggested before in Chapter 4, a Newton-type optimization algorithm is applied for non-linear model estimation (NLM routine in R). Ordinary least square estimation results of equations 6.15, 6.16 and 6.17 are used as initial parameter values in the NLM routine. Still, there is the problem of endogeneity and to solve the endogeneity problem, the causal relationships between the equations should be taken into account. In theory, this could be done by using a structural equations model (SEM) approach as done before in Chapter 4. However, in this case where frequency decisions are added, a SEM framework is considerably more complex. Therefore, it is left for future research.

6.4 Application

In this section, first the explanation of data will be given. Next, the results of estimation are presented.

6.4.1 Data

The estimation results are based on the activity-episode level data set which is described detailed in Chapter 5. The dependent variables considered in the model specification are; duration of the activity, money spent during the activity, frequency of the activity in a month. Travel related variables are not considered in this application.

Moreover, the independent variables considered in the model specification are individual socio-demographics (gender and age), time-budget variable (working hours) and money-budget variable (income). The purpose of this application is to illustrate the methodology rather than having a final model, thus only a limited set of independent variables are considered. For the income variable, the mid-point of each income category is used. Gender and age are used as dummy variables while others are used as continuous variables. Moreover, *t* variable, which represents the interval time, is used as $f/30$ in the data where *f* is frequency per month.

The activity categories that are used for estimation are as before;

- Recreation such as walking in a park, cycling for pleasure, recreation near water or in a park,
- Sport Event Visit such as going to a football match
- Sporting
- Wellness, beauty and relaxation such as beauty treatments, sauna and spa visits
- Attraction Visit such as attraction park, zoo
- Event Visit such as exhibition, fairs, festival
- Culture such as going to cinema, concert, musical, museum
- Going Out such as bar, café, disco visits, eating out
- Hobbies, Courses and Others such as club activities, courses for hobbies

Mean values of activity episode expenditure, activity episode duration and frequency of activity per activity category can be seen in Table 5.3.

6.4.2 Estimation Results

In this section, the estimation results of the proposed model are presented. As said, the estimation is done by using maximum likelihood estimation of joint *T*, *E* and *t* observations. For this estimation, a Newton-type optimization algorithm is applied (NLM routine in R) based on a classification of leisure activities into nine activity categories.

The result of log-likelihood proves the improvement of the model. As the model is estimated across all activity categories, there is a single log-likelihood function for this estimation problem. The log-likelihood of the null model is -32186.85 and it increases to -24324.97 which gives Rho-squared (McFadden) as 0.24. It shows that the model has significant explanatory value.

The estimates on time and money budget thresholds are found to be significant. The parameter estimate for μ_0 is 1.060 with a t-value of 19.780 ($p < 0.001$), for λ_0 is 10.951

with a t-value of 12.105 (p< 0.001). Moreover, it is also found that the parameter estimate for working hours (μ_k) is 0.003 with a t-value of 4.715 (p< 0.001) and the parameter estimate for income (λ_ℓ) is -0.001 with a t-value of -3.965 (p< 0.001). These results support the theory that is described earlier. Since, it is assumed that if an individual has a low income level, money-budget threshold λ_ℓ is high and vice versa. According to the results, increasing income has a negative effect on money-budget threshold which can be interpreted as increasing income lowers the money-budget threshold. Moreover, it is assumed that if an individual has high working hours, time-budget threshold μ_k is also high and vice versa. According to the results, increasing working hours has a positive effect on time-budget threshold μ_k. Thus, increasing working hours increases the time-budget threshold.

In addition, as the ratio between μ_0 and λ_0 gives an estimate of value of leisure, it is found that 1 hour of leisure time is equal approximately to 6 Euro for the base case. Jara-Diaz et al. (2008) reported that estimated value of leisure is found to be 2.9 US$/h for Santiago, 12.7US$/h for Karlsruhe and 26.7 US$/h for Thurgau. The value that is found in this chapter is lower compared to the results of European cities.

In terms of interpretation of results, the effect of socio-demographic variables are seen on the utility of duration and utility of expenditure as in Chapter 4. However, in this chapter *a* and *b* parameters show a speed of increase of utility of duration and expenditure respectively with interval time *t*.

According to the results, the scale of parameter estimates for the utility of duration is found to be very large. As the equation 6.15 shows, this parameter depends on the scale of *t* variable and *X* variables which are used as dummy variables. The large scale of parameter estimates for utility of duration is due to the small scale of t variables.

Regarding gender effect, being female has a negative effect on the utility of duration for sporting activity. Moreover, being female has a positive effect on the utility of expenditure for wellness. Being female has a positive effect on the utility of duration for attraction visit and event visit activities. For culture activity, being female has a negative effect on the utility of duration while it has a positive effect on the utility of expenditure. This result shows that females make a trade-off between utility of time and expenditure for culture activity differently than men. Furthermore, being female has a positive effect on the utility of duration while it has a negative effect on the utility of expenditure for hobbies, courses and other activity category. This result also shows that female respondents make a trade-off between utility of time and expenditure for this activity category differently than men.

Considering age category, the utility of duration for outside recreation is lower for people aged between 36 and 64. In addition, the utility of duration for sporting is higher for this age group. For culture and other activity, this age group has a positive effect on the utility of duration while it has a negative effect on the utility of expenditure. Moreover, for going out activity, this age group has a negative effect on the utility of duration while it has a positive effect on the utility of expenditure. These results show that people aged between 36 and 64 make trade-off between utility of duration and expenditure for culture, other and going out activities differently than people aged less than 36 years.

Table 6.1 Estimation Results

		Duration		Expenditure	
Activities	Variables	Estimate	t-value	Estimate	t-value
Outside Recreation	constant	224.761	18.813	14.220	4.418
	Female	7.062	0.355	-0.626	-0.202
	36-64 years	-75.679	-6.357	1.243	0.380
	65+ years	-116.568	-3.427	2.628	0.500
	c-parameter	11.896	1.692		
Sport Event Visit	constant	993.997	5.549	17.736	3.225
	Female	11.225	0.065	6.280	0.965
	36-64 years	21.447	0.115	-9.098	-1.425
	65+ years	-559.894	-14.751	-229.824	0.822
	c-parameter	938.671	9.665		
Sporting	constant	208.529	9.135	9.967	2.857
	Female	-103.621	-6.179	4.913	1.430
	36-64 years	96.300	3.016	-6.734	-1.755
	65+ years	53.988	0.943	-11.582	-1.780
	c-parameter	75.332	5.591		
Wellness	constant	37.721	1.083	37.878	8.877
	Female	-351.401	0.135	8.200	4.522
	36-64 years	73.215	0.931	0.508	0.171
	65+ years	4790.995	1.510	-46.042	-1.175
	c-parameter	2269.109	9.799		

Table 6.1 Estimation Results (continue)

		Duration		Expenditure	
Activities	Variables	Estimate	t-value	Estimate	t-value
Attraction Visit	constant	15.741	0.140	42.294	12.859
	Female	491.388	2.704	-1.527	-0.491
	36-64 years	-143.487	0.143	2.071	1.367
	65+ years	-1146.454	-61.278	19.115	6.010
	c-parameter	4423.187	15.845		
Event Visit	constant	217.967	2.428	36.466	8.949
	Female	371.518	2.637	-2.271	-0.543
	36-64 years	-128.215	0.986	4.607	1.768
	65+ years	-216.329	0.113	1.560	0.677
	c-parameter	1274.682	11.453		
Culture	constant	560.256	6.836	24.480	7.124
	Female	-781.656	-18.948	22.947	9.819
	36-64 years	1222.986	10.718	-25.883	-7.279
	65+ years	1245.805	5.703	-25.956	-4.041
	c-parameter	573.160	10.664		
Going Out	constant	264.838	4.513	18.391	6.014
	Female	-48.419	-0.587	4.085	1.446
	36-64 years	-113.594	-3.119	4.553	2.024
	65+ years	-843.568	-8.896	17.323	3.859
	c-parameter	783.533	13.436		
Hobbies, Courses and Other	constant	-90.009	-1.563	29.049	6.651
	Female	359.624	4.669	-9.520	-2.056
	36-64 years	327.128	4.314	-15.856	-3.276
	65+ years	183.644	1.227	-6.081	-0.667
	c-parameter	294.325	7.315		

Being older than 65 has a negative effect on the utility of duration for outside recreation and sport event visit activity. Moreover, it has a negative effect on the utility of duration while it has a positive effect on the utility of expenditure for attraction visit and going out. Furthermore, being older than 65 years has a positive effect on the utility of duration while it has a negative effect on the utility of expenditure for culture activity.

