Intertemporal Trade-Offs Between Contract Periods, Price Discounts and Flexibility

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Consumers face an intertemporal trade-off when choosing a contract period of a periodically offered product or service - a short contract period gives consumers the flexibility to switch plans or providers while a long one provides a price discount. To understand how consumers will discount future continuous benefits and its impact on their willingness-to-pay for contract periods is important especially for firms offering a product or service with periodic (monthly, yearly or seasonal) contractual pricing plans. In this paper, we characterize empirically individuals' discounting behavior of future continuous benefits which they receive from periodic use or access to a product or service. We show that individuals' discounting of future benefits is heavily biased towards the present. In particular, the rate at which future benefits are discounted decreases as the contract period gets longer. But after a certain length of contract duration, there is a structural break and discount rates increase. Our results show that these systematic discontinuities in consumer's discounting behavior are largely attributable to the interplay of contract length, price discounts and consumers' valuation of flexibility. Using a novel incentive-compatible experimental setting, we show that the empirical pattern of individuals' discounting of future continuous utility is robust even when consumers receive a monetary incentive to discount future benefits without any time inconsistency.

Key words: Intertemporal Discounting Behavior, Preferences for Flexibility, Pricing, Change Point Model

1. Introduction

Individuals frequently contend with intertemporal choices between an outcome in the present and one in the future. Such decisions may involve choosing an immediate consumption (e.g., buying a car) or saving money for future consumption (e.g., for retirement), or pursuing a higher education degree or joining the work force. A rich stream of past literature describes the relative value that individuals assign to two or more payoffs at different points in time (Ariely and Loewenstein 2000, Ariely and Zauberman

2000, Laibson 1997, Loewenstein and Prelec 1992, Thaler 1981). However, an intertemporal choice is not only involved when payoffs occur at future *discrete* time points but also when individuals have to choose between different durations of future *continuous* benefits and any associated costs. An example of such an intertemporal decision is the choice between a short subscription period associated with a high price per time unit and a long subscription period associated with a smaller price per time unit. Other examples in which customers have to choose contract durations include mortgage agreements, leasing agreements, insurance contracts or travel packages (i.e. the second week of such holiday offers is often cheaper).

Subscriptions or flat rate plans are a popular contract-based pricing mechanism for a variety of products and services such as health clubs, online information services, newspapers, Internet access, software updates or pay TV. Such pricing plans are characterized by different time periods (daily, monthly, quarterly, yearly or two-yearly or seasonal) and a decreasing price per time unit (a time-based price discount) as the length of the subscription or flat rate period increases. Contract-based tariffs such as subscriptions or flat rates can be described as block tariffs, a specific form of non-linear pricing, in which the price per time unit decreases after a specific length of duration. For example, in case of the Wall Street Journal Online, a customer pays $60 for 26 weeks or $100 for 58 weeks. In this case, while the duration of access to the service doubles, there is only a 66% increase in price.

From consumers' perspective, the incentive for choosing a longer contract (or subscription) period comes from time-based price discounts. Beyond that customers' choice of a specific plan or tariff involves an intertemporal decision based on future consumption. The literature on intertemporal choice (Loewenstein and Prelec 1992; Frederick et al. 2002; O'Donoghue and Rabin 1999; Thaler 1981; Zauberman 2003) shows how customers discount future utility and how their choice of tariffs is influenced by uncertainty about future consumption needs (DellaVigna and Malmendier 2004). In the context of contract-based plans, individuals may choose a plan with a longer period only if their additional cumulative discounted utility of consuming the product or service over a longer period is larger than the additional fee they have to pay.

From a firm's perspective, there are several advantages of selling longer contract periods (e.g. longer subscription or flate-rate plans) to customers. First, the marginal cost, especially for largely fixed cost-based products or services (such as health clubs, software, pay TV or online information services), are low or even zero. Second, customer lock-in effects can be achieved. Third, as customers usually pay the full subscription price at the beginning, a firm can leverage the increased assets based on interest rates in the marketplace.

In this paper, our objective is to characterize empirically individuals' discounting behavior of future *continuous* benefits which consumers receive from periodic (monthly, yearly or seasonal) use or access to a product or service offered with contracts or license agreements (such as subscriptions or flat rate plans). To do so, we propose a model of how consumers evaluate and discount future *continuous* benefits. Our proposed model accommodates any shifts (or discontinuities) in consumers' discounting behavior due to the interplay of contract length and their valuation of flexibility. We also develop a novel incentive-compatible experimental design to measure consumer's *accurate* and *true* discounting of future continuous benefits.

We derive the following three key results. *First*, using controlled laboratory experiments, we show that individuals' discounting of longer contract periods providing a future *continuous* stream of utility is heavily biased towards the present. In particular, the rate at which future utility is discounted over time decreases as the contract period gets longer. This finding is consistent with hyperbolic discounting (e.g., O'Donoghue and Rabin 1999; Thaler 1981; Zauberman 2003). *Second*, the results of our experiments also show that there are systematic discontinuities in consumer's discounting behavior largely attributable to the interplay of contract length, price discounts and consumers' valuation of flexibility. Put differently, a hyperbolic function alone cannot explain the entire variation in consumers' discounting pattern. In all our studies, we find that the monthly discount rate has a robust pattern - the discount rates initially decrease with contract duration (consistent with hyperbolic discounting), but after a certain length of contract duration, there is a structural break and discount rates increase slightly. We find that the location of the structural break is closely linked to the contract duration that consumers typically choose. *Third*, using a novel incentive-compatible experimental setting, we show that the empirical pattern of individuals' discounting of future continuous utility is robust even when they receive a monetary incentive to behave rationally and discount future benefits without any time inconsistency. The result of our incentive compatible experiment lead to important implications about individuals' intertemporal discounting behavior in general namely that individuals' are not able to discount future outcomes without a bias towards the present although they have an incentive to do so.

The remainder of the paper is organized as follows. In Section 2, we describe past research on intertemporal choice that relates to individuals discounting of a future continuous stream of utility. In Section 3, we introduce a model of how consumers evaluate and discount benefits coming from a continuous stream of utility. In Section 4, we characterize consumers' discounting patterns of future benefits. Section 5 concludes with a summary of results and directions for future research.

2. Theoretical Development

In the past few decades, research on intertemporal choice has gained a lot of attention. John Rae, the pioneer of this area of research, suggested that both psychological and sociological factors may explain how individuals make intertemporal decisions regarding accumulation of wealth over their lifetime (Rae 1834). Jevons (1888), BohmBawerk (1889) and Jevons (1905) further developed the psychological underpinnings of individuals' time preference behavior. In contrast to the vivid description of intertemporal decisions from a psychological perspective, Samuelson (1937) introduced the parsimonious and tractable *Discounted Utility Model* (DU model), which summarized the role of all underlying factors using a single parameter (the discount rate). Since its introduction, the DU model has been the building block for describing intertemporal decisions. In the last few decades, however, economists and psychologists have collected much empirical evidence to refute many of the model's assumptions. See Frederick et al. (2002) for a review of the main criticisms of the DU model.

The best documented empirical anomaly of the DU model is that individuals have present-biased preferences such that the rate at which an outcome is discounted over time is higher over a short than over a long time horizon (Strotz 1955, Thaler 1981). Alternative models such as the *Hyperbolic Discounting Model* (Loewenstein and Prelec 1992), or the *Quasi-Hyperbolic Discounting Model* (Laibson 1997) have been proposed to capture this empirical phenomenon.[1]

Hyperbolic discounting. A rich stream of past literature on individuals' intertemporal preferences has focused on their discounting of utility at *discrete* future time points (Ariely and Loewenstein 2000, Ariely and Zauberman 2000, Laibson 1997, Loewenstein and

[1] Several authors have also used discounting models to focus on other aspects of intertemporal choice such as cognition in decisions (DellaVigna and Malmendier 2006, Ainslie 1975, O'Donoghue and Rabin 2000), reactions to cues (Wilson and Daly 2004, Mano 1992, Winkielman et al. 2005), and delay of gratification (Mischel and Ebbesen 1970, O'Donoghue and Rabin 2001, Mischel et al. 1972).

Prelec 1992, Thaler 1981). More recent literature has considered the impact of "duration" and "intervals" on individuals' discount patterns (Ariely and Loewenstein 2000, LeBoeuf 2006, Overton and MacFadyen 1998, Read et al. 2005, Scholten and Read 2006, 2009). However, such investigations have been in the context of how far future outcomes are removed from the present, how far these outcomes are removed from one another and its effect on the evaluation of a sequence of outcomes.

As described above, contract business models such as subscriptions or flat rates provide consumers future continuous benefits which they receive from periodic (monthly, yearly or seasonal) use or access to a product or service. In such contexts, consumers have to discount future benefits over a *continuous* duration rather than at discrete future time points. Based on the findings of past research for individuals discounting of utility at *discrete* future time points, we anticipate that individuals discounting of future continuous benefits is also biased towards the present and the discount rates follow a hyperbolic pattern. However, as we next discuss, a hyperbolic pattern alone may not explain the entire variation in consumers discounting pattern.

