PERCEPTION, CHOICE AND DESIGN OF TARIFFS WITH COST CAPS

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Abstract

With the ongoing trend towards a competitive and service oriented economy, the need for innovative pricing schemes becomes increasingly important as pricing remains the only differentiation possibility for almost homogeneous services. This thesis studies the impact of innovative nonlinear tariffs that are formed by a cost cap component over and beyond the traditional tariff components of fixed fee, usage price, and allowance. Thereby, cost cap components fix an upper cost ceiling, after which consumption is exempt from further costs. Cost caps have recently been introduced for telecommunication services, but were also used earlier as deductibles in insurance contracts or as maximum day rates for rental services.

The thesis at hand demonstrates the use of different methodologies in order to study the effects of these innovative pricing schemes. Implications for consumers and providers caused by the extension of tariffs by a cost cap component are discussed in detail. Based on a theoretical model, the influence of cost cap components on consumers' consumption and tariff decision behavior under uncertainty is analyzed. The results show that cost cap tariffs are only an optimal tariff choice for those consumers that face considerable uncertainty about their future demand, such that both relatively low and relatively high consumption levels are considered feasible. The application of the developed model in a stated preference experiment confirms the model's external validity, and shows the importance of the two-way dependency of consumption and choice.

Further analyses provide evidence for the influence of psychological effects on cost cap tariff choice. Interestingly, framing of the cost cap tariff influences its perception and increases its attractiveness. However, the subsequent studies on further effects do not compose to a distinct finding. While the results of an empirical study show that respondents do not prefer a flat rate to a cost cap tariff due to the taximeter effect, a new psychophysiological measurement approach reveals that respondents still experience the pain of paying under a cost cap tariff. Furthermore, the conducted studies differ in explaining the importance of a tariff's insurance property on tariff choice.

Finally, circumstances under which the implementation of a cost cap component increases the providers' profits are analyzed on the basis of simulated annealing using estimated consumers' preferences. Thus, simulation results provide a profit forecast even in cases where novel tariff schemes cannot be implemented in real markets without barriers. The results show that the implementation of a cost cap component into tariffs with usage prices always increases the providers' profits. However, the superiority of the cost cap component suffers from increasing marginal costs and fierce competitive pressure.

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Finally, I would like to thank those people without whom this work would not have been possible. Foremost, I would like to thank my parents Ulla and Wolfgang and my sister Nina for their unconditional love and support throughout my life. Last but not means least, I thank Daniela for her love, encouragement and the joy she brings to my life. I owe them more than words can describe.

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Chapter 1

Introduction

"Price is what matters in the marketplace."

Financial Times

THE centrality of services to developed economies is ever increasing. Today, the service sector comprises a majority of the Gross Domestic Product in many countries, such as the United States (64%) and Germany (68%). Services cover a variety of different industries such as health care, transportation, media, information, entertainment or telecommunications. However, all services feature two common characteristics (Shoemaker and Mattila, 2009). Services are the intangible equivalent of goods, which induces consumer uncertainty in service preference. Furthermore, production and consumption of services are taking place at the same time. The perishability of services challenges service providers to correctly anticipate consumer demand. In this context, pricing of services is crucial for both consumer differentiation and shifting demand. In fact, for many homogeneous services such as telecommunications, pricing is the major service feature (Lambrecht et al., 2012).

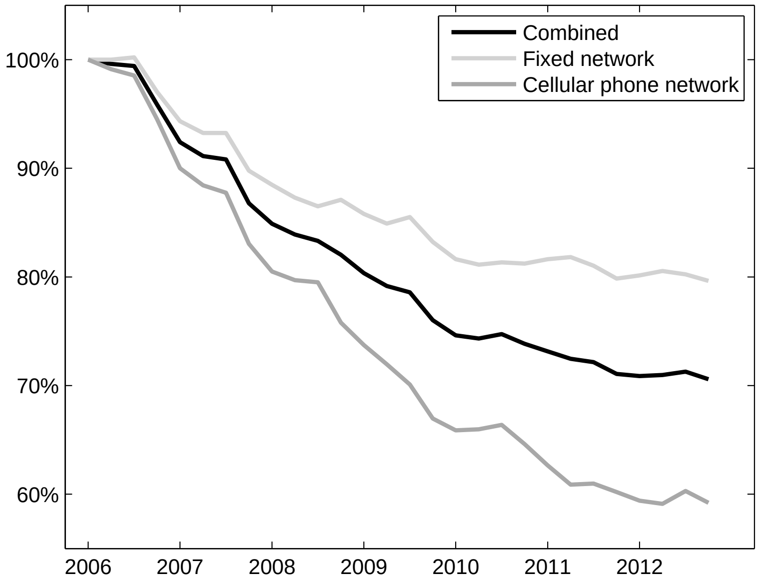
1.1 Motivation

Especially the telecommunications industry has been a major driver of economic growth, with an impact on both companies and consumers (Statistisches Bundesamt, 2013a). Telecommunication services are omnipresent and the availability of data and voice has changed our way of living. Thereby, telecommunications is a typical access industry, where consumers gain the right to use the service but do not acquire any right to the service itself (Essegaier et al., 2002). In most cases, access industries offer virtually identical services, which are often only differentiated by their pricing. Therefore, price discrimination is common (Lambrecht et al., 2012) and consumer heterogeneity is countered by complex nonlinear pricing schedules which are modeled by tariffs (Wilson, 1993). At the time when telecommunications companies were state owned, pricing was realized in simple nonlinear tariffs. Since the deregulation of former national monopolies, competition has become fierce and resulted in an increased price competition that lasts until now. Figure 1.1 exemplifies the decrease of producer prices in the German telecommunications market, dropping to almost 30% of its former price levels since 2006.

Service providers combat this price decline with innovative pricing practices to ease competitive pressure and differentiate consumers. A lot of research has attended to these new pricing approaches in various disciplines by studying the consumers' choice behavior and companies' price strategies (Lambrecht et al., 2012). This includes offering an allowance, which guarantees consumers a quantity of usage free of charge (Lambrecht et al., 2007; Ascarza et al., 2012), or offering services in predefined consumption buckets (Schlereth and Skiera, 2012). However, earlier results cannot be generalized to more complex tariffs and, thus, there remains a need for further tariff research as stated by Iyengar and Gupta (2009).

More recently, O2 Telefonica introduced such a complex pricing schedule by offering a new variant of the pay-per-use tariff into the German telecommunications market. This new tariff was advertised as the first tariff including a cost airbag. In addition to

FIGURE 1.1: *Trend of producer prices in the German telecommunications sector (Statistisches Bundesamt, 2013b)*



Note: Producer prices are based on a basket of 2,000 telecommunication services offered by major German providers and edited by the German Federal Statistical Office. The trend is shown as the percental deviation of producer's prices of 2006.

the marginal price for every minute on the phone, the tariff also included a cost ceiling. Consequently, the total bill at the end of the billing period could not exceed this predefined cost ceiling. With this pricing schedule O2 quickly attracted numerous competitors' customers (Briegleb, 2009). In the meantime other mobile operators have also adopted the same tariff scheme in pricing their mobile services (Petzke, 2010). While this type of tariff had not been implemented into telecommunications markets before, equivalent variants have been used in related industries. Many insurance plans such as car, household, or health insurances, include a deterrent fee, which acts as a cost ceiling a consumer has to pay for himself before reaching it. Cost ceilings have also been used in the rental industry, where day rates limit consumption-dependent costs by a predefined maximum. Such a nonlinear tariff has been implemented by Deutsche Bahn AG, which offers a bicycle sharing service. The basic tariff includes renting a bike for 8¢ per minute although costs can never exceed a day rate of 15€ per day.

Considering its use in different pricing contexts, cost caps should rather be seen as tariff components than as a tariff itself. In fact, combining the cost cap component with known tariff components enables service providers to offer several new tariff schemes. This might even climax in the combination of four tariff components. Actually, Deutsche Bahn was the first provider to offer such a four-part tariff.

Although cost caps are used in different industries, research on cost caps and in particular on four-part tariffs is limited. However, the possibility to extend tariffs with a cost cap component opens up several promising research questions, which will be discussed in the next section.

1.2 Research Questions

The implementation of a cost cap component into a tariff poses several research questions on both the consumers' as well as the providers' side. Earlier research on nonlinear tariffs has accounted for the interplay of tariff choice and consumption (Dubin and McFadden, 1984; Hanemann, 1984) by the use of discrete/continuous models. These models take into account that the discrete choice depends partly on the outcome of continuous consumption decision and vice versa. However, previous literature considered only tariffs of up to three components: fixed fees, usage prices and allowances. To this point it is not clear how the cost cap component influences the consumers' consumption and decision behavior. Particularly due to the fact that cost caps further increase the extent of nonlinearity in tariffs, the role of consumers' uncertainty in consumption (Lambrecht et al., 2007) is crucial. Thus, the first research question is as follows:

RESEARCH QUESTION 1. *How does uncertainty about future consumption influence the choice of tariffs with a cost cap component in comparison to pay-per-use and flat rate tariffs?*

Furthermore, earlier research found tariff specific (Train et al., 1987) and even component specific (Ascarza et al., 2012) preferences. These tariff biases significantly impact tariff choice, even if consumers were financially better off by choosing another tariff alternative. Several psychological factors have been identified (Lambrecht and Skiera, 2006a) to explain tariff biases. Several of them potentially interfere with a cost cap component so that the implementation of cost caps may significantly change tariff perception. Furthermore, tariff framing was found to significantly influence tariff choice (Ho and Zhang, 2008) and may also alter the perception of tariffs with a cost cap component. The second research question addresses these considerations:

Research Question 2. *Which psychological factors influence the perception of tariffs with cost cap components?*

From a provider's perspective two things are of special interest. First, whether and how consumers' tariff choice behavior can be estimated and second, how this knowledge can be used to optimize the offered tariff portfolio. Stated as well as revealed preference data has been used to study tariff choice within the last decade (see Schlereth and Skiera, 2012, for an overview). It is however unclear whether earlier approaches can be adopted to account for the cost cap component. Besides the degree of nonlinearity and the importance of uncertainty, it is questionable whether respondents in stated preference experiments can handle the complexity of four-part tariffs, i.e., tariffs including a cost cap component. Developing a behavioral model, which accounts for consumers' behavior under four part tariffs and verifying a methodology to estimate the very, is the focus of the third research question:

Research Question 3. *How can the existing models of consumer preferences be improved to accurately estimate consumers' behavior and choice under four-part tariffs?*

A thorough knowledge about prospective consumer behavior under four-part tariff enables providers to adjust their tariff portfolio in order to optimize profits. However, it is not clear whether cost cap components do in fact increase providers' profits. Earlier research studied nonlinear tariff optimization both under monopolistic and competitive circumstances and identified several factors to drive providers' profits. When considering the cost cap component, two aspects are of greater interest. As consumption is free of charge after reaching the cost cap, marginal costs seem to be critical as any consumption after reaching the cap relates to a decreased profit to the provider. Furthermore, adding a cost cap provides an additional possibility to price discriminate consumers. From a researcher's perspective, it is interesting to see whether a provider can take advantage of this ability even under competitive pressure. Consequently, the fourth research question asks:

RESEARCH QUESTION 4. *Under which constellations is the implementation of a cost cap component likely to increase providers' profits?*

1.3 Structure of this Thesis

The above research questions are addressed in the thesis at hand, which is organized as follows. Chapter 2 provides the necessary fundamentals of tariff research. It starts by structuring tariff schemes and the components they consist of. The chapter includes an overview on models for tariff choice together with a discussion on the existence and causes of tariff biases. Chapter 3, which is adopted from Koehler et al. (2012a), addresses Research Question 1 by developing a theoretical model to study the effect of cost cap tariffs on consumers' consumption and choice behavior. The chapter concludes in an empirical validation of the proposed model. In order to account for four-part tariffs, the model is further extended in Chapter 4. The complexity of four-part tariffs prevents the theoretical analysis of consumer behavior and is therefore approached as an empirical investigation. The proposed methodology allows to estimate consumers' tariff preferences and thus addresses Research Question 3. Based on the estimated preferences of Chapter 4, optimal tariff portfolios including cost cap components are studied under different market assumptions in Chapter 5. Using a simulation approach, circumstances are identified under which tariffs with cost caps outperform any other alternative. While these studies rely on the proposed behavioral model, Chapter 6 focuses on tariff perception aspects from a psychological as well as physiological perspective and addresses Research Question 2. Within this chapter, effects known to explain tariff biases are examined in order to explain tariff choice involving cost cap components. The framing effect is thereby studied in more detail. At last, as an adoption of Koehler et al. (2012b), a new methodology based on psychophysiological measurement is proposed to study the perception of tariffs with cost caps. The thesis concludes in Chapter 7 and presents promising future research.

Chapter 2

Foundations of Tariff Research

"An architect's exceptional creativity [...] could hardly compensate for an ignorance of structural engineering. No less important are the principles of economics to the successful study and practice of the art of pricing."

(Nagle, 1984)

THE second chapter provides an overview on tariff research and starts by classifying tariffs as the application of nonlinear pricing in Section 2.1. Then Section 2.2 explains in more detail how tariff components can be used to create different tariff structures. Tariff choice is further discussed in Section 2.3, before 2.4 concludes with an overview on tariff biases.

2.1 Nonlinear Pricing

Pricing has been an important field in marketing research ever since (Gijsbrechts, 1993; Rao, 1984) and it is still today (Rao, 2009). With the shift towards a service oriented economy especially research on nonlinear pricing has gained momentum (Danaher, 2002; Iyengar et al., 2008; Lambrecht et al., 2007; Sundararajan, 2004). Nonlinear pricing includes all schedules where the total costs that a consumer has to pay is not proportional to its consumption (Iyengar and Gupta, 2009; Wilson, 1993). Most known are quantity discounts for larger volumes or consumption. For instance, monthly payments for fitness memberships are lower when contracts are signed for a longer time period. Consumer packaged goods are another example where larger volume packages have a lower average price.

Wilson (1993) stated four preconditions to be satisfied in order to implement nonlinear pricing:

1. *Imperfectly competitive markets.* Prices are driven down to marginal costs in complete competitive markets and nonlinear pricing becomes obsolete. Wilson amplifies that the degree of competition limits the extend of nonlinear pricing.

2. *Absence of resale markets.* Another crucial precondition for nonlinear pricing is the absence of a resale market or at least its limitation and control by the supplier. With the possibility to resell products, buyers of large quantities can benefit from reselling the product in smaller proportions and act as secondary suppliers on the market. Often resale is limited by contractual prohibitions or high transaction costs (Murphy, 1977).

3. *Purchase monitoring.* As pricing schedules are tailored to match specific consumer types, it is crucial for a company to identify its consumers. Furthermore, nonlinear pricing may be realized in several different ways, such as the quantity of a single purchase, but also by the rate of purchases or the sum of purchases. This is why the ability to measure consumers' purchases is another important precondition for nonlinear pricing.

4. *Consumer heterogeneity.* Heterogeneity is the fundamental assumption for nonlinear pricing. Only if consumers value successive increments differently, companies are able to profitably adjust their pricing policy on consumption size.

As stated in the introduction, services, such as telecommunication services, are characterized by their intangibility and perishability (Shoemaker and Mattila, 2009). Thus, the immediate consumption after purchase guarantees the absence of resale markets. Furthermore, advances in information technology simplified the possibilities of purchase monitoring. Therefore, competition and consumer heterogeneity remain the most important factors influencing the applicability of nonlinear pricing. Iyengar and Gupta (2009) also highlighted the importance of consumer heterogeneity, calling it the primary factor of implementing nonlinear pricing schemes as consumers self select different pricing plans based on their expected consumption under such. However, Iyengar and Gupta point out that demand analysis under nonlinear pricing is nontrivial. This is due to the fact that there is a two-way dependency between the choice of nonlinear pricing schemes and consumption under the chosen schemes (Hanemann, 1984; Kridel et al., 1993) which will be explained in more detail in Section 2.3.

2.2 Tariff Design

Consumer heterogeneity is countered by complex nonlinear pricing schedules which are modeled through tariffs (Iyengar and Gupta, 2009; Wilson, 1993). Tariffs are used for nonlinear pricing of services in, e.g., telecommunications, information technology, energy, healthcare, and insurances (Bagh and Bhargava, 2013; Danaher, 2002; Iyengar and Gupta, 2009). The design of tariffs is built on multiple pricing components and thus, can be adapted for different consumer types. The following section provides an overview on components complementing different tariff schedules. The section is closely related to Skiera (1999).

2.2.1 Tariff Components

Tariff components are the basis for tariff design. Their composition strongly influences the nonlinearity of pricing under different tariff schemes and hence consumer behavior. Recent pricing literature differentiates between four components.

Fixed Fee The fixed fee is a consumption independent payment which is charged on a regular seasonal basis. It is also known as access, license or lump sum fee (Murphy, 1977; Oi, 1971). As the fee is consumption independent, it is often used to cover initial investment costs (Valletti, 2003). In the context of new subscription services, Danaher (2002) studied the effect of fixed fees in more detail. Danaher found two effects: First, fixed fees have some negative effect on consumption. Second and even more important, attrition elasticities increase as the fixed fee increases. The churn rate is an important feature for services, demonstrating the importance of the optimal design of fixed fees. Ho and Zhang (2008) further explained that the churn rate also depends on the framing of the fixed fee. Using the loss aversion theory (Kahneman and Tversky, 1979), Ho and Zhang were able to show that an increase in loss aversion leads to an increased chance of rejecting a tariff offer with fixed fee.

Minute Price While the fixed fee maps independently of consumption into the total bill, which a consumer is requested to pay at the end of the billing period, the minute price causes the total bill to increase proportionally with consumption. Thereby, the consumer is charged a price for each consumed unit. The minute price is therefore also called usage price, per unit charge, or marginal price. It is known to have a strong impact on consumption (Danaher, 2002; Prelec and Loewenstein, 1998), as consumption decreases with the marginal price. However, Danaher showed that the attrition elasticity is considerably smaller with respect to the minute price than with respect to the fixed fee.

Allowance Often an allowance is included in a tariff along a fixed fee. The allowance grants a predefined consumption with a minute price of zero. Thus, exceeding the allowance results in a positive marginal price. Lambrecht et al. (2007) found a strong impact of an allowance on consumers' tariff choice. The authors explain the tendency to choose a tariff with allowance by consumers' uncertainty in consumption. The expected bill increases with the variation in consumption which consumers try to avoid. Besides this effect, Ascarza et al. (2012) found an increase in consumption under tariffs with allowance that cannot be explained by the impact of the allowance on consumers' budget constraint.

Cost Cap Recently, the cost cap component was introduced as a new component in the design of telecommunications tariffs. It has only been studied by Kraemer and Wiewiorra (2010) until now. The cost cap equals an upper limit of the total bill. Before the total bill reaches the cost cap, consumption is charged with a positive marginal price. Afterwards consumption has no additional costs, so that consumers are only limited by their own satiation level. Kraemer and Wiewiorra showed the first evidence that tariff choice is affected by psychological effects on cost caps which are also studied in more detail in Chapter 6.

2.2.2 Tariff Structures

By combining different tariff components, a diverse amount of nonlinear tariff structures can be constructed. Earlier research differed between one-part, two-part, and three-part tariffs, depending on the number of components. While a lot of research focused on the most common two-part tariffs (Goh and Bockstedt, 2012), recent studies have shifted their focus on advantages of three-part tariffs (Goh and Bockstedt, 2012; Iyengar et al., 2008; Jensen, 2006; Lambrecht et al., 2007). However, with the introduction of the cost cap component, new tariff structures with up to four tariff components are possible. The following sections provide an overview.

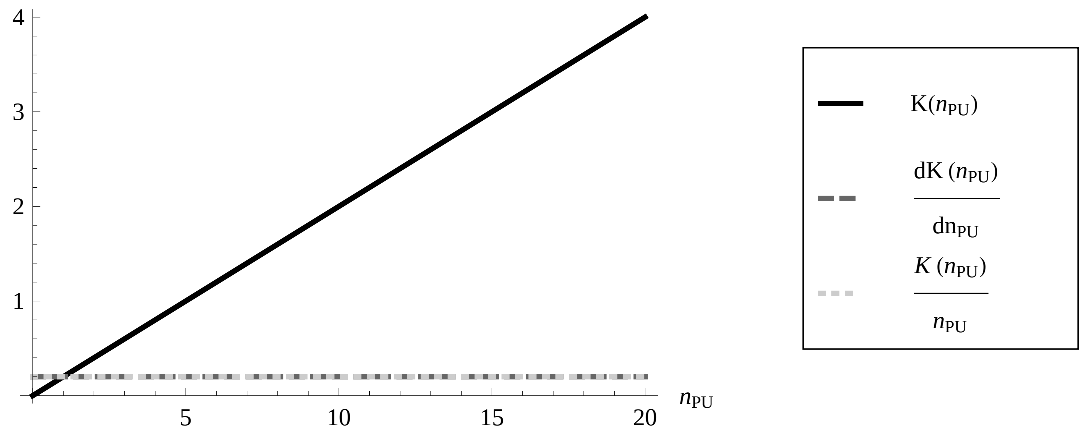
One-Part Tariffs

Pay-per-use tariff (PU) Pay-per-use tariffs, also known as linear tariffs, consist only of a minute price p_{pu} for every consumed unit. The total costs increase linearly in consumption n_{PU}:

$$K(n_{PU}) = n_{PU} p_{PU}$$

Therefore, the average costs as well as the marginal costs are equal to the minute price, which prevents price discrimination. Pay-per-use tariffs are a common pricing structure in practice (Skiera, 1999).

FIGURE 2.1: *Total, marginal and average costs under a pay-per-use tariff*



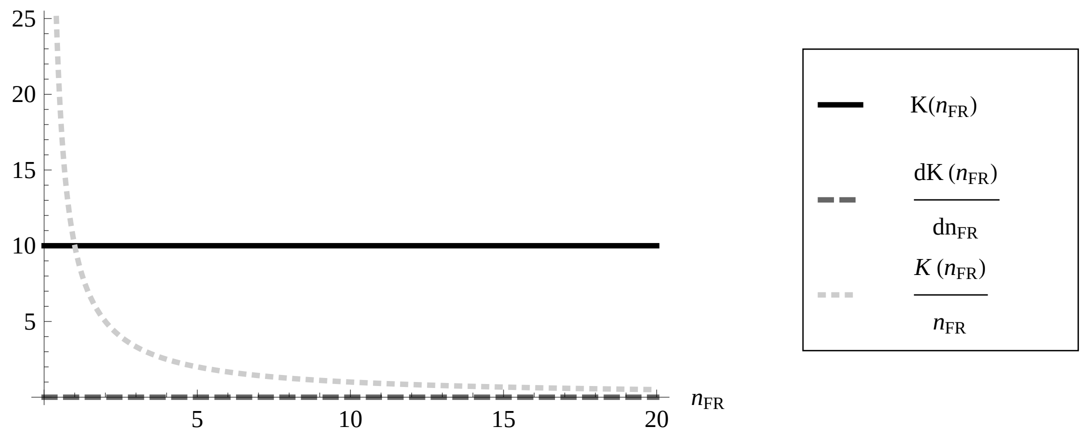
In their recent paper, Schlereth et al. (2010) investigated several different tariff structures and their impact on consumer choice and consumption. The authors found that it is often not revenue maximizing for a provider to offer only a pay-per-use tariff. While a fixed fee of zero attracts more consumers, the higher marginal price limits the consumers' consumption and therefore also the provider's revenues. Essegaier et al. (2002) found that pay-per-use tariffs can only be optimal under specific conditions. When consumers with high consumption satiation are more valuable and capacity constraints are sufficiently small, a pay-per-use tariff might be more profitable than, e.g., a flat rate tariff.

Flat rate tariff (FR) The flat rate tariff consists only of a fixed fee f_{FR} and is independent of the consumer's consumption.

$$K(n_{FR}) = f_{FR}$$

Consequently, the average costs per consumed unit decrease with consumption and converge towards the marginal costs of zero.

FIGURE 2.2: *Total, marginal and average costs under a flat rate tariff*



There are different beliefs about the flat rate's ability to maximize profits. Schlereth et al. (2010) explained that similar to a pay-per-use tariff, offering only a flat rate tariff results in suboptimal revenues. This is because tariff adoption is significantly mitigated due to a high fixed fee, while the remaining consumers have a much higher average consumption with zero marginal costs. Other researchers, such as Essegaier et al. (2002) and Sundararajan (2004), stated that a flat rate tariff can be optimal under specific conditions. Sundararajan showed that under the presence of transaction costs for administering tariffs, offering a flat rate in addition to a pay-per-use tariff is always profit improving. The reason is that pay-per-use tariffs involve a steady monitoring of consumers' consumption resulting in high transaction costs. In contrast, the flat rate tariff requires only a single payment transaction in every period. Essegaier et al. investigated pricing of services when the provider's service capacity is constrained and consumers are heterogeneous. The authors conclude that the costs of providing another service unit is typically negligible as long as the overall consumer demand is within the provider's capacity. Therefore, service providers should focus on revenue. In contrast, revenue strongly depends on the consumer mix that a provider is serving when the capacity constraint is exhausted. The fixed fee is an effective way to extract consumer surplus from light users as opposed to heavy users who are more sensitive to the minute price. Flat rate tariffs can therefore be the optimal pricing structure if the market consists of a high rate of more valuable light users. However, Essegaier et al. explain that under competition flat rate pricing opens up to rival's attacks on light users, as they subsidize heavy users. Goettler and Clay (2011) also found that flat rate tariffs can yield higher profits without a complementary two-part tariff. This is explained as consumers with initially high consumption expectations staying within the flat rate as long as their switching costs are high enough, even if they learn that their consumption is smaller than expected.

The flat rate tariff was also found to have a strong psychological attraction to consumers (Lambrecht and Skiera, 2006a; Train et al., 1987). The phenomenon of preferring a cost-inferior choice of a flat rate tariff has been named the flat rate bias (Train et al., 1989). Section 2.4 provides a more detailed overview on research on the flat rate bias.

Two-Part Tariffs

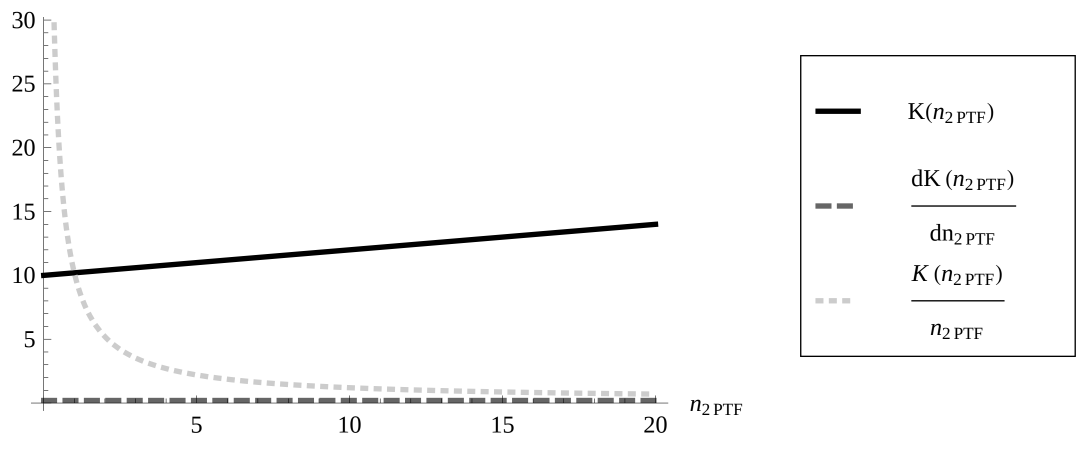
Traditional two-part tariff (2PTF) One of the most studied tariffs is the traditional two-part tariff which consists of a fixed fee f_{2PTF} and a minute price of p_{2PTF}. Consequently, the total costs a consumer has to pay are:

$$K(n_{2PTF}) = f_{2PTF} + p_{2PTF} n_{2PTF}$$

Figure 2.3 shows the decrease in average costs. With an increase in consumption they converge against the marginal minute price of p_{2PTF}.

The seminal paper of Oi (1971) showed the advantages of two-part tariffs in comparison to one-part tariffs. His work reviews whether it is optimal for an entertainment service provider to charge for the amusement park entrance or for every ride. Under the presumption of serving a homogeneous consumer by one monopolist, the two-part tariff is perfectly price discriminating. When setting p_{2PTF} equal to marginal costs, all consumer surplus can be extracted by adjusting f_{2PTF} accordingly. Murphy (1977) confirmed this finding and stated that no other tariff can extract profits better than the two-part tariff in this case. However, the monopolist's profit maximization problem becomes more complex when consumers are heterogeneous. To perfectly discriminate, every single consumer has to be separated and to be offered a unique tariff. Murphy emphasized the fact that such consumer identification is impossible and may also be illegal (Oi, 1971) for a provider, and therefore precludes perfect discrimination. However, he concluded that more complex tariff structures will generate an increase in profits if optimally designed. This may also imply excluding or subsidizing consumers (Oi, 1971). This finding has been recently confirmed by Schlereth et al. (2010), who find four two-part tariffs to be revenue maximizing for a provider. However, they also stated that revenue only increases slightly by providing four instead of one two-part tariff. Due to implementation costs, such as advertising and billing of a new tariff, it may be reasonable to limit the number of two-part tariffs.

FIGURE 2.3: *Total, marginal and average costs under a traditional two-part tariff*

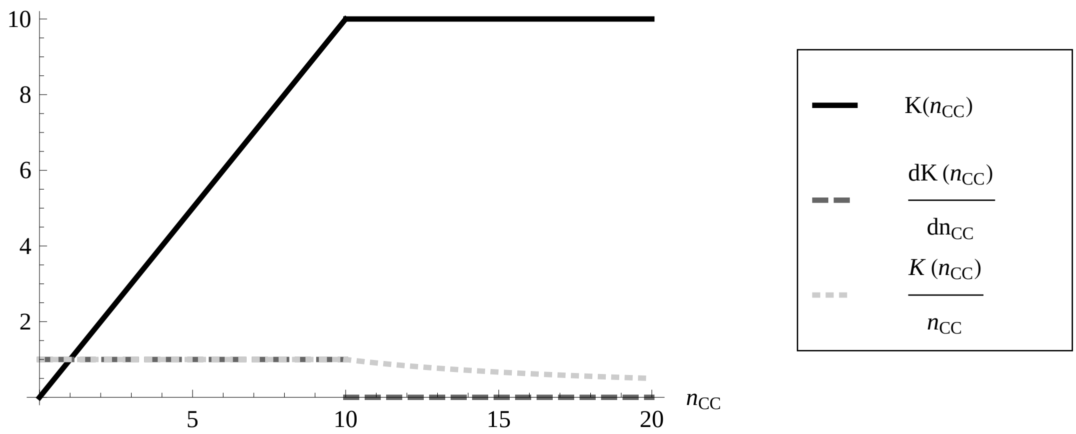


Cost cap tariff (2PTCC) The introduction of the cost cap component allows the creation of a new type of two-part tariff. The most simple possibility to implement a cost cap c_{2PTCC} is by combining it with a minute price p_{2PTCC}. This combination is the most dominant implementation of a cost cap component. Therefore, this tariff will also be cited as the cost cap tariff (CC) in the following. Under a cost cap tariff a consumer pays a marginal price for every consumed unit until his total costs reach the cost cap. At this point, the tariff becomes a flat rate with marginal costs of zero. Hence, total costs are

$$K(n_{CC}) = \begin{cases} p_{CC}n_{CC} & \text{if } p_{CC}n_{CC} \leq c_{CC} \\ c_{CC} & \text{otherwise.} \end{cases}$$

According to this equation, the marginal costs of p_{CC} equal the average costs before reaching the cost cap. Afterwards, the average costs decrease and converge towards zero. Figure 2.4 illustrate these circumstances.

FIGURE 2.4: *Total, marginal and average costs under a cost cap tariff*



Currently, the cost cap component is only offered in cost cap and four-part tariffs on the market. The cost cap tariff, however, has been barely studied, with the notable exception of Kraemer and Wiewiorra (2010, 2012). The authors found a consumer tendency to choose a cost cap tariff when they have a strong desire to be insured against high total monthly bills, and to be flexible considering the interplay of consumption and total bill. Kraemer and Wiewiorra assumed that providers can benefit from the additional risk premium consumers are willing to pay. On the other hand, they highlighted that providing a cost cap tariff might be risky as in contrast to flat rate tariffs, light users cannot compensate heavy users.

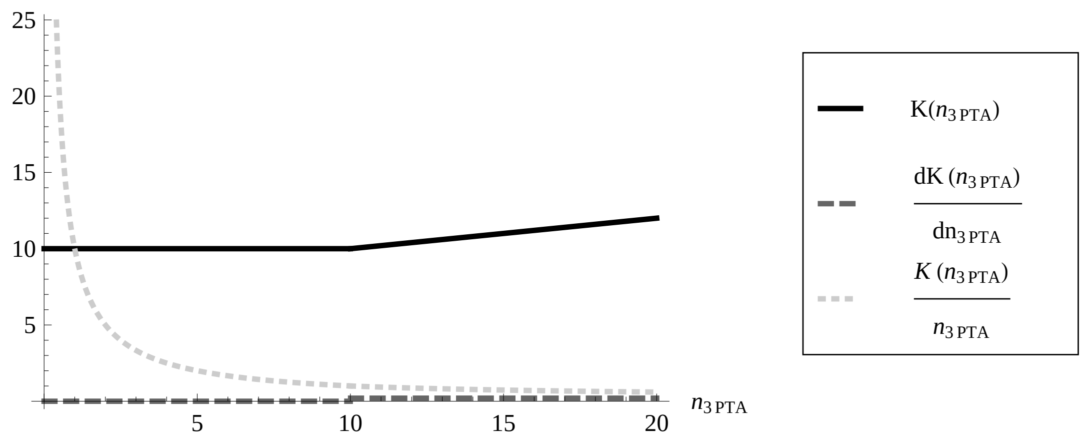
Three-Part Tariff

Three-part tariff with allowance (3PTA) Recent studies (Ascarza et al., 2012; Bagh and Bhargava, 2013; Iyengar et al., 2008; Jensen, 2006; Lambrecht et al., 2007) have focused on the impact of including an allowance A_{3PTA} to the traditional two-part tariff. When choosing such a tariff, the consumer pays a fixed fee f_{3PTA} upfront and gets a predefined number of free minutes with zero marginal costs. Only if consumption exceeds the allowance, a minute price of p_{3PTA} has to be paid. Therefore, the total cost function under a two-part tariff with allowance is:

$$K(n_{3PTA}) = \begin{cases} f_{3PTA} & \text{if } n_{3PTA} \leq A_{3PTA} \\ f_{3PTA} + p_{3PTA}(n_{3PTA} - A_{3PTA}) & \text{otherwise.} \end{cases}$$

The marginal costs are zero under the allowance and equal to the minute price afterwards. Therefore, the average costs under such a three-part tariff initially converge towards zero. Nevertheless, subsequent consumption after exceeding the allowance results in average costs converging towards the marginal price. Therefore, a further decrease, as illustrated in Figure 2.5, as well as an increase of average costs is possible, depending on the average price under the allowance.

FIGURE 2.5: *Total, marginal and average costs under a three-part tariff with allowance*



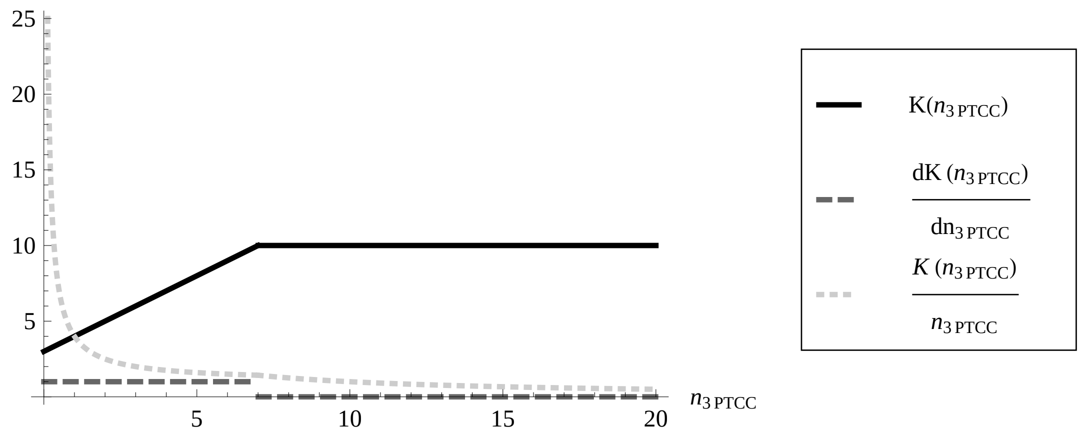
From a provider's perspective a three-part tariff can derive higher revenues compared to a two-part tariff. Lambrecht et al. (2007) explained that three-part tariffs can skim consumer surplus due to consumer uncertainty. This is especially true, when choice and consumption are decoupled in time. Today this is the case for many subscription services. Furthermore, Grubb (2009) demonstrated that consumers are overconfident about their prospective consumption and thus, underestimate their consumption variance. As a consequence, consumers tend to choose a tariff where the allowance matches their prospective consumption. However, they underestimate the probability of exceeding the allowance which in return enables the provider to charge steep marginal prices. Besides, Ascarza et al. (2012) showed that consumers have a tendency to overuse a three-part tariff with allowance in comparison to a traditional two-part tariff which cannot be explained by the shift in the budget constraint. Providers can increase their revenues by taking advantage of consumers' bias for allowances. So consumers should be encouraged to choose three-part instead of two-part tariffs by lowering tariff switching costs. Jensen (2006) did not take into account allowance specific preferences. On contrast, she focused on the profitability of three-part tariffs under competition. Under a duopoly a consumer can always choose an outside option which limits provider's options to acquire consumers' surplus by two-part tariffs. Adding an allowance helps the provider to overcome this incentive constraint. Consequently, the existence of two-part tariffs with allowance can be an indicator for a competitive market.