These results show that this age group makes trade-off between utility of duration and expenditure for attraction visit, going out and culture activities differently than people aged less than 36 years.

The c-parameter determines the relation between spending money and time. The c-parameter is found to have a significant positive effect on the interaction of interval time, duration and expenditure for all activity categories, except outside recreation. This means the utility of expenditure increases with increasing duration and vice versa which is in line with the theoretical assumption.

6.5 Conclusion

This chapter extends the utility function and therefore estimation method that is proposed in Chapter 4. It shows that activity timing decisions of individuals such as frequency on an activity in a month can be integrated to the previously proposed model. As a result, the model considers the decision of the quantities for duration and expenditure spent during the activity and also the frequency of activity in a month at the activity episode level. For estimation, the activity-episode level data set which is described detailed in Chapter 5 is used. In this chapter, it is shown that this model can be estimated by using a maximum likelihood estimation of joint frequency, duration and expenditure observations.

The analysis reveals that age and gender influence the utility of duration and expenditure of activities at episode level. The analysis provides plausible results and the log likelihood of the model shows that the model has significant explanatory value. The results also capture trade-off between utility of duration and expenditure for activity categories. Moreover, including the frequency of activities in the empirical model (Eq. 6.16) allows estimating both time and money budget-threshold parameters at the same time. Thus, these results prove that working hours and income have significant effect on time and money budget thresholds respectively, at activity episode level. In addition, these effects are found to be in line with the theory. Furthermore, c-parameter is found to be significantly positive for all activity categories, except outside recreation. Although it is not significant for outside recreation activity, it is found to be positive. This positive effect can be seen on the interaction of duration, expenditure and interval time for all activity categories which means the utility of duration increases with increasing expenditure and interval time and vice versa.

Frequency is important in order to understand duration and expenditure decisions as frequency influences these decisions. The model used in this chapter shows a speed of increase of utility of duration and expenditure respectively with interval time *t.* However, the error terms of duration, expenditure and interval time are found to be correlated hence the endogeneity still remains as a problem. In order to solve the endogeneity problem, the causal relationships between the equations should be taken into account. In theory, this could be done by using SEM approach as shown in Chapter 4. However, adding frequency decisions results in a more complex SEM framework. Therefore, this problem should be solved in a future research.

Overall, this chapter described an operational model for predicting duration, expenditure and frequency decisions of individuals simultaneously. This model can be used in a dynamic simulation. The method for a dynamic simulation is, given the last time activity conducted, every day the time constraint in equation 6.4 is checked to decide whether an activity will be conducted or not. This is done by using the predicted duration and expenditure values obtained by equations 6.7 and 6.8.

7

Understanding Savings

7.1 Introduction

In Chapter 5, it is explained that savings are considered in the stated adaptation component of data collection. As the theoretical framework suggests, people conduct their activities under time and money budget constraints. These constraints are generally set by working hours and income. Therefore, it is important to understand how people adapt their time and money expenditures to their activities and how they change their behavior in order to save time and money when there is a change in their constraints. To examine this content, this chapter explores the determinants of time and money saving behavior. For this aim, standard logit analyses are conducted in this chapter for descriptive purposes on the data from the survey that is described in Chapter 5. The analyses are done separately for time saving and money saving situations. The chapter is organized as follows.

First, in order to understand how savings are distributed across activity categories and what the determinants of this distribution are, a multinomial logit analysis is conducted. This analysis explores the effect of activity-specific variables, interaction between individual-level variables and activity categories, and the interaction between activity-specific variables and activity categories on the distribution of total amount saved across activity categories.

Next, Section 7.3 aims to understand whether there are different patterns in saving behaviors when individuals are grouped according to their saving behavior. Thus, first a cluster analysis is conducted in order to group individuals. Then a multinomial logit analysis is applied on clusters to understand the effect of individual-level variables on the membership of a cluster.

Following, to understand how individuals change their behavior in order to save time and money, a multinomial logit analysis is applied. This analysis explores the effect of activity-categories, individual-level variables and activity-specific variables on the indicated ways of time/money saving such as reducing activity frequency, reducing the episode duration/expenditure of activity, choosing a faster/cheaper transport mode, choosing a closer activity location and multiple options. Finally, the chapter is ended with summary of all sections and conclusion.

7.2 A Multinomial Logit Analysis on Savings

This section gives an explanation on the method and results of a multinomial logit analysis in order to understand what the determinants of distribution of the total amount to be saved across activity categories are. The same method described below is used for both time and money saving adaptations however, the analyses are done separately.

7.2.1 Method

A multinomial logit model is used to analyze the distribution of time and money savings across activity categories. Only the activities on which respondents indicated to spend time/money in the current situation are included in the analysis. Since, respondents can adapt their savings for the activities only if they spend time/money on that activity in the current situation.

For this aim, the activities are considered as choice alternatives and the distribution of a total amount to be saved across activities is considered as the choice behavior to be modeled. Several types of explanatory variables are considered in the model specification which are (1) activity-specific variables (activity frequency, activity-episode duration, travel-episode duration, activity-episode expenditure, travel-episode expenditure), (2) individual-level variables (gender, age, the number of persons in the household, number of autos in the household, working hours, income and total amount of time/money to be saved (stated by the scenario)), and (3) activity categories (outside recreation, sport event visit, sporting, wellness and beauty, attraction visit, event visit, culture, going out and, hobbies, courses and other).

In the model, activity categories are added as alternative-specific constants, and activity-specific variables are considered as attributes of choice alternatives. In addition to that, interaction effects between individual-level variables and alternative-specific constants, and between attributes of choice alternatives and alternative-specific constants are included in the analysis. The dependent variable is the distribution of total amount saved across activity categories which is calculated by dividing the saved amount of time/money of an activity to the total amount to be saved for each respondent. This gives the proportion of saving for activity categories. Hobbies, Courses and Others activity is used as the base category in the analysis. Activity frequency, activity-episode duration, travel-episode duration, activity-episode expenditure and travel-episode expenditure in the current situation are used as continuous variables while the others are coded as dummy variables. Estimates are obtained by using the economic software NLOGIT version 4.0 (Greene, 2007).

7.2.2 Results on Time Saving

Table 7.1 represents the estimation results. Only the significant variables are included in the model. The coefficients in the table indicate the effects of variables on the distribution of total amount of time saved across activity categories which indicates the proportion of saving time for an activity. McFadden's Rho-square is found to be 0.129.

Although alternative-specific constants (activity categories) are added to the estimation, none of them are found to be significant. This shows that there is no effect of activity category on the proportion of saving time. With respect to the effects of activity-specific variables, it is found that activity frequency has a positive effect on the proportion of saving time which means with increasing frequency of an activity, the proportion of saving time increases. Moreover, it is also found that the proportion of time saving increases with increasing activity-episode duration and travel-episode duration. This is a plausible effect because, in general, if more time is spent on an activity, the probability of saving time from the activity will be higher. Increasing activity-episode expenditure and travel-episode expenditure do not have significant effect on the proportion of time saving.

Regarding the interaction effects between individual-level variables and activity categories, only the interaction between total time saving and outside recreation is found to be significant. This interaction has a positive effect on the proportion of time saving. This result shows that the increasing amount of total time to be saved increases the proportion of time saving for outside recreation activity.

Considering the interaction effects between activity-specific variables and activity categories, frequency has a negative effect on the proportion of saving time for outside recreation while it has a positive effect on the proportion of saving time for going out. This indicates increasing frequency of outside recreation decreases the proportion of saving time for this activity while increasing frequency increases the proportion of saving time for going out. Finally, it is found that the increasing activity-episode duration decreases the proportion of saving time for attraction visit.

7.2.3 Results on Saving Money

Table 7.2 represents the estimation results. Only the significant variables are included in the model. The coefficients in the table indicate the effects of variables on the proportion of saving money. McFadden's Rho-square is found to be 0.011 which indicates that explanatory power of the considered variables on probability of money saving is very low.