Multiple temporal reference durations in intertemporal choice. In the context of contract-based products or services, consumers face a trade-off - a contract-based plan of short duration usually has a high price per-time unit but gives consumers the flexibility to switch plans or providers at the end of the contract. With a long contract-based plan, consumers lose their flexibility but benefit from time-based price discounts. For consumers, a choice of a contract-based plan involves consideration of immediate costs (flat fee), future continuous benefits from use of the product or service and their valuation of flexibility (DellaVigna and Malmendier 2006). The latter can impact consumers' discounting pattern in a systematic manner.

Past research shows that purchase decisions over time are influenced by consumers habitual level of consumption. In habit-formation models, the utility of consumption is assumed to depend on past levels of consumption (Benartzi and Thaler 1995). A variety of phenomena has been analyzed by using such habit-formation models. For instance, Becker and Murphy (1988) and O'Donoghue and Rabin (2000) investigated the impact of habit formation and time inconsistency for the consumption of addictive products. More recently, Wathieu (1997) and Baucells and Sarin (2010) explicitly included habit formation in discounted utility models and interpret the habitual level of consumption as a reference point. Such a reference point might depend on past consumption, expectations, social comparison or status quo. Loewenstein (1988) and Loewenstein and Prelec (1992) has discussed the impact of reference points on intertemporal decisions and shows that when individuals choose between immediate and delayed consumption, the reference point used to evaluate alternatives can significantly influence their intertemporal choice.

Psychologists allow a flexible interpretation of a reference point to arise from either the decision makers' habits, expectations, or aspiration levels (Tversky and Kahneman 1991, Baucells et al. 2011). In the current context, consumers may be habituated to choosing either a specific contract period (e.g. 24 months for cellular phone contracts or annual gym memberships) or are in need of flexibility because they expect a change in their life in the near future (e.g. they expect to start a new job or to relocate to another city). Both of these may act as a reference duration (similar to a reference point) for an intertemporal choice between contract periods of services. Thus, there may be multiple candidates for reference durations that may impact consumers intertemporal preferences.[2]

The presence of reference durations may lead to shifts or discontinuities in consumers' discount pattern of a future stream of utility (i.e., structural interruptions in the discount function) when consumers compare the contract duration with the reference duration. Specifically, different discount functions for benefits may be required when contract durations are either smaller than or exceed the reference durations. In sum, we anticipate that when reference durations are involved in consumers intertemporal trade-offs between contract periods, there will be systematic shifts in discounting behavior.

3. A Model of Consumers' Intertemporal Preferences

In this section we introduce a parsimonious consumer utility model that incorporates consumer discounting of future benefits and utility over a continuous duration. The proposed model accommodates any structural breaks in consumers' discounting behavior due to the interplay of contract periods and consumers' valuation of flexibility. Next, we derive consumers' willingness-to-pay (WTP) function for a contract period. Finally, we show how consumers' discounting pattern can be inferred from their WTP for different contract periods.

[2] Many other contexts also involve multiple reference points. For instance, in a grocery context, consumers observe multiple prices and compare those with reference prices (Lattin and Bucklin 1989, Putler 1992)

3.1. Utility model

Consider a single firm offering a product or service based on J plans. Each alternative j ($j = 1, \ldots, J$) is described in terms of length of time a customer can access the service and a one-time flat fee to be paid when signing a contract (e.g., a health club membership for 3 months for a flat-fee of $300.-). For an alternative j, let the contract duration be T_j. We assume that the utility consumer i associates with product j, $v_{ij}(T_j)$ starts from zero, $v_{ij}(0) = 0$, and increases with duration. We formulate a discounted utility type specification (Samuelson 1937) where the utility from the alternative j depends on the duration that a consumer has access to the service. Thus,

$$v_{ij}(T_j) = \int_{t=0}^{T_j} \nu_i \delta_i(t) dt, \tag{1}$$

where $\nu_i \geq 0$ is the utility consumer i derives from consuming product or service j for a unit time interval. In line with intertemporal choice literature (Read 2008) we assume ν_i is constant and not changing over time.[3] The consumer-level discount function, $\delta_i(t)$, for future utility from a product or service can be a function of time. The overall utility ($v_{ij}(T_j)$) is the discounted utility from accessing service j for duration T_j. Note that the utility function reduces to $v_{ij}(T_j) = \nu_i \cdot T_j$ when consumers do not discount future utility (i.e., $\delta_i(t) = 1.0$).

We assume that consumer i ($i = 1, \ldots, I$) cannot choose more than one alternative. Let $p(T_j)$ denote the one-time flat fee that a consumer pays for receiving access to service j for duration T_j. Let y_i be the consumer-specific budget. Consistent with economic theory, we assume that there is an individual-specific composite (outside) good with unit price p_i^y. A consumer can spend the entire budget on the composite good, or spend some of it on the composite good and the rest to buy one of the J choice options (e.g., service j with T_j duration). Let z_{ij} denote the number of units of the composite good.

Let $u_{ij}(T_j, z_{ij})$ represent the utility consumer i obtains from T_j duration of service j and z_{ij} units of the composite good. We assume that the consumer maximizes his or her utility, subject to a budget constraint $p(T_j) + z_{ij} p_i^y = y_i$. Without loss of generality, we normalize the price of the composite good to unity, i.e., $p_i^y = 1$. Hence the number of units of the

[3] This assumption is reasonable for any utilitarian good (e.g. Internet access) but may not be plausible for hedonic goods (Ratner et al. 1999)

composite good is given by $z_{ij} = y_i - p(T_j)$. We specify the following quasilinear utility function for consumer i:

$$u_{ij}(T_j, z_{ij}) = v_{ij}(T_j) + \beta_i(y_i - p(T_j)), \tag{2}$$

where $v_{ij}(T_j)$ is specified in equation (1) and $\beta_i > 0$ is the income effect or price sensitivity.

Let $j = 0$ denote the no-choice option. Then the utility of allocating the whole budget to the composite good (i.e., no-choice) for consumer i reduces to $u_{i0}(0, y_i) = \beta_i y_i$ since $v_{i0}(0) = 0$. Thus, a utility maximizing consumer would choose alternative j if it has the maximum utility $\{u_{ij} > u_{ik}, k = 0, \ldots, J, k \neq j\}$ and would choose none of the alternatives if the no-choice option ($j = 0$) has the maximum utility $\{u_{i0} > u_{ij}, j = 0, \ldots, J\}$. Note that in a choice context, the term $\beta_i y_i$ is irrelevant to the choice decision since it is a consumer-specific constant across alternatives. Consequently, the utility of the no-choice option is set to zero.

Using this utility model, we can determine consumers' willingness-to-pay for a given duration of service. When the utility function is quasilinear, utility maximization is equivalent to surplus maximization (Jedidi and Zhang 2002). Then dividing $u_{ij}(T_j, z_{ij})$ in equation (2) by the price coefficient β_i gives the consumer surplus function:

$$s_{ij}(T_j) = \frac{v_{ij}(T_j)}{\beta_i} - p(T_j) = \theta_i \int_{t=0}^{T_j} \delta_i(t)dt - p(T_j), \tag{3}$$

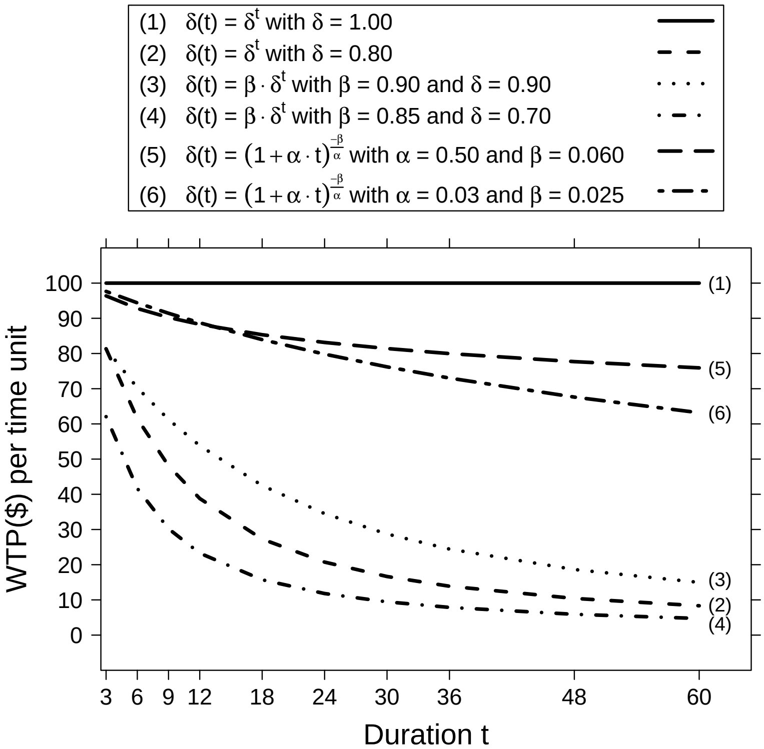
where $s_{ij}(T_j)$ is the surplus $(WTP - price)$ that consumer i derives from choosing alternative j and $\theta_i = \frac{\nu_i}{\beta_i}$ is consumer i's WTP for a unit time interval of the service with no discounting.

The left-hand side component of equation (3) represents the WTP function which describes the maximum price a consumer is willing to pay for a given duration of service j.[4] This function is given by:

$$WTP_{ij}(T_j) = \theta_i \int_{t=0}^{T_j} \delta_i(t)dt. \tag{4}$$

[4] WTP or reservation price is the price that equates the utility of consuming T_j units of service j to the utility from no-choice, which is set to zero (see Jedidi and Zhang (2002)).