Three-part tariff with cost cap (3PTCC) The cost cap component also allows the creation of new tariff structures which have not been introduced on the service market yet. For example, it is possible to charge a fixed fee f_{3PTCC} for a cost cap tariff. In other words, for a fixed fee a consumer can upgrade his pay-per-use tariff with a cost cap c_{3PTCC}. The total cost function then changes to:

$$K(n_{3PTCC}) = \begin{cases} f_{3PTCC} + p_{3PTCC} n_{3PTCC} & \text{if } f_{3PTCC} + p_{3PTCC} n_{3PTCC} \leq c_{3PTCC} \\ c_{3PTCC} & \text{otherwise.} \end{cases}$$

Note that similar to a classical two-part tariff, the average costs are decreasing as long as the cost cap has not been reached. After the cost cap has been reached, the marginal costs are zero and thus, the average costs are also converging towards zero.

FIGURE 2.6: *Total, marginal and average costs under a three-part tariff with cost cap*



The three-part tariff with cost cap has neither been studied in previous research nor has it been implemented.

Four-Part Tariff

Finally, all four components can be combined within a four-part tariff. By excluding single components, e.g., by setting a fixed fee of zero, all earlier presented tariff structures can be derived from the total cost function of the four-part tariff:

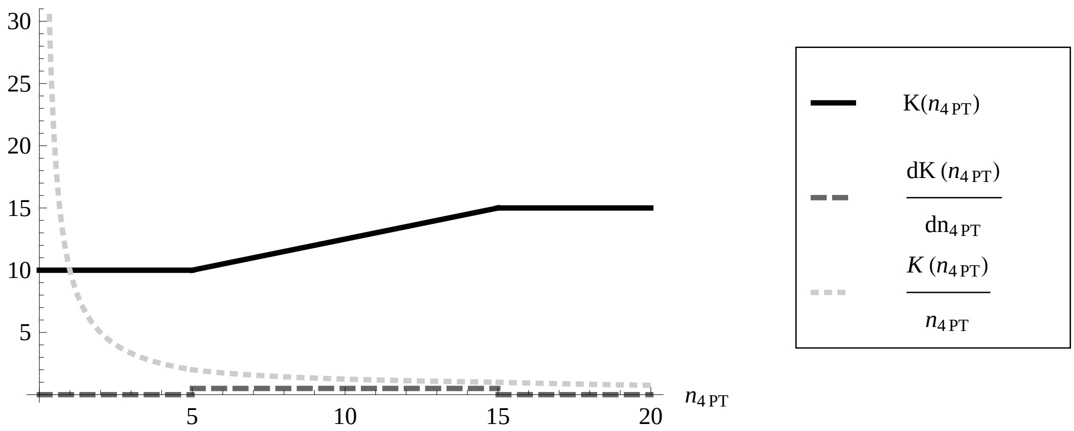
$$K(n_{4PT}) = \begin{cases} f_{4PT} & \text{if } n_{4PT} \leq A_{4PT} \\ f_{4PT} + p_{4PT}(n_{4PT} - A_{4PT}) & \text{if } A_{4PT} < n_{4PT} \leq C_{4PT} \\ c_{4PT} & \text{otherwise,} \end{cases} \tag{2.1}$$

where the critical consumption for reaching the cost cap is

$$C_{4PT} = \frac{c_{4PT} - f_{4PT}}{p_{4PT}} + A_{4PT} \tag{2.2}$$

The average costs under a four-part tariff decrease as long as consumption is within the allowance and the marginal costs are zero. However, exceeding the allowance results in an increase in total costs of p_{4PT} for every consumed unit. Therefore, the average costs are converging against the marginal costs of p_{4PT}. As soon as the cost cap is reached, further consumption is free of charge and average costs are decreasing towards zero. It is easy to see in Figure 5.1 that the distribution of total, average and marginal costs combine all earlier presented tariff structures.

FIGURE 2.7: *Total, marginal and average costs under a four-part tariff*



Deutsche Bahn AG is currently the only provider of a four-part tariff on the market to the best of knowledge. Besides a basic tariff, which is composed of an usage price and a cost cap, the company offers an advanced tariff with an additional allowance of 30 minutes of usage free of charge per day if consumers pay an additional yearly fixed fee of 48€.[1]

TABLE 2.1: *Tariff portfolio of Deutsche Bahn's service "Call a Bike"*

	basic	advanced
fixed fee	-	48 €/year
allowance	-	30 min/day
minute price	0.08 €/min	0.08 €/min
cost cap	15 €/day	15 €/day

[1]Tariff schemes are available at Deutsche Bahn's homepage: http://www.callabike-interaktiv.de/

Although this tariff scheme has been successfully implemented for renting bicycles, four-part tariffs have not been offered in other service markets. Furthermore, there has been no research on four-part tariffs. However, the characteristic structure makes the four-part tariff an ideal candidate to study the interaction of all tariff components.

2.3 Tariff Choice

Models for tariff choice are based on the theory of discrete/continuous choice models (Hanemann, 1984; Dubin and McFadden, 1984). These models take into account that the discrete choice depends partly on the outcome of continuous consumption choice and vice versa, and should therefore be modeled in a mutually consistent matter (Hanemann, 1984; Kridel et al., 1993). For example, a consumer is more likely to make calls under a flat-rate compared to a pay-per-use tariff and considers this when making a tariff decision.

The decision process for choosing a tariff j from a set of tariffs J involves two steps. First, the consumer i evaluates ex ante each tariff based on the expected consumption and chooses the most attractive respectively. Second, based on the ex post chosen tariff the consumer decides on his consumption. The evaluation and the actual choice of the tariff can be modeled in different ways and are explained in the following.

2.3.1 Evaluation Models

Cost minimization The simplest way to evaluate a tariff is by comparing the involved costs. A consumer then tries to minimize his costs. However, this approach requires either a tariff independent consumption or a consumption statement for each tariff for consideration. A consumer i evaluates the set of tariffs J based on their costs $K_{ij}(n_{ij}) \forall j \in J$. Empirical research has almost exclusively used the comparison of costs under a fixed usage level. In this vein, researchers such as Train et al. (1987) were able to study whether consumers have taken the cost minimizing "right" choice or whether they exhibit usage independent and tariff specific preferences.

Consumer surplus maximization A more sophisticated approach to evaluate tariffs is to quantify consumer surplus $CS_{ij}(n_{ij})$. Consumer surplus is defined by the difference between consumers' willingness to pay $WTP_{ij}(n_{ij})$ and the corresponding costs of $K_{ij}(n_{ij})$, whereas the willingness to pay describes the maximum amount of money a consumer would pay for every given consumption. Therefore, each tariff is evaluated by:

$$CS_{ij}(n_{ij}) = WTP_{ij}(n_{ij}) - K_{ij}(n_{ij}) \forall j \in J \tag{2.3}$$

The knowledge of consumers' willingness to pay functions is important for nonlinear pricing. Therefore, several different methodologies have been developed for this purpose (Jedidi and Jagpal, 2009; Miller et al., 2011). The methodologies can build upon three data sources: historical consumption data, consumption offers and preference data . Although historical data guarantees the highest validity, it is often difficult to obtain or it does not reflect the object of investigation. Usage offers provide an incentive compatible mechanism and provide good results for WTP estimation. However, they are difficult to conduct for services such as telecommunications (Schlereth et al., 2011). Preference data can be obtained with reasonable effort and this approach has shown to elicit valid WTP estimation even under hypothetical purchase scenarios (Miller et al., 2011). Today, open-ended questions (Abrams, 1964) and conjoint analysis (Jedidi and Zhang, 2002; Wertenbroch and Skiera, 2002) are most often used to identify consumers' willingness to pay through preference inquiry. Based on the WTP estimate, the consumer is assumed to adjust his consumption so that consumer surplus is maximized. This concept has been used for tariff choice in theoretical as well as empirical research (e.g. Bagh and Bhargava, 2013; Kridel et al., 1993; Murphy, 1977; Oi, 1971; Schlereth et al., 2011).

Utility Maximization Alternatively, the evaluation of tariffs can be modeled using utility theory. Thereby, the preference for one tariff is described by:

$$U_{ij}(n_{ij})\,\forall j \in J \tag{2.4}$$

The utility function can be modeled using a variety of functions with different curve progressions. Then, the demand function of a service or good can be derived from the utility function. Using the parameters $(\beta_{i1}, \beta_{i2}, \beta_{i3})$ to describe a consumer's preference for a service or good, the most common approaches to model utility functions are described in Table 2.2. As utility functions can be transformed into willingness to pay functions (Sonnier et al., 2007), the modeling approaches apply to them as well.

Skiera (1999) stated that the quadratic, semi-logarithmic, multiplicative and the modified exponential functions are the most common to describe consumer utility. These functions can be compared in several ways. First, there are two parameters to be estimated for all functions as long as externalities can be excluded. In this case an additional parameter has to be used in order to account for the non-consumption related utility. Consequently, estimating the utility function always allows to derive the demand function. The reverse is not possible if externalities have to be presumed. Second, utility functions differ in their course. While quadratic and the semi-logarithmic functions exhibit a satiation level with zero marginal utility thereafter, modified exponential and multiplicative functions always assume a positive marginal utility, hence a consumer would consume the service unlimitedly under zero marginal costs. Choosing the appropriate function thus depends on whether modeling a consumer's satiation is important in the research context. In that case, the quadratic function exhibits an advantage in modeling due to its linear demand function.

Utility theory has been used in the context of tariff choice in many theoretical as well as empirical studies (Iyengar et al., 2008; Lambrecht et al., 2007; Narayanan et al., 2007; Sundararajan, 2004; Schlereth and Skiera, 2012). Earlier studies on consumer tariff choice are summarized in more detail in Chapter 3 and Chapter 4 which develop a utility theory for consumer choice under tariffs with cost caps.

TABLE 2.2: *Comparison of utility functions in dependence on Skiera (1999)*

utility function	quadratic function	semi-logarithmic function
utility function	$U_{ij} = \begin{cases} \beta_{i1} n_{ij} - \beta_{i2} n_{ij}^2 & \text{if } n_{ij} \leq \frac{\beta_{i1}}{2\beta_{i2}} \\ \frac{\beta_{i1}^2}{4\beta_{i2}} & \text{if } n_{ij} > \frac{\beta_{i1}}{2\beta_{i2}} \end{cases}$	$U_{ij} = \begin{cases} \frac{n_{ij}}{\beta_{i2}}[1 + \ln(\beta_{i1}) - \ln(n_{ij})] & \text{if } n_{ij} \leq \beta_{i1} \\ \frac{\beta_{i1}}{\beta_{i2}} & \text{if } n_{ij} > \beta_{i1} \end{cases}$
marginal utility function	$MU_{ij} = \begin{cases} \beta_{i1} - 2\beta_{i2} n_{ij} & \text{if } n_{ij} \leq \frac{\beta_{i1}}{2\beta_{i2}} \\ 0 & \text{if } n_{ij} > \frac{\beta_{i1}}{2\beta_{i2}} \end{cases}$	$MU_{ij} = \begin{cases} \frac{\ln(\beta_{i1}) - \ln(n_{ij})}{\beta_{i2}} & \text{if } n_{ij} \leq \beta_{i1} \\ 0 & \text{if } n_{ij} > \beta_{i1} \end{cases}$
demand function	$n_{ij} = \begin{cases} \frac{\beta_{i1}}{2\beta_{i2}} - \frac{1}{2\beta_{i2}} p_j & \text{if } p_j \leq \beta_{i1} \\ 0 & \text{if } p_j > \beta_{i1} \end{cases}$	$n_{ij} = \beta_{i1} \exp(-\beta_{i2} p_j)$
satiation level	$S_{ij} = \frac{\beta_{i1}}{2\beta_{i2}}$	$S_{ij} = \beta_{i1}$

utility function	multiplicative function	modified exponential function
utility function	$U_{ij} = \beta_{i1} n_{ij}^{\beta_{i2}} + \beta_{i3}$	$U_{ij} = \beta_{i1}[1 - exp(-\beta_{i2} n_{ij-\beta_{i3}})]$
marginal utility function	$MU_{ij} = \beta_{i1}\beta_{i2} n_{ij}^{(\beta_{i2}-1)}$	$MU_{ij} = \beta_{i1}\beta_{i2} \exp(-\beta_{i2} n_{ij} - \beta_{i3})$
demand function	$n_{ij} = \left[\frac{p_j}{\beta_{i1}\beta_{i2}}\right]^{\frac{1}{\beta_{i2}-1}}$	$n_{ij} = \frac{1}{\beta_{i2}} \left(\ln(\beta_{i1}\beta_{i2}) - \beta_{i3} - \ln(p_j)\right)$
satiation level	*none*	*none*

2.3.2 Choice Models

The previous section explained how tariffs can be evaluated by either comparing the tariffs' total costs or consumer surplus, respectively utility. While total costs require a consumer statement about the intended consumption under every offered tariff, a consumer surplus or utility approach make this requirement dispensable. As long as consumer preferences are known, the expected consumption can be derived from the maximization of consumer surplus or utility, respectively. However, the evaluation of tariffs does not necessarily explain tariff choice. There are several alternatives to model consumer choice which are explained next. For simplicity, the different approaches are based on utility but may also apply for consumer surplus.

Maximum utility model The maximum utility model, which is also known as the first-choice rule, assumes that every consumer chooses the product or service with the highest utility (Green and Krieger, 1988). Hence a consumer chooses the tariff which solves the following maximization problem:

$$\max_{j \in J} U_{ij}(n_{ij}) \tag{2.5}$$

The model assumes a strictly rational choice behavior which may be too idealistic in practice as utility differences are not taken into account. Whether or not a product or service is only slightly or dramatically better than its alternatives does not impact consumer's choice. This assumption requires consumers to know their own preferences exactly. As this is rarely true, models which take utility differences into account, e.g. by assuming choice probabilities, are preferable. However, due to its simplicity first-choice rules have been implemented in several theoretical works on tariff choice (Bagh and Bhargava, 2013; Essegaier et al., 2002; Hayes, 1987; Oi, 1971).

Logit choice models An alternative approach to the first choice rule is to take proportions of utilities into account and assign choice probabilities for each alternative. The most prominent model for probabilistic choice in marketing literature is the logit choice model (Train, 2009; Rossi et al., 2005). The assigned choice probability is proportional to the product's or service's utility in relation to the combined utility of all available alternatives. Originally derived from Luce (1959) and later extended by McFadden (1974), the logit formula is derived from the fact that utility is partly unobserved and the corresponding error is extreme value distributed.[2] The following discussion is mainly based on Train (2009), who provides an excellent overview on logit models.

The logit model assumes that the utility a consumer i obtains from alternative j is partly observed (V_{ij}) by the researcher and partly unknown to the researcher:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \forall j \in J \tag{2.6}$$

McFadden (1974) showed that as long as ε_{ij} is independently, identically distributed extreme value, the probability for consumer i to choose alternative j is:

$$P_{ij} = \frac{\exp(\gamma V_{ij})}{\sum_{j=1}^{J} \exp(\gamma V_{ij})} \tag{2.7}$$

The representative utility V_{ij} is often specified as a linear combination of preference parameters such that $V_{ij} = \beta_i' x_j$, where x_j describes the observed alternative variables. Train (2009), however, argued that logit models are not limited to linear functions and may also include nonlinear representative utility. The parameter γ is a scale parameter to adjust for the variance of the unobserved utility. Note that the probability of choosing one alternative over another is independent of the number of alternatives. Therefore, the logit models involve the independence of irrelevant alternatives (IIA) property. The logit models exhibit further desirable properties. First, the logit model ensures $P_{ij} \in [0, 1]$ as required for probability. Second, the logit probability is S-shaped, so that a small increase on either a small or a large utility of the alternative has only a small effect on its choice probability. The logit parameters are generally estimated using maximum log likelihood algorithms. The logit model's quality to fit the data is measured by different goodness of fit indicators such as the likelihood ratio index.

[2]See McFadden (2001) for a brief history of logit choice models.

In any case, ordinary binary or multinomial logit models (MNL) have a major shortcoming. Due to the independence of error terms requirement, random taste variation cannot be considered (Hensher and Greene, 2003; Train, 2009). In most cases the independence restriction can be diminished by a proper specification of the representative utility function. However, if a correlation of errors is assumed, the researcher should rather use a mixed logit model. By assuming the model's parameter to be distributed rather than stated, mixed logit models allow for random taste variation, unrestricted substitution patterns and correlation of unobserved factors (Train, 2009). Thus, mixed logit models are the integrals of standard logit probabilities over a density of parameters. The model can approximate any random utility model (McFadden and Train, 2000) and a variety of different behavior specifications can be derived. In addition, its estimation is computationally simple since the advent of simulation methods (Hensher and Greene, 2003). The mixed logit probability is the weighted average logit over all values of β with density $f(\beta)$:

$$P_{ij} = \int L_{ij}(\beta) f(\beta)\,\mathrm{d}\beta, \tag{2.8}$$

with $L_{ij}(\beta)$ being the logit probability as stated in (2.7). Therefore, these models are mixed logit as their probability is a mixture of logit probabilities with $f(\beta)$ as the mixing distribution (Hensher and Greene, 2003). The density function $f(\beta)$ can be described by any distribution, so that the researcher is free to model his expectation about consumer behavior. Having said this, the mixed logit formula is capable of handling random coefficients, such that β varies over decision makers. In addition, the specifications are easily adjusted to account for repeated choice. Train explained that the simplest specification assumes that representative utility varies over respondents but not within the choice sets $t \in T$ one respondent faces. The conditional probability of respondent i to make a specific choice sequence $y = y_1, ..., y_T$ is simply the product of logit probabilities:

$$L_{iy} = \prod_{t=1}^{T} [\frac{V_{iy_t}}{\sum_j V_{ij_t}}] \tag{2.9}$$

Train highlights the suitability of mixed logit for simulation methods for estimation. By repeatedly drawing from the density function $f(\beta)$ an unbiased estimator of P_{ij} can be calculated. These simulated probabilities can be used with log-likelihood functions to estimate the parameters describing the density function.
Due to its flexibility in describing respondents' behavior and handling nonlinear utility functions, logit choice models have been used in several empirical studies on tariff choice (Goh and Bockstedt, 2012; Ho and Zhang, 2008; Iyengar et al., 2008; Lambrecht et al., 2007; Schlereth et al., 2011; Train et al., 1989). Chapter 4 provides a more detailed overview on utility and choice specifications of respective research.

2.4 Tariff Bias

A common assumption about consumer choice of nonlinear tariffs is that consumers do not have any tariff specific preference and choose, thus, the tariff which maximizes their surplus. However, earlier research in a wide area of different services have found that consumers prefer flat rate tariffs to alternative tariffs, even though they would have been better off not choosing the flat rate.[3] Train (1991) coined this effect *flat rate bias*, after he found a significant tendency of consumers choosing a flat rate over a matured tariff in a revealed preference study (Train et al., 1987). Later, Kridel et al. (1993) provided evidence that a pay-per-use bias also exists, so that tariff specific preferences are today referred to as tariff biases (Lambrecht and Skiera, 2006a). Today, there are numerous studies on the existence and causes of tariff biases. Table 2.3 provides an overview. The following section discusses the definition and existence of tariff biases on the basis of selected studies as well as the causes of tariff biases which have been identified so far.

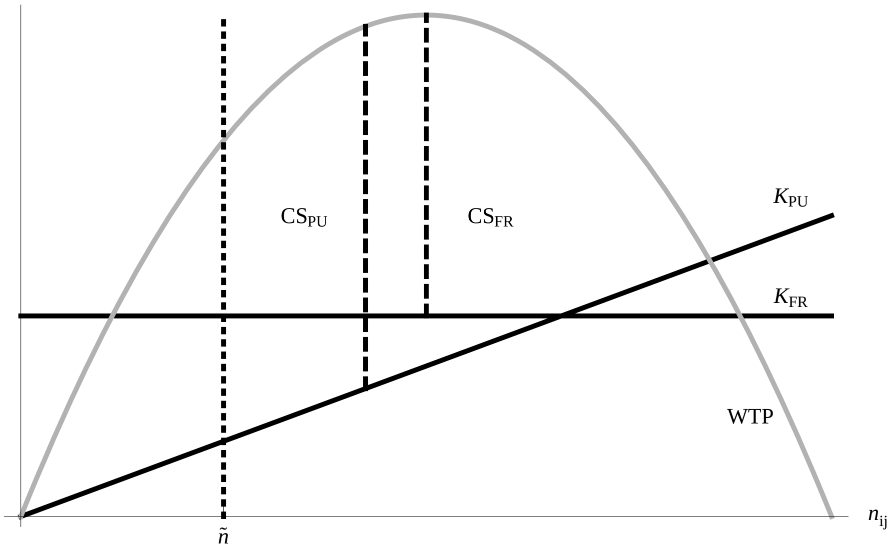
[3] Lambrecht and Skiera (2006a) and Stingel (2008) provide a detailed overview.

2.4.1 Existence and Definition of Tariff Bias

The definition of tariff bias is not clear. Some studies define a bias as to be present when a consumer would have paid less choosing another tariff under his given consumption level (e.g., Kridel et al., 1993; Narayanan et al., 2007). Figure 2.8 illustrates this bias definition. Under the assumption that a consumer has a consumption of $\tilde{n}$ units (highlighted by the dotted line), choosing a flat rate tariff would yield higher costs compared to a pay-per-use tariff. In this case, the bias equals the difference in costs between both tariff alternatives. There has been no discussion so far about a possible spread in cost deviation from the cheapest tariff alternative that still could be considered as rational rather than to be biased (Stingel, 2008). As this definition requires detailed information about consumers' actual consumption pattern, it has mostly been used with revealed preference data. This definition, however, does not take into account the two-way dependency of tariff choice and consumption. Other studies (e.g., Train et al., 1987; Lambrecht and Skiera, 2006a; Kraemer and Wiewiorra, 2012) relaxed this prerequisite by defining a bias to be already present as soon as a consumer prefers a specific type of tariff to another. While this definition is suitable for many stated preference studies, a quantification of a possible bias is difficult in this case. An exception is Schulze and Gedenk (2005) who combined both approaches by estimating consumers' willingness to pay first which is then used to anticipate consumers' consumption. For this purpose the consumption is assumed to yield the optimal consumer surplus. Following this approach, a consumer is biased when he chooses one tariff over another even though the anticipated consumer surplus is lower. Figure 2.8 demonstrates this for the case of choosing between a flat rate and a pay-per-use tariff. If a consumer decides to choose the flat rate tariff, although the pay-per-use tariff would have yield him a higher consumer surplus (highlighted by dashed lines), then the difference in consumer surpluses is considered as the extent of the tariff bias.

Tariff biases were found to exist across a wide area of different services. Most research has been conducted in the field of telecommunication services (Train et al., 1987, 1989; Kling and van der Ploeg, 1990; Kraemer and Wiewiorra, 2012; Miravete, 2003;

FIGURE 2.8: *Total costs and consumer surplus under pay-per-use and flat rate tariffs*



Narayanan et al., 2007), but also in other fields such as gym access (Nunes, 2000; Della Vigna and Malmendier, 2006), journal subscription (Schulze and Gedenk, 2005), public transportation (Uhrich et al., 2012; Prelec and Loewenstein, 1998) and Internet access (Lambrecht and Skiera, 2006a; Lambrecht et al., 2007). In order to study tariff biases, actual choice and consumption behavior has been observed in real markets as well as in choice experiments.

The work of Train et al. (1987) on tariff specific preferences is a seminal paper. The study analyzed residential consumers' tariff choice behavior of a local telephone company in the United States. Using a nested logit model, the authors found a significant impact of tariff specific preferences on tariff choice and, further, the preference for a flat rate to be much stronger than the preference for the alternative metered tariff. Later, Kridel et al. (1993) were the first to confirm the existence of a pay-per-use bias. While studying consumption and tariff choice behavior of citizens of Missouri and Arkansas, they found a small proportion of consumers who would have been better off by choosing a flat rate tariff instead of a pay-per-use tariff. Whereas tariff bias research had focused on field data, Prelec and Loewenstein (1998) demonstrated that tariff biases can also be measured by stated preference experiments. The authors found tariff specific preferences for flat rate as well as pay-per-use tariffs in various domains. Tariff biases were found to exist also in other domains other than telecommunication services, such as public transport or tourism. The use of stated preference experiments has later been found to be advantageous to study in detail the causes of tariff biases (Nunes, 2000; Lambrecht and Skiera, 2006a). More recently, Uhrich et al. (2012) showed that consumers' consumption goals impact the extent of flat rate biases. Consuming a service for a hedonic purpose leads to a significantly higher flat rate bias than consuming a service for utilitarian purposes. The authors demonstrated in three studies, which used services with varying hedonic and utilitarian value, that consumption goals have a significant influence on causes of tariff biases and mediate tariff choice.

Miravete (2003) is one of the few who contradicted that consumers irrationally choose their tariff and that they do not exhibit a tariff bias. While he agreed that consumers are guided by their consumption expectations from a static point of view, consumers behave rationally under a dynamic consideration and switch tariffs after learning from an initial mistake. Narayanan et al. (2007) followed this line of argument and stated that not cost-minimizing tariff choice is caused only ex post due to unexpected consumption shocks. The fact that consumers under a metered tariff switch more often to minimize their costs than consumers under a flat rate option can be explained by limited possibilities to learn one's own consumption pattern. From the authors' point of view, typical bills of flat rate tariffs do not include details on consumption and consumers do not care about consumption because variance has no influence on the bill amount. Goettler and Clay (2011), who also argued with posterior beliefs, argued that switching costs are another explanation why consumers tend to remain with a suboptimal tariff. However, Lambrecht et al. (2007) and Ascarza et al. (2012) showed in recent studies that tariff specific preferences remain even under learning and uncertainty considerations.

A major shortcoming of past literature on tariff biases is the focus on flat rate and pay-per-use tariffs. Alternative tariff schemes, such as two-part tariffs, have barely been studied (Narayanan et al., 2007; Goettler and Clay, 2011). Thus, it remains unclear whether previous results can be transferred to, e.g., tariffs with cost caps or whether new tariff components have a different influence on tariff biases.

2.4.2 Causes of Tariff Bias

Research on causes of tariff biases have focused on flat rate and pay-per-use tariff specific preferences. Several effects have been found to explain these tariff biases. Whereas at the beginning of tariff bias research causes were based on rather assumptions, later empirical research confirmed the impact of these effects to be significant. Today, a total of five effects is known to drive tariff biases. An overview on related literature is provided in Table 2.3.

Insurance effect Already in the seminal paper of tariff biases, Train et al. (1987) denoted the insurance property of the flat rate tariff as the major driver of flat rate choice. More precisely, consumers try to avoid cost variation as they are uncertain about their future consumption (Miravete, 2002). As a result, they are willing to pay a premium to be insured against high costs in times of of high consumption (Lambrecht and Skiera, 2006a; Train, 1991). Several papers have developed single- and multi-item scales to study the insurance effect. Lambrecht and Skiera (2006a) and Kraemer and Wiewiorra (2012) used multi-item scales to measure the perception of the insurance effect and studied the probability of choosing a flat rate in a stated preference experiment. Both studies found the insurance effect to be a significant parameter to describe flat rate choice. Similar results have been found by Mitomo et al. (2009) using a single-item scale. Furthermore, Schulze and Gedenk (2005) found the insurance effect, measured by a single item, to explain the extent of the flat rate bias which was measured as the difference in consumer surplus.

There are several possible explanations for this behavior. First, risk aversion might be a reason to choose a flat rate tariff, as costs are more certain compared to a more uncertain alternative tariff option, even if this choice involves higher expected costs.

TABLE 2.3: *Overview on empirical research on tariff biases*

reference	domain	revealed preferences	stated preferences	existence of FR bias	existence of PU bias	insurance	taximeter	overestimation	flexibility	convenience
Train et al. (1987)	telecom	●		●		⊠				
Train et al. (1989)	telecom	●		●		⊠				
Kling and van der Ploeg (1990)	telecom	●		●						⊠
Kridel et al. (1993)	telecom	●		●	●					
Prelec and Loewenstein (1998)	telecom, tourism, public transport		●	●	●		⊠			
Nunes (2000)	delivery service, leisure service		●	●				⊠		
Miravete (2003)	telecom	●		◐						
Schulze and Gedenk (2005)	journal subscription		●	●	●	⊠	⊠		⊠	□
Della Vigna and Malmendier (2006)	health club subscription	●		●	●			⊠		
Lambrecht and Skiera (2006a)	internet access	●	●	●	●	⊠	⊠	⊠		□
Lambrecht et al. (2007)	internet access	●		●						
Narayanan et al. (2007)	telecom	●		●	●					
Stingel (2008)	telecom	●	●	●	●	⊠	□	⊠		⊠
Grubb (2009)	telecom	●		●	●			⊠		
Mitomo et al. (2009)	telecom		●	◐		⊠	⊠			
Wolk and Skiera (2010)	internet access	●		◐						
Goettler and Clay (2011)	delivery service	●		●				⊠		
Kraemer and Wiewiorra (2012)	telecom		●	◐	◐	⊠	□	⊠	⊠	□
Uhrich et al. (2012)	leisure service, public transport		●	◐		⊠	⊠	⊠		

●: Respondents exhibit tariff bias
◐: Respondents have tariff specific preferences
⊠: Effect has been considered and affirmed to explain bias
□: Effect has been considered but not affirmed to explain bias

However, Nunes (2000) could not find any relationship between risk aversion and tariff choice. Second, when the price level of the flat rate tariff is used as a reference point, consumers' loss aversion (Kahneman and Tversky, 1979) can explain why higher costs are perceived more negatively than lower costs and, thus, consumers tend to prefer flat rate tariffs. Finally, Kridel et al. (1993) showed that the flat rate exhibits an option value irrespective of expected consumption. The authors stated that the mere option to use a service is valued, even though the service may not be used at all.

Taximeter effect Kridel et al. (1993) listed the aversion of being metered as a possible explanation for consumers' preferences for flat rate tariffs. Prelec and Loewenstein (1998) studied this phenomenon in more detail and concluded that consumers experience an immediate pain of paying at the time of the purchase. The authors exemplified that the pleasure of a taxi ride is reduced by the ticking of the taxi meter. Based on this plausible example, the effect has been named the taximeter effect. Prelec and Loewenstein developed an extended mental accounting theory (Thaler, 1985) which accounts for the interaction between the pleasure of consumption and the pain of paying. Thus, the pleasure of consumption can be reduced by the pain of paying, however, vice versa the pain of paying can be alleviated by the prospective consumption. As a consequence, consumers can exhibit a preference for prepayment which is even stronger for hedonic services (Uhrich et al., 2012). The choice of a flat rate tariff mentally decouples payment from consumption. As the flat rate consists of a single payment, subsequent consumption can be experienced as if it were free.

Prelec and Loewenstein verified their proposed model with a conjoint-like analysis by asking respondents on their travel planning in a stated preference experiment. 35% of their sample showed a preference for prepayment such as flat rates, while more than one half preferred pay-per-use payment. However, asking consumers in a subsequent study whether they would enjoy to phone more under a flat rate or a pay-per-use tariff, 60% of their sample preferred the flat rate option. The authors concluded: "Talking on the phone is more pleasurable when you don't have to think about what each call is costing you" (Prelec and Loewenstein, 1998, p.21). Schulze and Gedenk (2005) and

Lambrecht and Skiera (2006a) showed the applicability of item scales to measure the taximeter effect and both found a significant impact of the effect on flat rate choice.

Overestimation effect Another possible reason why consumers tend to choose the wrong tariff is that they are simply over- or underestimating their own prospective consumption. Mitchell and Vogelsang (1991) stated that a provider's advertising could possibly impact consumers' estimation. Nunes (2000) developed a ratio rule which provides a cognitive explanation for a tariff bias. The author explained that unexperienced consumers assign equal probabilities for all possible states of consumption. When a consumer has to decide between a pay-per-use and a flat rate tariff, he calculates the break-even point and assigns probabilities for consumption below or above this point. The ratio rule is defined as the ratio between these two probabilities. Consequently, a high ratio favors the choice of the flat rate tariff. However, as consumption is naturally distributed log-normal with values above zero, high consumption is considered to be more likely and as a result flat rate tariffs are chosen more often. Nunes conducted three empirical studies to study the effect of the ratio rule. Due to the lack of information on the distribution of prospective consumption, the author applied the difference between the maximum consumption a consumer can think of and the break-even level divided by the difference of the break-even level and the minimum consumption as the ratio:

$$ratio = \frac{n_{max} - \textit{break-even}}{\textit{break-even} - n_{min}} \tag{2.10}$$

As a result Nunes found the misinterpretation of consumption to be a major driver of tariff choice and the ratio to be a significant variable to explain flat rate choice. Lambrecht and Skiera (2006a) used a similar approach by systematically altering the range of maximum and minimum consumption in a stated choice experiment, confirming the results of Nunes. Uhrich et al. (2012) developed a multi-item scale to capture consumers' tendency to overestimate and found the scale to be a significant variable to explain flat rate choice. Furthermore, Grubb (2009) provided evidence that consumers do not only overestimate their prospective consumption, but are also overconfident that their expectation is correct, which leads to an underestimation of consumption variance. Hence, consumers' tariff choice turns out to be suboptimal ex post. Della Vigna and Malmendier (2006), who studied consumers' choice of health club subscriptions, found a similar result. In their case, consumers exhibit a flat rate bias which can be explained by consumers' overconfidence about future self-control which leads to an overestimation of gym attendance. Later, Goettler and Clay (2011) showed that such posterior beliefs about future consumption are strongly influenced by private signals which lead to an overestimation of future consumption. In contrast to Nunes, the authors argued that consumers learn their true consumption patter over time. In their own opinion, overestimation is rather a reason for tariff bias when consumers initially choose a tariff, but this does not explain why consumers remain with a suboptimal tariff.

Flexibility effect The flexibility effect has only recently been identified as a driver of pay-per-use choice. As stated by Kraemer and Wiewiorra (2012), the commitment of paying a fixed fee independently of the actual consumption under a flat rate tariff results in two adverse effects which are summarized as the flexibility effect. First, consumers may ex post regret the flat rate choice after realizing that they would have been better off under a pay-per-use tariff. Thus, consumers try to avoid the cost commitment by preferring a flexible pay-per-use tariff. Second, consumers may seek to avoid the ex post regret by exploiting the flat rate with an excessive consumption above the initial intention. This effect has been coined as the buffet effect by Just and Wansink (2011). Consequently, consumers who exhibit a strong aversion against the buffet effect or ex post regret are willing to pay an option premium to remain their flexibility. Using a single item scale, Schulze and Gedenk (2005) confirmed the flexibility effect to be significant on tariff choice - favoring to choose a pay-per-use tariff. Later, the study of Kraemer and Wiewiorra developed a more sophisticated multi-item scale to measure consumers' accordance to the flexibility effect. Similar to Lambrecht and Skiera (2006a), the authors used a repeated choice experiment and confirmed Schulze and Gedenk's findings. However, further analyses of Kraemer and Wiewiorra showed that the flexibility effect does not affect consumers' willingness to accept a higher usage price under a cost cap tariff. This is why the impact of the flexibility effect on more complex tariffs remains an open question.

Convenience effect Comparing several tariff alternatives and their expected total bills requires effort. Therefore, some consumers might try to avoid the involved information costs by choosing the market default tariff (Train, 1991). Kling and van der Ploeg (1990) showed that households that did not compare tariff alternatives are more likely to choose a flat rate tariff. Subsequent studies, however, failed to confirm the impact of the convenience effect on tariff choice (Kraemer and Wiewiorra, 2012; Lambrecht and Skiera, 2006a; Schulze and Gedenk, 2005) with the exception of Stingel (2008). She provided evidence that in a business-to-business environment the convenience effect can foster a flat rate bias.

Chapter 3

Consumer Choice under Cost Cap Tariffs

"The rational man of economics is a maximizer, who will settle for nothing less than the best."

Simon (1978)

THIS chapter studies the choice and consumption behavior of consumers under cost cap tariffs. The following Section 3.1 develops a theoretical utility model that is used to derive the optimal consumption pattern under cost cap tariffs and the conditions under which cost cap tariffs are chosen over pure pay-per-use and flat rate tariffs by a rational consumer. Afterwards, the proposed model is empirically evaluated in Section 3.2 by the use of a stated preference study. Overall, the chapter is an adoption of Koehler et al. (2012a).

3.1 Theory of Consumer Choice

3.1.1 Related Literature

With the exception of Kraemer and Wiewiorra (2012), cost cap tariffs have not yet received academic attention. Kraemer and Wiewiorra conducted an empirical investigation of the flexibility effect in tariff choice in which they also considered the cost cap tariff. They highlighted that there might exist a "cost cap bias", by which customers favor cost caps over pay-per-use tariffs and flat rates even if the tariffs yield the same economic costs. By contrast, for the most part the present section abstracts from any bias or other irrationality in tariff choice. Instead, a fully rational consumer is assumed, who may, however, face uncertainty about his preferences (demand). The papers that are most related to our approach are Lambrecht et al. (2007) and Iyengar et al. (2008). These papers proposed a similar utility model, however with the intention in mind to estimate the parameters of the utility function based on observed tariff choice. By contrast, we derive a formal utility model with the intention to explain tariff choice. Within this utility model, tariff choice relies on the preferences of a representative consumer, and not on an exogenous demand. This modeling approach has the distinct advantage that the demand for tariff usage is derived endogenously and depends also on the chosen tariff and the pricing structure. Hausman (1985) and Moffitt (1986) lay the groundwork for these models. The consumer's calculus in these situations consists of two steps. First, the utility-optimizing consumption on each tariff segment (e.g., the pay-per-use or flat rate segment) is calculated; then the segment which maximizes the overall utility is chosen, subject to the associated optimal consumption decision and the corresponding bill amount.

3.1.2 Methodology

Tariff choice and consumption under certainty In the following, we focus on the choice between a pay-per-use, flat rate and cost cap tariff from the point of view of a single, representative consumer. Any feasible tariff under one of these three tariff types can be described by the tuple $t = (f, p, c)$, where f denotes a fixed base fee which must be paid independent of the consumption, p is a constant price for each consumption unit and c stands for a cost cap, i.e., an upper threshold for the total billing amount. More specifically, for the PU tariff it holds that $t_{PU} = (0, p_{PU}, \infty)$; the FR tariff is characterized by $t_{FR} = (f_{FR}, 0, \infty)$; and for the CC tariff $t_{CC} = (0, p_{CC}, c_{CC})$. Depending on the tariff and given the consumption level $n \geq 0$, a consumer has total costs of

$$K_t(n) = \begin{cases} f_t + n\, p_t & \text{if } f_t + n p_t \leq c_t \\ c_t & \text{otherwise.} \end{cases} \tag{3.1}$$

The consumer's utility subject to his budget constraint is given by

$$U_t(n) = \beta_1\, n - \beta_2\, n^2 - \beta_3\, K_t(n), \tag{3.2}$$

where β_1, β_2, $\beta_3 > 0$ are the individual preference parameters that express the consumer's gross utility of consumption relative to the numeraire k. Notice that the utility function is quasi-concave and thus it implies that optimal consumption is bound, even at zero marginal costs. However, our results are not limited to this specification and should hold for any quasi-concave utility function. As noted above, we restrict our analysis to the interesting case where all parameters are non-negative and $c_{CC} > f_{FR}$ and $p_{CC} > p_{PU}$. Moreover, we assume that $\beta_1 > \beta_3 p_{CC}$, which ensures that the optimal consumption levels under all tariffs are positive.