Table 7.1 Estimation result for the proportion of saving time

Variables	B	Sig
Frequency	0.140	0.000
Activity-Episode Duration	0.005	0.000
Travel-Episode Duration	0.007	0.017
Total Time Saving*Outside Recreation	0.001	0.001
Frequency*Outside Recreation	-0.088	0.000
Frequency*Going Out	0.072	0.040
Activity-Episode Duration*Attraction Visit	-0.008	0.042
Number of Observations	402	
Log likelihood Null	-468.955	
Log likelihood Full	-538.368	
McFadden Pseudo R-squared	0.129	

Table 7.2 Estimation result for the proportion of saving money

Variables	B	Sig
Attraction Visit	1.421	0.000
Event Visit	0.500	0.044
Going Out	0.530	0.024
Frequency	0.082	0.000
Activity-Episode Expenditure	0.026	0.000
Travel-Episode Expenditure	0.018	0.018
Full-Time Work*Going Out	-0.454	0.095
Frequency*Outside Recreation	-0.068	0.002
Frequency*Sport Event Visit	0.138	0.056
Frequency*Going Out	0.105	0.032
Activity-Episode Expenditure*Outside Recreation	0.051	0.000
Activity-Episode Expenditure*Attraction Visit	-0.017	0.000
Travel-Episode Expenditure*Sporting	0.115	0.005
Number of Observations	400	
Log likelihood Null	-497.907	
Log likelihood Full	-503.338	
McFadden Pseudo R-squared	0.011	

Considering activity categories, attraction visit, event visit and going out activities are found to have a positive effect on the proportion of money saving. Regarding the main effects, it is found that increasing frequency increases the proportion of saving money for out-of-home leisure activities. Moreover, activity-episode expenditure and travel-episode expenditure have both a positive effect on the proportion of saving money. This indicates that with increasing activity-episode expenditures and travel-episode expenditures, the proportion of saving money also increases. This is a plausible effect because, in general, if more money is spent on an activity, the money saved for this activity will be higher. Moreover, increasing activity-episode duration and travel-episode duration are not found to have significant effect on the proportion of money saving.

Considering the interaction effects of individual-level variables and activity categories, only the interaction between full-time working and going out activity is found to be significant. The interaction between full-time working and going out has a negative effect on the proportion of saving money. This result indicates that individuals who work full-time save less money from going out.

Frequency has also effect on the proportion of saving money at activity category level. The interaction between outside recreation and frequency is found to be negative. This result shows that with increasing frequency of outside recreation, the proportion of saving money from that activity increases less than other activities. Furthermore, it is found that the interaction between frequency and sport event visit has a positive effect on the proportion of saving money. It is also found that the interaction between frequency and going out has a positive effect on the proportion of saving money. These results show that with increasing frequency, the proportion of saving money for sport event visit and going out increases above average increase of other activities.

The interaction between activity-episode expenditure and outside recreation has a positive effect on the proportion of saving money while the interaction between activity-episode expenditure and attraction visit has a negative effect on it. These results indicate that with increasing expenditure of activity per episode, the proportion of saving money increases for outside recreation above average. In addition, it increases for attraction visit less than the average increase of other activities. Finally, the results show that with increasing expenditure of travel per episode, the proportion of saving money increases for sporting.

7.3 A Multinomial Logit Analysis on Saving Clusters

In the previous section, the effect of activity-specific variables and the interaction effects between individual-level variables and activity categories and, activity-specific variables and activity categories on the distribution of the total amount to be saved across activity categories were analyzed. However, very few of the interactions between individual-level variables and activity categories are found to have significant effect on both proportion of saving time and money. Also the activity categories are not found to be significant for the proportion of time saving which shows that there is no effect of activity category on the proportions of time that individuals are willing to save.

In this section, again the determinants of distribution of the total amount to be saved across activity categories are explored in order to obtain more insights whether there are different patterns in behavior. For this aim, a cluster analysis is conducted to group individuals with similar type of saving behavior. Following, a multi-nominal logit regression is applied to understand the effect of individual-level variables on the membership of saving clusters. These analyses are done separately for time saving and money saving adaptations.

For clustering, first, the distribution of total amount saved across activity categories for each respondent is calculated by dividing the saved amount of time/money for an activity to the total amount to be saved. This gives the proportion of saving for activity categories. Differently from the above section, all activity categories for each respondent are entered in the analysis. Thus, in this section, the results are sensitive to how people spend their resources in the current situation. For instance, if one does not spend money on an activity, the saving will also be zero. Therefore, the results are not about choice behavior conditional upon an current situation but it is about how people overall implement their savings.

For this analysis, first, K-means clustering method is used both on proportion of time and money savings for each activity category. K-means clustering is a method of cluster analysis aiming to partition *n* observations into *k* clusters in which each observation belongs to the cluster with the nearest mean. To determine the number of clusters, the elbow technique is used. This technique requires looking at the ratio of the between-classes variance to the total variance for clustering. Adding a cluster to the analysis increases the information gained and therefore, this ratio increases. However, at some point marginal gain of adding a new cluster decreases. The number of clusters is chosen at the point where the marginal gain of adding a new cluster decreases (Thorndike, 1953).

Second, the cluster membership results for each respondent are used as dependent variable in multinomial logit analysis. The determinants for this analysis are the individual-level variables. Age, number of persons in the household, number of cars in the household and total amount of time to be saved are used as continuous variables while the others are used as dummy variables. The results explain the effect of individual-level variables on the membership of clusters. Statistical analysis software SPSS is used to obtain results for both k-means clustering and multinomial logit analyses.

In the following sub-sections, first the analysis on the proportion of time saving analysis then on the proportion of money saving analysis is given.

7.3.1 Results on Saving Time

7.3.1.1 K-means Clustering

K-means cluster analysis is conducted on the proportions of time saving of activity categories. Figure 7.1 shows the ratio of the between-classes variance to the total variance of clustering for proportions of time saving. The marginal gain starts to decrease after 7th cluster. Therefore, as the elbow technique suggests, 7 clusters are used for k-means clustering.

Table 7.3 shows the cluster centers for time saving proportions of each activity and also the number of observations for each cluster. Each cluster can be described by the variables' mean values. It can be seen that individuals in Cluster 1 tend to save time mostly from sporting activity followed by outside recreation. Individuals in cluster 2 tend to save time mostly from attraction visit activity followed by outside recreation. In Cluster 3, more variation is seen between activities. Individuals in that cluster tend to save time respectively from culture, event visit, going out and outside recreation. In Cluster 4 individuals tend to save mostly from outside recreation activity. In cluster 5 individuals tend to save time mostly from going out. In Cluster 6, individuals tend to save time mostly from other activities such as hobbies. Finally, in Cluster 7, individuals tend to save time mostly from sport event visit.

Figure 7.1 The ratio of between-classes variance and number of clusters

Table 7.3 Cluster centers of the proportions of time saving for each activity category

Activities/Clusters	1	2	3	4	5	6	7
Outside Recreation	0.130	0.103	0.146	0.796	0.095	0.074	0.118
Sport Event Visit	0.028	0.013	0.028	0.005	0.015	0.019	0.771
Sporting	0.639	0.053	0.045	0.015	0.056	0.025	0.030
Wellness	0.017	0.015	0.077	0.006	0.013	0.000	0.001
Attraction Visit	0.026	0.584	0.044	0.036	0.052	0.036	0.023
Event Visit	0.014	0.033	0.202	0.016	0.020	0.038	0.000
Culture	0.042	0.091	0.247	0.022	0.027	0.004	0.000
Going Out	0.069	0.090	0.159	0.087	0.704	0.042	0.026
Other	0.036	0.018	0.052	0.017	0.017	0.761	0.030
Observations	59	56	92	77	74	28	16

7.3.1.2 Multinomial Logit Analysis on the Membership of Time Saving Clusters

The estimation results of multinomial logit analysis on the membership of time saving clusters are shown in Table 7.4. Cluster 2 which contains mostly attraction visit activity is used as the base category for this analysis. The model has a relatively low Rho-squared (McFadden) of 0.064, which indicates that the explanatory power of individual-level variables is only modest.

According to the results, being female has a negative effect on the probability of membership of Cluster 1 which contains mostly sporting activity. Moreover, increasing total amount of time to be saved has a positive effect on the probability of membership of this cluster. Regarding the membership of Cluster 3 which contains mostly culture, event visit, going out and outside recreation activities, increasing age has a positive effect on the probability of belonging to this cluster. Furthermore, there is a negative effect of no work category on the probability of membership of Cluster 3. Moreover, increasing total amount of time to be saved has a positive effect on the probability of belonging to Cluster 3.