Figure 1: WTP Function for Different Types of Discounting



Consequently, we can specify consumer i's WTP of each time unit (e.g. a month) of alternative j with contract length T_j simply by dividing the right hand side by length T_j.

$$WTP_{ij}^{(\text{per time unit})}(T_j) = \frac{\theta_i}{T_j} \int_{t=0}^{T_j} \delta_i(t)dt. \tag{5}$$

For illustration, assume that consumer's willingness to pay for contract period of one time unit is \$100.- ($WTP_i^{(\text{per time unit})}(1) = 100$). Figure 1 illustrates the shape of the monthly WTP function for different types of discount functions $\delta(t)$. The monthly WTP function is constant when $\delta_i = 1$. As the figure indicates, there is a clear relationship between WTP and consumers' discount pattern. Thus, determining the WTP for a contract period will allow us to infer the underlying discount pattern.

3.2. Discount Function

Past research on individuals' intertemporal choice and discounting has shown that individuals have present-biased preferences, which results in a hyperbolic pattern of their discount rates (Strotz 1955; Thaler 1981). It is, therefore, reasonable to expect such a discount pattern also in the present context as well. A function that allows for hyperbolic discounting, and nests constant (exponential) discounting as well, is the generalized hyperbola discussed in Loewenstein and Prelec (1992), namely

$$\delta(t) = (1+\alpha t)^{-\frac{\beta}{\alpha}}, \quad \alpha, \beta > 0. \tag{6}$$

The parameter α captures the divergence from constant discounting. As the parameter α becomes close to 0, the discount function $\delta(t)$ simply becomes an exponential function with the discount rate β, i.e. $\delta(t) = exp(-\beta t)$. Consequently, in line with past research, anticipating a hyperbolic discount pattern, we allow for decreasing discount rates but also account for the possibility of constant discounting.

In the context of individuals' discounting of contract periods with different lengths of continuous utility, we anticipate that reference durations will be involved in individuals' intertemporal trade-offs between contract periods, price discounts and flexibility. Such reference durations may lead to shifts or discontinuities in consumers' discount pattern of a future stream of utility (i.e., a structural break in the discount function). We model these shifts in individuals' discount patterns as change points and allow for the parameters of the discount function to differ before and after a change point.

Change point (CP) models were developed in the area of stochastic quality control to accommodate structural breaks, shifts and changes in quality. For example, Khodadadi and Asgharian (2008) discuss the application of change point methodology within regression analysis. Similarly, Barry and Hartigan (1993) develop a model within a Bayesian framework to account for several structural breaks. We apply a change point modeling framework to capture the impact of any structural breaks in consumers' discounting pattern of future continuous benefits.

For a consumer i, let t_i^* be their latent change point. Then, the discount function is specified as follows:

$$\delta_i(t) = \begin{cases} (1+\alpha_i^{(1)} t)^{-\frac{\beta_i^{(1)}}{\alpha_i^{(1)}}}, \text{ if } t < t_i^* \\ \\ (1+\alpha_i^{(2)} t)^{-\frac{\beta_i^{(2)}}{\alpha_i^{(2)}}}, \text{ if } t \geq t_i^* \end{cases} \tag{7}$$

with $\alpha_i^{(1)}$, $\beta_i^{(1)}$ ($\alpha_i^{(2)}$, $\beta_i^{(2)}$) describing the discounting behavior before (after) t_i^*. Using this parameterization of the discount function, we are able to estimate consumers' willingness to pay in the presence of intertemporal trade-offs between contract periods, price discounts and flexibility.

3.3. WTP- (Change-Point) Model

The generalized discount function (7), capturing shifts in the discounting behavior, leads to the following WTP function:

$$WTP_i^{\text{(per time unit)}}(T) = \begin{cases} \frac{\theta_i}{T(\alpha_i^{(1)} - \beta_i^{(1)})} \left[\lambda\left(T; \alpha_i^{(1)}, \beta_i^{(1)}\right) - 1 \right], & \text{if } T < t_i^* \\ \frac{\theta_i}{T(\alpha_1^{(1)} - \beta_i^{(1)})} \left[\lambda\left(t_i^*; \alpha_i^{(1)}, \beta_i^{(1)}\right) - 1 \right] + \\ \frac{\theta_i}{T(\alpha_i^{(2)} - \beta_i^{(2)})} \left[\lambda\left(T; \alpha_i^{(2)}, \beta_i^{(2)}\right) - \lambda\left(t_i^*; \alpha_i^{(2)}, \beta_i^{(2)}\right) \right], & \text{if } T \geq t_i^* \end{cases} \quad (8)$$

with

$$\lambda\,(t; \alpha, \beta) = (1 + \alpha t)^{1 - \frac{\beta}{\alpha}}$$

We estimate the parameters of the discount function by gathering WTP data from respondents. A detailed description of model estimation is provided in Appendix A.

4. Discounting Pattern Of Contract Periods With Different Durations

We describe two experimental studies that reveal consumers' discounting pattern of future continuous benefits which they receive from periodic (monthly, yearly or seasonal) use or access to a product or service offered with contracts or license agreements. In the first study, we collect data using an adaptive online survey in which we ask participants to state the maximum price they are willing to pay to switch to various contract durations of a service *conditional* on their willingness-to-pay (WTP) for a baseline contract duration of that service. We ask such conditional questions as we are interested in inferring consumers' discounting pattern and not in their absolute WTP for the focal service. The results of the first study provide evidence for hyperbolic discounting but also for significant structural changes in consumers' discounting behavior. In the second study, we address the limitation of self-stated WTP surveys as being not incentive compatible by developing a novel incentive compatible mechanism to gather individuals' *accurate* and *true* discounting of future continuous benefits. The results confirm the robustness of our key finding that there are structural changes in consumers' discounting pattern even when consumers have an incentive to discount future benefits without any time inconsistency.

4.1. Study 1 - Adaptive Web Survey

Study 1 explores consumers' discounting behavior while they decide to stay with a baseline subscription plan or to switch to an alternative plan with a longer contract duration. In particular, we ask consumers to state their WTP to switch from the baseline plan to an alternative plan with a longer contract duration. We used Internet access as the focal service based on a pretest that indicated a majority of consumers use the service and are comfortable answering questions about their willingness-to-pay for different contract durations. As described above, we expect that respondents' discounting of future stream of utility may be influenced by several reference durations such as the baseline contract duration and the maximum contract duration that they typically subscribe to a service. The results of the first investigation support the idea of significant structural changes in consumers' discounting behavior as a direct consequence of the interplay between contract durations and valuation of flexibility. The critical contract duration for consumers reflects how much they value flexibility - the shorter (longer) is this duration, the more (less) they value flexibility.

Method

This study was an adaptive web survey. A total of 212 participants completed the study. At the beginning of the study, we asked all respondents three questions regarding their individual willingness-to-pay for Internet access - (i) the respondent's WTP for one month Internet access, (ii) number of months of Internet access the respondent expects for $150.- and (iii) the respondent's WTP for three month Internet access. Using the responses to the three questions, an online program calculated the average WTP of each participant for a month of Internet access.

After answering the three questions, participants were randomly assigned to two different surveys. In the first version (*"Absolute WTP"*), participants stated the maximum contract fee (in $) that they are willing to pay to switch from a month's baseline contract duration to a longer contract duration, i.e., *"For which monthly price p, would you choose a subscription of duration T months as compared to 1 month? $\$X.-$"* with p being the monthly payment and T the subscription period (e.g., 12 months). As noted earlier, the fee for the 1 month baseline duration for each respondent was customized based on their responses to the three initial WTP questions.

To account for any framing effects and their impact on respondents' stated WTP, we also collected data using a second version of the survey (*"Expected Price Discounts in %"*).

In this version, respondents had to state the minimum price discount (in %) they expected to switch to an alternative contract with a longer contract duration. Note that a different wording of questions may lead to other inferences regarding respondents' intertemporal discounting behavior. A comparison of results from the two surveys then will show the robustness of our findings.

In both surveys, each participant answered ten questions about switching to different contract durations (i.e. 3, 6, 9, 12, 18, 24, 30, 36, 48, and 60 months) from a 1 month baseline duration. The order of questions was counterbalanced. All participants were also instructed that they would be paying the access fee for the entire contract period while signing the contract. Next, we collected data from participants on various possible reference durations they may use while considering the contract for Internet access (which we term as "critical" duration) - (1) subscription length they usually subscribe to, (2) maximum contract duration they have ever subscribed to, (3) maximum contract duration they would consider in their choice between contract periods of different lengths, and (4) their actual planning horizon. Such data on critical durations can be related to any structural breaks in the observed discounting behavior. Finally, we collected demographic information (age, gender, nationality and field of study).