In a deterministic setting, where the consumer has no uncertainty about his preferences β, it is straightforward to show that the optimal consumption level under a PU and a FR tariff are

$$n^*_{PU} = \frac{\beta_1 - \beta_3 p_{PU}}{2\beta_2}, \qquad n^*_{FR} = \frac{\beta_1}{2\beta_2}, \tag{3.3}$$

respectively. The solutions are unique because the utility function is quasi concave and the corresponding cost function (3.1) is linear (see Hausman, 1985, p. 1257; Iyengar et al., 2008). The utility that is derived from these optimal consumption plans is given by

$$(3.4) \qquad U_{PU}(n^*_{PU}) = \frac{(\beta_1 - \beta_3 p_{PU})^2}{4\beta_2}, \qquad U_{FR}(n^*_{FR}) = \frac{\beta_1^2}{4\beta_2} - \beta_3 f_{FR}.$$

A consumer is thus indifferent between a PU and a FR tariff if and only if his preferences are such that $\beta_1^* = 2\beta_2 \frac{f_{FR}}{p_{PU}} + \frac{\beta_3 p_{PU}}{2}$. For every $\beta_1 < \beta_1^*$, the consumer prefers the PU tariff over the FR tariff and vice versa.

The derivation of the optimal consumption under a CC tariff is more complex because the cost function is concave here. In general, there will thus exist an optimal consumption level for each tariff segment (i.e, before and after reaching the cost cap) of the CC tariff. Therefore, it is necessary to calculate the utility-maximizing consumption on each tariff segment before one can then choose the segment that generates the higher overall utility (cf. Hausman, 1985, p. 1256). In other words, we derive the optimal consumption under a CC tariff under the expectation that the cost cap is not met (i.e., for the PU-segment) *and*, independently, under the expectation that it is met (FR-segment), constraint on the condition that the optimal consumption does not exceed the segment boundaries. Hence, the candidates for the optimal consumption level under the CC tariff are given by

$$(3.5) \qquad n1_{CC} = \min\{\frac{\beta_1 - \beta_3 p_{CC}}{2\beta_2}, C\}, \qquad n2_{CC} = \max\{\frac{\beta_1}{2\beta_2}, C\},$$

where C denotes the consumption level that corresponds to the cost cap, i.e., $C = \frac{c_{CC}}{p_{CC}}$. Notice, that for any $p > 0$, it follows that $n^*_{PU} < n^*_{FR}$. Thus, at most one of the consumption candidates can exceed bounds and admit the corner solution of C. Furthermore, it can be shown that whenever a consumption candidate admits a corner solution, then the other consumption candidate is optimal. Therefore, without loss of generality, we can restrict our attention to the case where neither consumption candidate admits a corner solution. Of course, a rational consumer would choose the consumption candidate that yields the higher utility. The corresponding threshold β_1^{**} is derived as follows:

$$U_{CC}(n1_{CC}) = U_{CC}(n2_{CC}) \Leftrightarrow$$

$$\beta_1^{**} = 2\beta_2 \frac{c_{CC}}{p_{CC}} + \frac{\beta_3 p_{CC}}{2} = 2\beta_2 C + \frac{\beta_3 p_{CC}}{2} \tag{3.6}$$

If $\beta_1 < \beta_1^{**}$, $n1_{CC}$ is realized, otherwise $n2_{CC}$. However, because $p_{CC} > p_{PU}$ and $c_{CC} > f_{FR}$ it is immediately clear that $U_{CC}(n1_{CC}) < U_{PU}(n^*_{PU})$ and $U_{CC}(n2_{CC}) < U_{FR}(n^*_{FR})$. Thus, independent of which consumption candidate is optimal under a CC tariff, both are utility dominated by the optimal consumption plans under either the FR tariff, or the PU tariff.

PROPOSITION 1 ≺CC CHOICE UNDER CERTAINTY≻. *A rational consumer would never choose a cost cap tariff over a flat rate or pay-per-use tariff if he has certainty about his preferences/demand.*

Tariff consumption under uncertainty In the following, we relax the assumption that the preferences are known with certainty and assume that β_1 is a realization of the random variable B_1 that is distributed according to the probability density function $f_{B1}(\beta_1)$ and the corresponding cumulative distribution function $F_{B1}(\beta_1)$. The only assumptions that are made about F_{B1} are that (i) $F_{B1}(\beta_3 p_{CC}) = 0$, which ensures a positive consumption level for all β_1 under all tariffs and (ii) that $0 < F_{B1}(\beta_1^{**}) < 1$, which ensures that both consumption candidates of the CC tariff, $n1_{CC}$ and $n2_{CC}$, are chosen with positive probability. Otherwise, the same logic as under certainty would apply and the CC tariff would never be chosen by a rational consumer.

Under a FR and a PU tariff, it is easy to see that every realization β_1 of the random variable B_1 directly determines the optimal consumption level according to equation (3.3). Thus, under these two tariffs, the optimal consumption level is derived by a linear transformation of the random variable B_1. Consequently, the optimal consumption levels, denoted by N_{PU} and N_{FR}, respectively, are distributed according to

$$F_{N_{PU}}(n) = Prob(N_{PU} \leq n) = Prob(\frac{B_1 - \beta_3 p_{PU}}{2\beta_2} \leq n)$$

$$= F_{B1}(2\beta_2 n + \beta_3 p_{PU}), \tag{3.7}$$

$$F_{N_{FR}}(n) = F_{B1}(2\beta_2 n). \tag{3.8}$$

However, under a CC tariff the distribution of B_1 does not linearly transform into the distribution of the optimal consumption levels. To see this, recall from equation (3.6) that given the realization β_1 of the random variable B_1, the consumer will consume $n1_{CC}$ if $\beta_1 < \beta_1^{**}$ and $n2_{CC}$, otherwise. For any β_1, $p > 0$ it follows that $n1_{CC} < n2_{CC}$. Thus, the consumption interval

$$\Delta = \left(\frac{\beta_1^{**} - \beta_3 p_{CC}}{2\beta_2}, \frac{\beta_1^{**}}{2\beta_2}\right) = \left(C - \frac{\beta_3 p_{CC}}{4\beta_2}, C + \frac{\beta_3 p_{CC}}{4\beta_2}\right), \tag{3.9}$$

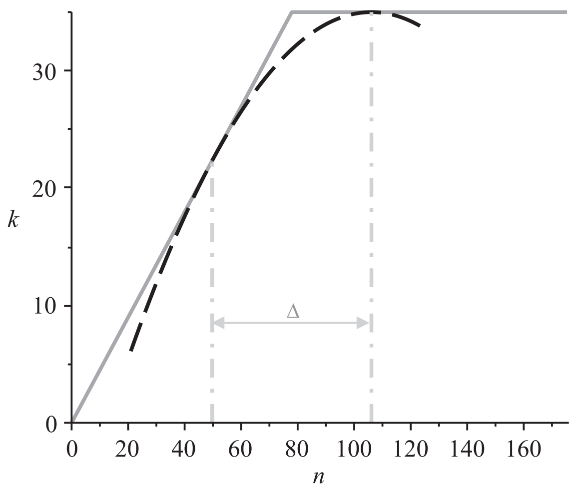
which is evenly spaced around the cost cap consumption C and has a width of $\delta = \beta_3 p_{CC}/2\beta_2$, is never optimal. This is demonstrated by Figure 3.1. The kink in the cost curve induces the consumer to avoid any consumption around the cost cap level. Intuitively, just below the cost cap level, the consumer would rather use the CC tariff like a flat rate because the negative effect of slightly higher costs is over-compensated by the positive effect of a much higher consumption level.

Consequently, the distribution of the optimal consumption levels under a cost cap tariff, denoted by $F_{N_{CC}}$, has zero mass in the interval Δ and can be written as follows:

$$F_{N_{CC}}(n) = \begin{cases} F_{B1}(2\beta_2 n + p_{CC}) & \text{,if } n \leq C - \frac{\beta_3 p_{CC}}{4\beta_2} \\ F_{B1}(2\beta_2 C + \frac{\beta_3 p_{CC}}{2}) & \text{,if } C - \frac{\beta_3 p_{CC}}{4\beta_2} < n \leq C + \frac{\beta_3 p_{CC}}{4\beta_2} \\ F_{B1}(2\beta_2 n) & \text{,if } n > C + \frac{\beta_3 p_{CC}}{4\beta_2} \end{cases} \tag{3.10}$$

PROPOSITION 2 $\prec$CC CONSUMPTION$\succ$. *A rational consumer of a cost cap tariff will never (expect to) consume exactly at the level at which the cost cap becomes binding.*

FIGURE 3.1: *Consumption under cost cap tariff*



Note: Cost curve of a a cost cap tariff (solid) and optimal indifference curve (dashed) corresponding to preference parameter β_1^{**}. The consumer is indifferent between consuming below or above the cost cap level, but will never consume in the interval Δ around the cost cap level.

Tariff choice under uncertainty We now investigate the tariff choice of a rational consumer under uncertainty. The representative consumer is considered to be risk-neutral and thus, he will choose the tariff that maximizes expected utility. From equations (3.4), (3.5) and (3.6) it follows that

$$
\begin{aligned}
E[U_{CC}] &= \int_0^{\beta_1^{**}} \frac{(\beta_1 - \beta_3 p_{CC})^2}{4\beta_2} f_{B1}(\beta_1) d\beta_1 + \int_{\beta_1^{**}}^{\infty} \left(\frac{\beta_1^2}{4\beta_2} - \beta_3 c_{CC} \right) f_{B1}(\beta_1) d\beta_1 \\
E[U_{FR}] &= \int_0^{\infty} \left(\frac{\beta_1^2}{4\beta_2} - \beta_3 f_{FR} \right) f_{B1}(\beta_1) d\beta_1 \qquad (3.11) \\
E[U_{PU}] &= \int_0^{\infty} \frac{(\beta_1 - \beta_3 p_{PU})^2}{4\beta_2} f_{B1}(\beta_1) d\beta_1.
\end{aligned}
$$

We can then write the difference in expected utility between a CC tariff and a FR tariff as follows:

$$\begin{aligned}
& E[U_{CC}] - E[U_{FR}] = \\
= \quad & \frac{1}{4\beta_2}\int_0^\infty \beta_1^2 f_{B1}(\beta_1)d\beta_1 - \frac{2\beta_3 p_{CC}}{4\beta_2}\underbrace{\int_0^{\beta_1^{**}} \beta_1 f_{B1}(\beta_1)d\beta_1}_{=F_{B1}(\beta_1^{**})\, E[B_1|B_1\leq\beta_1^{**}]} \\
& + \frac{\beta_3^2 p_{CC}^2}{4\beta_2}\underbrace{\int_0^{\beta_1^{**}} f_{B1}(\beta_1)d\beta_1}_{=F_{B1}(\beta_1^{**})} - \beta_3 c_{CC}\underbrace{\int_{\beta_1^{**}}^\infty f_{B1}(\beta_1)d\beta_1}_{=1-F_{B1}(\beta_1^{**})} \\
& - \frac{1}{4\beta_2}\int_0^\infty \beta_1^2 f_{B1}(\beta_1)d\beta_1 + \beta_3 f_{FR}\underbrace{\int_0^\infty f_{B1}(\beta_1)d\beta_1}_{=1}.
\end{aligned}$$

By using $c_{CC} = {}^{p_{CC}}/_{4\beta_2}(2\beta_1^{**} - \beta_3 p_{CC})$ from equation (3.6) we can derive:

$$\begin{aligned}
& E[U_{CC}] - E[U_{FR}] = \\
& \underbrace{\beta_3(f_{FR} - c_{CC})}_{<0} \quad + \quad F_{B1}(\beta_1^{**})\underbrace{\frac{\beta_3 p_{CC}}{2\beta_2}}_{\delta}\underbrace{(\beta_1^{**} - E[B_1|B_1 \leq \beta_1^{**}])}_{>0}.
\end{aligned} \tag{3.12}$$

Equation (3.12) demonstrates that the CC tariff may yield a higher expected utility than the FR tariff (i) if the cost cap c_{CC} is not much larger than the flat rate price f_{FR} and (ii) if low values of β_1, i.e., $\beta_1 < \beta_1^{**}$, are realized with a sufficiently high probability. The first condition ensures that the first, negative summand of equation (3.12) is not too small, whereas the second condition ensures that the second, positive summand is rather large.

Likewise, the difference between the expected utility of a CC tariff and a PU tariff can be written as:

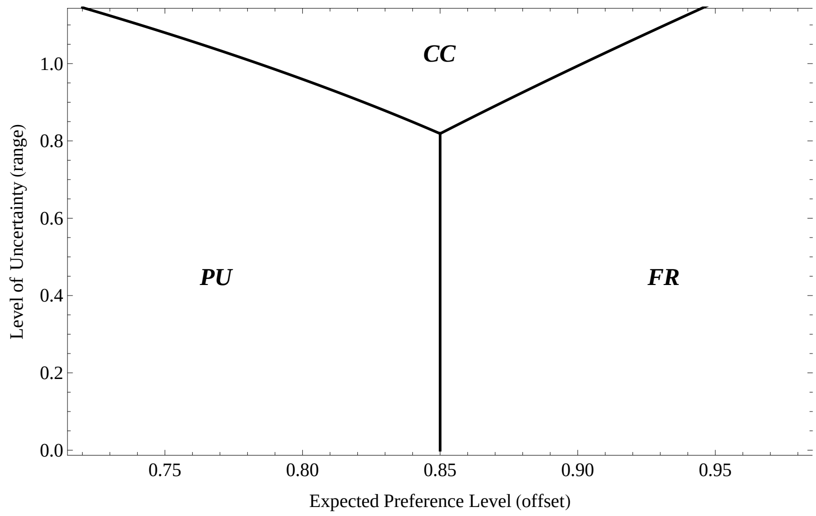
$$
\begin{aligned}
&E[U_{CC}] - E[U_{PU}] = \\
&= \frac{1}{4\beta_2}\Bigg(\beta_3^2 p_{CC}^2 \underbrace{\int_0^{\beta_1^{**}} f_{B1}(\beta_1)d\beta_1}_{=F_{B1}(\beta_1^{**})} - 2\beta_3(p_{CC}-p_{PU})\underbrace{\int_0^{\beta_1^{**}} \beta_1\, f_{B1}(\beta_1)d\beta_1}_{=F_{B1}(\beta_1^{**})\,E[B_1|B_1\le\beta_1^{**}]} \\
&\quad - 4\beta_2\beta_3\, c_{CC}\underbrace{\int_{\beta_1^{**}}^{\infty} f_{B1}(\beta_1)d\beta_1}_{=1-F_{B1}(\beta_1^{**})} + 2\beta_3 p_{PU}\underbrace{\int_{\beta_1^{**}}^{\infty}\beta_1\, f_{B1}(\beta_1)d\beta_1}_{=(1-F_{B1}(\beta_1^{**}))\,E[B_1|B_1\ge\beta_1^{**}]} \\
&\quad - \beta_3^2 p_{PU}^2\underbrace{\int_0^{\infty} f_{B1}(\beta_1)d\beta_1}_{=1}\Bigg).
\end{aligned}
$$

Again, replacing $c_{CC} = p_{CC}/4\beta_2(2\beta_1^{**} - \beta_3 p_{CC})$ yields:

$$
\begin{aligned}
E[U_{CC}] - E[U_{PU}] &= \frac{\beta_3}{4\beta 2}\Bigg(\underbrace{\beta_3(p_{CC}^2 - p_{PU}^2)}_{>0} \\
&\quad + 2p_{PU}\underbrace{\left(F(\beta_1^{**})\,E[B_1|B_1\le\beta_1^{**}] + (1-F(\beta_1^{**}))\,E[B_1|B_1\ge\beta_1^{**}]\right)}_{E[B_1]} \\
&\quad - 2p_{CC}\underbrace{\left(F(\beta_1^{**})\,E[B_1|B_1\le\beta_1^{**}] + (1-F(\beta_1^{**}))\,\beta_1^{**}\right)}_{=\hat{E}\le E[B_1]}\Bigg) \\
&= \frac{\beta_3}{4\beta 2}\Bigg(\underbrace{(p_{CC}-p_{PU})\,(\beta_3(p_{CC}+p_{PU}) - 2(E[B_1]+\hat{E}))}_{<0} \\
&\quad + 2\underbrace{\left(E[B_1]\,p_{CC} - \hat{E}\,p_{PU}\right)}_{>0}\Bigg).
\end{aligned}
\tag{3.13}
$$

Equation (3.13) reveals that the expected utility of a CC tariff may exceed that of a PU tariff if (i) the minute-price of the CC tariff, p_{CC}, is not much larger than the minute-price of the PU tariff, p_{PU} and (ii) if high values of β_1, i.e., $\beta_1 > \beta_1^{**}$ are sufficiently likely. Again, the first condition ensures that the first, negative summand of equation (3.13) is not too small, whereas the second condition ensures that the second, positive summand is rather large because $E[B_1] \gg \hat{E}$.

FIGURE 3.2: *Optimal tariff choice for different preference levels and uncertainty levels*



Note: The figure is derived for the values $p_{PU} = 0.10$, $p_{CC} = 0.12$, $c_{CC} = 45$, $f_{FR} = 40$, $\beta_2 = 0.001$, $\beta_3 = 1$.

Notice that in order for the CC tariff to dominate both the FR and the PU tariff, the consumer must face a sufficiently high probability for low *and* high values of β_1. Evidently, the CC tariff must additionally be reasonably priced in comparison to the FR and PU tariff.

3.1.3 Example

To exemplify the impact of the probability distribution and the pricing of the CC tariff on the choice of CC tariffs, consider the following uniform probability density function of $B1$:

$$f_{B1}(\beta_1) = \begin{cases} {}^{1}/_{\text{range}} & \text{, if offset} - {}^{\text{range}}/_{2} < \beta_1 < \text{ offset } + {}^{\text{range}}/_{2} \\ 0 & \text{, otherwise} \end{cases} \tag{3.14}$$

It is characterized by the two parameters *offset* and *range* which characterize the expected level of the preference parameter β_1 and the level of uncertainty about β_1, respectively.

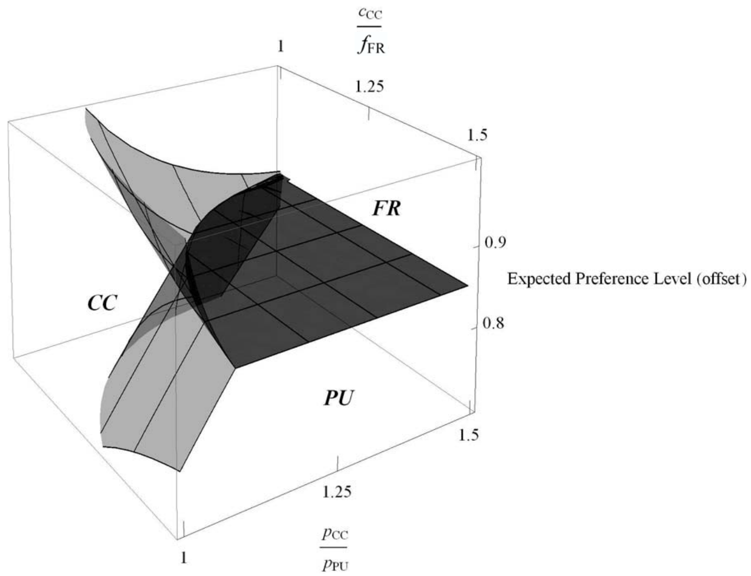
Figure 3.2 shows the optimal tariff choice of a risk-neutral consumer for different values of *offset* and *range*. In line with Proposition 1, the CC tariff is never optimal if the level of uncertainty is too low. In this case and depending on the offset of the preference parameter, i.e., whether the consumer is a 'light' or 'heavy' user, the FR or PU tariff is chosen respectively. In reverse, the CC tariff is optimal in a region that is characterized by an intermediate offset level and a large range. Intuitively, this means that the CC tariff is optimal when a consumer has a high uncertainty about his demand, with both a high probability that the demand will be low and and a high probability that the demand will be high.

Figure 3.3 additionally demonstrates the impact of the pricing of the CC tariff on tariff choice. More precisely, the figure shows the indifference hyperplanes between the different tariff options along the dimensions $^{p_{CC}}/_{p_{PU}}$, $^{c_{CC}}/_{f_{FR}}$ and *offset*. It is easy to see that the PU and FR tariff are chosen over the CC tariff if the latter is priced too high, i.e. if $^{p_{CC}}/_{p_{PU}}$ or $^{c_{CC}}/_{f_{FR}}$ are sufficiently large, respectively. In this case, the choice between the FR and the PU tariff is independent of the pricing of the CC tariff, of course, and depends only on the expected level of demand (*offset*).

To conclude, the example demonstrates that CC tariffs may indeed present an optimal tariff choice for a rational and risk-neutral consumer under certain parameter conditions. In particular, these depend on a consumer's level of uncertainty about his preferences, which, by equations (3.7) and (3.10), directly translates into demand uncertainty.

PROPOSITION 3 ≺CHOICE OF CC TARIFFS UNDER UNCERTAINTY≻. *A (reasonably priced) cost cap tariff may be chosen over a flat rate and a pay-per-use tariff by a risk-neutral consumer in the face of a sufficiently high demand uncertainty.*

FIGURE 3.3: *Optimal tariff choice for different preference levels and parametrizations of the cost cap tariff*



Cost cap tariff has been altered by its price levels (p_{CC}/p_{PU} and c_{CC}/f_{FR}). The figure is derived for the values $p_{PU} = 0.10$, $f_{FR} = 40$, $\beta_2 = 0.001$, $\beta_3 = 1$ and range $= 1$.

3.1.4 Discussion

Summary of results This section has developed a theory on consumer utility under cost cap tariffs by which the optimal consumption and choice under this new tariff type can be determined. Under a reasonable set of assumptions, we find that a rational consumer with no uncertainty in his preferences would never choose a cost cap tariff, as it is either dominated by a pay-per-use or a flat rate tariff. However, cost cap tariffs are an optimal tariff choice for those consumers that face considerable uncertainty about their future demand, such that both, relatively low and relatively high consumption levels are considered feasible. In this case, cost cap tariffs provide an insurance against extraordinary high costs (like a flat rate), but also cost flexibility in case of low demand (like a pay-per-use tariff).

Limitations and future research The present model merely considers the rational choice of a risk-neutral consumer. However, as stated in Chapter 2 earlier research found that the rational tariff choice is systematically biased, e.g., due the insurance effect (Lambrecht and Skiera, 2006a), the flexibility effect (Kraemer and Wiewiorra, 2012), or the overestimation effect (Nunes, 2000). The extend of a bias for cost cap tariffs, in particular in relation to the well-known flat rate bias, should therefore be considered in theoretical models in more detail by future research.

3.2 Empirical Validation

In the following, the previously developed utility theory is evaluated based on stated preference data.

3.2.1 Methodology

We contracted with a professional marketing research agency to conduct an online survey with a sample that is representative of the population of German mobile telephony users. A total of 122 respondents completed the survey, which consisted of two parts.

In the first part, respondents had to imagine that they use a PU tariff for mobile telephony and that this is the only tariff type available to them. In a repeated open-ended question design (Miller et al., 2011) the respondents had to estimate their average monthly mobile telephony usage (in minutes), given minute prices (in €/min) of $p_{PU} = \{0.40, 0.20, 0.10, 0.05\}$. Consequently, four price consumption tuples were reported for every respondent.

In the second part, respondents were presented six different mobile telephony tariffs. Each tariff type (PU, CC, FR) occurred twice with two different price levels (see Table 3.1). For each tariff, respondents had to estimate their maximum, minimum and average monthly usage (in minutes). In addition, the attractiveness of each tariff had to be rated on a seven-point scale (1=very unattractive, 7=very attractive).

TABLE 3.1: *Tariffs to be evaluated by respondents*

	PU	CC	FR
base fee (f)	0 (0) €	0 (0) €	20 (25) €
minute price (p)	0.10 (0.13) €/min	0.12 (0.15) €/min	0.00 (0.00) €/min
cost cap (c)	0 (0) €	25 (30) €	0 (0) €

Note: High price level in parentheses.

The data from the first part of the survey is used to estimate the individual preference parameters $(E[B_1], \beta_2)$. We know from equation (3.3) that $E[N_{PU}] = (E[B_1] - \beta_3 p_{PU})/(2\beta_2)$. Without loss of generality we further normalize $\beta_3 = 1$. Using the four consumption price tuples $[E[N_{PU}], p_{PU}]_{it}$ from each respondent i, an ordinary least squares regression (OLS) can be conducted for each individual in order to estimate the parameters $(E[B_1], \beta_2)$.

To derive $f_{B1}(\beta)$, a uniform distribution as in (3.14) centered around $E[B_1]$ (i.e., *offset*) is assumed. Whereby *range* is computed from the stated minimum and maximum usage under the PU tariff of the second part of the survey. According to (3.3), the *range* becomes

$$range = \beta_{1max} - \beta_{1min} = 2\beta_2(n_{max} - n_{min}).$$

We then evaluate our theoretical model in two different ways. First, the theoretically expected usage is compared to the average usage under each given tariff reported in the second part of the survey. Second, the theoretically derived expected utility is used as a predictor for the actual rating of these tariffs.

3.2.2 Results

Evaluation of the usage prediction Given the individual estimates, a respondent's expected usage is calculated according to equations (3.7), (3.8) and (3.10) for each of the six tariffs. We use an OLS regression (Model 1 in Table 3.2) to study the correlation of predicted and reported average usage, while controlling for the different tariffs and price levels. In order to account for individual differences in rating behaviour, a

TABLE 3.2: *Fixed-effects OLS regressions of model predictions on reported values*

	(1) Average usage		(2) Tariff rating	
Expected usage	0.901***	(0.147)		
Expected utility			0.058***	(0.006)
High price	−26.903***	(7.062)	−0.162	(0.116)
CC tariff	9.354	(6.390)	0.381**	(0.146)
FR tariff	73.069***	(10.214)	2.509***	(0.149)
Constant	−1.168	(20.123)	2.284***	(0.165)
Observations	6x122		6x122	
R^2	0.806		0.536	

Note: Robust standard errors in parentheses. ** $p < .01$, *** $p < 0.001$

fixed-effect estimation is considered.[1] The regression coefficient is significant and with 0.901 close to one, indicating a good prediction quality. However, the theoretical model has a slight tendency to overestimate the reported usage. This is particularly true for the reported usage under the tariffs with a high price level. Moreover, we find that respondents tend to overestimate their usage under a FR tariff. This so-called overestimation effect is well-known from previous research (see, e.g., Nunes, 2000). Finally, the regression model explains 80.6 % of the total variance, indicating a good model fit.

Evaluation of utility prediction Given the individual preference parameters, the utility for each tariff is predicted according to equations (3.11). A respondent's expected utility under a given tariff is then regressed on his rating for this tariff, using the same regression model and controls as before. Model 2 in Table 3.2 shows that there exists a significant and positive relationship between the expected utility derived from the theoretical model and a respondent's tariff rating. Moreover, a significant portion of the total variance can be explained, which indicates a good model fit. Furthermore, we find a significant tariff bias. In comparison to the PU tariff, the CC tariff is assigned a 0.381 higher rating score, everything else equal. By far the largest bias is found for the FR tariff, however. This finding is in line with earlier research on tariff bias (see, e.g., Lambrecht and Skiera, 2006a).

[1] This means that each respondent is allowed to have an individual intercept, whereas the regression coefficient is constrained to be the same across all respondents.

3.2.3 Discussion

Summary of results The results provide evidence for the validity of the implied utility model for consumption under cost cap tariffs. By the use of stated preference data from a simple repeated open-ended question design, respondents' individual preference parameter were estimated. The subsequently calculated utility is a significant explanatory variable to explain tariff choice. Furthermore, the predicted consumption is strongly correlated with actually stated average consumption.

Limitations and future research There are, however, two major shortcomings of the model as well as its empirical validation. First, the utility model is restricted to consumer choice under two-part tariffs and does not take into account a potential consumption allowance. Second, the empirical validation is limited in its calculation of consumer uncertainty, as it is determined under rather strict specifications. Thus, the following chapter develops an extended utility model with a more sophisticated empirical analysis to overcome these shortcomings.

Chapter 4

Consumer Choice under Four-Part Tariffs

"I hate being on the phone"

A survey respondent

THIS chapter extends the previously proposed model on consumer behavior to account for four-part tariffs. Due to the complexity of four-part tariffs a theoretical approach is difficult. Therefore, the model is empirically validated by a repeated choice experiment with subsequent hierarchical Bayes mixed logit estimation of respondents' preference parameters. The chapter is organized as follows. Section 4.1 provides an overview on earlier research on tariff choice. Deduced from these studies, a discrete/continuous choice model is developed in Section 4.2 along with an estimation of consumers' preference parameters. The results in Section 4.3 show the superiority of the extended model to alternative approaches in all evaluation criteria. The chapter closes with a summary of the results and an overview of prospective future research.

4.1 Related Literature

Research on nonlinear pricing is rooted in welfare economics (Leland and Meyer, 1976; Murphy, 1977; Schlereth and Skiera, 2012) and has been mainly studied from a theoretical perspective (Bagh and Bhargava, 2013; Essegaier et al., 2002; Hayes, 1987; Sundararajan, 2004). Yet, there has been an increase in empirical research (Danaher, 2002; Iyengar et al., 2008; Lambrecht et al., 2007; Schlereth et al., 2010) within the last decade. An important aspect of modeling of consumer behavior under different tariffs is the literature on discrete/continuous choice models (Dubin and McFadden, 1984; Hanemann, 1984). These models assume that a discrete choice and a continuous choice are made simultaneously. Applied to the case of tariffs, this assumption would state that a consumer already knows his exact consumption under every tariff alternative. Hence, the discrete choice of a tariff incorporates the continuous consumption choice. These models have been extended in several ways, such as incorporating attrition probabilities (Danaher, 2002). Even more, Lambrecht et al. (2007) demonstrated the importance of ex ante uncertainty about the continuous consumption choice at the time of discrete tariff choice. This study revealed that consumers have significant uncertainty and that the extent of such uncertainty is heterogeneous over consumers. As a consequence, uncertainty decreases consumer surplus and increases provider's revenues. Consequently, the discrete choice is made under the expectation of continuous choice. Subsequent studies provided further evidence for this finding (Goettler and Clay, 2011; Iyengar et al., 2008). Under the assumption of uncertain consumption, Iyengar et al. (2008) and Schlereth et al. (2011) developed a methodological approach to infer consumer preferences from a repeated choice experiment. The authors showed the superiority of their models in estimating individual consumption. The models consider the two-way dependency of consumption and price under three-part tariffs. Related studies improved the understanding of consumption under tariff specific characteristics. Ascarza et al. (2012) and Lambrecht et al. (2007) studied tariffs with allowance and flat rate tariffs and found a significant increase of consumption under such tariffs. Furthermore, Ho and Zhang (2008) focused on the effect of fixed fee framing of two-part tariffs on consumer churn rates. They found a relationship of consumers' loss aversion on market outcomes. Iyengar et al. (2011) studied the framing of pay-per-use and traditional two-part tariffs. The authors found that consumers derive a lower utility from consumption under the two-part tariff which cannot be explained by income effects. The so called "access fee effect" impacts consumers' retention, consumption and provider's pricing policy. Later, Goh and Bockstedt (2012) confirmed the importance of fixed fees in the connection with allowances as an anchor to initially evaluate tariff attractiveness, which in turn impacts decision making. Another more recent advancement in choice modeling is the consideration of learning effects (Ascarza et al., 2012; Goettler and Clay, 2011; Iyengar et al., 2007; Narayanan et al., 2007). These models account for consumer learning effects on their consumption uncertainty. By receiving feedback on ex post consumption consumers can adjust previous tariff choice and overcome a potential tariff bias (Lambrecht and Skiera, 2006a). However, only revealed preference studies were able to account for learning effects as they require observations over time. While previous research focused on two and three part tariffs, Schlereth and Skiera (2012) showed the portability of the discrete/continuous choice model to novel nonlinear pricing schemes. In this vein, Schlereth and Skiera studied consumer choice under bucket pricing plans, under which consumers pay a fixed fee allowing them to use a service up to a set allowance.

As proposed by Schlereth and Skiera (2012), empirical research can be separated into approaches using revealed (Ascarza et al., 2012; Goettler and Clay, 2011; Iyengar et al., 2007; Lambrecht et al., 2007; Narayanan et al., 2007) and stated consumer preferences (Iyengar et al., 2008; Schlereth and Skiera, 2012). Revealed preferences can be acquired from actual consumption and choice observations in the field. Therefore, revealed preferences feature high external validity. In contrast, controlled experiments are used to reveal stated preferences. Although having lower external validity, stated preferences imply the possibility to vary tariff conditions and to observe consumers' reactions.

Table 4.1 provides an overview of the most recent empirical research on tariff choice and consumption. The previous references are categorized in several ways. First, modeling the utility function can be differentiated by either using an additive or quadratic approach. Whereas the additive utility function is simply the sum of consumers' part worth utilities from tariff components, the quadratic utility function accounts for the relationship of perceived tariff utility and consumption. As discussed in Chapter 2, using a quadratic approach involves more complex calculations, but in turn also allows incorporating diminishing marginal utility, and to model consumption satiation level. With the exception of Ho and Zhang (2008) and Goh and Bockstedt (2012) who combined choice experiments with field observations, earlier research studied consumer behavior by either using revealed or stated preferences. Further modeling aspects include the consideration of uncertainty, the use of learning models, and aspects of tariff framing as discussed before. Table 4.1 points out the gap of research on innovative nonlinear pricing approaches, which has only been considered by Schlereth and Skiera (2012) so far.

Deduced from earlier research, this chapter develops a quadratic utility model for consumer choice of four-part tariffs incorporating consumer uncertainty in consumption preference. As the focus of this study is the interaction of all four tariff components, a controlled variation of the components is essential. Thus, a stated preference approach with a repeated choice experiment is used to study consumer behavior. Although this approach allows to control for framing effects, it is, however, limited in its applicability to study learning effects.

4.2 Methodology

A four-part tariff j can be described by a tuple $t_j = (f_j, A_j, p_j, c_j)$. In accordance to Chapter 2, f_j describes a fixed fee which has to be paid upfront. Often a consumer i acquires an allowance A_j for a limited consumption free of charge. Exceeding the allowance results in consumption which is further priced with a usage price p_j. The total costs K_{ij},

TABLE 4.1: *Overview on empirical research on tariff choice and consumption*

reference	general topic	additive course	quadratic course	revealed preferences	stated preferences	uncertainty	learning	framing	tariff structure
Danaher (2002)	consumption rate & consumer retention	●		●					2PT
Iyengar et al. (2007)	choice & consumption learning		●	●		●	●		3PT
Lambrecht et al. (2007)	choice & consumption with uncertainty		●	●		●		●	3PT
Narayanan et al. (2007)	choice & consumption learning			●		●	●		2PT
Iyengar et al. (2008)	choice & consumption with uncertainty		●		●	●			3PT
Ho and Zhang (2008)	effects of tariff framing	●		◐	●			●	2PT
Iyengar et al. (2011)	effects of tariff framing			●		●		●	2PT
Goettler and Clay (2011)	choice & consumption learning	●		●		●	●		2PT
Schlereth et al. (2011)	choice & consumption measurement		●		●	◐		◐	3PT
Redden and Hoch (2011)	heuristic choice				●	●		●	3PT
Ascarza et al. (2012)	effects of tariff framing		●	●		●	●	●	3PT
Goh and Bockstedt (2012)	effects of tariff framing	●		●	●			●	3PT
Iyengar and Jedidi (2012)	choice & consumption under quantity discounts	●	◐		●				2PT
Schlereth and Skiera (2012)	innovative pricing		●		●			●	2PT
this research	innovative pricing		●		●	●		●	4PT

however, can never exceed the predefined cost cap c_j. Consequently, the total costs a consumer has to pay under a four-part tariff depends on his usage n_{ij}:

$$K_{ij}(n_{ij}) = \begin{cases} f_j & \text{if } 0 \leq n_{ij} \leq A_j \\ f_j + p_j(n_{ij} - A_j) & \text{if } A_j < n_{ij} \leq C_j \\ c_j & \text{otherwise,} \end{cases} \tag{4.1}$$

with C_j being the corresponding consumption to reach cost cap c_j

$$C_j = (c_j - f_j)/p_j + A_j. \tag{4.2}$$

Note that the four-part tariff includes every possible tariff subcase (see Section 2.2) by adjusting $t_j = (f_j, A_j, p_j, c_j)$ accordingly. This includes traditional two-part tariffs ($t_j = (f_j, 0, p_j, \infty)$) and three-part tariffs with allowance ($t_j = (f_j, A_j, p_j, \infty)$).

Model Development Consider now a consumer i who has to choose one alternative j from a choice set with J tariffs. At that point in time the consumer assumes *ex ante* his consumption n_{ij} under this tariff and spends his remaining budget on an unobservable outside good z_{ij}. In doing so his utility increases in consumption with a decreasing rate. Assuming that the consumer is certain about his consumption, namely his *ex ante* consumption is equivalent to the *ex post* consumption, consumer's utility U_{ij} is equivalent to:

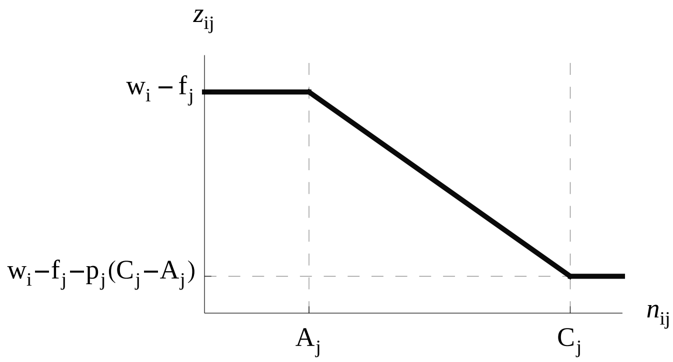
$$U_{ij} = \beta_{i1} n_{ij} - \beta_{i2} n_{ij}^2 + \beta_{i3} z_{ij} \tag{4.3}$$

subject to consumer's budget constraint

$$w_i = K_{ij}(n_{ij}) + z_{ij} p_z \tag{4.4}$$

where K_{ij} denotes the total costs under a four-part tariff in dependence on consumer's consumption, and w_i describes his available budget. The resulting relationship between w_i, n_{ij} and z_{ij} with $p_z = 1$ are visualized in Figure 4.1.