Considering the membership of Cluster 4 which includes mostly outside recreation, increasing age has a positive effect on the probability of membership. Furthermore, increasing number of persons in the household has a negative effect on the probability of belonging to this cluster. Finally, increasing number of autos is found to have a negative effect on the probability of membership of this cluster. With respect to Cluster 5 which includes mostly going out, increasing age is found to have a positive effect on the probability of membership. Moreover, increasing number of persons in the household has a negative effect. It is found that no work category has a negative effect on the probability of belonging to Cluster 5.

Regarding Cluster 6 which contains mostly hobbies, courses and other category, it is found that increasing age has a positive effect on the probability of membership. Moreover, middle income is found to have a negative effect on the probability of belonging to this cluster. Finally, considering Cluster 7 which contains mostly sport event visit, increasing age is found to have a positive effect on the probability of membership. In addition, increasing number of autos is found to have a negative effect on the probability of membership of Cluster 7.

Table 7.4 Estimation results for the probability of membership of time saving clusters

	Cluster 1	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Intercept	0.503	-0.665	0.494	1.264	-2.512*	-1.119
Gender (base: Male)						
Female	-0.905**	0.148	-0.029	-0.514	0.206	0.01
Age	0.013	0.045**	0.052**	0.026*	0.058**	0.056**
Number of Persons	-0.097	-0.199	-0.335**	-0.329**	-0.077	0.227
Working Hours (base: Part-time)						
No work	0.139	-0.845*	-0.818	-1.52**	-1.13	-1.378
Full-time	-0.256	0.089	-0.121	-0.655	0.221	-0.389
Income						
(base: Low income)						
Middle Income	-0.15	-0.445	-0.424	-0.609	-1.038*	-0.773
High Income	0.241	-1.034	-0.977	-0.091	-0.508	-0.571
Number of Autos	-0.341	-0.168	-0.559**	-0.127	-0.101	-1.12**
Total Time Saving	0.001**	0.001*	0.000	0.000	0.001	0.000
Number of Observations		402				
Log likelihood Null		-1475.876				
Log likelihood Full		-1381.038				
Chi Squared		94.838				
McFadden Pseudo R-squared		0.064				

*Significant at .10 level, **significant at .05 level, ***significant at .01 level

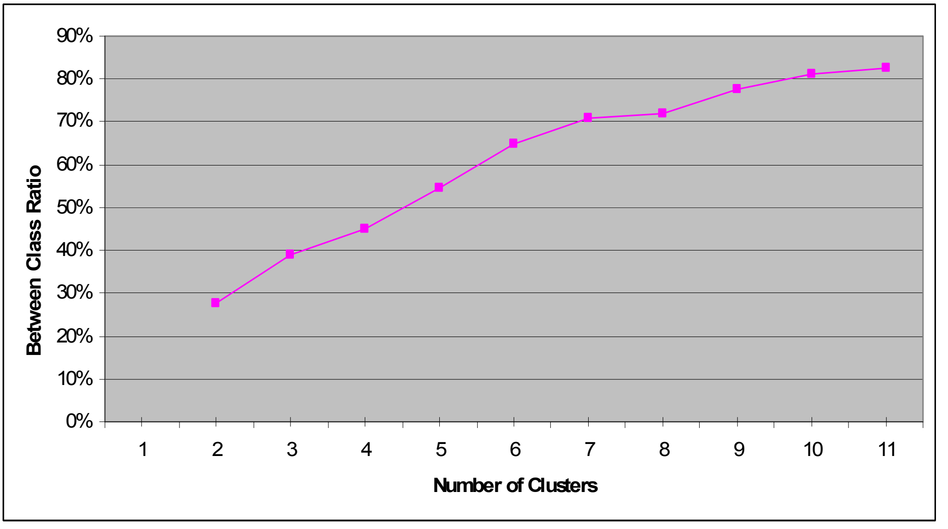

Figure 7.2 The ratio of between-classes variance and number of clusters

Table 7.5 Cluster centers of the proportions of money saving for each activity category

Activities/Clusters	1	2	3	4	5	6
Outside Recreation	0.655	0.038	0.022	0.018	0.030	0.026
Sport Event Visit	0.039	0.108	0.012	0.032	0.013	0.002
Sporting	0.025	0.039	0.016	0.020	0.745	0.013
Wellness	0.026	0.096	0.009	0.020	0.007	0.005
Attraction Visit	0.041	0.088	0.038	0.774	0.058	0.032
Event Visit	0.036	0.218	0.024	0.012	0.021	0.040
Culture	0.034	0.243	0.024	0.032	0.043	0.006
Going Out	0.131	0.145	0.848	0.084	0.061	0.054
Other	0.013	0.025	0.008	0.008	0.023	0.791
Observations	58	110	126	51	34	21

7.3.2 Results on Saving Money

7.3.2.1 K-means Clustering

K-means cluster analysis is conducted on the proportions of money saving for activity categories. Figure 7.2 shows the ratio of the between-classes variance to the total variance of clustering for proportions of money savings. According to the elbow technique, 6 clusters are used for k-means clustering because the marginal gain starts to decrease after 6th cluster.

Table 7.5 shows the cluster centers for proportion of money saving of each activity and also the number of observations for each cluster. This table describes each cluster by the variables' mean values. It is found that individuals in Cluster 1 tend to save money mostly from outside recreation. In Cluster 2, more variation is seen between activities. Individuals in that cluster tend to save money respectively from culture, event visit, going out and sport event visit. Individuals in cluster 3 tend to save money mostly from going out. In Cluster 4, most money is saved from attraction visit. In cluster 5 individuals tend to save money mostly from sporting. Finally, in Cluster 6, money is saved mostly from other activities such as hobbies.

7.3.2.2 Multinomial Logit Analysis on the Membership of Money Saving Clusters

The estimation results of multinomial logit analysis on the membership of money saving clusters are shown in Table 7.6. Cluster 4 which contains mostly attraction visit activity is used as the base category for this analysis.

According to the results, increasing age has a positive effect on the probability of membership of Cluster 1 which contains mostly outside recreation. Regarding Cluster 2 which includes culture, event visit, going out and sport event visit activities, being female has a positive effect on the probability of membership. Moreover, it is found that no work category has a negative effect on the probability of belonging to Cluster 2. In addition, increasing amount of money to be saved has a positive effect on the probability of membership of Cluster 2.

Considering Cluster 3 which contains mostly going out, no-work category has a negative effect on the probability of belonging to this cluster. In addition, increasing amount of money to be saved has a positive effect on the probability of membership. Moreover, no significant effects of individual-level variables are found on Cluster 5 which includes mostly sporting. Regarding Cluster 6 which contains mostly hobbies, courses and other category, increasing age has a positive effect on the probability membership. Full-time working has a negative effect on the probability of belonging to this cluster. Finally, it is found that high income has a negative effect on the probability of membership of Cluster 6. The model has a low Rho-squared (McFadden) of 0.050, which indicates that the explanatory power of individual-level variables is low.

Table 7.6 Estimation results for money saving clusters

	Cluster 1	Cluster 2	Cluster 3	Cluster 5	Cluster 6
Intercept	-1.675	0.222	0.589	-1.576	-3.540**
Gender (base: Male)					
Female	0.520	0.766*	-0.119	-0.204	0.256
Age	0.030**	0.013	0.021	0.010	0.063***
Number of persons	-0.149	-0.200	-0.168	-0.309	-0.024
Working Hours (base: Part-time)					
No work	-0.282	-0.961**	-0.906**	-0.040	0.023
Full-time	0.625	0.138	-0.496	0.183	1.307*
Income (base: Low income)					
Middle Income	0.180	0.427	0.021	0.853	-0.343
High Income	-1.057	-0.806	-0.261	0.249	-2.445**
Number of Autos	0.129	-0.037	0.032	0.347	-0.332
Total Money Saving	0.002	0.003*	0.003*	0.003	0.002
Number of Observations	400				
Log likelihood Null	-1297.830				
Log likelihood Full	-1232.522				
Chi Squared	65.308				
McFadden Pseudo R-squared	0.05				

*Significant at .10 level, **significant at .05 level, ***significant at .01 level

7.4 A Multinomial Logit Analysis on Ways of Saving

As explained in Chapter 5, respondents are asked to indicate how they would change their behavior for saving time and money. The given options for time saving are; reducing frequency, reducing the episode duration of activity, choosing a faster transport mode, choosing a closer location for activity and no change. Moreover, the given options for money saving are; reducing frequency, reducing the episode expenditure of activity, choosing a cheaper transport mode, choosing a closer location for activity and no change. Respondents could also choose multiple options to indicate their behavior for saving.