Non-parametric Calculation of Discount Rate. Past research on individuals' intertemporal preferences has focused on their discounting of utility at discrete future time points (e.g., an indifference between \$100 now and \$150 in 2 months). In that context, it is straightforward to calculate an individual's discount rate directly from the ratio of current and future outcomes (e.g., Thaler 1981). In contrast, in the current setting, consumers are discounting future benefits over a continuous duration. Thus, we cannot determine the discount rate directly from just the ratio of observed indifference prices. We can still, however, infer the consumer discounting pattern in a non-parametric manner (before estimating the discount function based on our parametric model) while taking the *continuous* nature of future benefits explicitly into account. We do so as follows. For a contract j with duration T_j, the monthly willingness-to-pay for individual i is:

$$WTP_{ij}^{(\text{per month})}(T_j) = \frac{\theta_i}{T_j} \int_{t=0}^{T_j} \delta_i(t) dt. \tag{9}$$

Suppose consumers have a constant monthly discounting pattern. This implies that the discount factor $\delta_i(t)$ can be replaced by $\exp(-r_i t)$ where r_i is a constant monthly discount rate. Consequently, the monthly willingness-to-pay for individual *i* for contract *j* is given by

$$WTP_{ij}^{(\text{per month})}(T_j) = \frac{\theta_i}{T_j} \int_{t=0}^{T_j} \exp(-r_i t) dt. \tag{10}$$

We can simplify the above equation for determining the monthly discount rate. Recall that for each respondent, $WTP_i^{(per month)}(1)$ (tariff for the baseline duration), is customized and fixed in the survey. Then, according to the above model, the willingness-to-pay for the baseline duration can be written as follows:

$$WTP_i^{(\text{per month})}(1) = \frac{\theta_i}{r_i}\left(1 - \exp(-r_i)\right). \tag{11}$$

We can solve for θ_i and obtain:

$$\theta_i = \frac{WTP_i^{(\text{per month})}(1) \cdot r_i}{1 - \exp(-r_i)}. \tag{12}$$

Consequently, for the willingness-to-pay for all durations greater than the baseline duration, we can insert θ_i from the above expression. Thus,

$$WTP_{ij}^{(\text{per month})}(T_j) = \frac{WTP_i^{(\text{per month})}(1)}{T} \cdot \frac{1 - \exp(-r_i \cdot T_j)}{1 - \exp(-r_i)}. \tag{13}$$

As there is no closed form solution for determining the discount rate r_i from equation (13), we have to rely on numerical methods. We use the Newton-Raphson algorithm (for details see Brent (1973)) to calculate the monthly discount rate r_i implied by the willingness-to-pay for different contract durations.[5]

Results

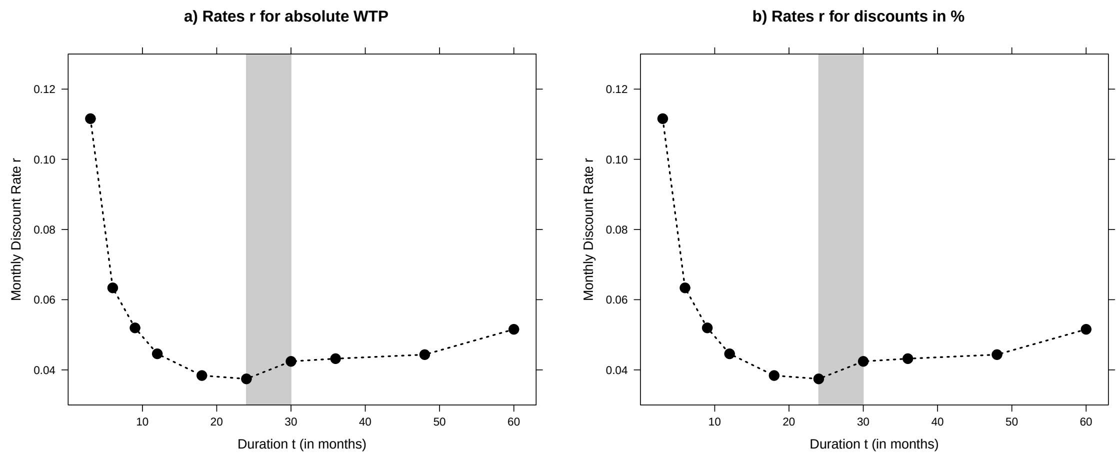
Descriptive Results. We used the numerical technique described above and calculated the monthly discount rate for each participant and every offered contract duration. Table 1 shows the estimated discount rates averaged across all respondents for both survey versions. We tested the statistical significance of the underlying discount pattern using paired t-tests. The results show that, in general, the pattern of monthly discount rate for future

[5] Equation (13) is a standard numerical problem and can be solved by other numerical methods.

Table 1: Study 1 - Monthly Discount Rates for Both Survey Versions

Absolute WTP						*Expected Price Discount in %*					
Duration t	Mean Discount Rate r	Standard Deviation of r	Difference in r	p-value		Duration t	Mean Discount Rate r	Standard Deviation of r	Difference in r	p-value	
3	0.11158	0.06663				3	0.12964	0.07999			
6	0.06337	0.03145	-0.04821	0.00000	***	6	0.07217	0.03406	-0.05747	0.00000	***
9	0.05197	0.02063	-0.01140	0.00000	***	9	0.06003	0.03491	-0.01214	0.00009	***
12	0.04458	0.01821	-0.00739	0.00000	***	12	0.04987	0.02353	-0.01015	0.00002	***
18	0.03839	0.01332	-0.00619	0.00001	***	18	0.04447	0.02379	-0.00541	0.00716	***
24	0.03743	0.01412	-0.00095	0.35020		24	0.04283	0.02514	-0.00163	0.24290	
30	0.04242	0.01676	0.00499	0.00009	***	30	0.04696	0.02465	0.00412	0.04103	**
36	0.04320	0.01600	0.00078	0.50030		36	0.04699	0.02646	0.00003	0.98390	
48	0.04434	0.01892	0.00115	0.32030		48	0.04771	0.02762	0.00073	0.63700	
60	0.05156	0.03247	0.00721	0.00017	***	60	0.05542	0.04196	0.00771	0.00986	***

Figure 2: Study 1 - Pattern of Discount Rates



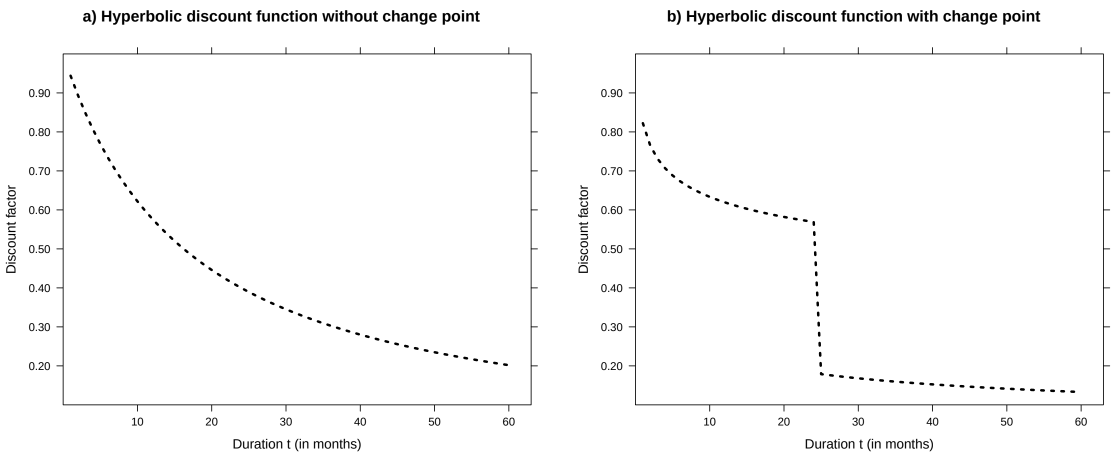
benefits from Internet access is consistent with hyperbolic discounting as the monthly rate decreases with contract duration (Zauberman et al. 2009). However, there are some differences from pure hyperbolic discounting - after contract durations exceed a specific length, there is an *increase* in the monthly discount rate. Specifically, the monthly discount rate declines until the contract duration exceeds 24 months. Thereafter, we observe a small, but significant, increase in the monthly discount rate ($p < 0.001$). Figure 2 summarizes this pattern graphically and emphasizes our evidence of discontinuity (structural break) in the monthly discount rate.

Model Results. Our descriptive results give preliminary evidence for the presence of a discontinuity (a structural break) in consumers' discounting behavior. We investigate the issue further by estimating the parametric discount function based on our model specification. We use the willingness-to-pay for various contract durations and estimate the parameters of our model both with and without a change point. In what follows, we show

Table 2: Study 1 - Parameter Estimates ("*Absolute WTP*")

Model without change point Parameter	Estimate [2.5%, 97.5%]-Quantiles	*Model with change point* Parameter	Estimate [2.5%, 97.5%]-Quantiles
α	0.0526 [0.0403, 0.0668]	$\alpha^{(1)}$	3.8095 [1.416, 10.3203]
β	0.0591 [0.0539, 0.0644]	$\beta^{(1)}$	0.4745 [0.2263, 1.1211]
	—	$\alpha^{(2)}$	6.3483 [0.7755, 16.46]
	—	$\beta^{(2)}$	2.1544 [0.4531, 4.8361]

Figure 3: Study 1 - Discount Functions ("*Absolute WTP*")

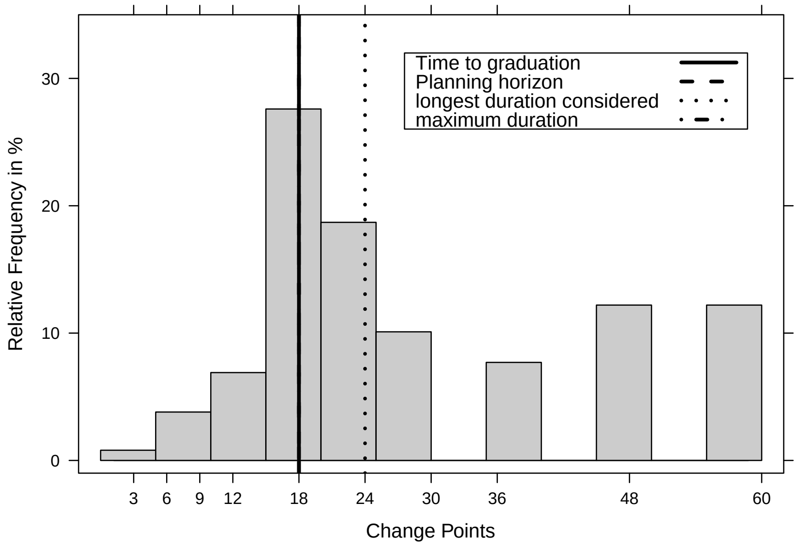


the results using data from the first version of the survey ("*Absolute WTP*"). We obtain similar results based on data from the other version ("*Expected Price Discount in %*") suggesting that our key findings are robust to alternative framing of questions. For details, please see Appendix B.