FIGURE 4.1: *Budget constraint under four-part tariff*



The utility function is specified by a quadratic function as described in Section 2.3, which guarantees satiation $s_i = \beta_{i1}/2\beta_{i2}$ in consumption (Iyengar et al., 2008; Schlereth and Skiera, 2012). β_{i1} determines the increase in utility from consumption, while β_{i2} determines the diminishing rate. Lastly, a preference for the outside option is described by β_{i3}. Thus, preferences are described by $\vec{\beta}_i$ and vary across consumers. Under the assumption that the consumer exhausts his budget, the indirect utility function can be obtained by substituting $z_{ij} = (w_i - K_{ij}(n_{ij}))/p_z$. Without loss of generality, the price of the outside good is normalized to $p_z = 1$, so that the indirect utility function becomes:

$$U_{ij} = \begin{cases} \beta_{i1}n_{ij} - \beta_{i2}n_{ij}^2 + \beta_{i3}(w_i - f_j) & \text{if } 0 \leq n_{ij} \leq A_j \\ \beta_{i1}n_{ij} - \beta_{i2}n_{ij}^2 + \beta_{i3}(w_i - f_j - (n_{ij} - A_j)p_j) & \text{if } A_j < n_{ij} \leq C_j \\ \beta_{i1}n_{ij} - \beta_{i2}n_{ij}^2 + \beta_{i3}(w_i - f_j - (C_j - A_j)p_j) & \text{if } C_j < n_{ij} \end{cases} \tag{4.5}$$

The budget constraint is piecewise convex as well as concave as illustrated in Figure 4.1. Hence, there is no unique solution to the maximization problem (Hausman, 1979). Yet, the budget constraint can be considered by two convex sections $(low, high)$ divided by C_j. Each section yields a unique solution to the maximization problem, so that the global optimum can be identified by $U_{ij}^* = max(U_{ij}^{low}, U_{ij}^{high})$ as stated by Hausman (1985). It is easy to see that due to the convexity of the budget constraint and the concavity of the utility function the break-even consumption of the cost cap will never be optimal. Therefore, there is an abrupt rise in consumption at $\beta_{i1}^* = 2\beta_{i2}C_j + \beta_{i3}p_j/2$ as already described in Section 3.1.2. For simplicity it is assumed that consumers always decide to consume within the low section if their utility is indifferent.

Maximizing the indirect utility function under these specifications entails the consumer's optimal demand function n_{ij}^*:

$$n_{ij}^* = \begin{cases} \frac{\beta_{i1}}{2\beta_{i2}} & \text{if } 0 \leq n_{ij}^* \leq A_j \\ \frac{\beta_{i1}-\beta_{i3}p_j}{2\beta_{i2}} & \text{if } A_j < n_{ij}^* \leq C_j \\ \frac{\beta_{i1}}{2\beta_{i2}} & \text{if } C_j < n_{ij}^* \\ A_j & \text{otherwise.} \end{cases} \tag{4.6}$$

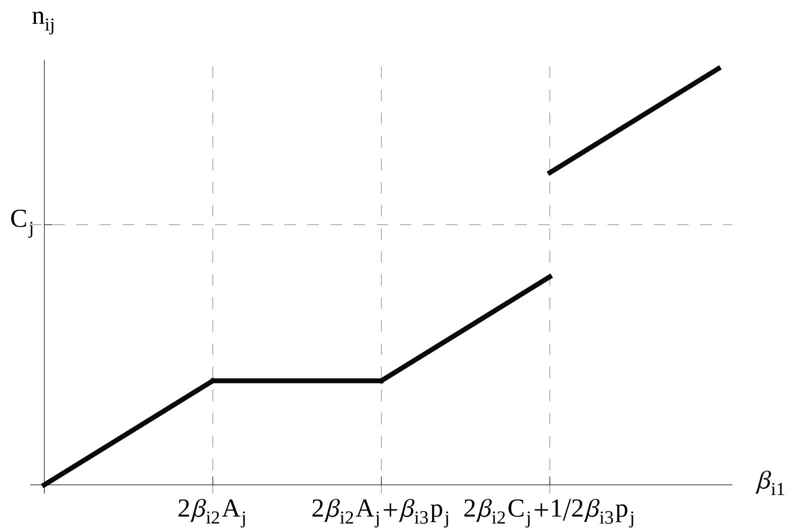
Note that optimal demand is independent of f_j and w_i because income effects are excluded. If a consumer's satiation s_i is small enough, consumption stays within the allowance A_j. However, if consumption is within $(A_j, C_j]$, the monetary perception of p_j causes a reduction in consumption. Substituting optimal demand into the indirect utility function yields consumer's optimal utility:

$$U_{ij}^* = \begin{cases} \frac{\beta_{i1}^2}{4\beta_{i2}} + \beta_{i3}(w_i - f_j) & \text{if } 0 \leq n_{ij} \leq A_j \\ \frac{(\beta_{i1}-\beta_{i3}p_j)^2}{4\beta_{i2}} + \beta_{i3}(w_i - f_j + A_j p_j) & \text{if } A_j < n_{ij} \leq C_j \\ \frac{\beta_{i1}^2}{4\beta_{i2}} + \beta_{i3}(w_i - f_j - (C_j - A_j)p_j) & \text{if } C_j < n_{ij} \end{cases} \tag{4.7}$$

So far a rational consumer has been assumed to exactly anticipate his usage under a given tariff - whereby the ex ante consumption was equivalent to its ex post. However, earlier studies have shown that this specification may not reflect actual consumer behavior (Lambrecht et al., 2007) and that consumers may be uncertain about their consumption preferences (Grubb, 2009; Hayes, 1987; Kridel et al., 1993). Hereafter, consumer preference β_{i1} is assumed to be a realization of the random variable B_{i1} distributed according to the probability density function $f(\beta_{i1})$ and the corresponding cumulative distribution function $F(\beta_{i1})$.

As a consequence, optimal consumption n_{ij}^* is distributed as well being dependent on β_{i1}. Figure 4.2 illustrates this dependency. As β_{i1} determines the increase in utility from consumption, the optimal consumption level increases linearly in β_{i1} as long as consumer's satiation level is below the tariff allowance. The consumer exhausts exactly the allowance as long as $\beta_{i1} \in [\tilde{\beta}_{i11} = 2\beta_{i2}A_j, \tilde{\beta}_{i12} = 2\beta_{i2}A_j + \beta_{i3}p_j]$. This is because his satiation level s_i is above the allowance and a negative perception of $\beta_{i3}p_j$ reduces his willingness to further consume. As soon as this preference exceeds the threshold $\tilde{\beta}_{i12} = 2\beta_{i2}A_j + \beta_{i3}p_j$ optimal consumption increases further. Finally, at $\tilde{\beta}_{i13} = 2\beta_{i2}C_j + 1/2\beta_{i3}p_j$ consumption jumps from linear pricing to consumption under the cost cap. Hereafter, consumption follows consumer's satiation similar to consumption below the allowance. Because s_i itself is linearly dependent on β_{i1}, consumption rises linearly again. Taking uncertainty into account, the consumer considers the whole nonlinear

FIGURE 4.2: *Optimal consumption as a function of preference parameter*



spectrum of the four-part tariff. The four possible sections can be summarized as:

i) consume below the allowance,
$0 \leq n_{ij} \leq A_j \Leftrightarrow 0 \leq \beta_{i1} \leq \tilde{\beta}_{i11} = 2\beta_{i2}A_j$

ii) consume exactly the allowance,
$A_j = n_{ij} \Leftrightarrow \tilde{\beta}_{i11} = 2\beta_{i2}A_j \leq \beta_{i1} \leq \tilde{\beta}_{i12} = 2\beta_{i2}A_j + \beta_{i3}p_j$

iii) consume with marginal price p_j per minute,
$A_j < n_{ij} \leq C_j \Leftrightarrow \tilde{\beta}_{i12} = 2\beta_{i2}A_j + \beta_{i3}p_j < \beta_{i1} \leq \tilde{\beta}_{i13} = 2\beta_{i2}C_j + 1/2\beta_{i3}p_j$

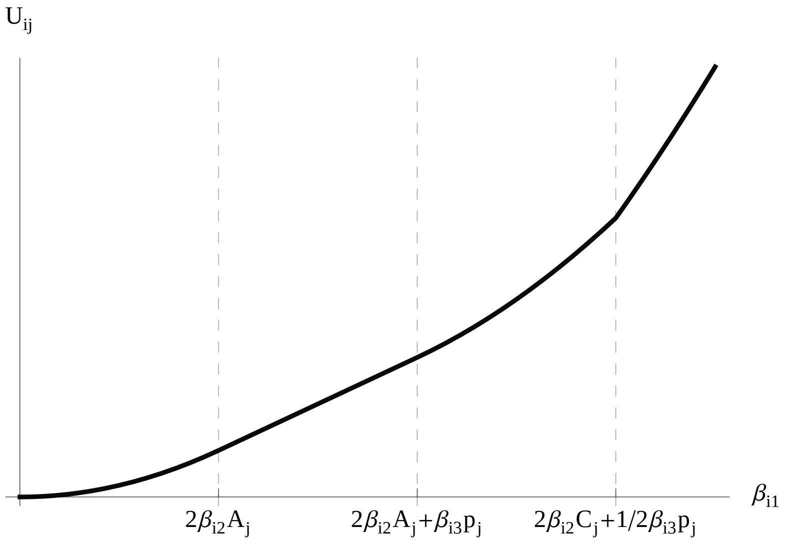
iv) consume within cost cap,
$C_j < n_{ij} \Leftrightarrow \tilde{\beta}_{i13} = 2\beta_{i2}C_j + 1/2\beta_{i3}p_j < \beta_{i1}$

Hence, prior to deciding for a tariff alternative, a consumer has only an expectation about future consumption. After the decision has been taken, the actual ex post consumption can differ from the expected ex ante consumption. Therefore, the model takes into account the intertemporal nature of the choice and consumption decisions (Miravete, 2002), instead of a simultaneous specification (Hanemann, 1984; Dubin and McFadden, 1984). A consumer considers preference uncertainty and then evaluates the tariff based on his expected utility which is:

$$
\begin{aligned}
E(U_{ij}) = & P(0 \leq \beta_{i1} \leq \tilde{\beta}_{i11})\, E(U_{ij} \mid 0 \leq \beta_{i1} \leq \tilde{\beta}_{i11}) + \\
& P(\tilde{\beta}_{i11} < \beta_{i1} \leq \tilde{\beta}_{i12})\, E(U_{ij} \mid \tilde{\beta}_{i11} < \beta_{i1} \leq \tilde{\beta}_{i12}) + \\
& P(\tilde{\beta}_{i12} < \beta_{i1} \leq \tilde{\beta}_{i13})\, E(U_{ij} \mid \tilde{\beta}_{i12} < \beta_{i1} \leq \tilde{\beta}_{i13}) + \\
& P(\tilde{\beta}_{i13} < \beta_{i1})\, E(U_{ij} \mid \tilde{\beta}_{i13} < \beta_{i1})
\end{aligned}
\tag{4.8}
$$

The relationship between β_{i1} and the corresponding utility U_{ij} are illustrated in Figure 4.3.

FIGURE 4.3: *Optimal utility as a function of the preference parameter*



Using the optimal indirect utility function from Equation (4.7) yields:

$$
\begin{aligned}
(4.9)\quad & E(U^*_{ij}) = \\
& (F(\tilde{\beta}_{i11}) - F(0))\,\frac{E(\beta_{i1}^2 \mid 0 \leq \beta_{i1} \leq \tilde{\beta}_{i11})}{4\beta_{i2}} + \\
& (F(\tilde{\beta}_{i12}) - F(\tilde{\beta}_{i11}))\left(E\left(\beta_{i1} \mid \tilde{\beta}_{i11} < \beta_{i1} \leq \tilde{\beta}_{i12}\right)A_j - \beta_{i2}A_j^2\right) + \\
& (F(\tilde{\beta}_{i13}) - F(\tilde{\beta}_{i12})) \\
& \frac{E\left(\beta_{i1}^2 \mid \tilde{\beta}_{i12} < \beta_{i1} \leq \tilde{\beta}_{i13}\right) - E\left(\beta_{i1} \mid \tilde{\beta}_{i12} < \beta_{i1} \leq \tilde{\beta}_{i13}\right)\beta_{i3}p_j + (\beta_{i3}p_j)^2}{4\beta_{i2}} + \\
& (1 - F(\tilde{\beta}_{i13}))\,\frac{E(\beta_{i1}^2 \mid \tilde{\beta}_{i13} < \beta_{i1})}{4\beta_{i2}} + \\
& \beta_{i3}(w_i - f_j) + (F(\tilde{\beta}_{i13}) - F(\tilde{\beta}_{i12}))(\beta_{i3}A_jp_j) - (1 - F(\tilde{\beta}_{i13}))(C_j - A_j)p_j
\end{aligned}
$$

Note that the expected utility is twofold. Firstly, there is the expected utility gained from consumption conditionally on each section; secondly, the expected disutility from involved costs. It is easy to see that the variance of β_{i1} is crucial for the probability to consume within different sections of the tariff.

It is reasonable to believe that β_{i1} is distributed lognormal $\ln\beta_{i1} \sim \mathcal{N}(\mu_i, \sigma_i^2)$, since then increasing utility with consumption would be assumed. Under this specification, the corresponding density function $f(\beta_{i1})$ and the cumulative density function $F(\beta_{i1})$ become:

$$f(\beta_{i1}) = \frac{1}{\beta_{i1}\sqrt{2\pi\sigma_i^2}} \exp(-\frac{1}{2}\left(\frac{\ln\beta_{i1} - \mu_i}{\sigma_i}\right)^2) \tag{4.10}$$

$$F(\beta_{i1}) = \Phi\left(\frac{\ln\beta_{i1} - \mu_i}{\sigma_i}\right) \tag{4.11}$$

with $\Phi(.)$ denoting the cummulative standard normal distribution. Hence, the expected values are:

$$E\left(\beta_{i1} \mid \tilde{\beta}_{i1k} < \beta_{i1} \leq \tilde{\beta}_{i1(k+1)}\right) =$$

$$\exp(\mu_i + \sigma_i^2/2) + \frac{\Phi\left(\sigma_i - \frac{\ln\tilde{\beta}_{i1k} - \mu_i}{\sigma_i}\right) - \Phi\left(\sigma_i - \frac{\ln\tilde{\beta}_{i1(k+1)} - \mu_i}{\sigma_i}\right)}{\Phi\left(\frac{\ln\tilde{\beta}_{i1(k+1)} - \mu_i}{\sigma_i}\right) - \Phi\left(\frac{\ln\tilde{\beta}_{i1(k)} - \mu_i}{\sigma_i}\right)}$$

$$E\left(\beta_{i1}^2 \mid \tilde{\beta}_{i1k} < \beta_{i1} \leq \tilde{\beta}_{i1(k+1)}\right) =$$

$$\exp(2\mu_i + 2\sigma_i^2) + \frac{\Phi\left(2\sigma_i - \frac{\ln\tilde{\beta}_{i1k} - \mu_i}{\sigma_i}\right) - \Phi\left(2\sigma_i - \frac{\ln\tilde{\beta}_{i1(k+1)} - \mu_i}{\sigma_i}\right)}{\Phi\left(\frac{\ln\tilde{\beta}_{i1(k+1)} - \mu_i}{\sigma_i}\right) - \Phi\left(\frac{\ln\tilde{\beta}_{i1(k)} - \mu_i}{\sigma_i}\right)}$$

$$\forall k \in \{0,1,2,3\}$$

Nevertheless, the expected utility is not dependent on the assumption of a lognormal distribution and may work with any other function as well.

In summary, a consumer's tariff choice is dependent on the expected utility across tariff alternatives. Uncertainty in preference affects utility in two ways simultaneous by varying both consumer's consumption as well as the likelihood of consuming within different sections of a tariff alternative.

Model Estimation The proposed model is estimated using a hierarchical Bayes mixed logit approach (Allenby and Rossi, 1999; Train, 2001, 2009). In doing so, a consumer $i \in I$ faces several choice sets $t \in T$ including J alternatives. It is assumed that the consumer chooses the alternative j which maximize his utility. However, the researcher is not able to observe all factors impacting consumer's utility which are only known to the consumer. This leads to an error term ϵ_{ijt} which is assumed to be distributed iid extreme value over consumers, alternatives, and choice occasions. Using McFadden's random utility model (McFadden, 1974), a consumer's utility becomes:

$$\tilde{U}_{ijt} = E(U_{ijt}) + \epsilon_{ijt}, \tag{4.12}$$

where $E(U_{ijt})$ is the expected utility as described by Equation (4.9). Due to the fact that calculating the expected costs under nonlinear pricing schemes is a complex task (Redden and Hoch, 2011; Viswanathan et al., 2005), it is reasonable to believe that consumers differ in their ability to cope with such a decision problem. Hence, a consumer having problems handling the complexity should exhibit a larger variance in his error term. Consumer's degree of choice rationality is described by γ_i which also states consumers ability to handle choice complexity (Ho and Zhang, 2008). Let θ_i summarize all parameters describing consumers' observed utility and choice rationality, i.e. $\theta_i^{'} = (\mu_i, \sigma_i, \beta_{i2}, \beta_{i3}, \gamma_i)$. Furthermore, consumers' tariff decisions are described by $y_i^{'} = (y_{i11}, ..., y_{ijt})$, with $y_{ijt} = 1$ when consumer i chooses alternative j in choice set t and zero otherwise. The choices of the full sample are denoted by $Y = (y_1, ..., y_I)$. Using the mixed logit as described in Equation (2.7), the likelihood of consumer i's observed choices, conditional on θ_i is then:

$$L(y_i \mid \theta_i) = \prod_t \prod_j \left(\frac{\exp(\gamma_i E(U_{ijt}))}{\sum_j \exp(\gamma_i E(U_{ijt})) + 1} \right)^{y_{ijt}} \tag{4.13}$$

Note that γ_i equals the logit precision parameter (Train, 2009). Hence, when a consumer exhibits a random choice behavior, γ_i becomes zero, while $\gamma_i = \infty$ describes a consumer always choosing the alternative with the highest observed utility.

To account for consumer heterogeneity, the individual parameters are assumed to be distributed lognormal with mean $\bar{\theta}$ and covariance matrix Ω: $\ln\theta \sim \mathcal{N}(\bar{\theta},\Omega)$. The unconditional likelihood is then the integral of $L(y_i \mid \theta_i)$ over all θ.

$$L(y_i \mid \bar{\theta},\Omega) = \int L(y_i \mid \theta_i) f(\theta_i \mid \bar{\theta},\Omega) d\theta \tag{4.14}$$

In order to draw from the posterior distribution, priors for $\bar{\theta}$ and Ω are described noninformative as $\bar{\theta}$ is distributed multivariate normal and Ω is distributed inverted Wishart (Iyengar et al., 2008; Train, 2009). By definition, the joint posterior distribution becomes:

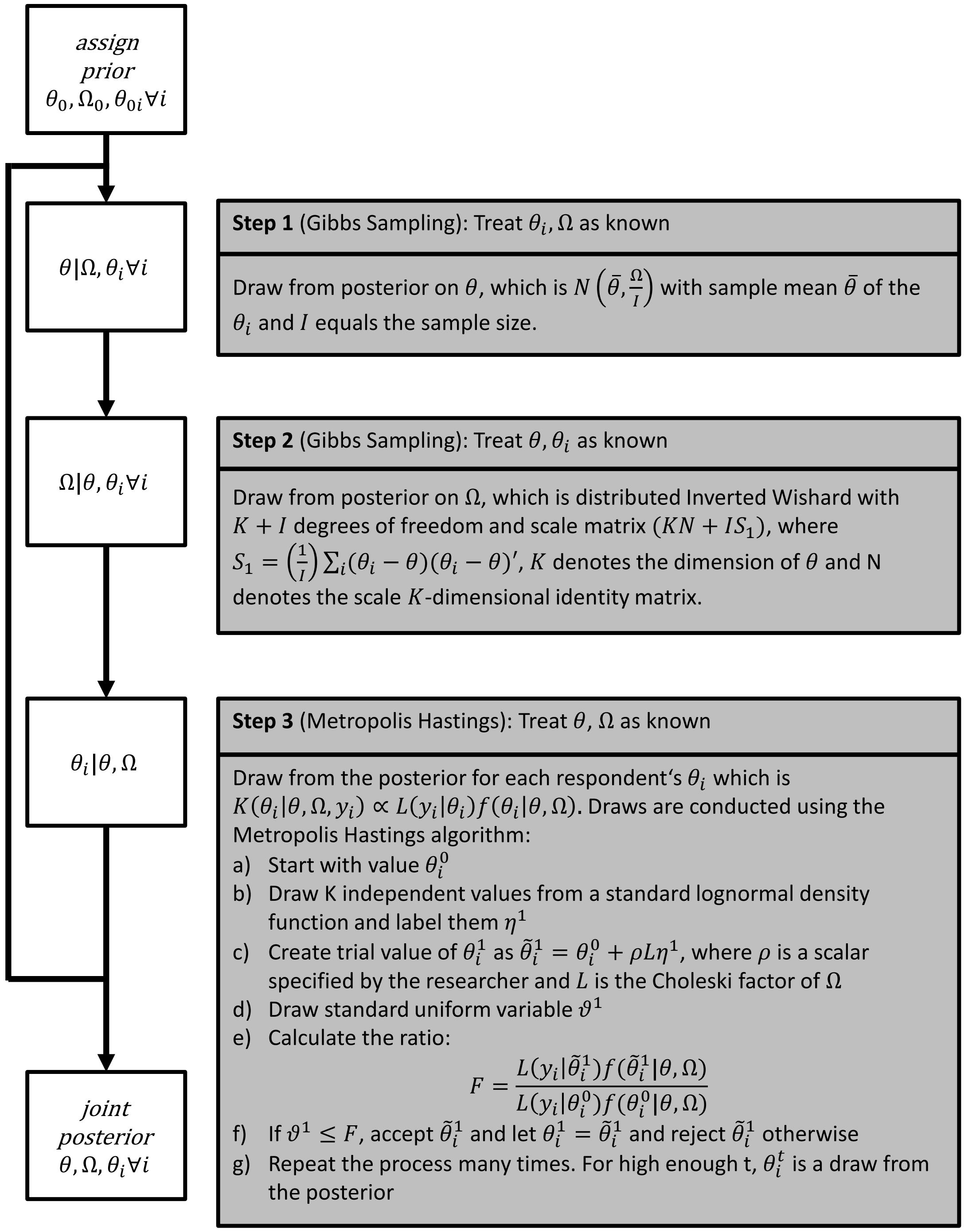
$$K(\bar{\theta},\Omega,\theta_i \forall i \mid Y) \propto \prod_i L(y_i \mid \theta_i) f(\theta_i \mid \bar{\theta},\Omega) k(\bar{\theta},\Omega) \tag{4.15}$$

As expected consumption is nonlinear, the applicability of classical maximum likelihood methods is difficult (Rossi and Allenby, 2003). However, using a hierarchical Bayes procedure allows a fast and simple way to draw from the posterior distribution (Train, 2009). Thereby, each θ_i is considered to be a parameter along with $\bar{\theta}$ and Ω. Drawing parameters conditional on the other parameters result in values which converge to draws from the joint posterior distribution. After convergence has been reached, the mean and standard error of the parameters can be calculated from additional draws and provide information on the individual consumer level. Drawing parameters is realized by the use of Markov chain Monte Carlo (MCMC) methods which are described in Figure 4.4

Study Design A repeated choice study on mobile telephony tariffs was conducted in order to evaluate the proposed model's ability to predict consumer choice. The choice study was embedded in an online questionnaire[1] alongside questions on respondents' consumption behavior and demographics. Respondents faced thirteen choice sets in random order which consisted of three alternative four-part tariffs and a no-choice option. In order to face respondents' heterogeneity and to avoid strictly dominant alter-

[1]The full questionnaire is available in Appendix A.2.3.

FIGURE 4.4: *Hierarchical Bayes estimation as described by Train (2009)*



Note: Repeating these steps for many iterations results to draws from the joint posterior distribution. After convergence is achieved, estimates and standard errors of the parameters can be obtained from the draws. A detailed describtion is provided in Train (2009).

natives, two arrangements have been made. First, three different heterogeneous designs have been implemented to accommodate for respondent's heterogeneity (Sandor and Wedel, 2005). As satiation levels differ between respondents, it is more likely for respondents with low or high consumption to encounter a dominant alternative. By generating choice sets adjusted on satiation levels for each consumer group, the number of dominant choices is reduced. Group specific choice sets have been created with an aggregated customization approach (Arora and Huber, 2001) using parameter estimates from an earlier pilot study. Second, each D-optimal design was revised using an utility-balance approach (Huber and Zwerina, 1996) to guarantee the absence of dominant alternatives in any choice set. Each tariff alternative was composed of a fixed fee, a usage price, an allowance as well as a cost cap with either three or four different levels. The possible levels were chosen to be discrete instead of continuous for statistical reasons (Kanninen, 2002). They are described in Table 4.2.

TABLE 4.2: *Tariff component levels for low, medium and high consumption group*

group	(l)ow (m)edium (h)igh	
fixed fee	$f_l =$	$\{0\,€, 5\,€, 7.5\,€, 10\,€\}$
	$f_m =$	$\{0\,€, 15\,€, 17.5\,€, 20\,€\}$
	$f_h =$	$\{0\,€, 25\,€, 27.5\,€, 30\,€\}$
usage price	$p_l =$	$\{0\,€/min, 0.10\,€/min, 0.15\,€/min, 0.20\,€/min\}$
	$p_m =$	$\{0\,€/min, 0.10\,€/min, 0.15\,€/min, 0.20\,€/min\}$
	$p_h =$	$\{0\,€/min, 0.10\,€/min, 0.15\,€/min, 0.20\,€/min\}$
allowance	$A_l =$	$\{0\,min, 25\,min, 50\,min\}$
	$A_m =$	$\{0\,min, 100\,min, 150\,min\}$
	$A_h =$	$\{0\,min, 300\,min, 450\,min\}$
cost cap	$c_l =$	$\{15\,€, 20\,€, \infty\}$
	$c_m =$	$\{30\,€, 40\,€, \infty\}$
	$c_h =$	$\{40\,€, 50\,€, \infty\}$

The proposed levels reflect actual market price levels at the time of the study. The tariff alternatives were created by the Cartesian product $f \times p \times A \times c$ for each consumer group separately. Note that defining the tariff alternative allows to exclude a single component by including the appropriate level, e.g. $f = 0$ excludes the fixed fee. This approach allows modeling of any one-part, two-part or three-part tariff. Possible examples include the pay-per-use and flat rate tariff. An exemplary choice set is illustrated in Table 4.3.

TABLE 4.3: *Exemplary choice set for medium consumption*

tariff component	Tariff 1	Tariff 2	Tariff 3	
fixed fee	20 €	0 €	17.50 €	None
usage price	0 €/*min*	0.15 €/*min*	0.10 €/*min*	
allowance	0 *min*	0 *min*	150 *min*	
cost cap	without	30 €	40 €	
Your choice:				

At the beginning of the questionnaire respondents were introduced to the tariff design by explaining each tariff component as well as their interaction. Two control questions were used to guarantee that every respondent did in fact understand the survey design. Afterwards, satiation levels have been approximated using an open-ended contingent valuation approach (Mitchell and Carson, 1989; Miller et al., 2011). Based on the approximated satiation level, respondents were redirected to the group specific choice sets.

Data Collection A total sample of 1,000 respondents were recruited in collaboration with a professional panel provider. The respondents were selected to be representative in gender, age and household income for the German mobile telecommunications market.[2] All respondents passed a screening procedure which ensured that they understood the tariff choice task prior to starting the repeated choice experiment. Moreover, the online questionnaire included three validity questions. The first question controlled for study attention by asking respondents to give a specific answer to a control question. The second question controlled for answer consistency by comparing answers of the same question in the middle and at the end of the questionnaire. The third question controlled for truthfulness by directly asking the respondents whether they have answered truthfully. 140 respondents were excluded from further analysis due to failing these control questions. A further 14 respondents were excluded due to an unreason-

[2]Sample demographics are illustrated in Appendix A.2.1.

ably low response time. Lastly, 100 respondents consistently choosing the non-choice option were not included in the analysis due to absence of choice information. The resulting sample included 746 respondents of whom 365 (48.93%) were female and 381 (51.07%) were male.

4.3 Results

Out of the thirteen choice sets, two choice sets were randomly selected for each respondent as hold-out sets. MCMC estimation (Train, 2009) was based on the remaining eleven choice sets for each respondent resulting in 8206 (=746×11) discrete choice decisions. In addition to the proposed model with *(Model 2)* and without uncertainty *(Model 3)* (see Equations 4.7 and 4.9), an extended model with consideration of the flat rate bias (Train, 1991; Lambrecht et al., 2007) was estimated *(Model 4)*. For this reason, an additive term ς_i has been used to account for consumers' preference for flat rate tariffs $t_{FR} = (f_{FR}, 0, 0, \infty)$:

$$\tilde{U}_{ijt} = E(U_{ijt}) + \varsigma_i I_j + \epsilon_{ijt}, \tag{4.16}$$

where I_j is an indicator function which is one if tariff j is a flat rate tariff and is zero otherwise. The three proposed models, which take the interplay of consumption and choice into account, are compared with a traditional conjoint approach using an additive utility function *(Model 1)*, i.e.:

$$\tilde{U}_{ijt} = \beta_i^{'}(f_j, p_j, A_j, c_j)^{'} + \epsilon_{ijt}. \tag{4.17}$$

The models were estimated using 50,000 MCMC iterations. The initial 25,000 draws were discarded as burn-in iterations. Of the remaining 25,000 every tenth draw was used for the final parameter estimation (Arora and Huber, 2001; Iyengar and Jedidi, 2012). Convergence was assessed by monitoring all draws (see Appendix A.1). The models are compared by considering their internal validity and predictive validity. Table 4.4 summarizes the results.

TABLE 4.4: *Internal and external validity*

	internal validity				external validity	
	SLL	Log BF	HR	MAD	HR	MAD
Model 1	-9,688	-	36.79%	0.12	33.18%	0.14
Model 2	-8,310	1,378	54.96%	0.21	51.81%	0.30
Model 3	-8,186	1,502	60.54%	0.20	56.30%	0.27
Model 4	-8,165	1,523	66.20%	0.20	60.52%	0.27

Notes: SLL: simulated log-likelihood, Log BF: log Bayes factor, HR: hit rate, MAD: mean absolute deviance

Internal validity The model fit is evaluated by comparing the simulated log likelihood (SLL) (Train, 2001) as well as the deduced log Bayes factor (BF) (Kass and Raftery, 1995) together with the mean absolute deviation (MAD) (Schlereth and Skiera, 2012) of the distribution of respondents' choice likelihood and the internal hitrate. The simulated log likelihood was calculated based on 2,000 draws of the estimated posterior distributions. The log Bayes factor is calculated as the difference of the simulated log likelihood between each model and the additive utility model which serves as a baseline. The log BF is a well-known measure for comparing different behavioral models on the basis of their data fit (Iyengar et al., 2008; Iyengar and Jedidi, 2012; Schlereth and Skiera, 2012), while penalizing model complexity. A model is said to have a strong superiority over a comparable model if $BF > 5$ (Kass and Raftery, 1995, p.777). The mean absolute deviation is a measure to account for variability and has previously been used to describe individual choice probabilities (Brazell et al., 2006; Schlereth and Skiera, 2012). The MAD is calculated by first determing each respondent's average individual choice probability over all choice sets and subsequently calculating the mean of the absolute deviation of each individual choice probability from the mean sample probability. Lastly, the hitrate describes the relationship between predicted and actual choice, whereas choice is predicted using a maximum utility choice model (see 2.3.2).

It is evident that the additive utility model (*Model 1*) performs the poorest when considering the SLL and the internal hitrate. The poor internal validity can be explained by the missing consideration of the interplay of nonlinear pricing and consumption. The fact that the base consumption model (*Model 2*) shows a very strong superiority compared to the additive model with a log BF of 1,378 emphasizes the importance of the simultaneous consideration. All consumption models (*2-4*) exhibit reasonable high hitrates of 54.96% up to 66.20%, while not differing in their mean absolute deviation. However, the results show that taking uncertainty into account strongly increases the model fit, considering the SLL as well as the internal hitrate. This is in line with earlier findings (Lambrecht et al., 2007; Iyengar et al., 2008) which found a strong impact of uncertainty in consumption towards tariff choice. Although the implementation of a flat rate bias in *Model 4* only slightly increases model fit considering by a BF of 21, it still increases the internal hitrate considerably by 5.66% and does therefore perform best in fitting the observed data.

External validity Two out of the thirteen choice sets each respondent have faced were individually and randomly excluded from parameter estimation. These hold-out sets are used to evaluate each model's external validity by its hitrates and MAD of choice probabilities. Besides the reduced number of observed choice decision, all measures were determined in the same way as described before. The results in Table 4.4 confirm the results of the internal validity comparison. Again, the additive *Model 1* predicts respondents' hold out choice poorly and performs only slightly better than a random choice model with a hitrate of 25%. In addition, *Model 4* with uncertainty and flat rate bias outperforms all comparable models considering its prediction power of tariff choice.

TABLE 4.5: *Parameter mixed logit estimation: Posterior means and 95% confidence intervals*

Parameter	Label	Model 2			Model 3			Model 4		
		M	95% confidence interval		M	95% confidence interval		M	95% confidence interval	
increase in utility	β_1	**0.380**	0.372	0.389						
	μ				**0.249**	0.227	0.275	**0.279**	0.268	0.290
	σ				**0.024**	0.023	0.024	**0.017**	0.016	0.018
decrease in marginal utility	β_2	**0.005**	0.004	0.007	**0.050**	0.037	0.070	**0.046**	0.035	0.063
marginal utility of income	β_3	**2.446**	2.066	2.934	**8.123**	6.857	9.747	**9.811**	8.201	11.901
flat rate bias	ς							**2.001**	1.670	2.431
logit precision	γ	**9.145**	6.467	13.364	**1.991**	1.140	2.937	**1.850**	1.306	2.707
Satiation level										
25% quantile		39.94			26.58			27.34		
50% quantile		113.17			86.74			95.48		
75% quantile		295.71			247.79			249.56		
Note:	Parameters for which 0 lies outside the 95% are highlighted in boldface.									

Parameter estimation The parameter estimates from *Models 2-4* are reported in Table 4.5 by their posterior mean and the corresponding 95% confidence interval. All estimated parameters are significantly different from zero and exhibit the expected signs. As described before, *Model 3* and *4* differ from *2* by incorporating uncertainty in consumption preference. While there are no significant differences in parameter estimates between *Model 3* and *4*, the results show that taking uncertainty into account leads to significantly different parameter estimates. First, the increase in utility in relation to the decrease in marginal utility defines consumer satiation level s_i as described before. Consequently, the differences in consumers' parameters lead to different satiation levels between uncertainty and certainty models. The distribution of satiation levels as described in Table 4.5 show that discounting uncertainty results in higher satiation. However, all expected satiation levels are within a reasonable range and are close to the German average consumption of 70 minutes per month, as reported by the OECD (2011, p.123). Second, taking uncertainty into account while choosing a tariff increases task complexity. This is reflected by a lower logit precision parameter under uncertainty models and confirms earlier findings of Ho and Zhang (2008). Finally, marginal utility of income is higher under uncertainty models.

4.4 Discussion

Summary of results The purpose of this section was to develop a behavioral model for four part tariffs. The model was empirically evaluated by the use of a conjoint experiment with a representative sample of German mobile telephony consumers. The results of the conjoint experiment provide evidence that it is important to account for the two way dependency of consumption and choice, as well as for uncertainty in consumer preferences to fully understand consumer choice of four-part tariffs. Considering the model fit, the model's ability to explain the observed choice data as well as predicting choice is further increased by taking the flat rate bias into account. The comparison of the parameter estimates reveal that not accounting for uncertainty leads to an overestimation of satiation levels and a lower marginal utility of income.

Limitations and future research There are several limitations of this study, which may inspire future research. First, the conjoint experiment is in its nature an almost static observation. It does not provide any information on how consumers learn about their preferences over time and consequently adapt their consumption pattern. Considering the new cost cap component, it is especially interesting to see how fast consumers change their behavior when their existing tariff is upgraded with a cost cap component. Therefore, a field experiment with revealed preferences and an extension of the proposed utility model to account for learning effects (Ascarza et al., 2012) is a promising future approach.

Second, the proposed model only accounts for psychological effects in a limited way by using a bias parameter. Yet, it is reasonable to believe that the psychological effects also impact tariff choice besides flat rate tariffs. It is therefore desirable to model effects such as the taximeter and insurance effect in a more general manner in order to make them applicable to four-part tariffs. Thereby, an approach based on prospective accounting theory (Prelec and Loewenstein, 1998) together with prospect theory (Kahneman and Tversky, 1979) seems to be a promising starting point.

Third, the proposed model is based on the random utility theory of McFadden (1974). However, choosing from a set of four-part tariff is a challenging task. It is likely that consumers use heuristics to simplify their decision problem. Common heuristics include conjunctive, disjunctive, and compensatory screening rules. Gilbride and Allenby (2004) demonstrated the use of a two stage decision model to account for these screening rules. The proposed model's fit may benefit from an extension in this vein.

Lastly, the model has only been used to study phone consumption. However, recent cell phone contracts consist of several tariffs including Internet consumption and text messaging. From a practitioner's perspective it would be interesting to see how these different services are substituted. A promising approach to address this question is to extend the proposed model for a tariff combination case and control for substituting effects.