In this section, a multinomial logit analysis is applied on the ways of saving time and money, respectively. For the analysis, indicated ways of saving are used as dependent variable. The multiple options are not chosen very frequently, thus, all chosen multiple options are considered as one category for the estimation. Moreover, only the cases, where savings are observed, are used in this analysis. As a result, no change category is omitted from the analysis. Therefore, the dependent variable has 5 levels. Reducing frequency level is used as the baseline for the analysis.

The results indicate the effect of activity-specific variables (activity frequency, activity-episode duration, travel-episode duration, activity-episode expenditure, travel-episode expenditure), individual-level variables (gender, age, the number of persons in the household, number of autos in the household, working hours, income and total amount of time to be saved (stated by the scenario)), and activity categories (outside recreation, sport event visit, sporting, wellness and beauty, attraction visit, event visit, culture, going out and, hobbies, courses and other) on ways of saving adaptation. Gender is used as dummy variable while all other variables are used as continuous. The analysis is done separately for time and money saving adaptations. The economic software NLOGIT version 4.0 is used for obtaining results.

7.4.1 Ways of Time Saving

The estimation results are given in Table 7.7. The Rho-squared is found to be 0.067.

Results show that except choosing faster transport mode category, the constants for baseline activity, which is hobbies, courses and other activities category, are found to be positively significant. Regarding effects of each activity category on the baseline constant, the results indicate that there is no explicit effect of activity categories on ways of saving time.

Regarding individual-level variables, increasing age has a negative effect on choosing faster transport mode and closer activity location options for saving time. Being female has a negative effect on choosing closer activity location for saving time. Increasing number of persons in the household has a positive effect on reducing episode duration of activity while it has a negative effect on choosing closer activity location for saving time. Moreover, increasing working hours has a negative effect on reducing the episode duration and choosing closer activity in order to save time. This result shows that individuals with higher working hours tend to save time by reducing frequency or choosing another transport mode. It is found that increasing income has a positive effect on reducing episode duration, choosing faster transport mode and choosing closer location. The results indicate that increasing number of autos has a negative effect on choosing faster transport mode. Finally, it is seen that increasing total amount of time to be saved has a negative effect on choosing faster transport mode and multiple options.

Table 7.7 Estimation Results for Ways of Time Saving

	Episode Duration	Transport Mode	Activity Location	Multiple Options
Constant	2.605***	1.662	5.275**	0.267*
Activity Categories (base: Other)				
Outside Recreation	-0.192	0.034	-0.286	-0.564
Sport Event Visit	0.891	0.372	0.575	0.445
Sporting	0.188	0.259	-0.723	-0.292
Wellness and Beauty	-0.682	0.157	-0.394	-0.596
Attraction Visit	0.096	-0.202	0.839	-1.108***
Event Visit	0.429	-0.127	-0.070	-0.656
Culture	-0.378	-0.098	-0.228	-0.468
Going Out	-0.557	-0.215	-0.205	-0.326
Individual-level Variables				
Age	-0.014	-0.012**	-0.055***	0.003
Female	-0.088	-0.057	-1.336***	0.070
Number of Persons	0.182*	0.024	-0.306**	-0.010
Working Hours	-0.026***	-0.003	-0.029**	-0.009
Income	0.383**	0.146*	0.805***	-0.138
Number of Autos	-0.212	-0.175*	0.031	0.175
Total Time Saving	-0.243	-0.181*	-0.249	-0.318***
Activity-Specific Variables				
Frequency	-0.035	0.102	0.128	0.209
Activity Duration	-0.830***	-0.052	-1.176***	0.100
Travel Duration	0.397***	0.048	0.214	0.237***
Activity Expenditure	-0.034	-0.002	-0.043	-0.123
Travel Expenditure	0.141	-0.049	0.301*	0.133
R-squared	0.067			

*Significant at .10 level, **significant at .05 level, ***significant at .01 level

With respect to activity-specific variables, the results indicate that increasing activity duration has a negative effect on reducing episode duration and also on choosing closer location. Moreover, increasing travel duration is found to have a positive effect on reducing the activity duration and choosing multiple options. Finally increasing travel expenditure is found to have a positive effect on choosing closer location in order to save time.

Table 7.8 Estimation Results for Ways of Money Saving

	Episode Expenditure	Transport Mode	Activity Location	Multiple Options
Constant	-2.104*	0.235	3.120**	-2.348***
Activity Categories (base: Other)				
Outside Recreation	-0.946*	-0.376	0.114	-0.914*
Sport Event Visit	-1.488**	-0.927*	-1.477*	-1.838***
Sporting	-1.603**	-0.204	0.474	-0.836
Wellness and Beauty	-2.334***	-1.339**	-1.461	-1.567***
Attraction Visit	-1.781***	-0.901**	-1.286*	-1.434***
Event Visit	-1.121**	-0.869*	-1.126	-1.065**
Culture	-2.173***	-0.548	-0.806	-0.895*
Going Out	-1.649***	-0.839**	-1.682**	-1.045**
Individual-level Variables				
Age	0.029***	-0.007	-0.028***	0.008
Female	0.097	0.188	-0.586*	0.626***
Number of Persons	0.119	0.023	-0.125	0.119
Working Hours	0.001	0.000	-0.011	0.000
Income	-0.125	0.089	0.025	0.114
Number of Autos	0.138	-0.184	-0.350	0.217
Total Money Saving	0.437***	0.096	0.091	-0.054
Activity-Specific Variables				
Frequency	-0.189	-0.038	-0.313	0.175
Activity Expenditure	-0.488***	0.105	-0.243	-0.060
Travel Expenditure	0.403***	-0.248***	0.112	0.212
Activity Duration	-0.197	0.001	-0.272*	-0.083
Travel Duration	0.014	0.049	0.312*	0.166
R-squared	0.076			

*Significant at .10 level, **significant at .05 level, ***significant at .01 level

7.4.2 Ways of Money Saving

The estimation results are given in Table 7.8. The Rho-squared is found to be 0.076.

The results show that except choosing cheaper transport mode category, the constants for baseline activity, which is hobbies, courses and other activities category, are found to be significant. Regarding effects of each activity category on the baseline constant, the results indicate that there are effects of activity categories on the ways of saving money. For reducing episode expenditure, parameters indicate strongest negative effect for wellness and beauty and followed by culture (compared to hobbies and other). Moreover, for choosing cheaper transport mode, parameters indicate significant strongest negative effect for wellness and beauty, followed by sport event visit, attraction visit, event visit and going out. For choosing closer activity location, going out has strongest negative significant effect followed by sport event visit and attraction visit. For choosing multiple options, sport event visit has the strongest negative significant effect followed by wellness and beauty, attraction visit and event visit.

With respect to individual-level variables, increasing age has a positive effect on reducing episode expenditure while it has a negative effect on choosing closer activity location. Being female has a negative effect on choosing closer activity location while it has a positive effect on choosing multiple options. Increasing total amount to be saved has a positive effect on reducing episode expenditure.

Considering activity-specific variables, increasing activity expenditure has a negative effect on reducing episode expenditure in order to save money. Moreover, the results indicate that increasing travel expenditure has a positive effect on reducing episode expenditure while it has a negative effect on choosing cheaper transport mode in.

Furthermore, increasing activity duration has a negative effect on choosing closer location. Finally, it is found that increasing travel duration has a positive effect on choosing closer activity location.

7.5 Summary and Conclusion

This chapter tries to understand how people adapt their time and money expenditures to their activities and how they change their behavior in order to save time and money when there is a change in their constraints which are working hours and income. Three different analysis are conducted separately on adaptations of time saving and money saving.