Table 2 shows the parameter estimates for the discount functions based on the two models. The model with a change point gives significantly different estimates as compared to the model without a change point. Figure 3 plots the two discount functions using the estimated parameters. The figure illustrates the difference in the predicted discounting pattern from the two models.

The estimates from the change point model also provides information regarding when a change point is likely to occur. Figure 4 shows the likelihood of a change point at various contract durations for a randomly chosen individual. The figure shows that the probability of a change point is highest for a duration of 18 months, which is quite close to time of graduation for this individual. We can similarly infer the probability of occurrence of a change point at various contract durations for each individual and relate it to their critical duration.

Figure 4: Study 1 - Change-Point (cp) Distribution of One Representative Individual (*"Absolute WTP"*)

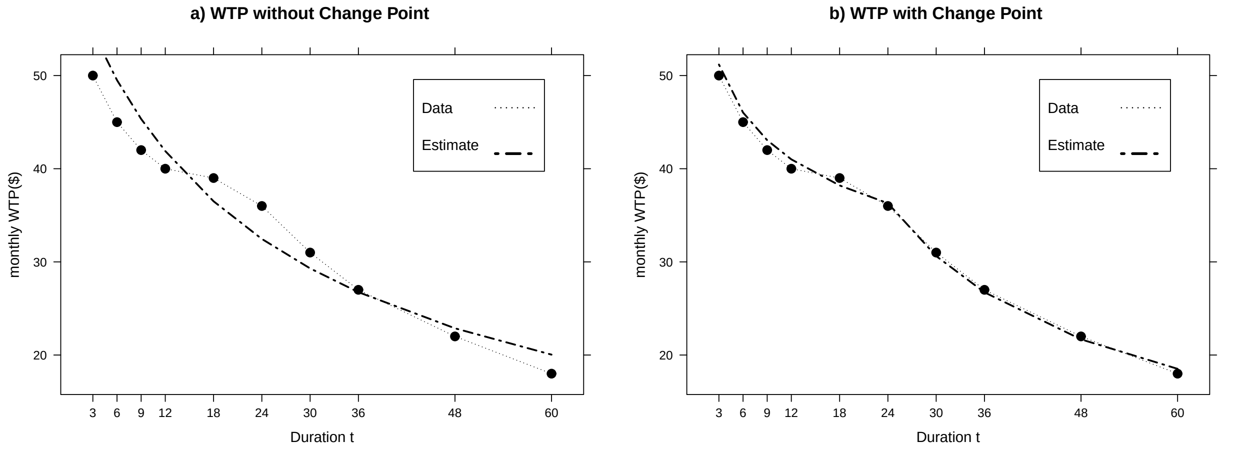


Finally, a comparison of model-based predictions of monthly willingness-to-pay also illustrates the differences between a model with and a model without considering a change point in individuals' discounting pattern. Figure 5 compares the model-predicted monthly WTP with the actual WTP for a randomly chosen individual. The model with the change point clearly fits the WTP data better. We calculated the mean squared error (MSE) across all respondents and there is a 53% improvement when using the model with a change point (MSE = 3.62) as compared to without a change point (MSE = 7.78).

In sum, the experiment provides evidence that individuals' discounting of different durations of *continuous* utility largely follows a hyperbolic pattern. But individuals' discounting of future *continuous* benefits is also characterized by structural discontinuities.

An important limitation of this study is that participants had no incentive to provide their accurate and true willingness-to-pay and discounting of future continuous streams of utility. This is a common problem when individuals are asked to state their willingness-to-pay (Jedidi and Zhang 2002). Note that while the absolute willingness-to-pay for an Internet service is not directly of interest, our inference regarding consumers' discounting

Figure 5: Study 1 - Willingness to Pay of One Representative Individual (*"Absolute WTP"*)



pattern might also be biased when they do not provide their true WTP. In the next study, we address this issue by developing a novel incentive-compatible mechanism to gather *"true"* consumer-level willingness-to-pay for longer contract durations.

4.2. Study 2 - Incentive-Compatible Experiments

The majority of methods used in the intertemporal choice literature, such as a choice or matching task, to measure individuals' discounting behavior suffer from an important limitation: they typically do not involve real payoffs and participants have no incentive to provide *true* answers (Frederick et al. 2002). Incentive-compatible methods are designed to circumvent this problem. For instance, a second-price private value Vickrey auction (Vickrey 1961) is a method in which the dominant strategy for each bidder is to bid their true value for the good regardless of what other bidders do. Although auction-based approaches have been used to measure individuals' discounting behavior of payoffs at discrete future time points (Olivola and Wang 2010), they are not directly applicable in our context where individuals are discounting future continuous benefits.[6] To address this issue, we develop a novel incentive-compatible method for eliciting discount rates for future *continuous* benefits. The survey and the questions were designed in a similar manner as our first study with the key difference being that participants received a monetary incentive to behave (i.e. discount) rationally.

[6] It is obviously extremely difficult to force participants to subscribe to a contract for Internet access after completing the experiment.

Method

This study was carried out in the form of two in-class experiments with the same group of thirty-eight participants (the second experiment was carried out a week after the first experiment). The sample consisted of MBA students, who were trained in business economics. Participants were told that they would be giving their willingness-to-pay for different contract durations for an Internet access service. The baseline contract duration was one month and its price was set at $ 30.-.

According to Samuelson (1937) rational individuals (*homo economicus*) discount future benefits according to a constant discounting pattern (Samuelson 1937, p. 156). We familiarized all participants (who were trained in business economics) with the constant discounting behavior of a rational agent. We explained to them that a constant discount rate corresponds to the actual interest rate of a loan or a deposit in a bank (since the structure of such financial products reflects constant discounting). For instance, a rational agent who expects an interest rate of 5% for a two year bank deposit of $ 10′000.- or a bank loan of $ 5′000.- should discount the utility of a two year contract duration (relative to an one month contract duration) at a constant 5% rate. Suppose a rational agent considers signing a two-year contract of a service, which is offered at a monthly fee of $30.-. In this example, the total payment for the contract without any price discount would be $720.- (=$30*24). But a rational agent will discount future benefits and would consider to sign the two-year contract only if its offered at a price lower than $\$30 * 24\text{months} * e^{-0.05*24} =$ $216.85.-. Thus, a rational agent would expect a 70% (=$720-$216.85)/$720) price discount when signing a two-year contract.

As an incentive to behave rationally and state their *true* WTP, participants were instructed that they will get a monetary reward when their stated WTP for a contract duration equals the WTP of a rational agent applying the constant interest rate that they expect for a deposit or a loan on a bank. The larger the deviation of their stated WTP from that of a rational agent, the smaller would be their reward. And, if their stated WTP (in absolute $ terms) differed from the WTP of a rational agent by more than 33%, they will not get any reward. Thus, participants had an incentive to discount future outcomes in a rational manner.

The participants first answered two questions about interest rates they expect for a bank deposit of $ 10′000.- and a bank loan of $ 5′000.-. Thereafter, in the first experiment (*"No Priming"*), they stated the maximum monthly contract fee (in $.-) that they were willing to pay to switch from a baseline duration of one month to a contract with a longer duration (i.e., 3, 6, 9, 12, 18, 24, 30, 36, 48, and 60 months). For each of the 10 questions, if their stated WTP was equal to the WTP of a rational agent applying the interest rate of the deposit and loan, respectively, the participant would get a reward of $ 2.-. Thus, across all 10 questions, each participant could receive a maximum of $ 20.-.

The second experiment (*"12 Months Priming"*) had the same format as the first experiment but we indicated to all participants that after 12 months an event may happen (e.g., a lucrative job offer abroad) that will prevent them from using the Internet service thereafter. Thus, in this experiment, we explicitly primed participants with a reference duration. As the reference duration plays a key role in the discounting behavior, we expect that there will be a discontinuity in the discount rate when the contract durations are greater than 12 months. Such a result would confirm the link between the reference duration and discounting behavior. Again, participants were given a reward of $ 2.- for each question when their stated WTP was the same as the WTP of a rational agent applying the interest rate of the deposit and loan, respectively. Thus, across all 10 questions, each participant could receive a maximum of $ 20.-.