Chapter 5

Optimal Tariff Portfolio Design

"Competitive strategies for pricing access services are quite complex to analyze."

(Essegaier et al., 2002)

THIS chapter shifts the perspective to service providers, as it studies the optimal design of tariff portfolios with cost cap components using a simulation approach. The chapter is organized as follows: First, past research on optimization of tariffs from theoretical and empirical perspectives are discussed in Section 5.1. Deduced from past research, a methodology to identify the optimal tariff portfolio with cost cap tariffs is presented in Section 5.2. Using the empirical data of Chapter 4, optimal tariff portfolios are estimated under monopolistic and competitive scenarios in Section 5.3. Detailed sensitivity analyses deepen the understanding of these optimal tariffs. Section 5.4 closes the chapter with a summary of the results and discusses promising future research.

5.1 Related Literature

There have been several extensions on tariff optimization since the seminal paper of Oi (1971).[1] Even with consideration to existing detailed research on theoretical perspectives of tariff pricing, innovative approaches have led to ongoing theoretical research (Essegaier et al., 2002; Sundararajan, 2004; Bagh and Bhargava, 2013). In contrast, empirical research has been scarce. However, within the last decade an increase in empirical research can be observed (Ascarza et al., 2012; Danaher, 2002; Iyengar et al., 2008; Lambrecht et al., 2007; Schlereth et al., 2011).

Iyengar and Gupta (2009) point out three decisions to take while implementing an optimal tariff portfolio: First, a provider has to decide which type of tariff he wants to offer his consumers. Second, the number of offered tariffs has to be defined before and finally the optimal pricing of each tariff has to be assessed. In the following, results and approaches of past theoretical and empirical research are summarized.

5.1.1 Theoretical Research

Monopoly The seminal research on optimal tariff design was undertaken by Oi (1971) in his study on Disneyland's two-part pricing dilemma. The study follows the question whether access services should charge a high fixed fee and provide the service for a low usage price, or vice versa, attracting consumers with a low access fee and charge high monopolistic usage prices. Oi stated that an optimal two-part tariff can easily be determined when all consumer are identical with respect to their utility function and income. In this case, the optimal fixed fee equals the consumer surplus enjoyed by the consumer under the given two-part tariff. As consumer surplus is increasing with smaller usage prices, the optimal usage price equals the marginal costs. The same logic applies to a market with consumers who are different in income and taste. A discriminating monopoly would charge a different fixed fee of every consumer according to

[1]See Wilson (1993); Iyengar and Gupta (2009) for a detailed discussion of past research.

his consumer surplus, setting the usage price at marginal costs. However, such pricing policy would certainly not withstand antitrust inspection. Consequently, Oi analyzed a single optimal two-part tariff to serve two heterogeneous consumer types. The theoretical results showed that a deviation of the usage price from marginal costs can increase profits depending on consumers' demand functions. This may also include offering the service for a usage price below marginal costs, as the subsequent loss can be more than compensated through a higher fixed fee. Oi further discussed the possibility to increase profits by excluding consumers from consumption by rising the fixed fee. Thereby, the price elasticity of the served consumers with respect to the fixed fee determines the distribution of consumer surpluses and thus the provider's profit.

Murphy (1977) extended the model of Oi (1971). In his case, a provider is not able to identify different consumers ex ante. Murphy stated that a provider can increase profits using alternative multi-part tariffs in contrast to a simple two-part tariff. He showed that several tariff alternatives can serve as a monitoring device which allows some degree of price discrimination ex post. One alternative is the so called declining three-part tariff which is a two-part tariff with an option for a price discount after a specific quantity. In this way additional consumer welfare can be extracted from consumers with higher willingness to pay. A similar result is achieved by providing several two-part tariffs which are tailored to match consumers' willingness to pay. Consumers then self-select their optimal tariff. Finally, Murphy argued that the costs of administrating additional and more complex tariffs may exceed the revenue increase of these tariffs.

Essegaier et al. (2002) released a detailed study on the effects of consumer heterogeneity on access service pricing when the provider's capacity to serve the consumers is constrained. Due to the characteristics of services, the authors assumed the marginal costs to be zero. The results under a monopolistic setting differ in consumers' evaluation of the service. If the market consists of a majority of more valuable light users, the monopolist should focus on them only when his capacity is not large enough to cover market demand. Heavy users, however, should only be served with increasing capacity. This goal is achieved by using a two-part tariff. Essegaier et al. highlight that the two-part tariff is not used to price discriminate but rather to achieve the optimal consumer mix under limited capacity. As soon as the monopolist's capacity is capable of serving the total demand, the monopolist should change to a flat rate pricing, as it is the most efficient way to penetrate the whole market. However, when heavy users are more valuable, the pricing of access services changes. The monopolist should try to attract more heavy users than light users. Charging a pay-per-use tariff with a high minute price achieves this goal. With increasing capacity the minute price should be lowered until all heavy users are served. Afterwards, the monopolist wants to attract light users as well. However, as a further decrease of the minute price would lower his revenue, he should instead offer a signing bonus. Similar to Oi (1971), Essegaier et al. find that subsidizing one group may be optimal, such as providing a negative fixed fee in this case.

Sundararajan (2004) studied nonlinear pricing of information goods by using pay-per-use and flat rate tariffs. Similar to Essegaier et al. (2002), marginal costs of producing an additional information good are assumed to be zero and consumers are heterogeneous and unknown to the monopolist. An assumption unique to Sundararajan is the consideration of transaction costs. Transaction costs occur by administrating tariffs. Especially pay-per-use tariffs require a steady monitoring of consumers' usage and hence induce higher transaction costs. Flat rate tariffs in contrast, require only a single transaction per billing period. The consideration of transaction costs has several implications for nonlinear pricing of information goods. Sundararajan showed that a profit maximizing provider has to consider the involved transaction costs while designing the optimal pay-per-use tariff. An increase in transaction costs results in a higher minute price. As a result, the fraction of consumers adopting such a tariff decreases. The design of the optimal pay-per-use tariff is independent of the introduction of an additional flat rate tariff. The latter does, however, increase a monopolist's profit. Therefore, a monopolist should always offer pay-per-use tariffs in combination with flat rate tariffs in markets with transaction costs. Introducing a flat rate tariff will result in a shift of formerly pay-per-use consumers to a flat rate. By charging a fixed fee, the monopolist avoids the transaction costs under a pay-per-use tariff and thus increases profit. In order to find the optimal combination of pay-per-use and flat rate tariffs, the monopolist should first determine the optimal pay-per-use tariff. Afterwards, the optimal fraction of flat rate consumers has to be identified and the fixed fee has to be set accordingly. Sundararajan concluded that an increase in transaction costs increases the fraction of consumers under flat rate tariffs. Monopolist's profit is decreasing in transaction costs up to a point where all consumers have adopted a flat rate tariff and profits are thus constant.

In a recent article, Bagh and Bhargava (2013) studied a provider's tariff portfolio decision when tariff management costs are significant enough to impose a constraint on the number of tariffs. Bagh and Bhargava revisited the earlier concern of Murphy (1977) that the optimality of a menu of two-part tariffs might be questionable when an additional tariff generates higher costs than revenue. There are several causes for increasing costs with additional tariffs. A menu of tariffs requires more information about consumer preferences and hence increases information and decision costs. Furthermore, consumers often fail to choose a tariff at all when they are overwhelmed with a large menu. This generates further costs of explaining and guiding consumers' choices. Finally, more tariffs require also additional advertising and communication costs. Altogether, these costs may limit the number of tariffs and their complexity. Bagh and Bhargava studied the optimal design of tariff portfolio under such tariff size constraint. Thereby, a single three-part tariff with allowance can outperform a menu of two-part tariffs while requiring even less information about the consumer distribution. A menu of two-part tariffs is limited by the fear of high-value consumers choosing the tariff designed for the low-value segment. In contrast, a single three-part tariff can outperform the menu of two-part tariffs by adjusting the allowance equal to the usage of low-value consumers under corresponding two-part tariff and charging a fixed fee equal to the total costs under such. Thus, the minute price can be assigned to optimally price discriminate high-value consumers. Bagh and Bhargava showed that these results are stable, as long as the low-value segment accounts for enough market share. Furthermore, a menu of three-part tariffs might always outperform a menu of two-part tariffs as long as tariff size is limited and consumer distribution is right skewed. Lastly, as there is less information required to design the optimal three-part tariff in comparison to the two-part tariff, the three-part tariff is also the better choice with respect to tariff management costs.

Competition Hayes (1987) was one of the first to study two-part tariff pricing under competition. From a theoretical perspective, competition seemed to eliminate the existence of two-part tariffs, as every competitor has an incentive to charge a one-part tariff and still earn nonnegative profits. Hayes showed that in the presence of consumer uncertainty, it is still profitable for competitors to charge two-part tariffs. Under the assumption of zero profits in competitive markets, charging a fixed fee has to result in a usage price below marginal costs. Consequently, service consumption in relation to an outside good increases. Hayes concluded that consumer utility decreases in low states of uncertainty and increases in high states of uncertainty under two-part tariffs. This is because the marginal utility of income is greater in states of high uncertainty and the two-part tariff is a form of insurance and strictly preferred by consumers. The results are extended by the case in which consumers' uncertainty is heterogeneous over consumers. In this case, several two-part tariffs can be offered to each type of consumer. The utility function and probability density function of uncertainty determines the optimal combination of fixed fee and usage price.

Besides considering tariff pricing under a monopoly, Essegaier et al. (2002) also studied the effects of consumer heterogeneity and provider capacity constraint under a competitive scenario, where one provider with a larger capacity competes against another. The author found several possible equilibria under the assumption that light users are more valuable. The providers can be either local monopolists, secret handshakers or competitors. The three scenarios are explained in the following. If the combined capacity is not large enough to cover all light consumers, both providers will act as local monopolies and charge two-part tariffs similar to a monopolistic setting. The two-part tariff remains the best pricing approach even if the larger capacity provider also serves some heavy users. If the capacity of the small provider increases, the larger provider will have an incentive for a secret handshake strategy where the market is covered but the providers do not compete. He leaves more of his capacity idle and respectively market demand unmet. This way, a flat rate tariff is optimal for the larger provider while the smaller provider continues charging a two-part tariff. The large provider has too much to lose if he competes against the small capacity provider who is best positioned to compete for light users. At last, if both providers have sufficient capacity to cover the market, flat rate tariffs is a provider's best choice as it focuses on the number of consumers he can attract instead of a consumer mix. If heavy users are more valuable, Essegaier et al. showed that the earlier results differ slightly. Providers should start pricing their services with a pay-per-use tariff as long as capacity is low. When capacity increases, two-part tariffs should be used to acquire the desired mix of light and heavy users. Again, if the capacity is large enough to meet the market demand, intense price competition will lead to flat rate pricing of both providers.

5.1.2 Empirical Research

Monopoly Danaher (2002) was one of the first studies using revealed preferences to study the optimal design of two-part tariffs for pricing access services. The introduction of a new telecommunication service was studied in an experimental setting to investigate the effect of fixed fee and usage price on consumption and attrition. Danaher developed a model that incorporated consumption and attrition under a subscription service, and estimated consumers' characteristics by maximizing the log likelihood of attrition. The author found that fixed fee elasticity is considerably lower than usage price elasticity. Furthermore, the fixed fee has a stronger effect on consumer retention, and usage price a stronger effect on consumption. Danaher used the parameter estimates to derive the optimal fixed fee and usage price by using partial derivates of the provider's expected total revenue function. An important feature of the revenue function is the incorporation of consumer acquisition cost due to attrition. Ignoring these costs result in unreasonable fixed fees. Moreover, the obtained fee and price were similar to market price levels at the time of the study.

Lambrecht et al. (2007) focused on the impact of consumer uncertainty on tariff choice. The authors found uncertainty to be a key driver of tariff choice. In line with Danaher (2002), prices affect tariff choice more than consumption. Lambrecht et al. developed a discrete/continuous choice model where consumers make a continuous consumption decision conditional on tariff choice. The model's parameters were estimated based on consumption data of a German DSL provider. Using the estimated parameters, Lambrecht et al. studied the impact of consumer uncertainty on provider's revenue by numerically integrating over the distribution of unobserved consumption. The authors showed that increasing uncertainty leads consumers to choose tariffs with higher allowance. Three-part tariffs, thereby, can well exploit consumers' uncertainty due to their nonlinear structure. Thus, their results indicate that providers may increase their revenues by offering three-part tariffs with a consumption allowance instead of a traditional two-part tariffs.

Ascarza et al. (2012) studied the effect of an usage allowance on tariff choice above and beyond the shift in consumers' budget constraints. The authors use a discrete/continuous choice model that accounts for the valuation of allowance to estimate consumer preference parameters. These parameters are used to study the effect of lowering consumers' costs to switch to another tariff on provider's revenue. The authors thereby accounted for consumers' preference for three-part tariffs. Ascarza et al. showed that decreasing switching costs increases provider's revenue due to consumers switching to more profitable three-part tariffs. This shift is due to a strong preference for free consumption under an allowance. Furthermore, the authors demonstrate that eliminating an alternative two-part tariff can increase revenues further, due to forcing consumers into three-part tariffs.

The innovative pricing scheme of bucket tariffs was studied by Schlereth and Skiera (2012). Under such tariff, a consumer pays a periodic fixed fee in order to use a service up to a set allowance. Schlereth and Skiera developed a discrete/continuous choice model and estimated preference parameters based on stated preferences from a conjoint experiment. The authors used these parameters in a simulated annealing algorithm in order to optimize bucket and three-part tariffs. Schlereth and Skiera found that the specification of the discrete/continuous choice model has an important impact on provider's profit. More precisely, non-optimal prices due to a failure in modeling the influence of service attributes leads to a profit loss of up to 22.75% of the optimal solution. Furthermore, their results indicate that a menu of three bucket tariffs performs best in exploiting consumers' heterogeneity. The authors also compare different tariffs with one another. Two-part, three-part, and bucket tariffs perform equally well as long as the number of tariffs is sufficiently large enough. However, if the number of tariffs is restricted to one, the bucket tariff generates less profit than two- or three-part tariffs and only outperforms an optimal pay-per-use tariff.

Competition The study of Iyengar et al. (2008) used a stated preference approach in order to identify consumers' preference parameters. Similar to Lambrecht et al. (2007), Iyengar et al. took uncertainty and the nonlinear character of three-part tariffs into account while modeling consumers' utility under the latter. The authors studied the effect of fixed fee, usage price and allowance by the use of a sensitivity analysis. The authors controlled for attrition by multiplying the expected revenue by consumers' choice probability of each tariff. The interplay of increasing revenue and a decreasing choice probability from increasing either the fixed fee or the usage price leads to optimal levels for both. Revenue is also increasing with an increasing allowance due to a higher choice probability. However, the marginal gain decreases due to consumers' satiation. Iyengar et al. used the estimated preference parameters to simulate tariff competition. Using a grid search, the authors identified the optimal three-part tariff for a new market entrant into an existing mobile telephony service market. The grid was composed by an incremental increase of each tariff component. The optimal tariff was identified by multiplying tariff choice probability with the expected revenue from each consumers' consumption under respective tariff. The results of the proposed choice model are reasonably close to actual market data and outperform standard conjoint approaches.

In a more recent study, Schlereth et al. (2011) analyzed the optimal pricing of metered tariffs. Based on preference parameters estimated from a stated preference experiment, Schlereth et al. used a simulated annealing approach to investigate profit, revenue, total consumption, and consumer share of alternative tariffs. Based on the seminal findings of Oi (1971) and Murphy (1977) on the optimality of two-part tariffs, Schlereth et al. demonstrate how the separated stepwise reduction of the fixed fee and usage price impacts tariff attractiveness from a monopolist's perspective. The transformation of the optimal two-part tariff towards either a pay-per-use or flat rate tariff results in a profit decrease in both cases. However, whereas the share of consumers under an optimal pay-per-use tariff increases, the share decreases under an optimal flat rate tariff. On the other hand, the consumption per consumer decreases under a pay-per-use tariff and increases under a flat rate tariff. Furthermore, Schlereth et al. studied tariff choice behavior by introducing an additional tariff within an oligopoly setting. The authors thereby differ between expansion, switching and cannibalization effects. The authors emphasize the importance of cannibalization effects for profit gain. Only if a reasonable number of new consumers to the market (expansion) and consumers of the competing provider (switching) can be acquired, cannibalization can be overcome and profits can be increased.

Table 5.1 summarizes earlier research on optimal tariff portfolio design. Both theoretical as well as empirical research have addressed the design of tariffs in competitive as well as monopolistic markets. It is not surprising that with the exception of Danaher (2002) all empirical studies used a stated preference approach as the optimization of tariffs within the field is expensive and difficult to operate. In general, tariffs are used to price discriminate consumers. Therefore it is not surprising that all studies have addressed consumer heterogeneity. However, consumer choice behavior is often modeled differently. Especially consumer uncertainty has mainly been addressed in empirical studies. While most studies included an incentive constraint on tariff choice, the impact of the option to opt out on tariff choice probability has been considered almost solely by empirical studies. In contrast, theoretical research has focused in more detail on provider's attendant circumstances such as capacity constraint, transaction costs and tariff management costs. As these details are often not released by the providers, empirical studies often lack these aspects or base their models on public market information. With the exception of Schlereth and Skiera (2012), all earlier studies focused on established one-, two-, or three-part tariffs. Hence, research on innovative tariff pricing is limited.

TABLE 5.1: *Overview on research on optimal tariff portfolios*

category	reference	competition	heterogeneity	uncertainty	attrition	capacity constraint	transaction costs	management costs	marginal costs	switching costs
theory	Oi (1971)		●		◐				●	
	Murphy (1977)		●						●	
	Hayes (1987)	●	●	●					●	
	Essegaier et al. (2002)	●	●			●				
	Sundararajan (2004)		●				●			
	Bagh and Bhargava (2013)		●					●		
empiricism	Danaher (2002)		●		●					
	Lambrecht et al. (2007)		●	●						
	Iyengar et al. (2008)	●	●	●	●			◐		
	Schlereth et al. (2011)	●	●						◐	
	Schlereth and Skiera (2012)		●		●				●	
	Ascarza et al. (2012)		●	●						●
	this research	●	●	●	●				●	

This chapter is studying the effect of the cost cap component on service provider's tariff portfolio. It is an open question whether adding a cost cap component to the existing tariff structure increases profits. Tariffs with cost caps are thus analyzed in a monopolistic as well as a competitive market scenario. In addition, the impact of marginal costs are studied in more detail. Consumer choice follows the holistic approach presented in Chapter 4, including consumer uncertainty as well as the option to opt out. However, neither switching and tariff management costs nor capacity constraints are considered.

5.2 Methodology

Tariff optimization is difficult to accomplish in ongoing markets. This is because the introduction of new tariffs is expensive due to ,e.g., advertising of the tariff, modification of the billing process, and training of the sales personal. Furthermore, consumers can get confused by a varying number of tariff alternatives within a short time. Simulation approaches are thus a reasonable alternative which are furthermore able to predict consumer behavior for novel tariff structures. However, the optimization of tariffs quickly becomes a complex problem due to the variety of optimization parameters. Obviously, whereas a simple one-part tariffs only includes one price component to optimize, a four-part tariff already includes four components. This number multiplies quickly as soon as several tariffs are optimized as a portfolio. Many earlier studies (e.g. Danaher, 2002; Iyengar et al., 2008; Lambrecht et al., 2007) focused on grid search techniques to identify the optimal tariff design. Grid search techniques, however, are only capable to handle a small number of tariffs to optimize together with a small number of respondents within a reasonable computing time (Schlereth et al., 2010). Schlereth et al. compared several heuristic methods on their ability to optimize nonlinear tariffs. The authors found that simulated annealing (Kirkpatrick et al., 1983) performs best and is also able to handle large samples. The advantage of simulated annealing compared to alternative heuristics is its ability to overcome local solutions. This is because the algorithm randomly accepts solutions with an inferior value of the target function. However, the increment to accept alternative solutions is reduced over time so that the algorithm converges against the global solution (Eglese, 1990). Furthermore, the solution depends only marginally on the initial values, making the algorithm flexible and robust (Aarts and Korst, 1988; Schlereth et al., 2010). Eglese (1990) named the ease of implementation, its applicability to a wide range of optimization problems, and the high quality of solutions as further advantages of the simulated annealing algorithm.

Providers' profits are modeled using the classical framework of indirect segmentation where a provider cannot identify consumers ex ante but can offer a portfolio of tariffs so that consumers do self-select into separate consumer segments (Rothschild and

Stiglitz, 1976; Bagh and Bhargava, 2013). Thereby, the provider has to balance carefully the trade-off between tariff choice and consumption. An increase of the general price level through higher usage prices, fixed fees or cost caps may increase profits, but it also increases the chances of consumers to opt out. Furthermore, higher usage prices decrease the overall consumption level (Danaher, 2002) and may decrease profits. The provider has to maximize the expected sum of all consumers' I profit over his whole tariff portfolio J, whereas the expected consumer profit from one tariff is based on consumer's probability to choose the tariff times his expected consumption. Thus, the maximization problem of the provider becomes:

$$\max \Pi = \sum_{j \in J} \sum_{i \in I} P_{ij} E(\pi_{ij}) \tag{5.1}$$

The expected profit $E(\pi_{ij})$ a single consumer i produces from a tariff j depends on his uncertainty which maps into his consumption. Additionally, the provider faces marginal costs of k_j.

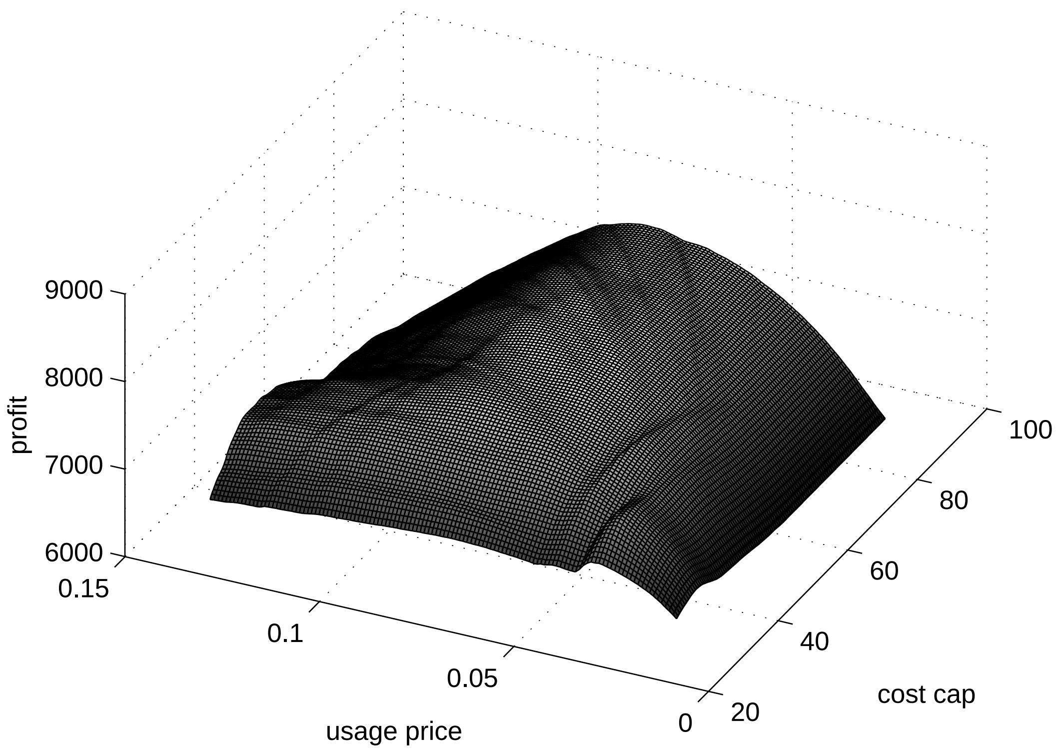
$$\begin{aligned} E(\pi_{ij}) = \; & Prob(n_{ij} \leq A_j)(f_j - k_j E(n_{ij} \mid n_{ij} \leq A_j)) \\ & + Prob(A_j < n_{ij} \leq C_j)(f_j + E(n_{ij} \mid A_j < n_{ij} \leq C_j)(p_j - k_j) - A_j k_j) \\ & + Prob(C_j < n_{ij})(c_j - k_j E(n_{ij} \mid C_j < n_{ij})) \end{aligned} \tag{5.2}$$

The probability P_{ij} of consumer i to choose tariff j follows the logit formula (Train, 2009) and depends on the one hand on the expected utility he derives from consumption under tariff j. The expected utility $E(U_{ij})$ is estimated similar to Equation (4.9) from Chapter 4. On the other hand, the choice probability depends on consumer's rationality factor γ_i. The rationality factor controls whether a consumer rather chooses tariffs randomly or chooses the tariff yielding the highest utility. Finally, a consumer has always the opportunity to opt out, deciding not to choose any tariff. Not choosing any tariff alternative yields an expected utility of zero. Thus, the individual probability becomes:

$$P_{ij} = \frac{\exp(\gamma_i E(U_{ij}))}{\sum_j \exp(\gamma_i E(U_{ij})) + 1} \tag{5.3}$$

The pricing decision of the service provider on fixed fees, usage prices, allowances and cost caps over his whole tariff portfolio impacts profits both directly and indirectly. Increasing price levels directly influences individual expected profits $E(\pi_{ij})$. However, increasing price levels also decrease tariff choice probability and increase the probability of consumers to opt out. The presented approach to model provider's profit takes into account both circumstances. Consequently, profits depend nonlinearly on tariff components. Figure 5.1 illustrate the dependency of provider's profit of a four-part tariff on different usage prices and cost caps in a monopoly setting without marginal costs.[2] The graph illustrates well the effect of usage price on expected profits. An initial

FIGURE 5.1: *Profit of four part tariff under different usage prices and cost caps*



increase of usage price increases profits. The increase, however is diminished by a decreasing consumption rate and a higher rate of consumers opting out. A low cost cap

[2]Further figures on alternative tariffs can be found in Appendix A.2.3.

increases the probability to choose a tariff, but it does also decrease the revenues from consumption.

Simulating annealing provides an efficient algorithm to optimize several tariff components simultaneously and has therefore been used to acquire the following optimization results. Consumer choice is based on parameter estimates obtained from the mixed logit hierarchical Bayes estimation presented in Chapter 4.

5.3 Results

Tariff optimization has been conducted under monopoly as well as a competitive market to demonstrate the impact of including cost cap components within the tariff portfolio.

5.3.1 Optimal Tariff Portfolio under Monopoly

Initially, optimal tariff design is studied under monopoly. Thereby, the provider offers solely one tariff and consumers have to decide whether to choose this tariff or to opt out. It is assumed that the marginal costs for providing the service is zero. This assumption is later relaxed and the effect of increasing marginal costs on optimal tariff design is thereby further analyzed.

Simulation results Table 5.2 summarizes the optimal price component parametrization for all possible tariffs, including usage price, fixed fee, allowance and cost cap. Besides these components, several quality criteria are reported as well. First, the expected profit is the sum over all consumers' profits times consumers' tariff choice probability as described in Equation (5.1). Consumer share measures the expected share of consumers to choose any tariff and not to opt out. Each respondent anticipates a consumption under a given tariff. The total expected consumption is the sum over all anticipated consumptions times the tariff choice probability. Finally, profit (consumption) per consumer is the ratio of the profit (total consumption) to the expected number of consumers.

TABLE 5.2: *Optimal tariffs under monopoly*

		tariffs						
		PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
usage price	¢/min	11.90		21.20	6.49	6.48	7.01	7.02
fixed fee	€		23.48		15.79	15.79	15.41	15.41
allowance	min					0		0
cost cap	€			40.32			61.98	62.03
profit	€	5,181	7,304	6,148	7,987	7,987	**8,163**	**8,163**
consumer share	%	**84.52**	39.89	80.59	39.35	39.37	39.52	39.50
total consumption	10^4min	4.35	**13.46**	5.17	5.17	5.17	6.13	6.13
profit per consumer	€/con	8.22	23.48	10.23	27.21	27.20	27.69	**27.70**
consumption per consumer	min/con	69.05	**449.68**	97.45	175.97	176.07	208.04	207.93

Note: Highest values in boldface.

A comparison of the expected profits reveals that the addition of a cost cap component always increases profits of tariffs with usage prices. For instance, extending a pay-per-use (PU) into a two-part tariff with cost cap (2PTCC) increases profits by 967€, which is equivalent to a profit increase of 18.66%. Similar, but smaller results can be achieved by upgrading a traditional two-part tariff (2PTF) into a three-part tariff with cost cap (3PTCC) with an increase of of 2.20% or by upgrading a three-part tariff with allowance (2.20%). Hence, it is concluded that:

PROPOSITION 4. *A monopolist with zero marginal costs can always increase his profits by extending his one-, two-, or three-part tariff with a cost cap component.*

Standard pricing literature (Wilson, 1993) state that consumers with high satiation level should be charged with low marginal costs to yield highest profits. However, charging a low minute price comes at the expense of smaller revenues from consumers with low consumption. Adding a cost cap uncouples the optimal pricing, as the minute price can be designed to face consumers with low satiation levels and the cost cap accordingly to exploit profits from high satiation consumers. Furthermore, the cost cap can exploit consumers' additional willingness to pay due to their uncertainty. Consumers valuate the cost cap according to one's probability to reach the cap and by the cap induced increased consumption level. The results provide evidence for this proposition, as expected consumption is higher under tariffs with cost cap than its counterpart without. Consequently, the expected profit per consumer increases as well. Expected profits per consumer range between 8.22€ and 27.70€ and are in line with the German average of 23.00€ reported by the OECD (2011).

Additionally, the results confirm the proposition of Oi (1971) that heterogeneous consumers are best served by appointing usage prices above marginal costs, as all usage prices are above the anticipated zero marginal costs. Furthermore, consumer choice and consumption behavior under one-part and two-part tariffs without cost caps confirm earlier findings of Schlereth et al. (2011). Profits under a two-part tariff with fixed fee and usage price are higher than profits under either pay-per-use or flat rate tariffs. Furthermore, deviation of the optimal two-part tariff towards a pay-per-use (flat rate) tariff increases (decreases) consumer share and decreases (increases) average profit and consumption per consumer at the same time. However, none of the tariffs is chosen by all consumers, which is in line with Oi's finding that it is profit increasing to exclude a fraction of consumers.

Surprisingly, the results show that extending a tariff scheme with an allowance option does not increase provider's profit and a provider is advised to offer no allowance. This finding remains true under a three-part tariff with allowance as well as under a four-part tariff. Similar results have been found by Schlereth and Skiera (2012), who also do not find any profit differences between two- and three-part tariffs. Still, this finding contradicts earlier studies of Lambrecht et al. (2007) and Ascarza et al. (2012). Lambrecht et al. (2007) stated that tariffs with a higher allowance and fixed fee can better exploit consumer uncertainty in consumption. However, the authors solely focused on tariff choice behavior between two given tariffs and did not study how to implement an optimal tariff design based on consumer heterogeneity. Thus, the question which tariff a provider should offer is hardly answered. The proposed provider model in this study, in combination with a simulated annealing approach, optimized tariff components while taking into account consumers' choice and consumption decisions. Nevertheless, Ascarza et al. (2012) showed that consumers exhibit a bias for free minutes under an allowance, which leads to an overuse of three-part tariffs. A sensitivity analysis revealed that when consumers do not exhibit such preferences a three-part tariff is no longer more profitable than a two-part tariff. However, accounting for an allowance bias does not improve the predictive power of the proposed model (see Appendix A.2.3 for details). Bagh and Bhargava (2013) showed that allowances are only profit increasing as long as a homogeneous low-value consumer segment is large enough. Therefore, the heterogeneity of consumer preferences in the applied sample might be another explanation why allowances do not increase tariff profits.

PROPOSITION 5. *Offering an allowance does not increase monopolist's profit.*

With this allowance limitation and the fact that extending a tariff with a cost cap always increases profit, it can be concluded that:

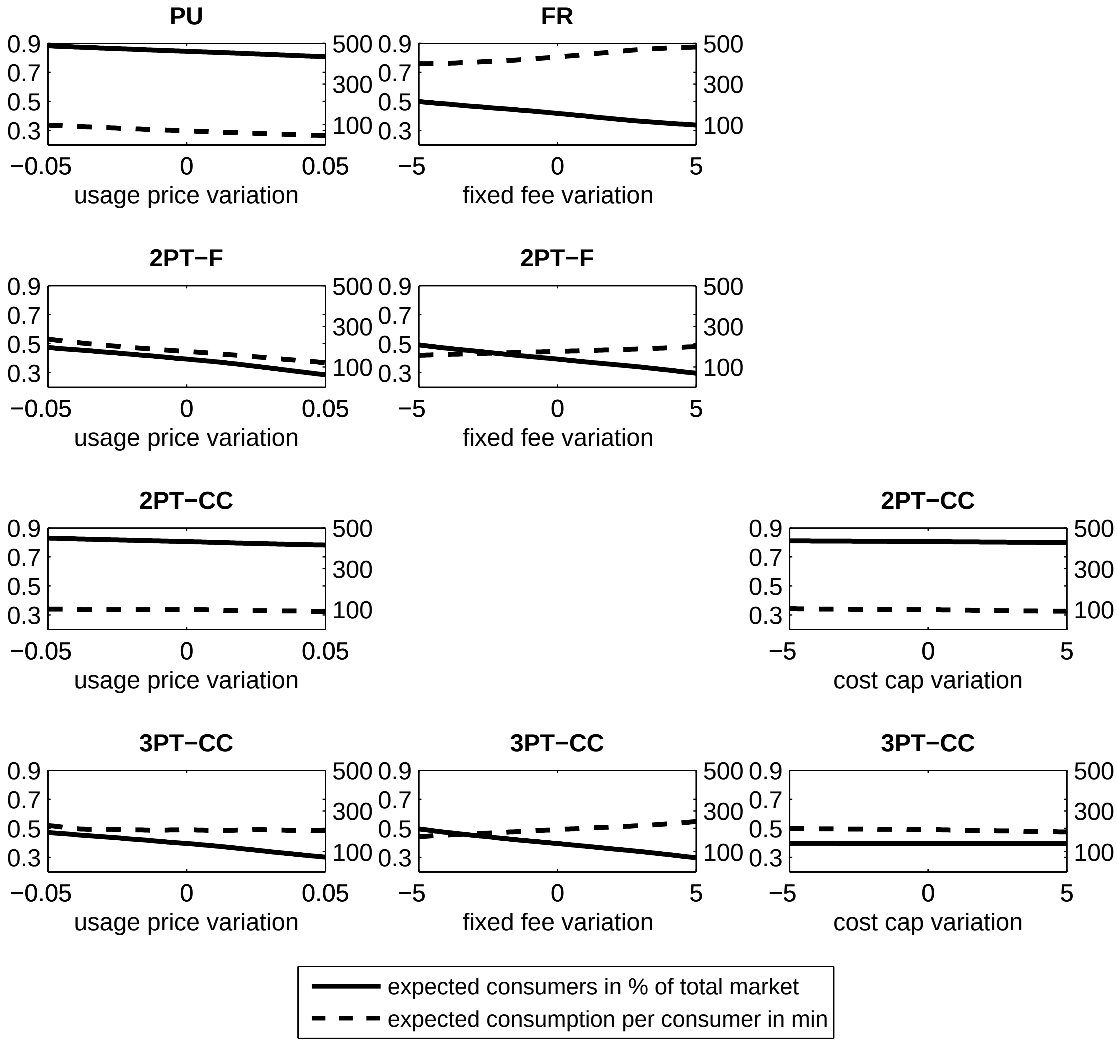
PROPOSITION 6. *The three part tariff with cost cap is the profit maximizing tariff a monopolist can offer.*

Yet, profit maximization is not always the only goal providers aim for. Not surprisingly, consumer share is the highest under a pay-per-use tariff and two-part tariff with cost cap. As the first consumption unit is only charged by a usage price, most consumers decide to choose a tariff even though their consumption is low. In contrast, linking a tariff with a fixed fee naturally forces consumers to opt out, as the initial utility threshold is too high. Thereby, the results partly confirm earlier findings of Danaher (2002). A higher usage price, as seen under a two-part tariff with cost cap compared to a pay-per-use tariff, reduces expected consumption but does only marginally impact consumers to choose a tariff. In general, the results provide evidence that charging a fixed fee decreases consumer retention. Comparing the level of the fixed fee between a flat rate tariff and a traditional two-part tariff seems to have no impact on consumer retention. However, as these tariffs are not identical and the effect of fixed fee and usage price under a two-part tariff cannot be distinguished, the variation of usage price and fixed fee are discussed in more detail.

Sensitivity analysis Figure 5.2 shows the results of a sensitivity analysis on the expected number of consumers and their expected consumption. The expected number of consumers is described as the share of the total sample. Whereas the expected consumption is the average of each consumer's optimal consumption under the given tariff times the probability to choose the tariff. This definition allows to study the effect of varying tariff components on choice and consumption simultaneously under consideration of consumers' option to opt out. As discussed earlier, an optimal tariff of a monopolistic provider does not include any allowance. Therefore, only tariffs with no allowance are further analyzed in Figure 5.2. Based on the optimal price levels as stated in Table 5.2, usage prices are varied with a step size of 0.1¢ within an interval of $[-5¢, +5¢]$ and fixed fees as well as cost caps with a step size of 0.1€ within an interval of $[-5€, +5€]$.

Comparing the sensitivity results of the pay-per-use and flat rate tariff confirms earlier findings of Danaher (2002). Variation of usage price only slightly affects consumer attrition, which is more sensitive to a variation of the fixed fee under a flat rate tariff. As expected, average expected consumption decreases with an increasing usage price. Consumption, however, increases with an increasing fixed fee. Danaher named this effect censoring which results from high consumption consumers who still choose the tariff under a higher fixed fee, while low consumption consumers decide to opt out. The censoring effect can be observed over all tariff types including a fixed fee component. However, the reaction towards a variation of usage price depends on the given tariff. While the decrease in average expected consumption remains almost the same under a traditional two-part tariff compared to a pay-per-use tariff, attrition rate is more

FIGURE 5.2: *Sensitivity analysis of usage price, fixed fee and cost cap on expected consumers and consumption*



sensitive towards a usage price increase when a fixed fee is present. As the fixed fee is used to exploit consumer surplus, an increase of the usage price affects consumers' probability to opt out much more strongly than under a pay-per-use tariff. The same effect can be observed under a three-part tariff with cost cap which exhibits a fixed fee as well. Furthermore, under tariffs including a fixed fee in combination with a usage price, the variation of either component has a similar effect on consumer attrition, which contradicts earlier findings of Danaher.

