# 1 Introduction

Economic benefits are often received at different points in time. There are numerous examples of economic applications where the outcomes occur at multiple points in time. Among these are the savings decisions of households, the environmental policies of countries, investment decisions of firms, health-related decisions of individuals, and educational activities of students.

In the majority of these cases, future outcomes are valued lower than similar present outcomes, i.e. there is positive time preference. There are several reasons for this behavior. One reason is that the future is almost always surrounded by uncertainty, whilst outcomes received immediately or in the nearer future are more certain. This translates into the discounting of future outcomes.

Second, utility is often concave in outcomes (diminishing marginal utility). This means that more units of a particular outcome give less additional utility the more one already possesses of that outcome or the more one has already consumed of it. A second cup of coffee, for example, often gives less utility than the first one. Because wealth is increasing over time due to economic growth, people have more possibilities to consume in the future than in the present. The utility of this extra consumption does, however, not increase proportionally with the increase of consumption, so that future outcomes give less utility than similar present outcomes.

Third, people tend to be myopic and do not always consider all available information about the future. This kind of behavior has the same effect as giving less weight (or no weight at all) to future outcomes.

Fourth, lifetime of individuals is finite (Bommier, 2006), whereas society has an infinite lifetime, and, hence, individuals may not care about so much about society after their lives have ended.

## 1.1 Measuring time preference

Time preference has profound implications for many economic choices. Therefore, it is necessary to obtain good measurements of time preference. In several scientific disciplines, including economics, psychology, and medicine, an interesting debate is going on about the proper way to discount future benefits (Frederick et al., 2002). A major part of the literature assumes *time-separability*, which means that total discounted utility can be obtained by multiplying utility in each period by a time weight and then adding up these discounted utilities. This implies that marginal utility of an outcome at some point in time is independent of the amount of that outcome at some other point in time. The most widely used discounted utility model is *constant discounting* in which the discount function is determined by a constant rate of discount. However, the practice of discounting future utility streams with a constant rate has been disputed, due to empirical violations of some axioms of the constant discounting model (e.g. Ainslie, 1975; Thaler, 1981; Benzion et al., 1989). Hyperbolic discounting models (e.g. Harvey, 1986; Loewenstein and Prelec, 1992) are popular alternatives. The discount rate is

not constant but decreases with the time delay in hyperbolic discounting models, i.e. hyperbolic discounters act as if they become more patient when payoffs are more remote. Several other violations have been observed as well, including differential discounting of gains and losses (Thaler, 1981; Loewenstein, 1988).

A drawback of most of the previous empirical studies on time preference is that they assumed linear utility of money, or assumed that the utility function had a particular parametric shape. Their time preference estimates are therefore biased if this assumption does not hold. An important purpose of this thesis is to solve this problem by proposing and testing new methods for measuring time preference that do not need these assumptions. First, an intertemporal utility elicitation method is introduced that can measure utility without having to assume a particular parametric shape and subsequently can be used to correct measured time preference for utility curvature. I am able to compare different discounting models with these corrected estimates, and to indicate which model gives the best fit, which was done hardly before. I also test whether the gain-loss asymmetry can be explained by differential utility functions for gains and losses.

Another method is introduced in this thesis that allows for directly testing whether individuals deviate from the constant discounting model and to quantify their deviation from this model without having to elicit the utility function over money. The method can test whether alternative time preference models correspond better to the data. This method has a lot of potential use. It, for example, makes it possible, by means of a few simple questions, to test whether individuals are prone to intertemporal arbitrage (see Attema, 2006, for an example).

Finally, a new method is proposed to measure time preference for future life years, also known as *utility for life duration*. It is important to have knowledge about this utility function, as it is crucial in making treatment recommendations that best reflect the interests of the patient. The usual way to obtain information about this function is through the certainty equivalence method, which elicits utility under risk. This method requires *expected utility*, the normative theory for decision making under risk, to hold. Unfortunately, expected utility lacks descriptive validity (Starmer, 2000), so that the elicited utilities may be biased. In addition, these methods need the outcome death as stimulus, which tends to produce strong risk aversion and, hence, strong concavity of utility (e.g. Tversky and Kahneman, 1986; Stiggelbout and de Haes, 2001; Bleichrodt et al., 2003). It therefore seems worthwhile to find new techniques to obtain estimates of utility curvature for life duration that use a risk-free context and avoid the inclusion of the outcome death. In this thesis I propose such a technique, i.e. the *risk-free method*.