After completing the main survey, each participant stated their critical durations when subscribing to an Internet access service by answering the following questions - (1) subscription length they usually subscribe to, (2) maximum contract duration they have ever subscribed to, (3) maximum contract duration they would consider in their choice between contract periods of different lengths, and (4) their actual planning horizon. Such data on critical durations can be related to structural breaks in the observed discounting behavior. Finally, we collected some demographic information (age, gender, nationality and field of study).

Results

All thirty-eight participants responded to all questions in both experiments. We paid a total of $624.62 as monetary incentive whereby each participant being paid around $18.37 (median) for his/her participation in both experiments. Next, we present descriptive results for the monthly discount rate in the two experiments.

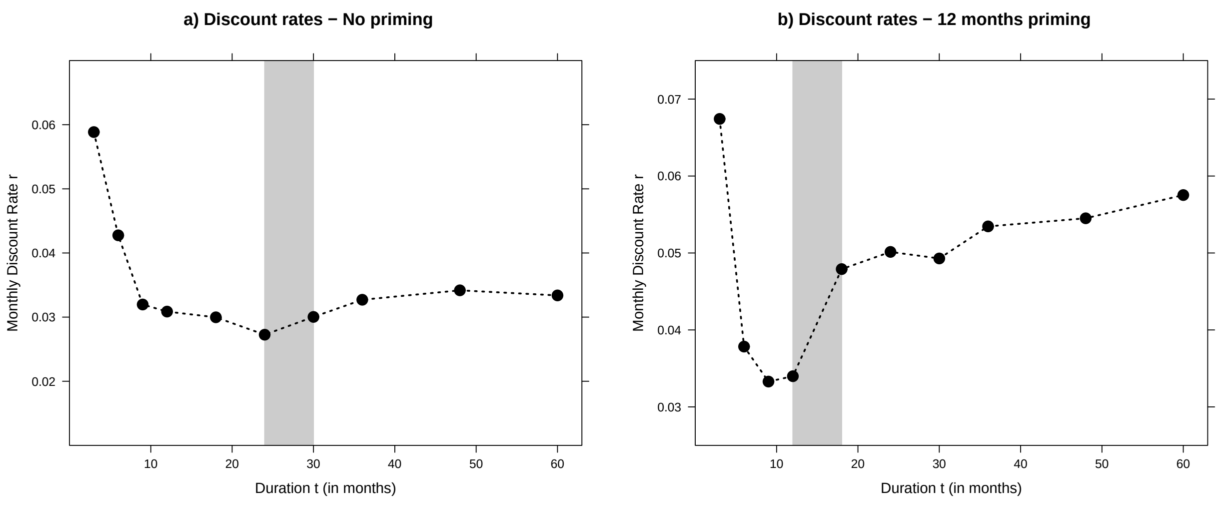
Descriptive Results. We calculated the monthly discount rates using the numerical technique as described in Study 1. Recall that these results are based on a non-parametric calculation of the discount rate. Table 3 provides the discount rates averaged across respondents for both experiments. The results show that for the first experiment (*"No Priming"*),

Table 3: Study 2 - Discount Rates

No Priming						*Priming of a Change Point at 12 Months*					
Duration t	Mean Discount Rate r	Standard Deviation of r	Difference in r	p-value		Duration t	Mean Discount Rate r	Standard Deviation of r	Difference in r	p-value	
3	0.05885	0.05822				3	0.06742	0.07415			
6	0.04275	0.04196	-0.01610	0.05998	*	6	0.03784	0.02975	-0.02958	0.00155	***
9	0.03196	0.02125	-0.01079	0.07739	*	9	0.03329	0.02703	-0.00455	0.05755	*
12	0.03086	0.02210	-0.00110	0.34330		12	0.03399	0.02474	0.00070	0.81030	
18	0.02997	0.01898	-0.00089	0.70330		18	0.04791	0.02740	0.01392	0.00014	***
24	0.02726	0.01701	-0.00271	0.15860		24	0.05014	0.02608	0.00223	0.46650	
30	0.03003	0.01735	0.00277	0.08230	*	30	0.04929	0.02687	-0.00085	0.58610	
36	0.03271	0.02177	0.00268	0.10310	*	36	0.05345	0.03459	0.00417	0.14780	
48	0.03418	0.02659	0.00147	0.40260		48	0.05451	0.04238	0.00105	0.74060	
60	0.03338	0.02368	-0.00079	0.04232		60	0.05753	0.04128	0.00302	0.01984	**

the monthly discount rate decreases with increasing duration. Similar to the results in Study 1, there is a marginally significant increase in the discount rate at a contract duration of 30 months. Note that the marginal significance is primarily due to the averaging of discount rates across individuals as each individual has their own critical duration. In the parametric analysis described later, we perform an individual-level estimation and provide a much stronger evidence for the discontinuity in the discount rate. The increase in the discount is more noticeable in the second experiment (*"12 Months Priming"*) in which participants were told that after 12 months their life may change (e.g., new job). We find that the shift in the discount rate clearly occurs after a contract duration of 12 months. Figure 6 shows the discount rates for both experiments. The figure reemphasizes that

Figure 6: Study 2 - Pattern of Discount Rates

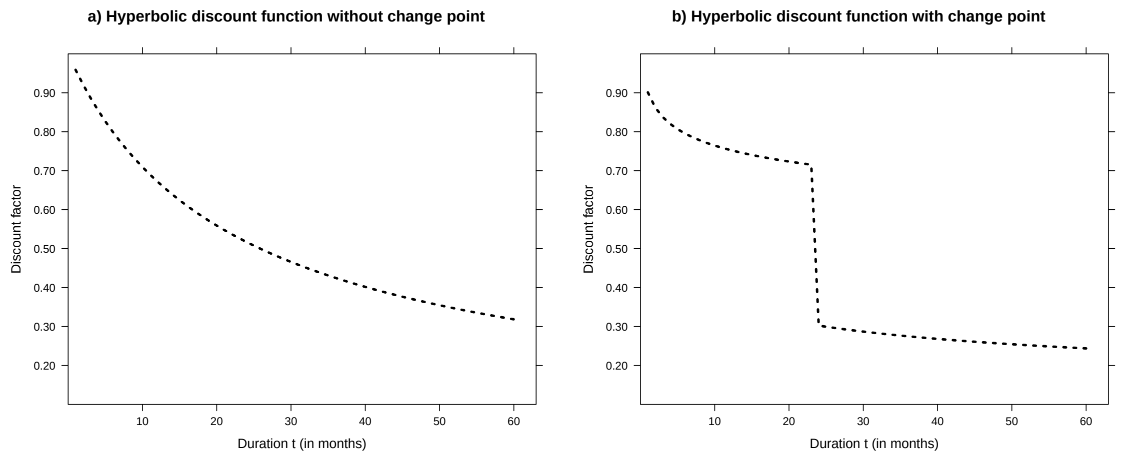


the priming in the second experiment (i.e., manipulation of a reference duration) worked

Table 4: Study 2 - Parameter Estimates (*"No Priming"*)

Model Without Change Point		*Model With Change Point*	
Parameter	*Estimate [2.5%, 97.5%])-Quantiles*	*Parameter*	*Estimate [2.5%, 97.5%]-Quantiles*
α	0.0546 [0.0303, 0.0873]	$\alpha^{(1)}$	2.5758 [0.4202, 11.1318]
β	0.0430 [0.0317, 0.0549]	$\beta^{(1)}$	0.2104 [0.0708, 0.7174]
	—	$\alpha^{(2)}$	6.6236 [0.5191, 18.962]
	—	$\beta^{(2)}$	1.5613 [0.2428, 4.0832]

Figure 7: Study 2 - Discount Functions (*"No Priming"*)

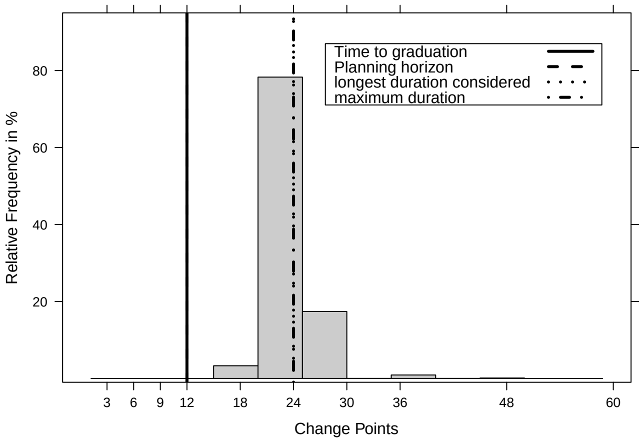


extremely well. In sum, reference points play a key role in influencing individuals' discounting behavior of longer contract durations.

Model Results. We estimated consumers' discount function based on our proposed model with and without change point. We begin with the results for the experiment with no priming. Table 4 shows the estimates of the discount function with and without a change point. The model with a change point gives significantly different estimates as compared to the model without a change point. Figure 10 plots the two discount functions using the estimated parameters. The figure illustrates the difference in the predicted discounting pattern from the two models.