The introduction of a cost cap component has side effects on the sensitivity of usage price variation on average expected consumption. Under a two-part as well as under a three-part tariff with cost cap the average expected consumption remains stable, although the number of expected consumers decreases. A possible explanation is that consumers who do not exploit the cost cap decrease their consumption but continue using the tariff. This decrease compensates the earlier mentioned censoring effect. However, the cost cap does not have any effect on fixed fee sensitivity, which remains almost similar under a three-part tariff with cost cap compared to a traditional two-part tariff. The variation of the cost cap itself has no effect on the expected number of consumers and an almost diminishing effect on expected consumption. A possible explanation is that a variation of the cost cap only affects consumers whose consumption level is close to the critical cost cap consumption level. Therefore, only a small proportion of consumers will change their consumption behavior due to a change of the cost cap level. On the other hand, the sensitivity results show that when a consumer decides to consume below instead of above the critical cost cap consumption level, he still prefers to remain with the given tariff instead of opting out.

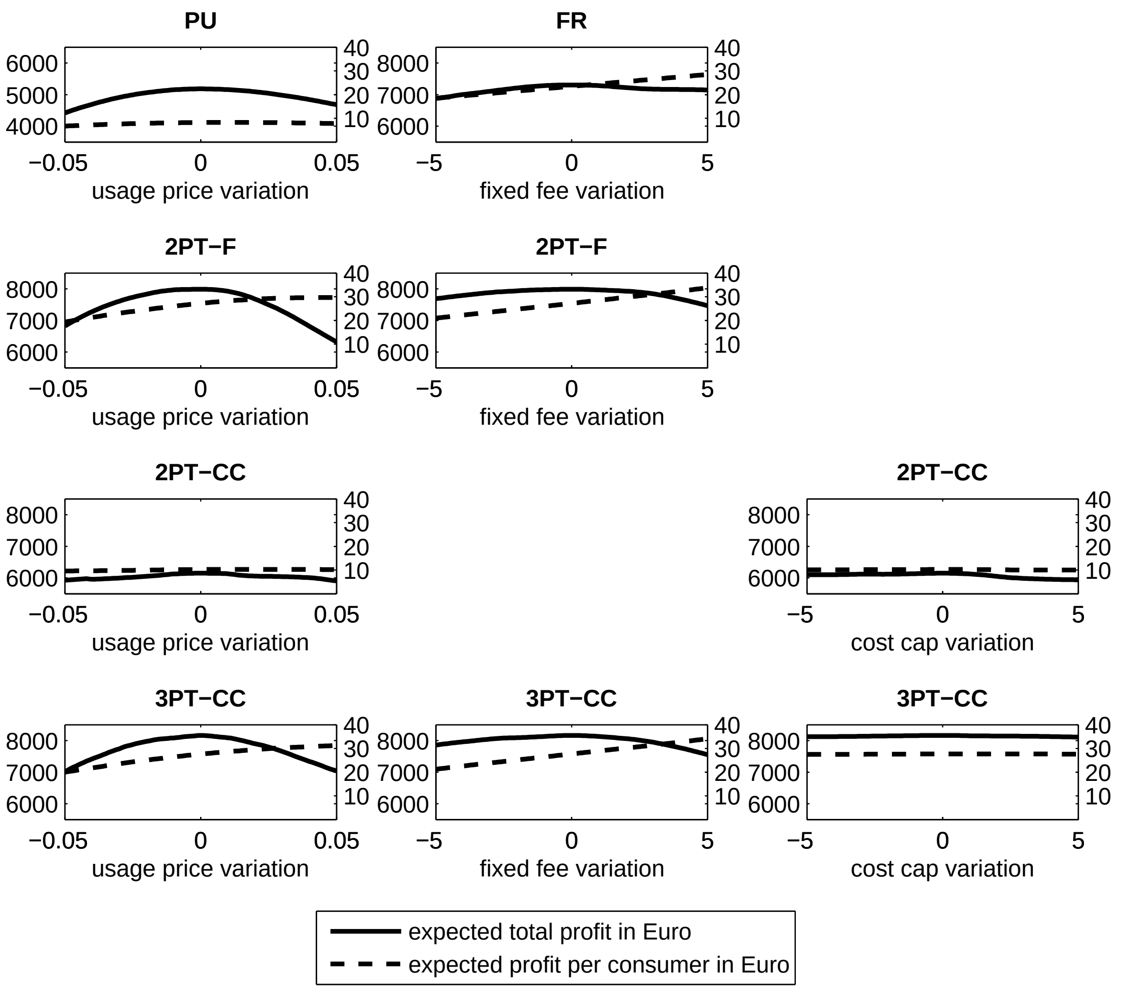
Results of the sensitivity analysis of expected profits, which are illustrated in Figure 5.3, provide insight on the robustness of profits considering varying tariff components. Profits under different tariffs all follow an inverted U-shaped trend over tariff components. The shape is based on an initial increase of profit due to a higher price level, with a decreasing rate due to consumers starting to opt out with a higher probability or decreasing their consumption. At a given point, the profits decrease, as the increase from higher price levels are overcompensated by decreases from consumer attrition. The resulting curvature of profits differ between components as well as tariffs. In general, profits are more sensitive to usage price variation than to fixed fee variation. As seen in Figure 5.2, the increase of usage prices do not only affect attrition, but also the expected consumption level, which reinforces profit reduction. Compared to fixed fee and usage price, cost cap variation has only a marginal impact on provider's profit. As explained earlier, the optimal cost cap only counts for a small fraction of consumers with high consumption who react almost inelastic to variation of the cost cap component.

PROPOSITION 7. *Profits and consumer attrition are less sensitive to a variation of the cost cap than to variations of the usage price or fixed fee.*

Similar to the earlier sensitivity findings, the censoring effect applies to the average profit per consumer, as it is increasing under tariffs with fixed fees when either the usage price or the fixed fee is increased. In contrast, average profits remain stable under tariffs without fixed fees such as the pay-per-use tariff as well as the two-part tariff with cost cap.

Marginal costs In order to study the effect of marginal costs on provider's profits, tariff components have been optimized under marginal costs of 1¢ and 5¢, which are within the range of the termination rate of 3.4¢ in the German mobile telecommunication market at the time of the study (Bundesnetzagentur, 2012). The resulting expected profits are shown in Table 5.3 in absolute values as well as in comparison to the optimal profits under a monopoly with zero marginal costs. As expected, profits decrease with increasing marginal costs. The results, however, show that the decrease is not linear, but rather with a slight diminishing trend. The strongest reduction occurs under the flat rate as well as under tariffs with a cost cap component. As demonstrated earlier, consumption under a flat rate tariff is the highest and only limited by consumers' personal satiation level. Consequently, increasing marginal costs have the strongest effect on profits under flat rate tariffs. The same logic applies to consumers who reach the cost

FIGURE 5.3: *Sensitivity analysis of profit on usage price and fixed fee*



cap and thereafter consume for free. The only possibility to reduce overall consumption under such tariffs is by either increasing the fixed fee to force consumers to opt out or to increase the cost cap component so that the probability to hit the cap decreases. In contrast, providers offering pay-per-use tariffs can face decreasing profit margins by increasing usage prices and thus decrease overall consumption. In general, providers react on increasing marginal costs by increasing the price level itself, which results to a lower number of expected consumers (see Table D.1 in the Appendix for more details) and overall consumption. A similar effect has been proposed by Sundararajan (2004) with respect to increasing transaction costs.

TABLE 5.3: *Impact of marginal costs on profits under monopoly*

	tariffs							
	PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT	
¢/min	5,181	7,304	6,148	7,987	7,987	**8,163**	**8,163**	€
	(-)	(-)	(-)	(-)	(-)	(-)	(-)	%
1¢/min	4,759	5,965	5,565	7,483	7,483	**7,576**	**7,576**	€
	(-8.15)	(-18.33)	(-9.48)	(-6.31)	(-6.31)	(-7.19)	(-7.19)	%
5¢/min	3,321	2,006	3,523	**5,659**	**5,659**	**5,659**	**5,659**	€
	(-35.90)	(-72.53)	(-42.70)	(-29.15)	(-29.15)	(-30.67)	(-30.67)	%

Notes: Percental deviance from zero marginal costs in parentheses.
Highest values are highlighted in bold.

As a consequence, the advantage of extending existing tariffs with a cost cap, as proposed earlier, decreases with marginal costs and even is negligible after a certain marginal cost level. The results show that under marginal costs of 1¢ extending a pay-per-use or a traditional two-part tariff with a cost cap is still profit increasing. However, unlimited consumption after reaching the cap is already causing a loss under marginal costs of 5¢. Therefore, a provider increases the cost cap component to a level at which the cap becomes irrelevant for consumers' consumption decision.

PROPOSITION 8. *Increasing marginal costs diminish the advantage of extending a tariff with a cost cap component.*

The earlier finding that providing an allowance is not profit increasing remains stable under different marginal costs.

5.3.2 Optimal Tariff Portfolio under Competition

This section extends the previous counterfactual simulations by including static competition. The optimal tariff portfolio is identified in three different competitive scenarios. *Scenario A* assumes that a monopolist is offering a single tariff (either pay-per-use or flat rate tariff) on the market. It is then discussed which tariff a new competitor should offer when he enters the market. In *Scenario B* the competition pressure is more intense as it is assumed that there are two incumbents who are already offering a pay-per-use as well as a flat rate tariff. Again, the profitability of different tariff alternatives which a new competitor could offer are analyzed. Finally, *Scenario C* assumes the case of an incumbent duopoly with both incumbents offering a single tariff. This time, however, it is discussed whether it is reasonable for one of the incumbents to offer an additional tariff and which could be the best tariff extension.

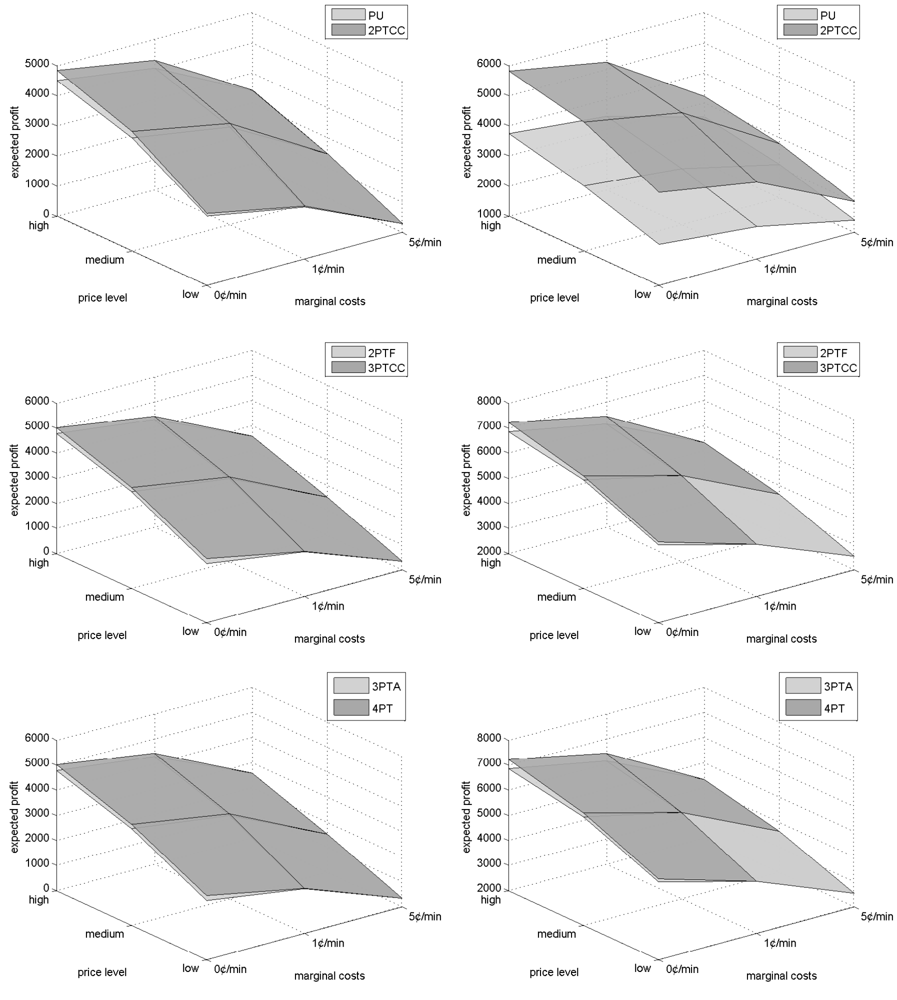
It is important to note that in all three scenarios switching costs are not considered, although earlier research showed their possible influence on tariff choice (Goettler and Clay, 2011). Competitive pressure is simulated by the use of three different price levels (**L**ow, **M**edium, **H**igh). The minute price of the pay-per-use tariff was varied by {5¢/min, 10¢/min, 15¢/min} and the fixed fee of the flat rate tariff by {20€, 30€, 40€}, which reflect common price levels in the German mobile telecommunication market at the time of the study. Moreover, the influence of marginal costs is further analyzed in a competitive setting. In contrast to the earlier study of Sundararajan (2004), marginal costs are assumed to be independent of the tariff scheme. For every possible combination of predominant tariff, competitive pressure and marginal costs, profits of every possible new tariff scheme were approximated by the use of simulated annealing.

Scenario A: Market entry into monopolistic market Figure 5.4 demonstrates the profitability of extending tariffs with a cost cap component under different marginal costs and competitive pressure. Note that the left column shows the case where the monopolist solely offers a pay-per-use tariff, whereas in the right column solely offers a flat rate tariff. Not surprisingly, the expected profits decrease with an increase of marginal costs. As proposed by Wilson (1993), expected profits also decrease under higher competitive pressure, i.e. low price levels. Yet, the results demonstrate the robustness of the applied methodology. Similar to the monopoly findings, it can be seen in Figure 5.4 that extending an existing tariff with a cost cap is always profit increasing under zero marginal costs. However, increasing marginal costs diminishes the superiority of the cost cap component until being irrelevant. The progression of profits shows that the decrease depends on the competing tariff. Under marginal costs of 1¢ it is still profit increasing to offer a cost cap in order to compete against an existing pay-per-use tariff. But it is no longer beneficial if the flat rate tariff is the predominant tariff irrespective of competitive pressure. Under high marginal costs, only upgrading a pay-per-use tariff with a cost cap is beneficial in case of medium to high price levels. Furthermore, the variation of the competitive price levels shows that an increasing competitive pressure diminishes the superiority as well. This result is stable independent whether the competing tariff is a pay-per-use or flat rate tariff.

PROPOSITION 9. *Increasing competitive pressure diminishes the advantage of extending a tariff with a cost cap component.*

The profits of all possible tariffs with varying marginal costs and competitive pressure are summarized in Table 5.4. The profits are further compared in Figure 5.5. The competitive scenario has several implications for optimal tariff design in contrast to a monopolistic setting. In contrast to the monopolistic results of Table 5.2, a cost cap tariff can in fact produce higher profits compared to flat rate tariffs, as long as the predominant tariff on the market is a pay-per-use tariff (see Figure 5.5). Under such market conditions, even a traditional two-part tariff can be displaced as long as marginal costs are reasonably low. Furthermore, the results show that in contrast to the earlier mo-

FIGURE 5.4: *Effect of cost cap component on profits for competing tariffs (PU | FR) under varying competitive price levels and marginal costs*



(A) *competing against PU* (B) *competing against FR*

TABLE 5.4: *Profits under competing tariffs (PU | FR) with varying competitive price levels and marginal costs*

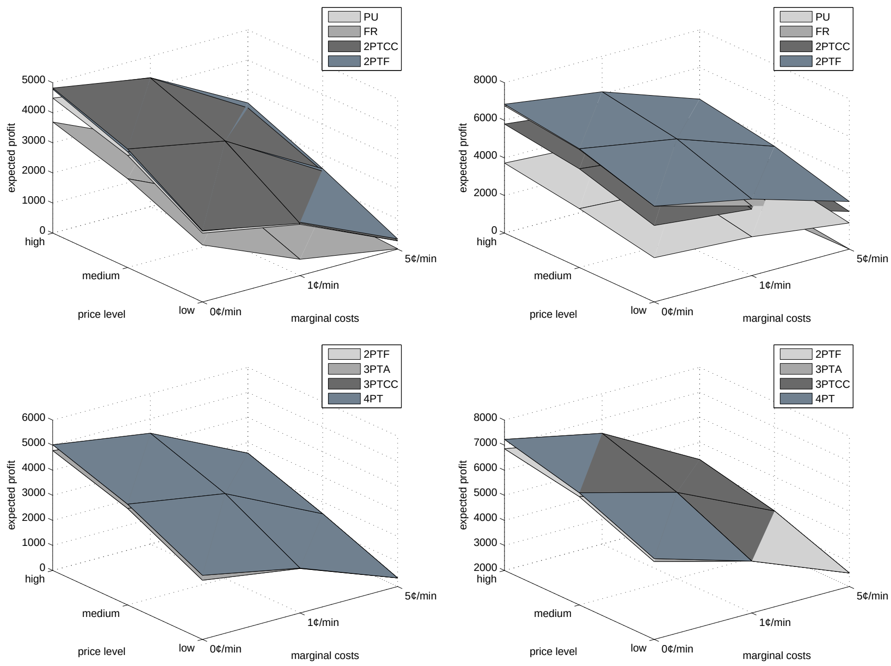
marginal costs	competitive price level	competing tariff	tariffs PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
0¢/min	L	PU	2,287	1,896	2,372	2,356	2,359	**2,556**	**2,556**
	L	FR	2,355	5,096	4,071	5,100	5,100	**5,219**	**5,219**
	M	PU	3,729	2,953	3,944	3,849	3,851	4,016	**4,022**
	M	FR	3,136	6,281	5,254	6,318	6,318	**6,475**	**6,475**
	H	PU	4,489	3,693	4,825	4,784	4,784	5,017	**5,018**
	H	FR	3,727	6,774	5,803	6,859	6,859	**7,231**	**7,231**
1¢/min	L	PU	1,704	541	1,736	1,772	1,773	1,788	**1,790**
	L	FR	2,063	3,701	3,530	4,069	4,069	**4,069**	**4,069**
	M	PU	3,209	1,495	3,331	3,318	3,320	3,384	**3,387**
	M	FR	2,829	5,046	4,685	5,439	5,439	**5,439**	**5,439**
	H	PU	4,022	2,263	4,282	4,290	4,291	4,421	**4,423**
	H	FR	3,420	5,470	5,222	6,117	6,117	**6,422**	**6,422**
5¢/min	L	PU	276	14	276	**339**	**339**	**339**	**339**
	L	FR	1,396	6	2,006	**2,537**	**2,537**	**2,537**	**2,537**
	M	PU	1,446	145	1,446	**1,527**	**1,527**	**1,527**	**1,527**
	M	FR	2,089	462	2,782	**3,640**	**3,640**	**3,640**	**3,640**
	H	PU	2,393	344	2,409	**2,574**	**2,574**	**2,574**	**2,574**
	H	FR	2,519	1,478	3,202	**4,320**	**4,320**	**4,320**	**4,320**

Note: Expected profits are in €. Highest profits are in bold.

nopolistic findings, including an allowance can be profit increasing under competition. This is because offering an allowance increases consumers' probability to choose one's tariff (Iyengar et al., 2008; Jensen, 2006). Due to more outside options in a competitive market, the higher choice probability compensates possible loss from giving away free minutes. In case the predominant tariff on the market is a pay-per-use tariff, a new competitor is best advised to offer a four-part tariff as long as marginal costs are medium or low. However, the three-part tariff with cost cap is the best offer to compete against a predominant flat rate.

Nevertheless, comparing profits under high marginal costs reveals that it is always optimal for a provider to enter the market with a traditional two-part tariff to acquire the optimal mix of consumers (Essegaier et al., 2002). This optimal profit cannot be further

FIGURE 5.5: *Profits under competing tariffs (PU|FR) with varying competitive price levels and marginal costs*



(A) *competing against PU*

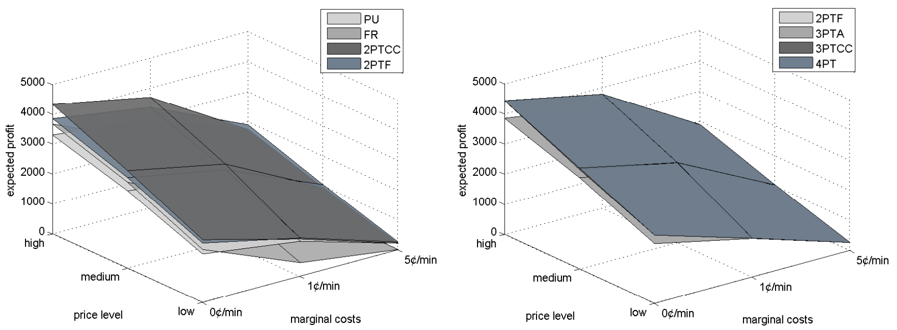
(B) *competing against FR*

increased by either including an allowance or cost cap. The additional revenue from attracting more consumers with an allowance or from an enhanced price discrimination with a cost cap does not outweigh the loss of providing the service for free under the allowance, respectively cost cap.

PROPOSITION 10. *In a competitive market it is always optimal to offer a traditional two-part tariff when marginal costs are high.*

Scenario B: Market entry into duopolistic market So far it has been assumed that only a single tariff is offered on the market. However, this is rarely the case in mature service markets. Next, instead of a single tariff, both, a pay-per-use and a flat rate tariff are offered at different price levels. Again, the new competitor offers only a single tariff. The expected profits under these considerations are shown in Figure 5.6 and listed in Table 5.5. As expected, the overall expected profits of the new competitor decrease

FIGURE 5.6: *Profits under competing tariffs (PU&FR) with varying competitive price level and marginal costs*



over all possible tariff schemes due to the increased competitive pressure. Again, the four-part tariff is the optimal tariff when marginal costs are zero or very small. High marginal costs of 5¢ favor the implementation of a traditional two-part tariff. However, under zero and small marginal costs, cost cap tariffs substantially perform better in almost every case in comparison to pay-per-use, flat rate and traditional two-part tariffs. The same result applies for the comparison of the three-part tariff with allowance option versus the same with cost cap option. Thus, it can be concluded that:

TABLE 5.5: *Profits under competing tariffs (PU&FR) with varying competitive price level and marginal costs*

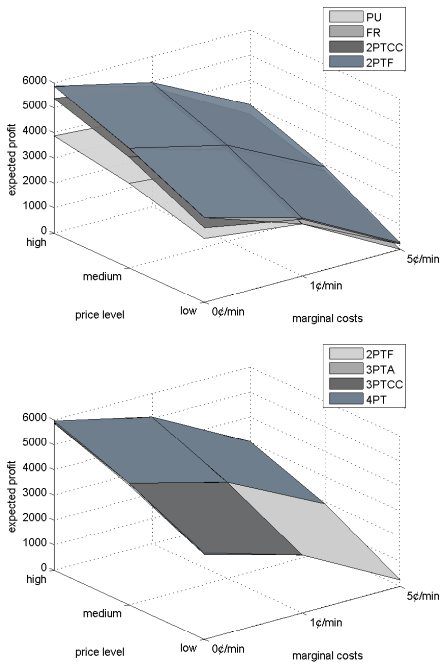
marginal costs	competitive price level	competing tariff	PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
0¢/min	L	PU&FR	1,612	1,762	2,085	1,974	1,974	**2,255**	**2,255**
	M	PU&FR	2,575	2,864	3,248	3,016	3,016	3,289	**3,337**
	H	PU&FR	3,291	3,655	4,316	3,836	3,836	4,420	**4,423**
1¢/min	L	PU&FR	1,157	444	1,228	1,266	1,267	**1,274**	**1,274**
	M	PU&FR	2,171	1,399	2,592	2,398	2,398	2,635	**2,638**
	H	PU&FR	2,914	2,232	3,674	3,339	3,339	3,760	**3,762**
5¢/min	L	PU&FR	210	4	210	**253**	**253**	**253**	**253**
	M	PU&FR	940	9	940	**1,022**	**1,022**	**1,022**	**1,022**
	H	PU&FR	1,724	22	1,728	**1,873**	**1,873**	**1,873**	**1,873**

Note: Expected profits are in €. Highest profits are in bold.

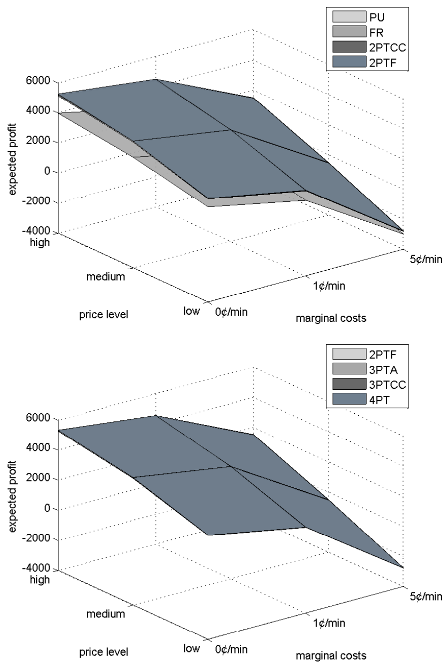
PROPOSITION 11. *Tariffs with cost cap components are more flexible in competing against existing tariffs in a matured market than any other tariff scheme.*

Scenario C: Tariff extension in duopolistic market The last scenario discusses the case of a duopoly where two incumbents are already offering a pay-per-use or a flat rate tariff and one decides to extend his tariff portfolio by offering an additional tariff on the market. Figure 5.7 compares the expected profits of every possible tariff extension. Table 5.6 lists all possible profits of an incumbent who is already offering a pay-per-use tariff. In contrast, Table 5.7 lists profits from offering an additional tariff along an existing flat rate tariff. If the incumbent is already offering a pay-per-use tariff, offering an additional four-part tariff yields the highest expected profit as long as marginal costs are low. However, the advantage of the four-part tariff is diminished under medium and high marginal costs as it can be seen on the first column of Figure 5.7. In this case, a traditional two-part tariff is the best additional tariff the incumbent can offer. The traditional two-part tariff is also the best offer, if the incumbent is somehow restricted to extend his tariff portfolio only with one- and two-part tariffs. In case the incumbent's predominant tariff is a flat rate tariff, three- and four-part tariffs with

FIGURE 5.7: *Profits under competing and supplement tariffs (PU | FR) with varying competitive price level and marginal costs*



(A) *competing against FR with supplement PU tariff*



(B) *competing against PU with supplement FR tariff* cost cap components are the best addition to the tariff portfolio. Thereby, four-part tariffs outperform any tariff alternative under low and medium marginal costs. Yet, high marginal costs abolish the advantage of the allowance so that a three-part tariff with a cost cap is the better offer. If the incumbent, however, is restricted to more simple tariff schemes the traditional two-part tariff becomes the best addition.

TABLE 5.6: *Profits under supplement (PU) and competing tariff (FR) with varying competitive price level and marginal costs*

marginal costs	competitive price level	competing tariff	tariffs PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
0¢/min	L	FR	2,541	3,367	2,965	3,375	3,375	3,435	**3,375**
	M	FR	3,368	4,754	4,409	4,765	4,765	**4,840**	**4,840**
	H	FR	3,875	5,861	5,369	5,861	5,861	5,867	**5,950**
1¢/min	L	FR	2,064	2,061	2,247	**2,300**	**2,300**	**2,300**	**2,300**
	M	FR	3,030	3,619	3,741	**3,828**	**3,828**	**3,828**	**3,828**
	H	FR	3,591	4,796	4,754	4,955	4,955	**5,056**	**5,056**
5¢/min	L	FR	210	4	210	**253**	**253**	**253**	**253**
	M	FR	1,743	1,571	1,744	**1,913**	**1,913**	**1,913**	**1,913**
	H	FR	2,573	2,436	2,635	**3,021**	**3,021**	**3,021**	**3,021**

Note: Expected profits are in €. Highest profits are in bold.

TABLE 5.7: *Profits under supplement (FR) and competing tariff (PU) with varying competitive price level and marginal costs*

marginal costs	competitive price level	competing tariff	tariffs PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
0¢/min	L	PU	2,837	2,306	2,865	2,879	2,881	2,903	**2,906**
	M	PU	4,317	3,317	4,380	4,379	4,387	4,432	**4,442**
	H	PU	5,098	3,939	5,159	5,226	5,230	5,286	**5,290**
1¢/min	L	PU	1,617	982	1,640	1,664	1,664	**1,680**	**1,680**
	M	PU	3,314	1,959	3,366	3,362	3,364	3,407	**3,411**
	H	PU	4,340	2,546	4,389	4,452	4,454	4,503	**4,505**
5¢/min	L	PU	-2,845	-3,021	-2,821	-2,811	-2,811	**-2,797**	**-2,797**
	M	PU	-585	-1,441	-555	-573	-573	**-546**	**-546**
	H	PU	1,383	-72	1,422	1,452	1,452	**1,486**	**1,486**

Note: Expected profits are in €. Highest profits are in bold.

5.4 Discussion

Summary of results This chapter proposed a methodology to study optimal tariff design based on stated consumer preferences, both under a monopolistic as well as competitive consideration. The use of simulated annealing offered the possibility to study the effects of different tariff schemes, including novel four-part tariffs, without the necessity to implement these tariffs in an actual mobile telecommunications market. Therefore, simulation results provide a profit forecast where novel tariff schemes cannot be easily implemented in real markets.

The results under a monopolistic consideration showed that the implementation of a cost cap component into tariffs with usage prices always increases provider's profits. The highest profits can be achieved by offering a three-part tariff with cost cap. Surprisingly, offering an additional allowance component does not improve monopolist's profits. The effect of fixed fees and usage prices on consumer attrition and expected consumption were studied by the use of a sensitivity analysis. Results on pay-per-use and flat rate tariffs concerning consumer attrition and consumption correspond to earlier findings of Danaher (2002). While fixed fee mainly influences attrition, consumption is both influenced by increasing usage prices and fixed fees, due to the censoring effect. In contrast to earlier findings, increasing usage prices under two- and three-part tariffs induce consumer attrition in a similar fashion as fixed fees. Even more, a variation of the cost cap component barely influences attrition and consumption due to the small number of consumers consuming within a critical range of the cost cap. The same argument applies for profits which are not sensitive to cost cap variation, but to usage price and fixed fee variation. Additionally, the impact of marginal costs on optimal tariff profits has further been analyzed. The results show that the superiority of the cost cap component decreases with increasing marginal costs. In general, a monopolist should face an increase in marginal costs by an overall increase of the price level to select more profitable consumers. Furthermore, tariffs with the option to consume with zero usage prices suffer the most of increasing marginal costs.

The effect of marginal costs also remains under a competitive consideration. However, the profit maximizing tariff depends not only on marginal costs but even more on the competitive scenario. Three different cases have been analyzed. First, a new competitor offers a new tariff in a market with a single predominant tariff, which can either be a pay-per-use or flat rate tariff, offered by an established incumbent. Extending tariffs with a cost cap component increases profit in almost any case. The results show that the new competitor should offer a four-part tariff as long as marginal costs are reasonably low. In contrast to the monopoly, offering an allowance increases provider's profit due to attracting competitor's consumers. The second case involves a market where two predominant tariffs are offered at the same time. While a four-part tariff remains the profit maximizing option, a cost cap tariff also outperforms any other one- or two-part tariff in this case. The third case involves two incumbents each offering either a pay-per-use or a flat rate tariff. If one provider decides to offer an additional tariff, the four-part tariff is the best option as long as marginal costs are low. Otherwise, the traditional two-part tariff as originally proposed by Oi (1971) creates the highest profit synergies.

Limitations and future research There are several limitations of the proposed approach, which may foster future research. First, the proposed consumer choice model is based on a random utility model and do not take into account possible switching costs. However, Goettler and Clay (2011) showed that charging a switching fee results in consumers sticking with one tariff. Second, the results are based on a single tariff decision and does not take into account consumer choice behavior over time. Tariffs with cost cap components may be more attractive under a dynamic scenario. Especially under switching costs considerations, the hybrid character of a two-part tariff with cost cap reduces the risk of being stuck with the wrong tariff after learning one's own consumption behavior. Third, incumbents were assumed not to react on competitors introducing new tariff schemes into the market. While this static consideration permits an understanding of beneficial tariff portfolios, its forecast of market equilibrium is limited. Therefore, a game theoretical extension (Steiner and Baumgartner, 2009) of the proposed approach should be addressed in future research.

Chapter 6

Perception of Cost Cap Tariffs

"The existence of both flat-rate and pay-per-use bias contradicts the assumption that consumers choose the tariff that leads to the lowest billing rate for a given amount of usage."

(Lambrecht and Skiera, 2006a)

THE last chapter focuses on the perception of cost cap tariffs from a psychological as well as physiological perspective. Tariff choice is known to be influenced by psychological effects which causes consumers to exhibit a tariff bias. They then end up choosing tariffs which are financially not optimal. In Section 6.1 the effects known to explain tariff biases are examined in order to understand their interplay with the cost cap component on tariff choice. The study reveals that the choice of cost cap tariffs is significantly influenced by psychological effects. Then, Section 6.2 proposes a new methodology to measure the psychophysiological perception of tariffs. The methodology is exemplarily applied to explain the perception of the taximeter effect under various tariffs. At last, the effect of framing is studied in more detail in Section 6.3. By conducting a stated preference experiment the study shows that the description of the cost cap component significantly increases the probability to choose a cost cap tariff.

6.1 Tariff Bias under Cost Cap Tariffs

This section studies the influence of psychological effects known to influence tariff biases on cost cap tariff choice. The study is based on the stated preference experiment discussed earlier in Chapter 4 and presented in Appendix A. Comparing consumers' choice between a pay-per-use, flat rate and cost cap tariff reveals a significant influence of all known psychological effects. It wasn't expected, however, that the taximeter effect is not in favor of the cost cap component. Yet, the insurance property is found to be the strongest driver of cost cap tariff choice.

6.1.1 Related Literature

Earlier research found a strong tendency to prefer flat rate tariffs (Lambrecht and Skiera, 2006a; Train, 1991) and a similar bias was found in Chapter 4 where a flat rate bias parameter ς was introduced into the proposed utility model. Several psychological effects have been found to explain the tendency to prefer a flat rate. Among the most important are the taximeter effect (Prelec and Loewenstein, 1998), the insurance effect (Train et al., 1987), as well as the overestimation effect (Nunes, 2000; Uhrich et al., 2012). The taximeter effect states that consumption is less pleasurable if it is linked to marginal payment - or as Prelec and Loewenstein (1998) stated - the consumer suffers from the pain of paying. Flat rate tariffs decouple the pain of paying by separating payment and consumption. Furthermore, Train et al. (1987) explained that consumers are rather loss averse and therefore choose a flat rate to insure themselves against high bills. Limited foresight and the tendency to overestimate future consumption also leads to choosing a flat rate, as the expected break-even point to alternative tariffs such as pay-per-use tariffs is rather reached (Nunes, 2000). Moreover, Kraemer and Wiewiorra (2012) discussed a flexibility effect which argues against flat rate choice due to the fact that consumers tend to prefer tariffs under which the total bill adjusts to actual consumption.

It is reasonable to believe that several of these effects have a similar impact on tariffs including the new cost cap component. More precisely, as the cost cap provides an upper ceiling, the insurance effect should dictate consumers to choose a cost cap tariff over a pay-per-use tariff. In addition, the flexibility property of a cost cap should favor its choice over a flat rate tariff. However, it is not clear whether the taximeter effect is alleviated by the cap.

6.1.2 Methodology

To study the perception of the cost cap component in more detail, one choice set with three tariff options and a no-choice option was included as an addition to the conjoint analysis of Chapter 4. Thereby, the choice set included a predefined pay-per-use (PU) together with a flat rate tariff (FR). Besides these one-part tariffs, which have been intensively studied for possible biases before (Lambrecht and Skiera, 2006a), respondents could also choose a linear tariff with a cost cap (CC). At last, respondents were also able to choose none of the presented tariffs. Based on an indirect consumption self-assessment, consumers were separated into three groups and redirected to group specific questionnaires. Each group then faced a choice set which was adopted with consideration to price levels in order to account for consumer heterogeneity in consumption (Sandor and Wedel, 2005). Table 6.1 summarizes the tariffs which were presented to the low consumption group. The additional choice sets can be found in Appendix A, Table A.4.

TABLE 6.1: *Choice sets for evaluating tariff perception*

	PU	CC	FR
fixed fee (f)	0 €	0 €	7.50 €
minute price (p)	0.15 €/min	0.17 €/min	0.00 €/min
cost cap (c)	∞ €	8 €	∞ €

Note: Tariffs are presented for low consumption group only.

A multi-logit analysis has been conducted to explain the impact of individual psychological effects on tariff choice. For this purpose, multi-item scales which were used before to identify consumers' perception of the taximeter, insurance, overestimation and flexibility effects (Lambrecht and Skiera, 2006a; Uhrich et al., 2012; Kraemer and Wiewiorra, 2012) were included in the survey. All questions have been adopted to account for tariffs with cost caps.[1] The new multi-item scales have been validated by the use of a exploratory factor analysis and were found to have an adequate model fit (see Appendix A, Table A.2 for details). The scales were used as an explanatory variable in the multi-logit choice analysis. Further explanatory variables include dummy coded variables controlling the consumption group along tariff utility. The utility that consumers perceive under the given tariffs was calculated by the use of the proposed utility model of (4.9) and the estimated parameters presented in Chapter 4. Note that the estimated flat rate parameter was unconsidered in the utility calculation, as the purpose of the study was to explain causes of tariff biases by the use of multi-item scales which likely correlate with the estimated parameter.