The first analysis is done to understand how individuals distribute the total amount to be saved across activity categories and what the determinants are for this distribution. In this analysis, only the activities where savings are observed for each respondent are included. The results show that activity categories have no significant effect on the proportion of time saving. Possibly individuals have no preference for the activities as the time has to be saved in general from out-of-home leisure activities. However, it is found that attraction visit, event visit and going out activities have a positive effect on the proportion of money saving. Moreover, the analysis indicated that activity-specific variables such as frequency, activity episode duration and travel episode duration have positive effect on the proportion of savings of time. This result shows that the more time spent on an activity in the current situation, the more time is saved when the time budget is constrained. The same holds for the money savings. However, it is seen that those activity-specific variables may affect the proportions of time and also money saving differently at the activity level. It is also found that activity and travel-episode duration does not have any significant effect on saving money, in addition activity and travel episode expenditure does not have an effect on saving time. Finally, very few of the interactions between individual-level variables and activity categories are found to be significant for these analyses. This may indicate that the individuals' specifications do not have effect on the saving time and money at activity-category level.

The second analysis aims to obtain more insights whether there are different patterns in behavior when individuals with similar saving behavior are grouped. Therefore, the determinants of distribution of the total amount to be saved across activity categories are explored. In order to do that, first k-means cluster analysis is conducted for all activity categories. As all activity categories are considered for each respondent, the results are sensitive to how people spend their resources in the current situation. K-means analysis clusters the activities according to the proportions of saving adaptations of individuals. Then, a multinomial logit analysis is applied to obtain effects of individual-level variables on the membership of clusters. For both time and money saving adaptations, only the constant for Cluster 6, which mostly contains hobbies, courses and other activity category, is found to be significant. Moreover, individual-level variables are found to have effect on the membership of clusters however; the low Rho-squared results for savings of time and money indicate that that the explanatory power of individual-level variables is low.

Finally, a multinomial logit analysis is conducted to obtain the effects of activity categories, individual-level variables and activity-specific variables on the ways how individuals save their time and money. The results show that except the effect of attraction visit activity on choosing multiple options, there is no significant effect of activity categories on the ways of saving time. However, it is seen that there are significant effects of activity categories on ways of saving money. Moreover, individual-level and activity-specific variables are found to have effects on ways of saving time and money. In particular, the results show that individuals prefer reducing frequency with increasing activity duration in order to save time. It is also found that individuals prefer reducing the activity episode duration and choosing multiple options with increasing travel duration. In addition, in order to save money, increasing activity expenditure has a negative effect on reducing episode expenditure. Moreover, the results indicate that increasing travel expenditure has a positive effect on reducing episode expenditure while it has a negative effect on choosing cheaper transport mode. Furthermore, it is found that activity and travel expenditure has effect on ways of saving time and also activity and travel duration has effect on ways of saving money.

Overall, the results of these analyses offer insights to understand the saving behavior of individuals when there is a change in time or monetary budget constraint. It is seen that activity categories do not have explicit effect on the savings of time. Moreover, individual-level variables have very few effects on the savings while they do have effect on the ways of savings of time and money. The results show the importance of including activity-specific variables such as frequency, duration and expenditure in saving analysis. Therefore, these findings might be useful for future policy studies in order to understand the effects of time and money budget cuts, such as economic crisis and increasing working hours, on travel demand. Finally, in a future study, the savings should be modeled and integrated to the analytical framework that is suggested by this dissertation.

8

Conclusion and Discussion

8.1 Summary and Conclusions

The aim of this research has been to develop and empirically test the approach for modeling time and money allocation decisions of individuals under time and money budget constraints in the context of activity based models of transport demand. First, based on the available literature, and adding to it, a broad theoretical framework was developed for analyzing and modeling time and monetary allocation decisions in response to changing land use and transport policies and to potential shifts in exogenous factors such as cost and income changes. This framework considered all activity categories. However, this thesis focused on leisure activities because this is the most important category for the interface between expenditure and activity participation/travel. Therefore, a modeling framework has been developed to empirically estimate the frequency, duration and expenditure decisions of individuals at activity-episode level on out-of-home leisure activities. Third, data was collected with the purpose of empirically estimating the developed modeling framework and understanding how the budgets are re-allocated in response to the changes on income and working hours.

Chapter 3 developed a comprehensive theoretical framework of time and money allocation on activities, goods and travel considering long-term and short-term decisions of households and individuals. The assumptions of this theoretical framework were based on the existing literature. This chapter first described the basic concepts in order to build the theoretical framework and then focused on the utility function as the mathematical translation of the assumptions. This chapter also addressed the activity choice behavior, which shows how an agent determines the activity agenda by taking into account the time and money budget constraints.

The objective of Chapter 4 was to propose an activity-based model under time and money budget constraints in order to simultaneously predict the allocation of time and money particularly on out-of-home leisure activities. The proposed framework considered the activity episode level, given the activity is scheduled. Thus, the model considered the decision of the quantities for duration and expenditure spent during an activity. A flexible utility function which has no closed form solution was introduced. This chapter showed how this model can be estimated by using structural equations model (SEM) estimation techniques in order to see the effects of duration and expenditure on activities simultaneously and to solve the endogeneity problem. The model and estimation technique in this chapter provides a significant contribution to the existing literature as simultaneity and endogeneity problems were addressed and solved.

The estimation results were based on a large national continuous leisure diary data set collected in 2008 in the Netherlands. The analysis provided plausible and intuitive results and the log likelihood of the model showed that the model has significant explanatory value. The analysis showed that socio-demographics, travel party, timing and location variables influence the duration and expenditure of activities at episode level. As a simultaneous estimation was conducted, the model could capture the trade-off between duration and expenditure for an activity. Moreover, the results showed that the utility of expenditure increases with increasing duration and vice versa. Another significant result was the positive effect of distance on duration and expenditure which suggests that individuals generally can find more attractive locations for out-of-home leisure activities by traveling further and this affects the amount of time and expenditure for the activities.

Data used in Chapter 4 did neither include information about frequency nor information about income and working hours. Thus, it was not possible to estimate the effect of those variables on the time and money budget thresholds. Due to the lack of information in the data set, a new data collection was required.

Chapter 5 described the development and application of a stated adaptation experiment for individuals' time and money budget allocation decisions focusing on out-of-home leisure activities. This experiment aimed at collecting data on individuals' activity-travel time and money allocation first in a baseline situation and then under time and money budget-reduction scenarios, focusing on out-of-home leisure activities. The data collection was conducted online through a platform that was developed in the DDSS group at TUE to generate web-based questionnaires. The data was collected in the Netherlands in June 2012 by sending the web link to a respondent panel of a research bureau in the Netherlands. The panel includes individuals from all over the Netherlands. As a result of the data collection, completed responses from 521 respondents were obtained and after cleaning the data 423 of them were useful for the analysis.

This chapter also reported the descriptive results of the data. The results of reported time and money expenditures indicated that frequencies of activities differ between individuals. Moreover, the result of the stated adaptation data showed that respondents tend to save time and money from the activities where they spend more time and money in a month. Furthermore, it is found that time and money is saved mostly by reducing the frequency of the activity or by spending less time or money per episode. Finally, the results indicated that if respondents have to save time and money from all activity categories, they would save less time and less money than indicated amounts from their out-of-home leisure activities.

Chapter 6 extended the utility function and therefore estimation method that is proposed in Chapter 4. It showed that activity timing decisions of individuals in terms of frequency on an activity in a month can be integrated to the previously proposed model. As a result, the model considered the decision of the quantities for duration and expenditure spent during the activity and also the frequency of activity in a month at the activity episode level. For estimation, the activity-episode level data set which is described detailed in Chapter 5 is used. In this chapter, it was shown that this model can be estimated by using a maximum likelihood estimation of joint frequency, duration and expenditure observations.

The analysis revealed that age and gender influence the utility of duration and expenditure of activities at episode level. The analysis provided plausible results and the log likelihood of the model showed that the model has significant explanatory value. The results also captured trade-off between utility of duration and expenditure for activity categories. Moreover, including the frequency of activities in the empirical model allowed estimating both time and money budget-threshold parameters at the same time. Thus, these results proved that working hours and income have significant effect on time and money budget thresholds respectively at activity episode level and these effects were found to be in line with the theory. Furthermore, it is found that the utility of duration increases with increasing expenditure and interval time, and vice versa for all activity categories.

Chapter 7 reported the findings of 3 different logit analyses to understand how people adapt their time and money expenditures to their activities and how they change their behavior in order to save time and money when there is a change in their constraints such as increasing working hours and decreasing income. The analyses were conducted separately on adaptations of time saving and money saving.