As noted earlier, the change point model also provides information regarding when a change point is likely to occur. Figure 8 shows the likelihood of a change point at various contract durations for a randomly chosen individual. The figure shows that the probability of a change point is highest for a duration of 24 months, which is quite close to the maximum duration that this individual considers for Internet access. We can similarly infer the probability of occurrence of a change point at various contract durations for each individual and relate it to their critical duration.

Figure 8: Study 2 - Change-Point (CP) Distribution of One Representative Individual (*"No Priming"*)



A comparison of model-based predictions of monthly willingness-to-pay from the two models also illustrates the differences between them. Figure 9 compares the model-predicted monthly WTP with the actual WTP for a randomly chosen participant. The figure shows that the model with the change point fits the WTP data better. We calculated the mean squared error (MSE) across all respondents and found that there was a 53% improvement when using the model with a change point (MSE = 1.29) than without a change point (MSE = 2.78).

Next, we discuss the results from the experiment with an explicit priming of the reference duration. Table 5 shows the estimates of the discount function with and without a change point. Similar to our earlier results, the model with a change point gives significantly different estimates as compared to the model without a change point. Figure 10 plots the two discount functions using the estimated parameters. The figure shows that when participants were primed with a reference duration of 12 months, there was a sharp discontinuity in their discounting pattern at 12 months.

Figure 11 shows the likelihood of a change point at various contract durations for a randomly chosen individual. The figure clearly shows that the probability of occurrence

Figure 9: Study 2 - Willingness to Pay of One Representative Individual (*"No Priming"*)

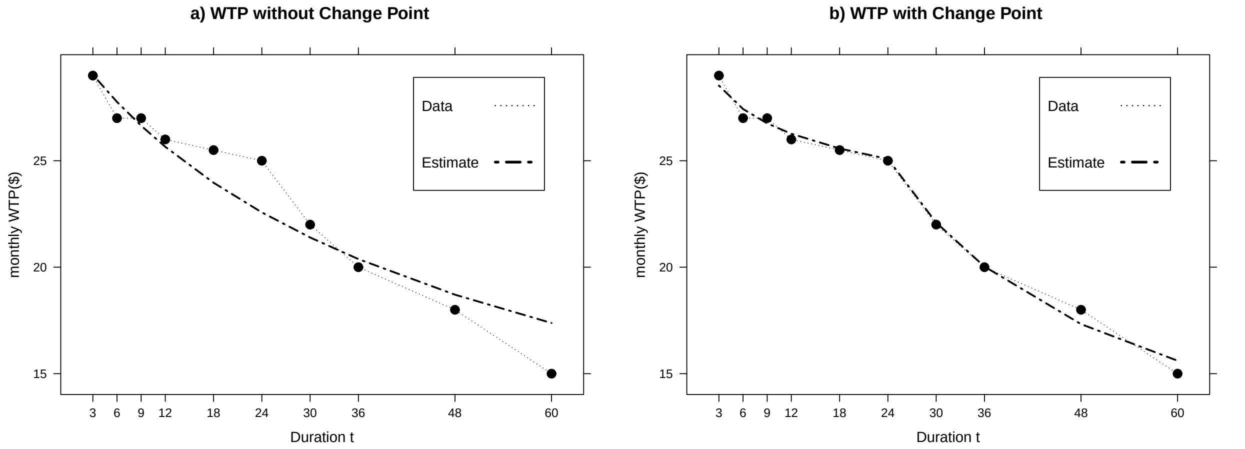
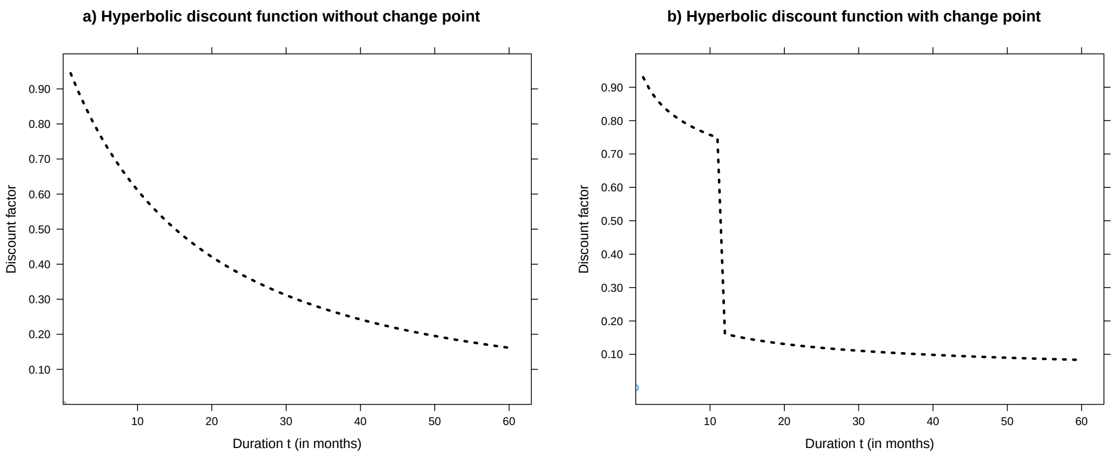


Table 5: Study 2 - Parameter Estimates (*"12 Months Priming"*)

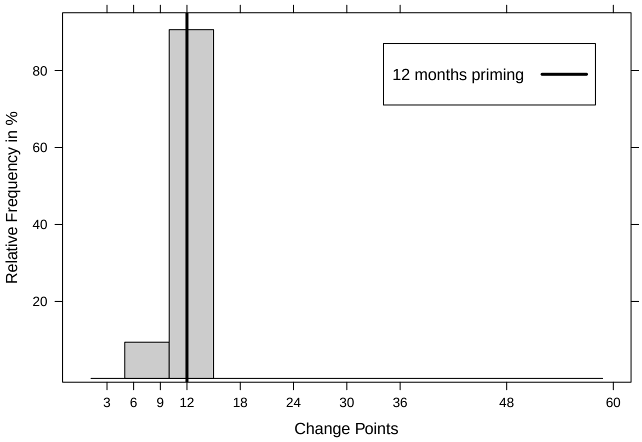
Model Without Change Point		*Model With Change Point*	
Parameter	*Estimate* [2.5%, 97.5%]-*Quantiles*	*Parameter*	*Estimate* [2.5%, 97.5%]-*Quantiles*
α	0.0375 [0.0204, 0.0589]	$\alpha^{(1)}$	0.7473 [0.0769, 4.9704]
β	0.0580 [0.0465, 0.0705]	$\beta^{(1)}$	0.0972 [0.0425, 0.3893]
	—	$\alpha^{(2)}$	6.7992 [0.9479, 16.8213]
	—	$\beta^{(2)}$	2.8100 [0.5846, 6.2821]

Figure 10: Study 2 - Discount Functions (*"12 Months Priming"*)



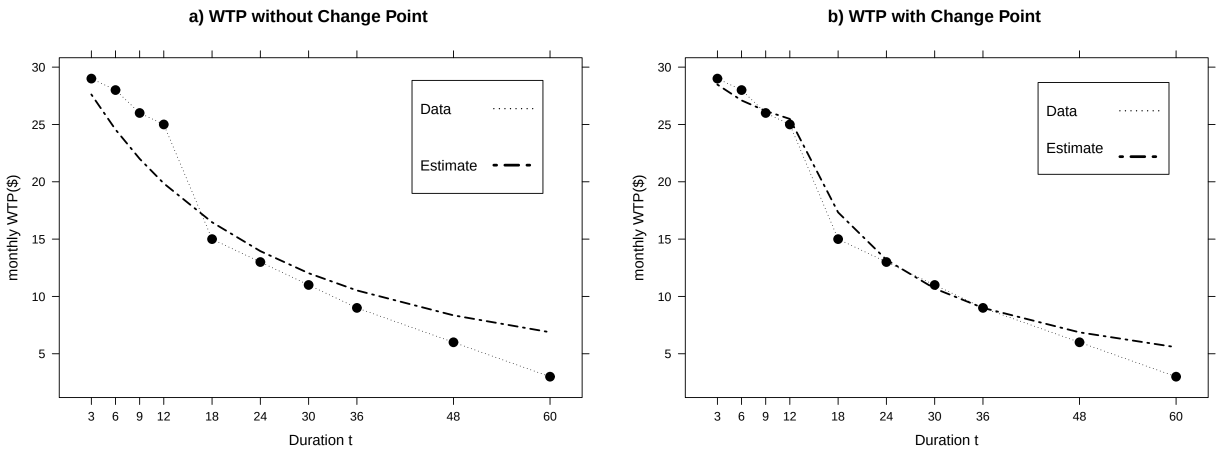
of a change point is highest for a duration of 12 months. We obtain a very similar distribution while inferring the probability of occurrence of a change point at various contract durations for all other individuals.

Figure 11: Study 2 - Change-Point (CP) Distribution of One Representative Individual (*"12 Months Priming"*)



Finally, Figure 12 compares the model-predicted monthly WTP with the actual WTP for a randomly chosen individual. The figure confirms that the model with the change point fits the WTP data better. We calculated the mean squared error (MSE) across all participants and there was a 44% improvement when using the model with a change point (MSE =2.72) than without a change point (MSE= 4.88).