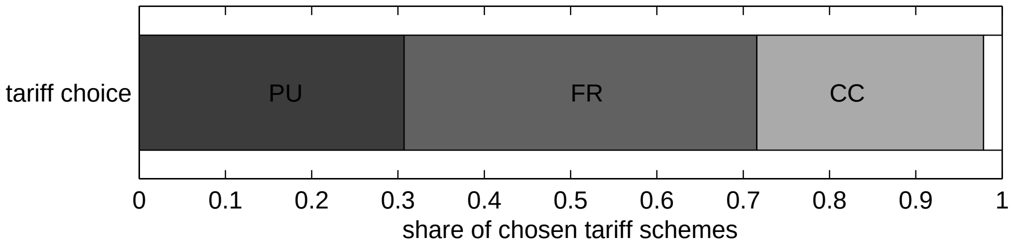
6.1.3 Results

Respondents' tariff choices are illustrated in Figure 6.1. 26% of the respondents has chosen a cost cap tariff, which demonstrates the general attractiveness of the new tariff. Besides the choice of the pay-per-use tariff (31%), the majority of respondents have chosen the flat rate tariff (41%) which might be an indication for a possible flat rate bias. In general, the low number of only 2% of non-choices demonstrate that all tariffs were reasonably priced.

Respondents' choice behavior was further analyzed by a mulit-logit analysis with the cost cap tariff as the baseline. It should be noted that non-choices have been excluded from the analysis. Table 6.2 summarizes the results. The multi logit model (1) in Table 6.2 solely includes the calculated tariff utility alongside of the control variables for group affiliation. The calculated utility is a significant explanatory variable for tariff choice. A high pay-per-use utility increases the chances of choosing a pay-per-use tariff, while a high flat rate utility does so for flat rate choice. This result supports the

[1] All questions related to the bias multi-item scales can be found in Appendix A, Table A.1.

FIGURE 6.1: *Share of chosen tariff schemes by respondents*



Note: The figure shows the share of chosen tariffs in relation to the decisions of all 746 respondents. The 16 non choices in the choice set are shown as a blank bar.

external validity of the proposed utility model. The multi logit models (2) and (3) are extended by the psychological effect scores based on the multi-item scales. Thereby, tariff utility remains a robust significant variable for explaining tariff choice. Finally, all models exhibit a reasonably high Nagelkerke R^2.

The analysis of psychological effects provides a better understanding of consumers' psychological tariff perception. The results show that all psychological effects are significant variables to explain pay-per-use over cost cap tariff choice. The insurance effect is the strongest driver for consumers to choose a cost cap tariff over a pay-per-use tariff, both economically as well as statistically. Furthermore, there is a tendency that consumers who exhibit a strong taximeter effect favor a cost-cap tariff over a pay-per-use tariff. This finding suggests that consumption dependent pricing does not foster the taximeter effect per se, but rather depends on the tariff structure as a whole. The flexibility and overestimation effects are significant under the second model at a 0.01 level, but are less significant when taking the expected utility into account as well. A possible explanation might be the utility model's ability to take uncertainty into account. The overestimation effect leads to choosing a cost cap tariff, which is not surprising, as a higher expected consumption makes the cost cap tariff more attractive in comparison to the pay-per-use tariff. However, the flexibility effect is perceived stronger under the pay-per-use tariff.

TABLE 6.2: *Multi-logit analysis on pay-per-use and flat rate versus cost cap tariff choice compared to low-usage group*

		(1)	(2)	(3)
pay-per-use	medium group	-0.720^{**}	-0.013	-0.328
		(0.226)	(0.239)	(0.251)
	high group	-0.622^{+}	0.583	0.177
		(0.348)	(0.393)	(0.414)
	pay-per-use utility	0.663^{***}		0.533^{***}
		(0.109)		(0.111)
	flat rate utility	-0.003^{*}		-0.001
		(0.001)		(0.001)
	taximeter effect		-0.362^{**}	-0.243^{+}
			(0.135)	(0.140)
	insurance effect		-1.247^{***}	-1.012^{***}
			(0.152)	(0.156)
	flexibility effect		0.529^{***}	0.388^{*}
			(0.146)	(0.152)
	overestimation effect		-0.538^{***}	-0.328^{*}
			(0.152)	(0.161)
	constant	0.551^{***}	-0.129	0.173
		(0.159)	(0.176)	(0.190)
flat rate	medium group	0.638^{**}	0.485^{*}	0.523^{*}
		(0.204)	(0.212)	(0.217)
	high group	0.698^{*}	0.353	0.440
		(0.289)	(0.324)	(0.328)
	pay-per-use utility	0.009		0.005
		(0.019)		(0.021)
	flat rate utility	0.012^{**}		0.010^{**}
		(0.004)		(0.003)
	taximeter effect		0.205	0.171
			(0.129)	(0.131)
	insurance effect		-0.467^{***}	-0.514^{***}
			(0.134)	(0.139)
	flexibility effect		-0.306^{*}	-0.263^{*}
			(0.123)	(0.126)
	overestimation effect		0.296^{*}	0.262^{*}
			(0.121)	(0.125)
	constant	0.166	0.165	0.271
		(0.166)	(0.159)	(0.173)
	Observations	730	730	730
	Nagelkerke R^2	0.302	0.310	0.400

Note: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Considering the choice between a flat rate and cost cap tariff, especially the insurance, flexibility and overestimation effects are significant variables to explain tariff choice. First, the framing of the cost cap tariff seems to induce a stronger perception of the insurance effect and hence leads to a higher chance of choosing a cost cap tariff. The framing might also explain the stronger perception of flexibility under a cost cap tariff, as its associated costs partly depend on consumption. Second, the overestimation effect significantly explains flat rate choice. Similar to the previous argumentation, respondents who overestimate their possible consumption have a stronger tendency to prefer a flat rate tariff, as a higher consumption level favors the cost advantage of a flat rate tariff. Finally, there is no significant influence of the taximeter effect on respondents' choice between a flat rate and a cost cap tariff. In line with the previous finding that consumers, exhibiting a taximeter effect, have a tendency to prefer a cost cap to a pay-per-use tariff, this finding suggests that the taximeter effect is perceived less strong under the cost cap tariff.

Overall, the multi-logit analysis shows that the influence of the flexibility and overestimation effect on cost cap tariff choice depends on the alternative option. While the taximeter effect only significantly influences the choice between a cost cap and a pay-per-use tariff, the insurance effect is the only effect that increases chances to choose a cost cap over both a pay-per-use and flat rate tariff.

PROPOSITION 12. *The insurance effect is the major driver for cost cap tariff choice.*

6.1.4 Discussion

Summary of results The influence of psychological effects on cost cap choice has been studied by the use of a stated preference experiment. Respondents had to choose between a pay-per-use, flat rate and a cost cap tariff and report their psychological tariff perception by answering several multi-item scales. A multi-logit analysis revealed the influence of the insurance, taximeter, flexibility as well as overestimation effect on tariff choice. More precisely, the insurance effect is the major driver for choosing a cost cap tariff. In addition, the findings suggest that the taximeter effect is alleviated by the insurance property of the cost cap. Furthermore, the influence of flexibility and overestimation on cost caps depends on the tariff alternative. While flexibility is stronger perceived under cost cap than flat rate tariffs, it is not perceived as strongly as under a pay-per-use tariff. In a similar fashion overestimation leads consumers to prefer a cost cap tariff to a pay-per-use tariff, but not over a flat rate tariff.

Limitations and future research The study solely considered consumers' tariff preference, which is one possible definition of tariff biases as discussed in Chapter 2. The experimental setting did not allow for financial consequences of consumers' tariff choice. Hence, the financial extent of cost cap tariff biases could not be evaluated. However, service providers are especially interested in the extent of such biases and adjust their pricing accordingly. Schulze and Gedenk (2005) provide a possible extension of the proposed experiment by estimating the willingness to pay along tariff choice. Adopting their framework on tariffs with cost caps promises insights into the extent of biases. Furthermore, other psychological effects than the ones discussed in this study might further explain tariff choice. Schwartz et al. (2002) showed that consumers in fact might feel worse as the number of choice alternatives increases due to being overstrained by the choice task. Schwartz (2004) later named this phenomena the "paradox of choice." Consumers differ in their psychological reaction to handle situations with increasing number of choice alternatives. Thus, the paradox of choice might explain as well the tariff bias and provide an explanation why providers offer an overprovision of tariffs (Miravete, 2004).

6.2 Psychophysiological Perception of Tariffs

Tariff choice has been shown to be biased through a number of psychological effects. Whereas the previous study used multi-item scales to identify the importance and existence of these effects, this section presents how consumers' perceptions of various tariffs can be assessed through psychophysiological measurements. Such measurements cannot be influenced by the respondents' free will and thus provide an objective scale of tariff perception. This approach also helps in overcoming potential common method biases. Moreover, its use can readily measure the perception of various complex tariffs without necessitating prior construction and validation of multi-item scales. The use of psychophysiological measurements is applied and validated in an experiment in which respondents have to place several costly hotline calls under different tariff types. The experiment was specifically designed to manage to control for differences in the perception of the taximeter effect. In addition to a pay-per-use and a flat rate tariff, a hybrid cost cap tariff is considered for which the perception of the taximeter effect was previously unknown. The psychophysiological measurements indicate that the cost cap tariff is similarly perceived to a pay-per-use tariff. The section is an adoption of Koehler et al. (2012b).

6.2.1 Related Literature

The pricing of services and products is undoubtedly considered to be one of the main premises for their success (Bub et al., 2011; Fritz et al., 2011). In service industries like telecommunications, flat rates and pay-per-use tariffs are palpably the two most prominent pricing schemes. However, several empirical studies have shown that consumers have a tendency to prefer flat rates (unmetered) over pay-per-use (metered) tariffs (e.g. Kridel et al., 1993; Lambrecht and Skiera, 2006a; Nunes, 2000; Schulze and Gedenk, 2005; Train et al., 1987) even if they yield the same costs. This is known as the flat rate bias (Train, 1991).

From a psychological perspective, one of the main differences between pay-per-use and flat rate tariffs is that costs are sunk in a flat rate plan and, consequently, consumers do not need to worry about the costs of their current or future usage. The underlying theory is mental accounting (Kivetz, 1999; Shefrin and Thaler, 1992; Soman and Lam, 2002; Thaler, 1985), which assumes that consumers keep different mental accounts with virtual budgets for consumption. When a consumer makes a purchase, he or she debits the costs from the respective mental account. Each mental account transaction causes pain that lowers the pleasure of the purchase (Prelec and Loewenstein, 1998). This effect has been coined the taximeter effect and is considered to be one of the main drivers of the flat rate bias (Lambrecht and Skiera, 2006a; Prelec and Loewenstein, 1998). Several other drivers of flat rate bias were also suggested in the literature. The most relevant of these are the overestimation effect (Lambrecht and Skiera, 2006a; Miravete, 2003; Nunes, 2000) and the insurance effect (Lambrecht and Skiera, 2006a; Train et al., 1987). The overestimation effect relates to the fact that consumers have a tendency to overestimate their expected usage. This increases the likelihood of preferring a flat rate. The insurance effect denotes that consumers prefer to be insured against unexpectedly high costs of usage. Such insurance is offered by the flat rate tariff, but not by a pay-per-use tariff.

The first and to-date most comprehensive study that has related these psychological effects to tariff choice was by Lambrecht and Skiera (2006a). The authors first developed and validated psychometric multi-item scales (Nunnally, 1978) in order to measure respondents' self-assessment of the strength of the taximeter and insurance effects in the context of pay-per-use and flat rate tariffs (Lambrecht and Skiera, 2006b). These scales were then used in two separate studies. The first study was exclusively based on survey data from 241 students of management in which tariff perception (via the scales) and tariff bias (via choice sets) were collected simultaneously. In this study, the taximeter and insurance effects were found to explain the flat rate bias at a 1% significance level. The second is a ground-breaking study in assessing tariff perception. For the first time, tariff perceptions were collected via a survey and combined with transactional data on tariff biases. Based on 941 observations, the taximeter and insurance effects were now only significant at the 10% and 5% levels, respectively. This decline in observed significance level when the dependent variable was collected with a different method can be interpreted as an indication for the existence of a common method bias (Bagozzi et al., 1991; Chang et al., 2010; Jo, 2000; King and Bruner, 2000; Podsakoff et al., 2003; Richardson et al., 2009).

This is a well-documented phenomenon in behavioral research, which may result in an inflation of the observed relationships - particularly as a result of the so-called self-report bias, which stems from the existence of a common source or rater (Podsakoff et al., 2003). Hence, studies that rely exclusively on a self-assessment of tariff choice and tariff perception from the same survey (like the first study by Lambrecht and Skiera (2006a), but unlike their second) are prone to exhibit a systematic measurement bias. This is, however, common practice in many studies conducted in a similar fashion, most of which used the original or slightly adapted scales from Lambrecht and Skiera (e.g. Gerpott, 2009; Kraemer and Wiewiorra, 2012; Mitomo et al., 2009; Schulze and Gedenk, 2005).

This section departs from the common practice in two fundamental ways. First, a new approach in assessing tariff perceptions by means of psychophysiological measurements is suggested. In particular, the approach relies on previous insights from psychophysiology that find a strong relationship between a subject's emotional state and physiological correlates, such as the heart rate or skin conductivity (Bradley et al., 2008; Hubert and De, 1990). This relationship is established through the autonomous nervous system, which normally acts outside of conscious awareness and, therefore, cannot be directly influenced by free will (Cacioppo et al., 2007). Thus, it is proposed and conjectured that heart rate measurements provide an objective and direct proxy for the perception of tariffs; in this vein, a common method bias can be overcome. Second, this new approach on tariff perception implies that subjects actually experience the tariff under investigation during the measurements, e.g., by placing calls in a laboratory experiment or in the field. This complements the previous approach in which respondents were asked to imagine a hypothetical scenario. Although the methodological foundations of survey research are well advanced and established in marketing, the responses of the survey participants to hypothetical questions nevertheless lack incentive compatibility and therefore might not reflect true behavior (Falk and Heckman, 2009; Smith, 1976). Another decisive advantage of the proposed methodology is that it can be readily applied to measure and compare the perception of complex, multi-part tariffs without the need to construct and validate appropriate psychometric item scales first.

This is demonstrated with respect to measuring the taximeter effect under the so-called cost cap tariff, which is a two-part tariff that is a hybrid between a pay-per-use tariff and a flat rate. Thus, ex ante it is unclear whether the taximeter effect under the cost cap tariff is perceived similarly under a pay-per-use tariff or a flat rate.

The remainder of this section is organized as follows. First, the theoretical background for psychophysiological measurements of tariff perception is established. Next, the design of a laboratory study is developed in which this new methodology is applied and validated with respect to the perception of the taximeter effect under a pay-per-use, flat rate, and cost cap tariff. Thereafter the results are presented and discussed. Finally, the article concludes with a summary and insights for practice and future research.

Theoretical Background on Psychophysiological Measurements Physio- or neuroeconomic studies (Adam et al., 2011; Camerer et al., 2005; Wang and Minor, 2008) have become an established toolset in economics during the last two decades, resulting in both incremental and radical changes in the understanding of economics and decision making. Camerer et al. argued that automatic processes, which are faster than conscious deliberations, and finely tuned affective (emotion) systems have not been considered in economics so far. Particularly, the heart rate is a well-known proxy for emotions in psychophysiology (Berntson et al., 2007; Wang and Minor, 2008). Specifically in the context of this section, new neuropsychological findings on the perception of money are of relevance (Breiter et al., 2001; Crone et al., 2004; Delgado et al., 2000; Gehring and Willoughby, 2002). In a physioeconomic experiment, Crone et al. analyzed the reaction of the heart rates of participants during gambling tasks with disadvantageous and advantageous options. The authors found that overall the respondents' heart rates slowed down following loss relative to reward outcomes. In addition, they were able to show that the heart rate is sensitive to the magnitude of punishment rather than the frequency of punishment. More specifically, analyzing phasic changes in heart rate allows the perceived averseness of the external stimulus to be evaluated, the so-called valence. The more negative a stimulus is perceived; typically the stronger is the subject's average deceleratory heart rate responses (ADHRRs) (Bradley et al., 2008). The ADHRR has been found to be a valid, reliable and sensitive measure of emotional processing (Wang and Minor, 2008).

In addition, the ADHRR is moderated by a person's heart rate variability, as it is well known that heart rate variability explains individual differences in regulated emotional response to a large degree (Appelhans and Luecken, 2006; Suetterlin et al., 2011). It can be assessed by means of the so-called LFHF ratio and SDNN. The LFHF ratio corresponds to the ratio of the low-frequency (LF) and high-frequency (HF) components of the heart rate. The SDNN refers to the standard deviation (SD) of time intervals between successive "normal" (N) heart beats (Appelhans and Luecken, 2006). Low LFHF ratio and high SDNN values reflect that a specific subject has a greater capacity for regulated emotional responses, respectively. Therefore, these measures must be used as control variables when considering the ADHRR as a measure for tariff perception.

Research Hypotheses on the Validation of the Method Based on these insights it is reasonable to expect that, controlling for heart rate variability, a person's perception (valence) of a certain tariff can be assessed by measuring his or her deceleratory heart rate response while he or she is exposed to the tariff (external stimulus). For example, the taximeter effect, if present, was initially described as a pain of paying (Prelec and Loewenstein, 1998). Thus, subjects that have to place a call under a flat rate tariff should not experience such a pain. By contrast, subjects that place the same call under a pay-per-use tariff, and are thus exposed to the taximeter effect, should experience a pain of paying with each cost tick. However, the psychophysiological basis of the taximeter effect was never tested, although it was already posited by Camerer et al. (2005) as an open research question: "While there is no direct evidence that paying is painful, the assumption that paying hurts can explain many market phenomena which are otherwise puzzling. An example is the effect of payment- neutral pricing schemes on choices" (p. 36).

In order to test this conjecture and to validate the methodology, subjects are exposed to either a pay-per-use or a flat rate tariff condition during a controlled laboratory experiment by asking them to place a series of costly hotline calls. During the calls, the ADHRRs are measured. The experiment is designed such that only the taximeter effect is feasible.[2] Complementary to previous studies, the experimental methodology employed in this study allows letting participants actually experience a (controlled) tariff situation. In particular, it can be presumed that under the pay-per-use tariff each cost tick (i.e., when incrementing the costs of the call) is perceived as a negative external economic stimulus. Subjects should therefore experience such an event with a negative valence. Consequently, if this methodology is valid, the taximeter effect, which results from the linkage of usage and payment, should induce a stronger ADHRR to cost ticks under a pay-per-use tariff than under a flat rate tariff. In order to demonstrate the applicability of the approach, the following hypotheses are tested:

HYPOTHESIS 1. *Participants' ADHRR to relevant stimuli (cost ticks) are stronger under the pay-per-use tariff than under the flat rate tariff.*

Furthermore, in order to exclude that the possible difference in ADHRR was caused by some economic irrelevant stimulus and not by a cost tick, the following hypothesis is also tested:

HYPOTHESIS 2. *Participants' ADHRR to relevant stimuli are stronger than participants' ADHRR to irrelevant stimuli.*

In order to show that the proposed methodology is valid, both research hypotheses must be confirmed.

Research Hypothesis on the Perception of the Cost Cap Tariff The methodology's ability to assess tariff perception for more complex tariffs is demonstrated by investigating the taximeter effect under the so-called cost cap tariff. This new tariff is a hybrid tariff between a flat rate and a pay-per-use plan.[3] The cost cap tariff is a metered pay-

[2]The details of the experimental design are described in the next subsection.
[3]This tariff type was introduced to the German mobile communications market in May 2009 by O2/Telefonica.

per-use plan until a predefined cost cap is reached, at which point it effectively becomes an unmetered flat rate. It is especially interesting to study the perception of the cost cap tariff, because it separates the insurance effect from the taximeter effect. Under a flat rate plan the alleviation of the taximeter effect is inevitably coupled to the insurance effect. In reverse, under a pay-per-use plan the taximeter effect arises in the absence of a cost insurance. These circumstances make the cost cap tariff an ideal candidate to demonstrate the above psychophysiological methodology, because one is able to study how the taximeter effect is perceived under a pay-per-use tariff with cost cap. In other words, using the cost cap tariff allows the measurement of the taximeter effect in the presence of a cost insurance. In this setting, it is open how the taximeter effect is perceived.

On the one hand, the advertisement campaign for the cost cap tariff suggested that the taximeter effect is not present under the cost cap tariff. The ad proclaimed "Are you counting cents per minute? We do not want you to think about the phone call when making a phone call."[4] Note that the promise of the advertisement is directly related to Prelec and Loewenstein (1998) seminal description of the taximeter effect when they wrote: "Talking on the phone is more pleasurable when you don't have to think about what each call is costing you" (p. 21). Following this view, the taximeter effect under the cost cap tariff should be perceived similar as under the flat rate tariff, where the taximeter effect does not exist by definition. On the other hand, because usage is metered until the cost cap becomes binding, the taximeter effect may well exist under the cost cap tariff. Then, the cost cap tariff and flat rate tariff should be perceived differently. Hypothesis 3 investigates which conjecture is rather true:

HYPOTHESIS 3. *Participants' ADHRR to relevant stimuli are stronger under the cost cap tariff than under the flat rate tariff.*

[4]Translated from German. Original advertisement available at http://www.youtube.com/watch?v=AbyctGmoZ5w.

6.2.2 Methodology

Experimental Design The intention of this study is to measure the perception of the taximeter effect more directly through psychophysiological measurements in a controlled laboratory setting. To this end, the participants were exposed to a lifelike experience of being put on hold at a costly hotline under either a flat rate, pay-per-use, or cost cap tariff. A between-subjects design was selected, in which students were randomly and exclusively assigned to one of the three tariff conditions (flat rate, pay-per-use, and cost cap). The participants were then told that they had to place eight calls to a hotline, which would inform them about a voucher code that could be redeemed for money.[5] During each call, the participants were put on hold for an unknown period of time with no possibility to opt out. Four of the eight calls had a short waiting time of one minute and the other four a long waiting time of two minutes. The subjects did not know about these expected waiting times. Short and long calls were selected in random order. Additionally, each call was randomly and individually extended by up to 29 seconds. This design was chosen in an effort to balance two opposing factors: On the one hand, a high degree of control could be achieved by taking the psychophysiological measurements repeatedly under the same conditions. On the other hand, conditioning effects of the subjects that result from the repetition of the same call durations could be avoided. In addition, the economic costs should be kept identical across the different tariff conditions.

While considering calls of different lengths, the impact of billing periods of different lengths were also considered. To this end, two different voucher redemption schemes were deliberated. In one set of treatments the voucher could be redeemed after each call. In another set of treatments the voucher was redeemed only after all eight calls were completed.

Under a pay-per-use tariff, respondents had to pay 1.29€ for every 30-second time interval that they were on hold in the hotline, whereas flat rate respondents paid a fixed

[5]The complete introduction for participants is available in the Appendix C

amount of 3.87€ for short and 6.45€ for long calls. Under a cost cap tariff, the participants had to pay the pay-per-use rate (1.29€ for each 30-second interval) until the cost cap was reached. The cost cap was set at the level of the corresponding flat rate, i.e., at 3.87€ for short calls and at 6.45€ for long calls, respectively. This price structure was chosen to ensure comparability between the pay-per-use, flat rate, and cost cap treatments. Given a per-minute price under the pay-per-use treatments of 1.29€, the flat rate price as well as the cost cap have to be different for long and short calls in order to guarantee comparability between the treatments. For the cost cap treatments the same per-minute rate as for the pay-per-use and the same cost cap as for the flat rate were chosen in order to guarantee similar treatment conditions for measuring the taximeter effect.[6] Finally, calls that were placed under a cost cap or a flat rate tariff were extended for another 30 seconds to control for differences in perception of the taximeter effect after reaching the cost cap. However, these time extensions had no impact on the actual costs of the respondents. This price structure was chosen to ensure that all subjects had the same account balance after all hotline calls were completed, independently of the voucher redemption scheme or tariff. Moreover, it achieves that a negative balance at the end of a call could not occur. The account balance was paid out in real money at the end of the experiment.

The participants were informed about the number of calls they had to make, the costs of placing a call, and the value of the voucher. In particular, as mentioned above, there were two different voucher redemption schemes in effect that were equally assigned in each treatment. Under the first scheme, the participants received a voucher of 1.50€ value after each call, which was immediately balanced to their account. Under the second scheme, the participants received only a part of a voucher code after each call and could, therefore, only redeem the voucher with a total value of 12.00€ after all eight calls had been completed. Participants were able to review the elapsed call time,

[6]Clearly, actual providers of cost cap tariffs will likely charge a premium on the per-minute rate or set the cost cap higher than the costs for a comparable flat rate. In any case, this will rather emphasize the taximeter effect under cost cap tariffs. Therefore, when a taximeter effect is found under cost cap tariffs, it is rather underestimated.

call budget, and accumulated costs of the current call at any time on their computer screen.

Finally, it is emphasized that the subjects did not select their tariff themselves and were uninformed about the alternative tariff possibilities, such that regret effects could be excluded (between-subjects design). Therefore, differences in the tariff perception of the participants between the three tariff conditions can be solely attributed to the taximeter effect.

Taximeter and Reference Events In the experiment, several different external stimuli were deliberately introduced in order to be able to disentangle the relevant from the irrelevant stimuli. While being on hold, the subjects in all treatments were exposed to neutral ("elevator") music, which was played to them over headphones. The music was interrupted every 15 seconds by either a taximeter event (relevant stimulus) or a reference event (irrelevant stimulus) in alternating order.

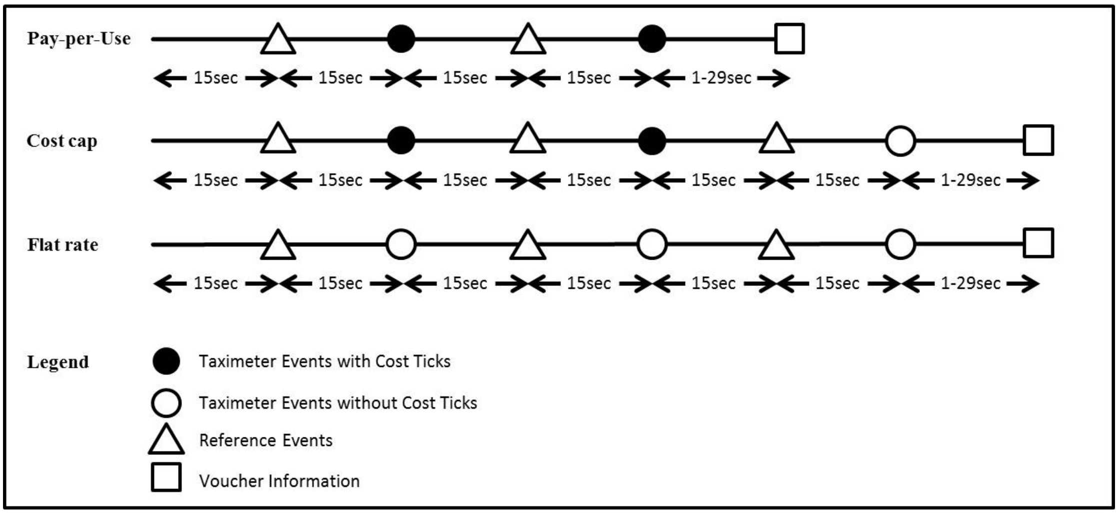
Taximeter events, which occurred every 30 seconds, are characterized by a highlighting of the accumulated costs in red alongside with an acoustic signal. For participants under a pay-per-use tariff or under a cost cap tariff before reaching the cost cap, this taximeter event appeared at the same time at which the costs were incremented by 1.29€. Therefore, these taximeter events are said to have a cost tick.[7] By contrast, participants in the flat rate condition and participants in the cost cap condition after reaching the cost cap received the same taximeter event (i.e., color highlighting and acoustic signal) but did not experience the cost increase (no cost tick).

Reference events, which occurred every 30 seconds and 15 seconds before each taximeter event, are simply characterized by a voice message saying "Please hold the line". This acoustic reference event was identical for all participants and did not coincide with

[7]In the past, a similar acoustic signal, called "minute beep" was present in all Siemens mobile phones. Today, the same feature is available through third party applications for Android and Symbian phones as well as the Apple iPhone.

a change in costs (cost tick) in any of the three tariff conditions. Figure 6.2 summarizes the structure of hotline calls exemplarily for the short calls.

FIGURE 6.2: *Structure of hotline calls*



Procedure and Psychophysiological Measurement The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). A total of 150 students, 111 male and 39 female, were recruited using ORSEE software (Greiner, 2004) from different academic programs at the Karlsruhe Institute of Technology to participate in the experiment during two weeks in July 2010. Out of the 150 participants in the experiment, physiological measurements could be successfully obtained for 129 (41/45/43 in the flat rate/cost cap/pay-per-use tariff conditions, respectively). Due to technical issues with one measurement device, the data of 21 participants was not properly recorded and thus had to be discarded from further analysis.

During each call, the heart rates of the participants were measured. Following the recommendations of Jennings et al. (1981), the electric activity of the heart was measured by means of an electrocardiogram (ECG). The heart rate was then quantified by measuring the time between successive R-waves in the ECG. The ECG recording is based on a two-lead method with single-use electrodes placed on the left and right wrist. The guidelines of the Society for Psychophysiological Research regarding heart rate studies were taken into account (Jennings et al., 1981) in order to exclude any measurement artifacts. Furthermore, the subjects were visually separated from the recording equipment. Between two consecutive calls, a one minute rest period was introduced such that the physiological values could return to an individual normal level. At the beginning of the experiment, participants had to complete a five minute rest period. In the subsequent analysis, changes in heart rate are evaluated relative to the average heart rate in the rest period in order to account for interpersonal differences. Moreover, the heart rate measurements that were taken during this initial rest period are used to compute the LFHF ratio and SDNN.

Because the taximeter events occur at fixed time intervals, anticipatory effects have to be considered in measuring the ADHRR. Anticipatory reactions can occur several seconds before the actual event (Bechara and Damasio, 2005), whereas a psychological reaction to external stimulation occurs up to five seconds after the external stimulus (Bradley et al., 2008). Therefore, all physiological reactions are considered relevant that occur up to five seconds before an event and up to five seconds after an event. More precisely, the individual ADHRR of each participant is measured as the average of the difference between his/her maximum heart rate (up to five seconds before an event) and his/her minimum heart rate (up to five seconds after an event).

6.2.3 Results

In order to test the research hypotheses, the average physiological reaction (ADHRR) to the taximeter and reference events is considered and compared by means of ordinary least squares regression (OLS) analysis. More specifically, the participants' ADHRR is regressed on the treatment variables (cost cap, pay-per-use and voucher type, all encoded as dummy variables[8]), the event type (reference or taximeter event) as well as control variables for the call duration and interpersonal differences in physiological reaction (LFHF ratio and SDNN).

[8]Consequently, the flat rate treatment serves as a benchmark in this and all further regressions.

For the first set of regressions, a total of four ADHRR values are computed for each of the 129 participants: One for each combination of short and long calls, and taximeter and reference events. This results in a total of 516 observations for all treatments. In order to control for the fact that some observations come from the same subject, robust standard errors clustered by subject are used in all regressions.

Model 1 in Table 6.3 only considers the observations from the flat rate and pay-per-use treatments to test Hypotheses 1 and 2. Hypothesis 2 is confirmed as participants' ADHRR to taximeter events is significantly stronger than to reference events. In addition, the ADHRR is significantly stronger in the pay-per-use treatment as compared to the flat rate treatment. This confirms Hypothesis 1.

Moreover, the used voucher redemption scheme, i.e., billing periods of different length, does not have an effect on the participants' physiological responses. However, the ADHRR is found to be significantly weaker under long calls than under short calls. This indicates that the taximeter effect may decay over time. Finally, the participants' individual psychophysiological characteristics (SDNN and LFHF ratio) have a significant impact on the observed measurements (Appelhans and Luecken, 2006). The signs of all effects are as expected. In summary, these results confirm the validity of the proposed methodology.

Model 2 in Table 6.3 shows the results of the regression when the observations of the cost cap treatment are also included. Here the ADHRR is computed over all taximeter events, i.e., before and after reaching the cost cap. Whereas the previous results are unchanged, it can be observed that the ADHRR under the cost cap tariff are significantly stronger than under the flat rate tariff. This result only holds at the 10% level. The reason is that there are obvious differences between the subjects' ADHRR before and after reaching the cost cap. If the ADHRR is computed using only taximeter events before reaching the cost cap (see Model 3 in Table 6.3), the ADHRR increase under the cost cap tariff (compared to the flat rate tariff) is significant at the 0.1% level. In summary, this confirms Hypothesis 3.

TABLE 6.3: *Regression on ADHHR in comparison to flat rate*

	(1) pre & post	(2) pre & post	(3) pre only	(4) pre vs. post
Pay-per-use	0.797^{*}	0.814^{*}	0.822^{*}	
	(0.330)	(0.333)	(0.337)	
(Pre) Cost cap		0.549^{+}	1.393^{***}	1.006^{*}
		(0.304)	(0.314)	(0.487)
Post Cost Cap				-0.661^{*}
				(0.310)
Event	0.948^{**}	0.960^{***}	0.798^{**}	0.942^{**}
	(0.299)	(0.227)	(0.249)	(0.356)
Long call	-0.927^{***}	-0.973^{***}	-1.145^{***}	-0.385
	(0.233)	(0.195)	(0.211)	(0.341)
Voucher	0.564	0.305	0.171	-0.185
	(0.339)	(0.263)	(0.269)	(0.453)
SDNN	0.513^{***}	0.541^{***}	0.593^{***}	0.824^{***}
	(0.0907)	(0.0619)	(0.0684)	(0.137)
LFHF Ratio	-0.127^{+}	-0.136^{**}	-0.124^{*}	-0.240^{**}
	(0.0694)	(0.0493)	(0.0476)	(0.0714)
Constant	0.137	0.106	0.113	1.679
	(0.734)	(0.571)	(0.628)	(1.136)
Observations	336	516	516	688
R^2	0.265	0.321	0.339	0.253
Adjusted R^2	0.252	0.311	0.330	0.246

Standard errors in parentheses

Robust clustered standard errors by subject

$^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In order to investigate the difference in reaction to taximeter events before and after reaching the cost cap further, an individual's ADHRR is computed for the last taximeter event and the last reference event before reaching the cost cap, and the first taximeter and reference event after reaching the cost cap. As there was exactly one taximeter and reference event after reaching the cost cap, this procedure achieves that averages are computed over the same number of events before and after reaching the cost cap, thus ensuring comparability. The ADHRR is compared to the flat rate treatment only, because there were no taximeter events without cost tick under the pay-per-use tariff. In total, this yields eight observations per subject (four as above, before and after the cost cap was reached, respectively) in each of the two tariff conditions, totaling to 688. Model 4 in Table 6.3 shows the results, where "post cost cap" is a dummy variable that indicates whether the cost cap was reached. In this way the results can be directly compared to results of the previous regressions. While the main results are qualitatively unchanged[9], it can additionally be observed that a subject's ADHRR under the cost cap tariff is significantly decreased after the cost cap has been reached. While this result seems intuitive, because the cost cap tariff effectively becomes a flat rate at this point, also notice that the net effect in comparison to the ADHRR of participants in the flat rate treatment remains positive. In summary, it can therefore be concluded that the taximeter effect under the cost cap tariff prevails (at least for some time), even after the cost cap has been reached.

6.2.4 Discussion

Summary of Results In this section, a psychophysiological methodology was presented to measure the perception of tariffs, which is a complementary approach to previous survey-based approaches. Perception is measured through objective physiological responses in terms of the participants' heart rates. In this way, the perception can be assessed more objectively and potential issues due to common method variance can be

[9]With the exception that the duration of the call does not seem to have a significant influence anymore. This is likely to be driven by the fact that for this regression only the two neighboring taximeter and reference events are considered.

avoided. Moreover, the proposed methodology does not require the construction and validation of psychometric scales. The methodology was validated by studying the taximeter effect of consumers during telephone calls under a flat rate, pay-per-use and cost cap tariff. In a controlled laboratory environment, participants were exposed to a lifelike experience of a costly hotline call under one of these three tariffs. Under these conditions it is shown that the individual average deceleratory heart rate response is an indicator for the taximeter effect: Under a pay-per-use tariff, participants experience a significantly stronger physiological response than participants with a flat rate tariff.

Furthermore, the applicability of this new methodology was demonstrated with respect to measuring the perception of the taximeter effect under the new cost cap tariff, which is a hybrid between a flat rate and a pay-per-use tariff. Contrary to the announcements of recent advertisement campaigns, it was found that the insurance property of the cost cap tariff does not alleviate the taximeter effect. Thus, the cost cap tariff is perceived similar as a pay-per-use tariff, particularly before the cost cap is reached. However, the results also indicate that the perception of the taximeter effect under cost cap tariffs prevails (at least for some time) even after the cost cap has been reached. Although the taximeter effect is significantly reduced after the cost cap was reached, it is still stronger than under a comparable flat rate tariff. This finding, however, contradicts earlier results of Section 6.1. This might be due to differences between expected and actual perception of tariffs, which should be studied in more detail by future research.

Implications for Practice Increased competition has lead the firms in the service and communications sector to differentiate themselves through innovative and appealing pricing schemes (Bub et al., 2011; Mueller et al., 2012; Lambrecht et al., 2012). The results of the study highlight how the application of methods from neuro- and psychophysiology to marketing can contribute to a deeper understanding of the consumers' emotions to different tariff options. Service providers can directly use these methods to gain a better understanding on the perception of their tariffs. In the context of the telecommunications industry, for example, firms may be interested to combine the processing power of smart phones with wireless physiological measurements. For instance, heart rate measurements can be easily realized in the field by means of wearable sensor technology. In this vein, the firms can conduct field experiments and assess how consumers physiologically respond to different tariffs while using their own mobile phones. By conducting such measurements in the daily environment of consumers, a high degree of external validity can be achieved. This in turn can help telecommunications firms to design tariffs that are tailored to the specific needs of various consumer groups.

For example, this study shows that the taximeter property prevails even in the presence of a cost insurance. Therefore, from a managerial point of view, the results of this study question the recent advertisement campaign of mobile communications companies, which emphasize that the cost cap tariff is an opportunity to call without experiencing a pain of paying. With respect to the cost cap tariff, it is therefore advisable to focus more on the fact that this tariff offers increased flexibility in comparison to a flat rate.