The first analysis was done to understand how individuals distribute the total amount to be saved across activity categories and what the determinants are for this distribution. In this analysis, only the activities where savings were observed for each respondent are included. The results showed that activity categories have no significant effect on the proportion of saving time while several activity categories have significant effect on the proportion of saving money. Possibly individuals have no preference for the activities for saving time as the time has to be saved in general from out-of-home leisure activities. Moreover, the analysis indicated that activity-specific variables such as frequency, activity episode duration and travel episode duration have positive effect on the proportion of savings of time. This result showed that the more time spent on an activity in the current situation, the more time is saved when the time budget is constrained. The same held for the money savings. It was also seen that those activity-specific variables may affect the proportions of time and also money saving differently at the activity level. It was also found that activity and travel-episode duration does not have any significant effect on saving money, in addition activity and travel episode expenditure does not have an effect on saving time. Finally, very few of the interactions between individual-level variables and activity categories were found to be significant for these analyses. This may indicate that the individuals' specifications do not have effect on the saving time and money at activity-category level.

The second analysis aimed to obtain more insights whether there are different patterns in behavior when individuals with similar saving behavior are grouped. Therefore, the determinants of distribution of the total amount to be saved across activity categories were explored. In order to do that, first k-means cluster analysis was conducted for all activity categories. As all activity categories were considered for each respondent, the results are sensitive to how people spend their resources in the current situation. K-means analysis clustered the activities according to the proportions of saving adaptations of individuals. Then, a multinomial logit analysis was applied to obtain effects of individual-level variables on the membership of clusters. For both time and money saving adaptations, only the constant of the cluster which mostly contains hobbies, courses and other activity category, was found to be significant. Moreover, individual-level variables were found to have effect on the membership of clusters however; the low Rho-squared results for savings of time and money indicated that that the explanatory power of individual-level variables is low.

Finally, a multinomial logit analysis was conducted to obtain the effects of activity categories, individual-level variables and activity-specific variables on the ways how individuals save their time and money. The results showed that except the effect of attraction visit activity on choosing multiple options, there is no significant effect of activity categories on the ways of saving time. However, it was seen that there are significant effect of activity categories on ways of saving money. Moreover, individual-level and activity-specific variables were found to have effects on ways of saving time and money. In particular, the results showed that individuals prefer reducing frequency with increasing activity duration in order to save time. It was also found that individuals prefer reducing the activity episode duration and choosing multiple options with increasing travel duration. In addition, in order to save money, increasing activity expenditure has a negative effect on reducing episode expenditure. Moreover, the results indicated that increasing travel expenditure has a positive effect on reducing episode expenditure while it has a negative effect on choosing cheaper transport mode. Furthermore, it was found that activity and travel expenditure has effect on ways of saving time and also activity and travel duration has effect on ways of saving money.

Overall, the research reported in this thesis led to a better understanding of the allocation of time and money at activity-episode level under time and money budget constraints. Moreover, it also allowed understanding re-allocation of budgets when there is a change in the constraints. The empirical studies in this thesis focused on out-of-home leisure activities. The empirical studies showed that it is possible to collect specific data for the developed models and also to estimate the developed models.

8.2 Discussion and Future Research

The previous section summarized the research components and results of the analysis that has been carried out. This section is going to discuss what can be improved and how this can be achieved.

The proposed comprehensive theoretical model in Chapter 3 suggested the integration of time and money budgets in an activity-based model at an activity episode level. This model allows allocation of time and money to activities, goods and travel by considering long-term and short-term decisions of households and individuals. A crucial element of the model is the distinction between process and product utility of activities, which allows for a linkage between expenditures, investments, activity engagement and utility. However, the empirical studies that are conducted in this thesis consider only out-of-home leisure activities which result in process utility. Therefore, long-term decisions of households and individuals, and also the product utility component which takes into account the activities that result in goods are left out in the context of this thesis. In order to achieve an overall understanding of allocation of time and money to activities and travel, all activity categories and long-term decisions such as investments, expenditure to goods should be included in the analysis in a future work.

This research did not focus on the choice of travel as the travel duration and expenditure are not included in the analysis in Chapter 4 and 6. However, travel has indirect utility on activities depending on transport mode and locations that it brings in reach. Moreover, it affects the occurrence of activities and also allocation of time and money as the time and money spent on travel cannot be spent on activities. For that reason, an extension of the proposed activity-based model which will incorporate the travel choice component is needed.

Frequency decisions are added to the empirical model in order to simultaneously estimate the frequency, duration and expenditure decisions of individuals. However, the endogeneity still remained as a problem for this study. Since, the error terms of duration, expenditure and interval time were found to be correlated. In order to solve the endogeneity problem, the causal relationships between the equations should be taken into account. In theory, this could be done by using SEM approach as shown in Chapter 4. However, adding frequency decisions results in a more complex SEM framework. Therefore, this problem should be studied and solved in a future research.

Regarding the stated adaptation experiment, some improvements can be made in order to improve the data collection and the estimated models. First, data collection focused on frequency, duration and expenditure decisions of individuals in the baseline situation whereas other choice facets such as activity location, transport mode, travel party, timing of activity may have influence on activity and travel decisions. Therefore, these choice facets can be added in a future survey. Second, the stated adaptation experiment was conducted separately for time and money saving situations. It may be worthwhile to conduct this experiment simultaneously for time and money saving adaptations under hypothetical situations. Thus the experiment can give more insight on the re-allocation of and trade-off between time and money.

On the whole, the research reported in this thesis improves the activity-based models under time and money budget constraints. In particular, opposed to the existing studies, this research considers allocation of budgets at activity episode level. Therefore, it can incorporate conditions and choice facets such as timing and location that may vary across episodes of an activity and hence influence duration and expenditure choices as well. Thus, it allows understanding of budget effects on activities. The results shown in this thesis also confirm the assumptions that are made such as the duration and expenditure spent on activities are positively affected by each other. In addition, income and working hours are found to have effect on money and time budget thresholds, respectively. Moreover, the frequency decisions are not considered in the existing studies as these studies are done at activity category level. However, frequency of activity is important since the timing decision of activity affects the utility. Finally, savings adaptations of individuals are also studied in the context of this thesis. This is done by means of a new data collection instrument that was developed for this dissertation study.

The results, in general, showed that this study can provide relevant information for policy formulation and planning in order to understand the effects of time and location effects on duration and expenditures for activity and travel and also the effects and relations of time and money budgets on travel demand. For instance, if there is a budget cut in situation of a economic crisis resulting decreasing income or increasing working hours, the model can predict the behavior of individuals. Therefore, existing transport demand forecasting models such as ALBATROSS can benefit from incorporating time and money allocation decisions of individuals.

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Summary

Time and Money Allocation Decisions in Out-of-Home Leisure Activity Choices

One of the important aspects when evaluating alternative urban plans from the perspective of sustainable development concerns their impact on travel and accessibility. Typically, travel demand models and traffic assignment models are used to evaluate travel and accessibility impacts. Since the mid 1990s, activity-based models have been developed to better represent the decision mechanisms of individuals and households that underlie their travel demand. Main characteristic of activity-based models is their consideration of time expenditure on activities and travel for predicting activity-travel patterns in time and space.

Many activities require money directly or indirectly, however these models do not include monetary budgets as an explanatory variable. Moreover, monetary budget constraint determines the precedence of activities and travel. People conduct their activities under budget constraints which involve time and money. It is important to understand those constraints as they shape the set of feasible configurations of activity-travel patterns. In this context, the impact of income and monetary budgets on activity participation and travel, in relation to the costs of activities, travel and goods should be examined in the urban planning literature and beyond. Since, on the longer run, both household incomes as well as prices of petrol, goods and agricultural products may significantly change, due to economic developments, depletion of materials and changes in demand. These changing budget constraints and varying elasticities will have short-term and long-term effects on activity-travel patterns and may influence the (dis)functioning of the cities.

The aim of this research has been to develop and empirically test the approach for modeling time and money allocation decisions of individuals under time and money budget constraints in the context of activity based models of transport demand. First, based on the available literature, and adding to it, a broad theoretical framework was developed for analyzing and modeling time and monetary allocation decisions in response to changing land use and transport policies and to potential shifts in exogenous factors such as cost and income changes. This framework considered all

activity categories. However, this thesis focused on leisure activities because this is the most important category for the interface between expenditure and activity participation/travel.