Figure 12: Study 2 - Willingness to Pay of One Representative Individual (*"12 Months Priming"*)



Overall, the empirical results of both studies provide strong evidence that individuals' discounting pattern for future *continuous* benefits from contract-based products or services is, in general, consistent with hyperbolic discounting - the monthly discount rate decreases with contract duration. This finding is in line with past research that has considered intertemporal discounting of utility at *discrete* future time points (Ariely and Loewenstein 2000, Ariely and Zauberman 2000, Laibson 1997, Loewenstein and Prelec 1992, Thaler 1981). Pure hyperbolic discounting, however, cannot account for the entire variation in consumers discounting behavior especially for benefits under long contract periods. We find that there are discontinuities in the consumers' discount function attributable to their valuation of flexibility. Our results, therefore, reveal that for intertemporal decisions in which individuals have to choose between different durations of future *continuous* benefits, it is necessary to account for structural changes in individuals' discounting behavior.

5. Discussion and Conclusions

Individuals often face intertemporal decisions in which they have to discount future *continuous* benefits from periodic (monthly, yearly or seasonal) use or access to a product or service offered with a contract (such as a subscription or flat rate). For example, many products or services (health clubs, online information services, newspapers, Internet access, software updates and pay TV) are offered with contracts of differing lengths and consumers, in turn, have to choose the contract duration that maximizes their net utility. Such intertemporal choices are characterized by trade-offs between a short contract period associated with a high price per time unit and a long subscription period associated with a price discount. In this paper, we study and characterize how individuals discount future *continuous* benefits which they receive from periodic use or access to a contract-based product or service. We propose a parsimonious model of how consumers evaluate future benefits. Our proposed model accommodates any shifts (or discontinuities) in the consumers' discounting behavior due to the interplay of contract length and their valuation of flexibility. We estimate our model using self-stated data from consumers regarding their willingness-to-pay for various contract durations of an access-based service. In this context, we also address an important limitation of self-stated data collection as being not incentive compatible by developing a novel incentive-compatible experimental design.

We have three key results. First, individuals' discounting behavior of future continuous stream of utility is heavily biased towards the present. This finding is consistent with past research on hyperbolic discounting (e.g., O'Donoghue and Rabin 1999, Thaler 1981, Zauberman 2003). Second, there are discontinuities in consumers' discounting behavior largely attributable to the interplay of contract length, price discounts and consumers' valuation of flexibility. In all our studies, we find that the monthly discount rate has a robust pattern - the discount rates initially decrease with contract duration (consistent with hyperbolic discounting), but after a certain length of contract duration, there is a structural break and the discount rate increases. Put differently, a hyperbolic function alone cannot explain the entire variation in consumers' discounting pattern. Third, our observed pattern of individuals' discounting of future continuous utility is robust even when individuals receive a monetary incentive to discount future benefits without any time inconsistency in an incentive-compatible experimental setting.

Although our findings about individuals' discounting of future continuous stream of utility are general, the results of our paper are especially relevant for firms that employ subscription-based pricing (e.g., business-to-consumer companies). For instance, OECD Communications Outlook (2011) indicates that fixed, mobile and broadband subscriptions are rapidly growing around the world. Similarly, according to the Newspaper association of America (NAA), more than 55% of adults in the U.S. subscribe to weekday papers. Such services offer a common type of subscription characterized by a length of time (e.g., a month or a year) a customer can use the service and a corresponding one-time flat fee. A key aspect of such pricing is that the price per-time unit declines with a longer subscription period. Our modeling framework and results provide insights for the optimal design of such plans.

In this paper, we empirically investigated the discounting behavior of consumers in the context of subscriptions. We found that there are discontinuities in the discount rate with long contract durations. Further research can disentangle the impact of usage uncertainty and contract obligations on the observed discounting behavior. We restricted our focus to the initial purchase of a subscription. Future research may consider issues related to repurchase of plans, customer retention and actual usage in consumers' choice of tariffs. Finally, we characterized willingness-to-pay as the price at which a consumer is indifferent between buying and not buying the product or service. Recent work has characterized willingness-to-pay as a range (Wang, Venkatesh and Chatterjee 2007). This suggests extending our model to allow for consumer uncertainty in WTP. We hope this paper encourages work in these and related directions.

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Appendix A: Model Identification and Estimation

In this Appendix, we discuss model identification and estimation.

In order to estimate all parameters of our WTP-(CP) Model in equation (5), we have to apply some model transformations. These transformations are necessary due to model identification. Consider the WTP specification in (5) closely. Due to model identification, it is necessary to eliminate the utility parameter θ_i from the expression. This can be seen as follows. Let θ_i be A_i, and

$$B_{i,t} = \frac{1}{t(\alpha_i - \beta_i)} \left[(1 + \alpha_i t)^{1-\frac{\beta_i}{\alpha_i}} - 1 \right].$$

We can easily see that the monthly WTP for a contract duration of t months is given by:

$$WTP_i(t) = A_i \times B_{i,t}$$

Given that the expression for WTP contains a product of model parameters, clearly all parameters cannot be separately identified. In order to address this issue, we use the fact that in the surveys all WTP statements are based on the WTP for baseline contract duration (one month), i.e. $WTP_i^{\text{(per month)}}(1)$ is either set to a specific amount or self-stated by the respondents. We can then use the known $WTP_i^{\text{(per month)}}(1)$ to reduce the number of parameters to be estimated. In particular, we can eliminate the estimation of θ_i from the model as follows. The $WTP_i^{\text{(per month)}}(1)$ is known from the surveys, so according our model:

$$WTP_i^{\text{(per month)}}(1) = \frac{\theta_i}{(\alpha_i - \beta_i)} \left[(1 + \alpha_i)^{1-\frac{\beta_i}{\alpha_i}} - 1 \right]$$

Then, solving for θ_i, we get:

$$\theta_i = \frac{WTP_i^{\text{(per month)}}(1)(\alpha_i - \beta_i)}{\left[(1 + \alpha_i)^{1-\frac{\beta_i}{\alpha_i}} - 1 \right]}$$

Consequently, for all contract durations greater than the baseline duration, we can replace θ_i from the above expression. For a model with no-change point, we can then calculate the $WTP_i(t)$ as

$$WTP_i^{\text{(per month)}}(t) = \frac{WTP_i^{\text{(per month)}}(1) \left[(1 + \alpha_i t)^{1-\frac{\beta_i}{\alpha_i}} - 1 \right]}{t \left[(1 + \alpha_i)^{1-\frac{\beta_i}{\alpha_i}} - 1 \right]}$$

We can do the same for WTP formulation with a change-point to obtain the following expression:

$$WTP_i^{\text{(per month)}}(T) = \begin{cases} \frac{WTP_i^{\text{(per month)}}(1)}{T\left[\lambda\left(1;\alpha_i^{(1)},\beta_i^{(1)}\right)-1\right]} \left[\lambda\left(T;\alpha_i^{(1)},\beta_i^{(1)}\right) - 1 \right], & \text{if } T < t_i^* \\ \frac{WTP_i^{\text{(per month)}}(1)}{T\left[\lambda\left(1;\alpha_i^{(1)},\beta_i^{(1)}\right)-1\right]} \left[\lambda\left(t_i^*;\alpha_i^{(1)},\beta_i^{(1)}\right) - 1 \right] + & \\ \frac{WTP_i^{\text{(per month)}}(1)(\alpha_i^{(1)}-\beta_i^{(1)})}{T(\alpha_i^{(2)}-\beta_i^{(2)})\left[\lambda\left(1;\alpha_i^{(1)},\beta_i^{(1)}\right)-1\right]} \left[\lambda\left(T;\alpha_i^{(2)},\beta_i^{(2)}\right) - \lambda\left(t_i^*;\alpha_i^{(2)},\beta_i^{(2)}\right) \right], & \text{if } T \geq t_i^* \end{cases}, \quad (14)$$

with

$$\lambda(t;\alpha,\beta) = (1 + \alpha t)^{1-\frac{\beta}{\alpha}} \quad (15)$$

Without loss of generality, we can assume that for the $WTP_i(1)$ the parameters $\alpha_i^{(1)}$ and $\beta_i^{(1)}$ are applied in the discount function (behavior).

We use Markov Chain Monte Carlo Methods (MCMC) methods to estimate both models with and without a change point. Our approach follows standard Bayesian estimation for hierarchical models (Rossi and Allenby 2003). Details are available from the authors upon request.

Appendix B: Study 1 - Results from the Survey on Expected Price Discounts

In this Appendix, we describe the results based on the second survey ("Expected Price Discounts"). Table B1 shows the parameter estimates for the discount functions based on the models with and without a chance point. A comparison of the estimates from the first survey ("Absolute WTP") as shown in the main text (Table 2) and from the second survey reveals that they are not statistically different from each other. The 95% confidence interval around the estimates corresponding to the models estimated on the two surveys have an overlap. The comparison emphasizes that our key results are robust to framing effects.

Table B.1: Study 1 - Parameter Estimates ("*Expected Price Discount in %*")

without change point		*with change point*	
Parameter	*Estimate* (2.5%;97.5%)-Quantiles	*Parameter*	*Estimate* (2.5%;97.5%)-Quantiles
α	0.07	$\alpha^{(1)}$	1.52
	(0.05, 0.09)		(0.66, 3.79)
β	0.07	$\beta^{(1)}$	0.26
	(0.06, 0.08)		(0.15, 0.52)
	—	$\alpha^{(2)}$	7.41
			(0.61, 18.31)
	—	$\beta^{(2)}$	2.92
			(0.46, 6.31)