## 1.2 Applications of proposed measurement methods

Another purpose of this thesis is to consider a number of applications of the introduced measurement methods. First, I will investigate the universality of the utility concept. Some economists have argued that utility is only valid within the domain in which it was measured, whereas others consider utility to be a universal concept that is applicable in different contexts. I test these conjectures by comparing the results of the proposed intertemporal utility of money elicitation

method to existing results generated by methods that used risky utility. In the same vein, I compare risk-free utility of life duration to risky utility of life duration.

A second application concerns the use of the risk-free method for correcting the time tradeoff (TTO) method, an important and frequently used method to measure health state utilities, for utility of life duration. I discuss each of these investigations in more detail hereafter.

## 1.3 Universality of utility

This thesis considers whether one unifying concept of utility exists that holds under different situations or that utility is context-dependent and varies across domains. Economists have traditionally argued that utility differs across domains and, hence, that the utility function that is relevant for decision making under risk cannot be applied in other contexts, such as decision making under certainty or intertemporal decision making (see Wakker, 1994, for an overview). In contrast, in the health economics field there is a tendency to assume transferability of utility. For example, the TTO method measures utility in an intertemporal context, but the resulting TTO utilities are often used in economic evaluations of health care, i.e. in welfare judgments. The same holds true for utilities elicited by the standard gamble method, which considers a risky situation.

This thesis experimentally measures utility functions for money and health in several decision contexts. A novelty in this thesis is that utility for money is elicited in an intertemporal setting. The results are compared to previous utility

elicitations in a risky setting (Chapter 3). The risk-free method to measure the utility for life duration in a risk-free situation is proposed in Chapter 5. It is compared to the results obtained with two familiar elicitation methods that use a risky setting for the same respondents.

## 1.4 The time tradeoff method

The final part of this thesis applies the measurement of utility over life years to correct the TTO method for utility curvature. In a TTO, individuals need to make a tradeoff between quality of life and duration of life. A problem of the TTO method is, however, that it assumes linear utility of life duration, whereas this is often found to be concave, because many people discount future lifetime. This results in a downward bias of health state utilities (Bleichrodt, 2002). It is desirable to quantify this bias and to correct for it.

There have been done some previous attempts to correct TTO scores for the utility of life duration (e.g. Stiggelbout et al., 1994; Stalmeier et al., 1996; van Osch et al., 2004; van der Pol and Roux, 2005), but most of these studies used the CE method and therefore required expected utility to hold. When expected utility does not hold, the correction of TTO scores will be biased. In this thesis the risk-free method is employed to correct TTO scores for utility of life duration curvature, so that one is not dependent on the validity of expected utility and the influence of the outcome death. The differences with uncorrected TTO scores are investigated and the role of utility correction in several violations of the TTO method is explored.

## 1.5 Outline

The structure of the thesis is as follows. It begins with an overview of the available evidence on time preference in Chapter 2, with special attention to the health economics field. The most important findings are presented and their implications for medical decision making are discussed. Chapters 3 and 4 continue with experiments concerning the measurement of time preference. These chapters are of a general nature and therefore not specific to health outcomes. Chapter 3 develops a new method to measure time preference that corrects for utility curvature in a nonparametric way. This method is subsequently employed in an experiment to estimate utility and time preference for both gains and losses. Chapter 4 introduces another method that enables us to quantify the deviation from constant discounting without having to elicit the utility function over money. An experiment is presented to test this method and its results are discussed.

In the remainder of this thesis, I focus on the health domain. Chapter 5 proposes and tests the risk-free method to measure the utility function for life duration. In addition, it compares this method with two risky methods and presents the results of a questionnaire about the feasibility of these methods. Chapter 6, 7, and 8 use the new method of Chapter 5 in TTO measurements. In Chapter 6 it is explained how the risk-free method can be used to correct TTO scores for utility of life duration curvature. I measure the magnitude of this correction by means of an experiment. Chapter 7 investigates whether the elicitation procedure used in the TTO method influences its results and whether this influence is diminished when correcting for utility of life duration. Chapter 8 tests an important assumption of the TTO method, known as the assumption of

constant proportional tradeoffs (CPTOs). This means that individuals are willing to give up the same proportion of lifetime irrespective of its duration. The empirical evidence about this assumption so far available is reviewed and I test whether individuals also (or instead) constantly proportionally trade off *utilities*. Finally, Chapter 9 discusses the main findings of this thesis and concludes.