First objective was to develop a comprehensive theoretical framework of time and money allocation on activities, goods and travel considering long-term and short-term decisions of households and individuals. The assumptions of this theoretical framework were based on the existing literature. Theoretical framework consists of the basic concepts and the utility function as the mathematical translation of the assumptions. Finally, it also addresses the activity choice behavior, which shows how an agent determines the activity agenda by taking into account the time and money budget constraints.

Based on the theoretical framework, an activity-based model under time and money budget constraints was proposed in order to simultaneously predict the allocation of time and money particularly on out-of-home leisure activities. The proposed framework considered the activity episode level, given the activity is scheduled. Thus, the model considered the decision of the quantities for duration and expenditure spent during an activity. A flexible utility function which has no closed form solution was introduced. This chapter showed how this model can be estimated by using structural equations model (SEM) estimation techniques in order to see the effects of duration and expenditure on activities simultaneously and to solve the endogeneity problem. This model and estimation technique provides a significant contribution to the existing literature as simultaneity and endogeneity problems were addressed and solved.

The estimation results were based on a large national continuous leisure diary data set collected in 2008 in the Netherlands. The analysis provided plausible and intuitive results and the log likelihood of the model showed that the model has significant explanatory value. The analysis showed that socio-demographics, travel party, timing and location variables influence the duration and expenditure of activities at episode level. As a simultaneous estimation was conducted, the model could capture the trade-off between duration and expenditure for an activity. Moreover, the results showed that the utility of expenditure increases with increasing duration and vice versa. Another significant result was the positive effect of distance on duration and expenditure which suggests that individuals generally can find more attractive locations for out-of-home leisure activities by traveling further and this affects the amount of time and expenditure for the activities.

Data used for that estimation did neither include information about frequency nor information about income and working hours. Thus, it was not possible to estimate the effect of those variables on the time and money budget thresholds. Due to the lack of information in the data set, a new data collection was required.

In order to collect data, a stated adaptation experiment was developed and applied for understanding individuals' time and money budget allocation decisions focusing on out-of-home leisure activities. This experiment aimed collecting data on individuals' activity-travel time and money allocation first in a baseline situation and then under time and money budget-reduction scenarios, focusing on out-of-home leisure activities. The data collection was conducted online through a platform that was developed in the DDSS group at TUE to generate web-based questionnaires. The data was collected in the Netherlands in June 2012 by sending the web link to a respondent panel of a research bureau in the Netherlands. The panel includes individuals from all over the Netherlands. As a result of the data collection, completed responses from 521 respondents were obtained and after cleaning the data 423 of them were useful for the analysis.

The results of reported time and money expenditures indicated that frequencies of activities differ between individuals. Moreover, the result of the stated adaptation data showed that respondents tend to save time and money from the activities where they spend more time and money in a month. Furthermore, it is found that time and money is saved mostly by reducing the frequency of the activity or by spending less time or money per episode. Finally, the results indicated that if respondents have to save time and money from all activity categories, they would save less time and less money than indicated amounts from their out-of-home leisure activities.

As the new dataset provides information about frequency, duration and expenditure of out-of-home leisure activities, it has been showed that activity timing decisions of individuals in terms of frequency on an activity in a month can be integrated to the previously proposed model. As a result, the model considered the decision of the quantities for duration and expenditure spent during the activity and also the frequency of activity in a month at the activity episode level. By using the new dataset, it was showed that this model can be estimated by using a maximum likelihood estimation of joint frequency, duration and expenditure observations.

The analysis revealed that age and gender influence the utility of duration and expenditure of activities at episode level. The analysis provided plausible results and the log likelihood of the model showed that the model has significant explanatory value. The results also captured trade-off between utility of duration and expenditure for activity categories. Moreover, including the frequency of activities in the empirical model allowed estimating both time and money budget-threshold parameters at the same time. Thus, these results proved that working hours and income have significant effect on time and money budget thresholds respectively at activity episode level and these effects were found to be in line with the theory. Furthermore, it is found that the utility of duration increases with increasing expenditure and interval time, and vice versa for all activity categories.

The new dataset contains information also about saving adaptations. 3 different logit analyses were conducted in order to understand how people adapt their time and money expenditures to their activities and how they change their behavior in order to save time and money when there is a change in their constraints such as increasing working hours and decreasing income. The analyses were conducted separately on adaptations of time saving and money saving.

The first analysis was done to understand how individuals distribute the total amount to be saved across activity categories and what the determinants are for this distribution. In this analysis, only the activities where savings were observed for each respondent are included. The results showed that activity categories have no significant effect on the proportion of saving time while several activity categories have significant effect on the proportion of saving money. Possibly individuals have no preference for the activities for saving time as the time has to be saved in general from out-of-home leisure activities. Moreover, the analysis indicated that activity-specific variables such as frequency, activity episode duration and travel episode duration have positive effect on the proportion of savings of time. This result showed that the more time spent on an activity in the current situation, the more time is saved when the time budget is constrained. The same held for the money savings. However, it was seen that those activity-specific variables may affect the proportions of time and also money saving differently at the activity level. It was also found that activity and travel-episode duration does not have any significant effect on saving money, in addition activity and travel episode expenditure does not have an effect on saving time. Finally, very few of the interactions between individual-level variables and activity categories were found to be significant for these analyses. This may indicate that the individuals' specifications do not have effect on the saving time and money at activity-category level.

The second analysis aimed to obtain more insights whether there are different patterns in behavior when individuals with similar saving behavior are grouped. Therefore, the determinants of distribution of the total amount to be saved across activity categories were explored. In order to do that, first k-means cluster analysis was conducted for all activity categories. As all activity categories were considered for each respondent, the results are sensitive to how people spend their resources in the current situation. K-means analysis clustered the activities according to the proportions of saving adaptations of individuals. Then, a multinomial logit analysis was applied to obtain effects of individual-level variables on the membership of clusters. For both time and money saving adaptations, only the constant of the cluster which mostly contains hobbies, courses and other activity category, was found to be significant. Moreover, individual-level variables were found to have effect on the membership of clusters however; the low Rho-squared results for savings of time and money indicated that that the explanatory power of individual-level variables is low.

Finally, a multinomial logit analysis was conducted to obtain the effects of activity categories, individual-level variables and activity-specific variables on the ways how individuals save their time and money. The results showed that except the effect of attraction visit activity on choosing multiple options, there is no significant effect of activity categories on the ways of saving time. However, it was seen that there are significant effect of activity categories on ways of saving money. Moreover, individual-level and activity-specific variables were found to have effects on ways of saving time and money. In particular, the results showed that individuals prefer reducing frequency with increasing activity duration in order to save time. It was also found that individuals prefer reducing the activity episode duration and choosing multiple options with increasing travel duration. In addition, in order to save money, increasing activity expenditure has a negative effect on reducing episode expenditure. Moreover, the results indicated that increasing travel expenditure has a positive effect on reducing episode expenditure while it has a negative effect on choosing cheaper transport mode. Furthermore, it was found that activity and travel expenditure has effect on ways of saving time and also activity and travel duration has effect on ways of saving money.

Overall, the research reported in this thesis led to a better understanding of the allocation of time and money at activity-episode level under time and money budget constraints. Moreover, it also allowed understanding re-allocation of budgets when there is a change in the constraints. The empirical studies in this thesis focused on out-of-home leisure activities. The empirical studies showed that it is possible to collect specific data for the developed models and also to estimate the developed models.

Curriculum Vitae

Gamze Dane was born on 29th September, 1982, in Izmir, Turkey. In 2005, she obtained her bachelor degree in City and Regional Planning at Izmir Institute of Technology. Her graduation project, which was an urban conservation plan in Urla, Izmir, was rewarded by the Turkish Chamber of City Planning. From 2005 to 2007 she had her Master education at the Department of Geographical Information Systems of Dokuz Eylul University. Her graduation project dealt with the multi-criteria spatial decision analysis and GIS for the purpose of locating light rail system in Izmir. From 2006 to 2009, she worked as a research assistant at the same department for assisting the master courses and department's GIS projects.

In 2009, she became a PhD candidate at the Urban Planning Group of the Eindhoven University of Technology. Her PhD project dealt with modeling of time and money budget allocation decisions of individuals. Her research interests include urban and transport planning, activity-travel behavior and data collection methods.