Limitations and Future Research Since this section proposes a new methodological approach to measuring tariff perception, there are several promising future topics to be addressed by this methodology and existing limitations yet to be overcome. For example, although the methodology does not require the construction and validation of effect or tariff specific scales, the measurement of psychophysiological indicators does not differentiate between different sub effects per se. If this is the goal of the researcher, a careful experimental design is mandatory, by which it is possible to disentangle these effects. Furthermore, it is reasonable to believe that the negative perception of the taximeter effect does not increase linearly with an increase in the marginal price. Whereas this study focused on the validation of the new methodology and has therefore considered the same marginal prices in all treatments for comparability, future research may focus on the impact of different marginal prices on the perception of the taximeter effect. Furthermore, in this study the participants were randomly assigned to one of the tariff conditions. Therefore, tariff choice and its interaction with psychophysiology could not be studied. Future research may focus more on this interaction. In particular, differences in emotion regulation capabilities may be important consumer characteristics for tariff choice. Thus, it may also be interesting to investigate correlations between a subject's heart rate variability (SDNN and LFHF ratio) and tariff choice.

6.3 Framing of Cost Cap Tariffs

So far the cost cap tariff has only been discussed with initially increasing costs, which are capped at a predefined cost level. However, the cost cap tariff can also be framed as an initial fixed fee with a payback option for every minute below a predefined consumption level. The cost schedules are identical between this payback tariff (PB) and the cost cap tariff, as long as the initial fixed fee is equivalent to the cost cap, the marginal payback is the same as the marginal usage price and the critical consumption is set at the corresponding cost cap consumption. Yet, there is reason to believe that cost schedules can be perceived differently although they are functionally the same. Table 6.4 provides an example of mobile telecommunications tariffs, which illustrates the framing of both tariffs and their total costs respectively.

TABLE 6.4: *Exemplary cost cap and payback tariffs*

	cost cap tariff	**payback tariff**
description	You pay 0.10€ for every minute on the phone. However, your total costs cannot exceed a predefined cost cap of 20€ per month. If you use more than 200 minutes no further costs accrue.	You pay a fixed fee of 20€ per month, which includes all calling costs. However, if you use less than 200 minutes you get 0.10€ for every unused minute.
total costs	under the assumption of 100 minutes of telephony usage:	
	$K_{CC} = 0.10€/_{min} 100min = 10€$	$K_{PB} = 20€ - 0.10€/_{min}(200 - 100)min = 10€$

6.3.1 Related Literature

Earlier research on the perception of nonlinear pricing has found a significant impact of tariff framing (Goh and Bockstedt, 2012; Iyengar et al., 2011; Ho and Zhang, 2008) on choice. For instance, Iyengar et al. studied the effect of tariff framing by comparing pay-per-use with traditional two-part tariffs in a field experiment. The authors developed a utility model and estimated consumer preferences accordingly. Their results show that marginal utility from consumption is significantly lower under a two-part tariff, even after controlling for income effects and consumer heterogeneity. This so called "access fee effect" decreases both consumer retention and consumption. Iyengar et al. demonstrated that ignoring this framing effect results in a profit reduction of 11%. Ho and Zhang studied the perception of fixed fee framing by either charging a fixed fee upfront or alternatively charging the fixed fee in an opaque frame as quantity discounts. Although both approaches result in the same total costs, offers with a fixed fee are rejected more often. As the authors explained, such behavior can be explained by loss aversion (Kahneman and Tversky, 1979) and mental accounting (Thaler, 1985). The prospective accounting theory of Prelec and Loewenstein (1998), which is an extension of the mental accounting theory, is especially well suited in the context of payback tariffs. Prelec and Loewenstein found that consumers tend to couple costs with consumption and vice versa. Timing and the interference of costs and consumption are thereby most important. The derived pleasure of consumption is reduced by the pain of paying, which leads to a strong debt aversion. Thus, consumer prefer to pay in advance because they can enjoy consumption as if it is free.

The same logic applies to the different perception of payback and cost cap tariffs. Payback tariffs involve a prepayment which decouples consumption from payment. Following this argumentation, a payback tariff should be perceived more positively than a cost cap tariff. Although the payback as well as the cost cap tariff end up with the same total fee at the end of a month, the payment process is different. While consumers' bill increases linearly with consumption under a cost cap tariff, consumers start with a fixed fee under a payback tariff which linearly decreases afterwards. Thus, prospect theory (Kahneman and Tversky, 1979) suggests that the loss from the fixed fee should not be outbalanced by the gains afterwards. Following this argumentation, a cost cap tariff should be preferred to a payback tariff. It is therefore an open question, whether accounting theory is perceived stronger than prospect theory and whether a payback tariff is in fact preferred to a cost cap tariff.

Compared to a flat rate tariff, both tariffs provide a similar insurance against high costs. As discussed before, from a provider's perspective it is only reasonable to set the fixed fee of a payback tariff and the cost cap higher than the fee of a flat rate tariff, as otherwise these tariffs would dominate the flat rate. Therefore, in times of high consumption consumers are better off choosing a flat rate. It is unclear whether the option to pay less in times of low consumption outbalances the bill difference in times of high consumption, so that consumers prefer a payback to a flat rate tariff.

6.3.2 Methodology

The research question was studied by conducting a stated preference experiment.[10] A total of 330 respondents were recruited by a professional marketing research agency to conduct an online survey. The corresponding sample is representative of the population of German mobile telephony users. Respondents had to answer two repeated choice settings. In one choice setting, respondents had to choose five times between a flat rate and a cost cap tariff with varying usage prices. The other choice setting included the same pricing, this time, however, the cost cap tariff was framed as a payback tariff. The presented flat rate, cost cap and payback tariffs are illustrated in Table 6.5. Both choice settings were presented to the respondents in random order to avoid sequence effects.

Additionally, respondents answered several multi-item constructs on psychological effects, which have been found to explain tariff choice before. This includes the overestimation, insurance, taximeter, and flexibility effect (see Chapter 2). The scales are related to Lambrecht and Skiera (2006a), Kraemer and Wiewiorra (2012) and Uhrich et al. (2012) and have been adjusted to account for cost cap and payback tariffs.[11] In addition, an

[10]The full questionnaire is available in Appendix B.1.

[11]All questions related to the multi-item scales and the subsequent exploratory factor analysis can be found in Appendix B.2.2.

TABLE 6.5: *Tariff framing under different price levels*

pricing level	FR	CC	PB
1	20 €/month	0.05 €/min 25 €/month cost cap above 500min	25 €/month 0.05 €/min payback below 500min
2	20 €/month	0.10 €/min 25 €/month cost cap above 250min	25 €/month 0.10 €/min payback below 250min
3	20 €/month	0.15 €/min 25 €/month cost cap above 166min	25 €/month 0.15 €/min payback below 166min
4	20 €/month	0.20 €/min 25 €/month cost cap above 125min	25 €/month 0.20 €/min payback below 125min
5	20 €/month	0.25 €/min 25 €/month cost cap above 100min	25 €/month 0.25 €/min payback below 100min

external calling pattern was given to the respondents who were asked to assume an average consumption of 200 minutes with their consumption n being equally distributed between 0 and 400 minutes. Hence, the uniform density distribution is given by:

$$f(n) = \begin{cases} \frac{1}{400} & \text{if } n \in [0,400] \\ 0 & \text{otherwise} \end{cases} \tag{6.1}$$

Note that in the following the parameter c is used for both describing the cost cap as well as the initial fee under a payback tariff. Likewise, p describes the usage price as well as the marginal payback rate. The flat rate fee is described by f. At $C = c/p$ consumption reaches the cost cap. Given the external calling pattern, a risk neutral respondent with no tariff specific preferences is assumed to choose a flat rate tariff if the expected costs under such are lower than under a cost cap respectively payback tariff:

$$\begin{aligned} & E(K_{FR}) < E(K_{CC}) = E(K_{PB}) \\ & \qquad f < Prob(n < C)E(n \mid n < C)p + Prob(n \geq C)c \end{aligned} \tag{6.2}$$

$$f < F(C) \int_{n<C} n \frac{f(n)}{F(C)} p\, dn + (1 - F(C))c$$
$$f < \int_{n<C} n f(n) p\, dn + (1 - F(C))c$$

Applying the assumed uniform distribution with range $r = (400 - 0)$ provides the critical price for a rational consumer to choose a flat rate tariff:

$$p > \frac{c^2}{2r(c - f)} = \frac{25^2}{2 * 400 * (25 - 20)} = 0.156 \tag{6.3}$$

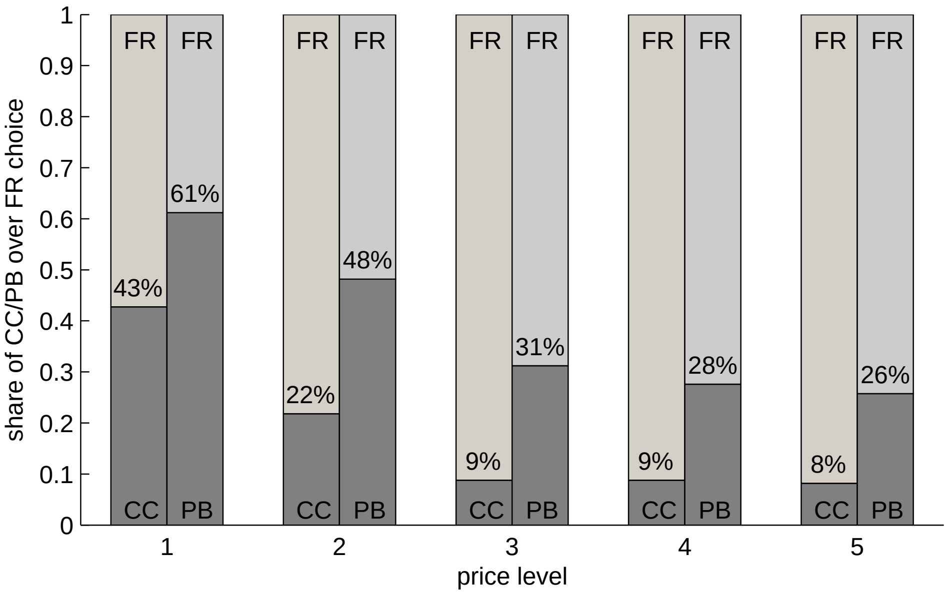
Consequently, if respondents are risk neutral and do not exhibit tariff framing specific preferences, respondents were expected to choose the cost cap (payback) tariff first and then switch to the flat rate tariff after the fourth price level. However, even if respondents are risk averse, there should be no differences in choice behavior between the cost cap and payback choice.

6.3.3 Results

Respondents tariff decisions are illustrated descriptively in Figure 6.3. Surprisingly, respondents' choice behavior strongly differs from the theoretical proposition in several ways. First, the flat rate tariff is chosen with a significant share even if the given price level had favored the flat rate alternative. Thus, respondents either exhibit a flat rate bias as stated in earlier research (Train et al., 1989) or a noticeable risk aversion. Second, the share of cost cap tariff choice seems to be different from the share of payback tariffs, which will be statistically verified later. This finding suggests that the framing of the cost cap tariff strongly influences its choice. At last, the share of cost cap choice sharply drops after the second price level. While the payback tariff shows a similar pattern, the decrease is not as strong, which confirms the framing effect.

Respondents' choices are further analyzed using two logit regression with the flat rate tariff as a baseline. The first logit regression solely studies the implied treatments. The two choice settings are differentiated by a dummy variable named payback framing.

FIGURE 6.3: *Share of CC/PB over FR tariff choice*



Note: The figure shows the share of 330 consumers who have chosen a cost cap (respectively payback tariff) over a flat rate tariff. The increasing price level correspond to an increasing usage price (marginal payback) of the cost cap (payback) tariff.

The five different price levels are dummy coded as well, using the first and lowest price level as a baseline. In addition, the second logit regression also accounts for possible psychological effects to influence tariff choice. Multiple choices per respondents are controlled for by using clustered standard errors. The results of the logit regression are illustrated in Table 6.6.

As expected, a higher price level significantly increases the chances of choosing the flat rate option. Thus, respondents became aware of the nonlinear course of the payback and cost cap tariff, and realized that with an increasing price level the flat rate tariff becomes the cost minimizing alternative. Consequently, the chances of choosing the flat rate is increasing with the height of the price level of the payback and cost cap tariff respectively. It is interesting to see that the payback dummy which controls for the framing of the cost cap/payback tariff significantly decreases the chances to choose the

TABLE 6.6: *Choice of cost cap and payback tariff*

	flat rate choice	
	(1)	(2)
2nd price level	0.757***	0.780***
	(0.082)	(0.085)
3rd price level	1.575***	1.619***
	(0.135)	(0.139)
4th price level	1.698***	1.745***
	(0.153)	(0.159)
5th price level	1.786***	1.835***
	(0.164)	(0.170)
payback	-1.171***	−1.201***
	(0.110)	(0.114)
overestimation effect		0.250*
		(0.098)
insurance effect		0.243*
		(0.114)
taximeter effect		0.188+
		(0.104)
flexibility effect		−0.126
		(0.103)
constant	0.500***	0.512***
	(0.116)	(0.117)
Observations	330x10	330x10
Nagelkerke R^2	0.194	0.222

Standard errors clustered by subject in parentheses
$^{+}$ $p < .1$, * $p < 0.05$, ** $p < .01$, *** $p < 0.001$

flat rate tariff. Thus, the payback tariff is perceived differently and more positively than the cost cap tariff.

PROPOSITION 13. *Framing of the cost cap tariff as a payback tariff significantly increases its choice probability.*

Hence, it can be concluded that the positive effect of accounting theory is perceived stronger than the negative effect of prospect theory. Therefore, consumers' preference for prepayment is an important factor in framing tariffs with a cost cap option. The framing effect remains significant, even when psychological effects known to explain tariff choice are added to the logit analysis. Thereby, model (2) partly contradicts the earlier findings of Section 6.1. In contrast, the taximeter has a tendency to drive flat rate choice and thus, the effect is not compensated by the cap. Overestimating one's consumption is another significant parameter to favor flat rate choice. However, in contrast to the findings of Section 6.1, exhibiting a need for insurance significantly favors flat rate choice. A possible explanation might be that the systematic variation of cost cap's usage price increased the need for insurance. At last, the flexibility effect does not have a significant effect on tariff choice, which might be due to the weak interitem correlations of the flexibility scale (see Appendix B.2.2).

6.3.4 Discussion

Summary of results The effect of tariff framing has been applied on cost cap tariffs in a stated preference experiment. Framing the cost cap as an initial fixed fee with payback option significantly increases chances to prefer a cost cap tariff to a flat rate alternative. Thus, the results provide evidence that the positive effect from advanced payment, as stated by the accounting theory, outbalances the negative effect from loss aversion, as stated by the prospect theory. In general, consumers realize the nonlinear course of cost cap tariffs and choose the cost cap tariff with higher probability if the cost cap tariff provides the option to save money. Furthermore, psychological effects known to explain tariff choice remain a significant influence for choosing a flat rate tariff.

Limitations and future research The study focused solely on the impact of framing on tariff choice. Future research may also study the effect of framing on actual consumption. Earlier research provided evidence that consumption is subdued due to marginal pricing (Danaher, 2002). It is, however, unclear whether a marginal gain under a payback tariff results in the same effect or whether consumers exhibit a similar consumption pattern as under a flat rate tariff.

Chapter 7

Conclusion

"Pricing remains a black box to many companies;
misunderstood, undermanaged and virtually ignored."

Robert A. Garda

THE purpose of this thesis was to study consumers' perception and choice behavior of tariffs including cost caps, and its implication for providers' tariff portfolio design. Besides a theoretical consideration, stated preference experiments as well as simulations have been used to study several derived research questions. In the following, the results of this thesis and their implications are summarized in Section 7.1 and promising future research is presented in Section 7.2.

7.1 Summary and Implications

The first research question this thesis addressed was whether the presence of a cost cap component changes consumers' tariff choice and consumption behavior. Therefore, a theoretical model was developed in Chapter 3 and later extended and empirically evaluated in Chapter 4. The results showed that consumption at the level of the cost cap is never optimal for a rational consumer. In fact, a subsequent empirical study in Chapter 3 showed that respondents did not overestimate their consumption beyond the model's prediction. However, the cost cap causes a sudden increase of consumption due to a shift in consumption preferences. Considering the choice of a cost cap tariff, the theoretical model showed that consumers would only prefer a cost cap tariff to a pay-per-use or flat rate tariff if they exhibited a reasonable uncertainty in their prospective consumption. Empirical findings of Chapter 4 confirmed the importance of such uncertainty in explaining consumers' choice behavior. Thereby, the cost cap tariff will only be chosen if its higher price level is outbalanced by the uncertainty in consumption. Counterfactual simulations in Chapter 5 confirmed that providers' can in fact profit from consumers' uncertainty by offering tariffs with cost caps.

Consequently, service providers who consider offering cost cap tariffs should be aware of the kind of consumers they are targeting at. Especially providers who are limited in their capacity to provide a service should be aware that the introduction of a cost cap tariff may foster a steep increase of consumers' consumption level.

The next research question focused on the ability of utility models to represent consumers' behavior. Therefore, several utility models were evaluated by their internal and external validity to predict consumers' tariff choices in a stated preference experiment. The results in Chapter 4 showed that a traditional additive part-worth utility model poorly predicts consumers' choice behavior. In contrast, discrete/continuous choice models can account for the dependency of discrete tariff choice and corresponding continuous consumption decision, and exhibit a clearly better prediction power. In addition, the choice models are further improved by including consumer uncertainty and accounting for possible flat rate biases. Besides the analysis in Chapter 4, these utility models were applied in two empirical studies in Chapter 3 and 6 and were found to explain tariff choice significantly.

From a provider's perspective the specification of consumers' utility model is important for predicting future profits, as a misspecification might lead to an overestimation of consumers' satiation points as shown in Chapter 4.

In addition, this thesis addressed the question under which constellations the implementation of a cost cap component increases providers' profit. Based on the estimated consumer preferences of Chapter 4, several counterfactual simulations and sensitivity analyses were conducted in Chapter 5 to address this question. The results provided evidence that extending an existing tariff with a cost cap component is always profit increasing under zero marginal costs, whereas the extension with an allowance is only reasonable in a competitive scenario. This is because the cost cap component allows a better price discrimination of consumers, as the usage price can be designed to face consumers with low consumption and the cost cap accordingly to exploit profits from consumers with high consumption. Furthermore, the cost cap exploits consumers' willingness to pay due to their demand uncertainty. Further sensitivity analyses revealed this result to be robust against a variation of the cost cap component, as variations only address a small number of consumers. Nevertheless, the advantage of the cost cap component is diminished by increasing marginal costs and an increased competitive price pressure. However, tariffs with cost cap components perform especially well in matured markets where pay-per-use and flat rate tariffs are already established. Furthermore, the analysis of framing effects in Chapter 6 showed that the perception of the cost cap component can be positively influenced by framing the cost cap as an initial fixed fee with payback option. This way the chances to choose a cost cap tariff can be increased, which is likely to lead to increased profits.

In summary, providers should consider the extension of their existing tariffs with cost cap components if they face low marginal costs. In case they face fierce competition or high marginal costs, the implementation requires a case sensitive analysis. Nevertheless, the cost cap component should always be framed as an initial fixed fee with payback option to be most effective.

Finally, the thesis studied the influence of psychological effects on the perception of cost cap tariffs. In general, the empirical study of Chapter 4 showed that respondents

exhibit tariff specific preferences in form of a flat rate bias that significantly influences tariff choice. However, subsequent studies on psychological effects that drive cost cap tariff choice did not achieve a clear finding. The first study on psychological effects in Chapter 6 found the insurance effect to be the major driver to prefer a cost cap tariff to a pay-per-use as well as a flat rate tariff. Furthermore, the taximeter effect significantly influenced consumers to prefer a cost cap to a pay-per-use tariff. This finding suggests that the cost cap diminished the pain of paying. Yet, a new psychophysiological approach to measure consumers' tariff perception, which was presented in Chapter 6, contradicted this finding. There was no significant difference between consumers' reaction to price increases under pay-per-use and cost cap tariffs. Consequently, this finding proposed that the taximeter effect remains under the insurance of a cost cap. The second empirical study strengthened this finding, as the taximeter effect significantly influenced consumers to prefer a flat rate to a cost cap tariff. Moreover, the results showed that the respondents of this study perceived the insurance effect stronger under a flat rate than a cost cap tariff. Nevertheless, both empirical studies agreed that overestimating one's future consumption leads to a preferred choice of the flat rate tariff. Yet, all results are limited to a provision of telecommunication services. It remains an open research question whether cost cap tariffs are equally perceived in a different service industry.
Hence, service providers are advised to conduct case specific studies before launching possible cost cap extension as the psychological perception may be dependent on the consumer group, existing tariff portfolio or the service industry. Needless to say, insights of tariff perception can help to improve targeting the desired consumer group and shape tariff advertisement to be more effective.

Overall, the thesis showed that a combination of different methodologies allows studying in detail the effects of innovative pricing approaches such as cost cap tariffs. The proposed utility models and simulation approaches provide synergies which service providers can use to anticipate consumer reactions to price adjustments and optimize their tariff portfolio accordingly. Thereby, this approach is not limited to four-part tariffs and may also include further tariff components such as quantity discounts.

7.2 Outlook

There are several limitations within this thesis which may foster future research in modeling consumers' choice behavior, measuring their tariff perception and optimizing service providers' tariff portfolio.

The proposed utility model of Chapter 3 and its extended variant of Chapter 4 only accounted for tariff specific preferences in a limited way by using a bias parameter. Earlier research, however, found that the rational tariff choice is systematically biased due to several psychological effects, such as the insurance, taximeter, overestimation, or flexibility effect. It is therefore desirable to model these effects in a more general manner which copes the complexity of four-part tariffs by future research. Such an affect based model could help to understand the interaction of tariff components with psychological effects and to estimate corresponding tariff biases from stated preference experiments directly. Furthermore, the proposed model accounted for the interdependency of discrete tariff choices and continuous consumption decisions. However, its application was limited to the use of telephone usage only. As cell phone contracts are offered as bundles of tariffs for telephony, messaging, and Internet usage nowadays, it would be interesting to see how consumers substitute these different services. From a practitioner's perspective these insights have direct implications for the pricing of such tariff bundles.

Considering the estimation of consumer preferences under four-part tariffs, there are two prominent aspects to consider in the future. First, the applied conjoint experiment did not offer the possibility to study learning effects over time as it is a static approach. Yet, earlier research studies (Narayanan et al., 2007; Miravete, 2003) showed that consumers learn their preferences over time and consequently adapt their consumption pattern. In fact, this thesis showed that the implementation of a cost cap tariff may induce a strong increase of consumers' consumption. Therefore, it would be interesting to see how fast consumers change their behavior in case their current tariff is further extended by a cost cap option. The application of a field experiment together with an extension of the proposed utility model to account for learning effects promises to study consumer behavior over time. Second, consumers face a challenging task when it comes to the point of choosing from a set of four-part tariffs. It is therefore likely that consumers simplify their decision by the use of heuristics. Gilbride and Allenby (2004) demonstrated the use of a two stage decision model to account for common heuristics including conjunctive, disjunctive, and compensatory screening rules. The proposed model's fit may benefit from an extension in this vein.

This thesis also studied the perception of tariffs with cost caps. While the conducted studies in Chapter 6 found a significant influence of different psychological effects on tariff choice, they did not account for the financial consequences of these choices. Hence, the financial extent of cost cap biases could not be evaluated. The extent, however, and its implication on tariff pricing are especially interesting from a provider's perspective. Therefore, future research should extend the applied experiment in a similar way as Schulze and Gedenk (2005) to study the additional willingness to pay induced by psychological effects. Furthermore, other psychological effects than the taximeter, insurance, flexibility or overestimation effect may explain tariff choice. Thus, effects such as the paradox of choice (Schwartz et al., 2002) should be studied in detail to explain tariff choice better. Finally, the perception of cost cap tariffs was solely studied in the context of telecommunication services. Yet, cost cap tariffs are also used to price insurance and rental services. It would be interesting to see whether cost cap tariffs are equally perceived in these industries.

The measurement of tariff perception was further studied by a new methodological approach using psychophysiological data as a proxy. There are several promising future topics to be addressed by this methodology. The conducted experiment provided evidence that the perception of the taximeter effect results in an actual pain of paying which can be measured by the average decrease of the heart rate response. However, the relationship between the extent of the negative perception of the taximeter effect and the marginal price level remains an open question and should be addressed by future research. Furthermore, the conducted experiment was designed as a between-subject study and required an assignment of respondents into tariff conditions. Hence, the influence of psychophysiological perception on tariff choice could not be studied. It is, however, reasonable to believe that consumers' psychophysiological characteristics, such as the emotion regulation capability, may explain tariff choice. In addition, the relationship of stated perception in surveys and actual experienced perception in experiments should be addressed by future research.

Finally, the thesis studied the effect of cost caps on providers' optimal tariff portfolio. In particular, there are two promising avenues for future research. First, switching costs were unaccounted in the proposed model of Chapter 5, although they might increase the attractiveness of tariffs with cost cap components. Charging a switching fee results in consumers sticking with one tariff (Goettler and Clay, 2011). Therefore, consumers can reduce the risk of being stuck with the wrong tariff after learning their consumption behavior by choosing a cost cap tariff. It would be interesting to see whether consumers are willing to pay a risk premium for the cost cap component consequently. Second, the applied simulation considered a static reaction of market competitors to the introduction of new tariffs. While this static consideration permitted an understanding of beneficial tariff portfolios, its forecast of market equilibrium is limited. Hence, future research should address a dynamic competition model in line with current research in game theory (Steiner and Baumgartner, 2009).

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Appendix A

Empirical Study I

A.1 Questionnaire

Dear participant,
this questionnaire is about choosing tariffs for cell phone usage. Thereby, only air time minutes are considered. Additional services, such as text messaging and data usage, remain unconsidered.
The questionnaire is part of a research project of the Institute of Information Systems and Marketing at the Karlsruhe Institute of Technology.
The questionnaire will take about 15 minutes to complete.
Your data will be used for scientific purposes only and not be given to any third party.
Thank you for your participation.

A.1.1 Introduction

QUESTION 1. *What is your gender?*

- ○ male
- ○ female

QUESTION 2. *How old are you?*

- ○ 0-13 years
- ○ 14-19 years
- ○ 20-29 years
- ○ 30-39 years
- ○ 40-49 years
- ○ 50-59 years
- ○ 60-69 years
- ○ 70 years and older

QUESTION 3. *Do you own a cell phone contract or a prepaid card, which you are currently using?*

- ○ yes
- ○ no

QUESTION 4. *Do you pay for one of them?*

- ○ yes
- ○ no

A.1.2 Explanation of Tariff Schemes

You will encounter different tariff schemes within this questionnaire. They consist of the following tariff components:

Fixed fee	Fixed monthly access fee, which has to be paid independent of your consumption.
Usage price	Price paid for every air time minute. This price is the same independent of the calling network within this questionnaire.
Allowance	A predefined number of minutes, which are free of charge.
Cost cap	The monthly total bill consisting of fixed fee and costs of calls cannot excess a predefined cost ceiling (cost cap).

These tariff components together with your monthly calling pattern define your monthly total bill. The following example illustrates this relationship. If you have been on the phone for 200 minutes, the following total bills sum up under the given tariffs:

Consumption of 200 min	Tariff 1	Tariff 2	Tariff 3
Fixed fee	24 €	0 €	9 €
Usage price	0,00 €	0,15 €	0,10 €
Allowance	0 min	0 min	100 min
Cost cap	none	27 €	none
Total bill in €	24 €	27 €	19 €

Tariff 1: You pay 24 € independent of your consumption.

Tariff 2: You pay 0.15 € per minute. After the 180th minute you reach the cost cap of 27 € and no further costs will occur.

Tariff 3: Independent of your consumption, you pay a fixed fee of 9 €. 100 minutes of your total consumption of 200 minutes are covered by the allowance. The remaining 100 minutes are charged by 0.10 € per minute.

Your total bill is accordingly 9 € + 100 min * 0.10 € = 19 €.

Question 5. *Please imagine you have been on the phone for exactly 100 minutes. Please calculate the total bill of the following tariffs:*

Consumption of 100 min	Tariff 1	Tariff 2	Tariff 3
Fixed fee	0 €	10 €	25 €
Usage price	0.10 €	0.15 €	0.00 €
Allowance	0 min	0 min	0 min
Cost cap	none	20 €	none
Total bill in €			

A.1.3 Evaluation of Your Calling Pattern

Question 6. *Please estimate how many minutes you are on your phone per month (only outgoing calls).*

I'm calling minimal ___ minutes per month.
I'm calling on average ___ minutes per month.
I'm calling maximal ___ minutes per month.

Question 7. *How sure are you about this estimation?*

very uncertain						very certain
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Please assume in the following, that you have to phone under a pay-per-use tariff and that there is no alternative tariff to choose. You only have to pay for each air time minute according to the usage price. This tariff does not include any fixed fee, allowance or cost cap.

QUESTION 8. *Please state how many minutes you would on average be on the phone with the given usage prices (outgoing calls only).*

0.40€/min	___ minutes
0.20€/min	___ minutes
0.10€/min	___ minutes
0.05€/min	___ minutes
0.01€/min	___ minutes
free of charge	___ minutes

QUESTION 9. *How sure are you about your consumption pattern?*

very uncertain						very certain
1	2	3	4	5	6	7
○	○	○	○	○	○	○

A.1.4 Tariff Choice (1/3)

Next, there will be three sets of questions each consisting of five choice tasks. In each choice task you have to choose one out of three tariff alternatives.
Please consider these tariffs as the only choice option. Do not compare these tariffs with your current tariff or recent offers on the mobile telecommunications market.
Even if the choice tasks appear to be similar, each alternative is different. Thus, please focus on every decision.
Choose every tariff according to your personal consumption.

QUESTION 10. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	0 €	5 €	10 €	none of these
Usage price	0.20 €	0.10 €	0.15 €	
Allowance	0 min	0 min	50 min	
Cost cap	15 €	20 €	15 €	
Your choice	○	○	○	○

QUESTION 11. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	10 €	7.50 €	5 €	none of these
Usage price	0.10 €	0.15 €	0.20 €	
Allowance	50 min	25 min	0 min	
Cost cap	15 €	none	20 €	
Your choice	○	○	○	○

QUESTION 12. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	0 €	7.50 €	0 €	none of these
Usage price	0.15 €	0.0 €	0.17 €	
Allowance	0 min	0 min	0 min	
Cost cap	none	none	8 €	
Your choice	○	○	○	○

QUESTION 13. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	5 €	10 €	7.50 €	none of these
Usage price	0.20 €	0.10 €	0.15 €	
Allowance	0 min	25 min	50 min	
Cost cap	none	15 €	20 €	
Your choice	○	○	○	○

QUESTION 14. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	10 €	7.50 €	0 €	none of these
Usage price	0.00 €	0.15 €	0.20 €	
Allowance	0 min	0 min	0 min	
Cost cap	none	20 €	15 €	
Your choice	○	○	○	○

A.1.5 Your Opinion on Tariff Schemes (1/3)

QUESTION 15. *Please state by the use of the following scale, whether the following statements apply to you.*

The probability of calling more than expected is higher than calling less.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Even though a tariff with cost ceiling is a little bit more expensive, I'm happy as my costs will never exceed this cost ceiling.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I don't want to bind myself paying a fixed fee regularly for mobile phone consumption.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I less enjoy being on the phone when costs are rising with every minute.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I feel way loose and impartial to use my cell phone, when the fixed fee includes already all running costs.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

While choosing a tariff, I pay attention to a low fixed fee, as I phone less from time to time.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

A.1.6 Tariff Choice (2/3)

You have to choose again between three alternative tariff in the following 5 choice sets. Please choose one tariff each.
Please take into account that only these offered tariffs are available to you. Do not compare these tariffs with your current tariff or recent offers on the mobile telecommunication market.

QUESTION 16. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	0 €	7.50 €	5 €	none of these
Usage price	0.20 €	0.00 €	0.10 €	
Allowance	0 min	0 min	50 min	
Cost cap	20 €	none	15 €	
Your choice	○	○	○	○

QUESTION 17. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	7.50 €	10 €	5 €	none of these
Usage price	0.15 €	0.10 €	0.20 €	
Allowance	25 min	50 min	0 min	
Cost cap	15 €	20 €	none	
Your choice	○	○	○	○

QUESTION 18. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	10 €	5 €	7.50 €	none of these
Usage price	0.15 €	0.20 €	0.10 €	
Allowance	25 min	0 min	50 min	
Cost cap	20 €	15 €	none	
Your choice	○	○	○	○

QUESTION 19. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	10 €	7.50 €	5 €	none of these
Usage price	0.15 €	0.10 €	0.20 €	
Allowance	50 min	25 min	0 min	
Cost cap	20 €	none	15 €	
Your choice	○	○	○	○

QUESTION 20. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	0 €	7.50 €	5 €	none of these
Usage price	0.20 €	0.15 €	0.10 €	
Allowance	0 min	25 min	0 min	
Cost cap	none	15 €	20 €	
Your choice	○	○	○	○

A.1.7 Your Opinion on Tariff Schemes (2/3)

QUESTION 21. *Please state by the use of the following scale, whether the following statements apply to you.*

It is important for me to be able to use my cell phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I don't like when calling costs are rising every minute.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It bothers me when the flat rate does not pay out in a month.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It's great when the monthly costs cannot exceed a defined amount, because I don't have to think about costs every minute.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I can well imagine to call more than the average.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

For the security that my costs will never exceed a predefined amount, I'm willing to pay a bit more on average.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It is important for me to be able to use my cell phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

A.1.8 Tariff Choice (3/3)

You have to choose again between three alternative tariff in the following 5 choice sets. Please choose one tariff each.

Please take into account that only these offered tariffs are available to you. Do not compare these tariffs with your current tariff or recent offers on the mobile telecommunication market.

QUESTION 22. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	7.50 €	5 €	0 €	none of these
Usage price	0.15 €	0.10 €	0.20 €	
Allowance	25 min	50 min	0 min	
Cost cap	15 €	none	20 €	
Your choice	○	○	○	○

QUESTION 23. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	0 €	7.55 €	0 €	none of these
Usage price	0.15 €	0.00 €	0.15 €	
Allowance	0 min	0 min	0 min	
Cost cap	none	none	7.50 €	
Your choice	○	○	○	○

QUESTION 24. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	7.50 €	7.50 €	10 €	none of these
Usage price	0.15 €	0.10 €	0.00 €	
Allowance	0 min	25 min	0 min	
Cost cap	15 €	none	none	
Your choice	○	○	○	○

QUESTION 25. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	7.50 €	5 €	10 €	none of these
Usage price	0.15 €	0.20 €	0.10 €	
Allowance	25 min	0 min	50 min	
Cost cap	none	20 €	15 €	
Your choice	○	○	○	○

QUESTION 26. *Which of these three tariffs would you choose?*

	Tariff 1	Tariff 2	Tariff 3	
Fixed fee	10 €	7.50 €	5 €	none of these
Usage price	0.15 €	0.10 €	0.20 €	
Allowance	50 min	25 min	0 min	
Cost cap	15 €	20 €	none	
Your choice	○	○	○	○

A.1.9 Your Opinion on Tariff Schemes (3/3)

QUESTION 27. *Please state by the use of the following scale, whether the following statements apply to you.*

The risk of calling more than average is higher than the risk of calling less than average.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

The assurance that my total bill will never exceed a certain amount is more important to me than choosing the cheapest tariff.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I don't like when costs are higher than originally anticipated.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Only if I don't have to pay per minute I'm happy to use my phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

If you pay attention to this questionnaire, answer this question with 7 "fully applies".

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It bothers me that I pay too much under a flat rate in times of low consumption.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

A.1.10 Consumption Pattern

QUESTION 28. *Who is the provider of your current tariff?*

- ○ T-Mobile
- ○ Vodafone
- ○ O2
- ○ E-Plus
- ○ 1und1
- ○ Alice
- ○ Base
- ○ BILDmobil
- ○ Blau
- ○ Congstar
- ○ Fonic
- ○ Mobilcom
- ○ Simyo
- ○ Other

QUESTION 29. *Please state all components your current tariff includes.*

- ○ Monthly fixed fee
- ○ Usage price
- ○ Flat rate for calling in any network (including fixed line)
- ○ Flat rate for calling in specific networks (e.g. only to fixed line)
- ○ Allowance
- ○ Cost cap
- ○ Minimum turnover
- ○ Internet/ data packet
- ○ SMS packet
- ○ Further components

QUESTION 30. *Please state how important the following components are when choosing a mobile tariff.*

	not important at all						very important
	1	2	3	4	5	6	7
Allowance	○	○	○	○	○	○	○
SMS packet	○	○	○	○	○	○	○
Usage price	○	○	○	○	○	○	○
Fixed fee	○	○	○	○	○	○	○
Data packet	○	○	○	○	○	○	○
Cost cap	○	○	○	○	○	○	○

QUESTION 31. *How do you pay for your mobile services?*

- ○ Prepaid (by cash before delivery)
- ○ Postpaid (by bill)

QUESTION 32. *How much is your average monthly total bill (including all services such as SMS or data consumption)?*

___ €

QUESTION 33. *Do you use a smartphone with this tariff?*

- ○ yes
- ○ no

QUESTION 34. *Please state whether the following statements apply to you.*

I mainly use my cell phone for private purposes.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I'm responsible for choosing my mobile tariff.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Friends ask for my advice when choosing a tariff.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It is important for me to be able to use my cell phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I have mainly chosen my tariff due the affiliated cell phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

My consumption pattern is significantly influenced by tariffs and usage prices.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

A.1.11 Questions about Yourself

Please answer some general questions about yourself.

QUESTION 35. *What is your profession?*

- ○ High school student/ apprentice
- ○ University student
- ○ Employee without personnel responsibility
- ○ Employee with personnel responsibility
- ○ Freelancer without personnel responsibility
- ○ Freelancer with personnel responsibility
- ○ Housewife/ househusband

- ○ Seeking work
- ○ Retired
- ○ Other

QUESTION 36. *What is your highest education level?*

- ○ Higher academic degree
- ○ Graduate degree
- ○ Undergraduate degree
- ○ General qualification for university entrance
- ○ General certificate of secondary education
- ○ Certificate of secondary education with apprenticeship
- ○ Certificate of secondary education without apprenticeship
- ○ Apprenticed/ student
- ○ No graduation
- ○ Other

QUESTION 37. *What is the net income of all persons living in your household?*

- ○ smaller or equal to 500€
- ○ 500 up to 1000€
- ○ 1000 up to 1500€
- ○ 1500 up to 200€

- 2000 up to 2500€
- 2500 up to 3000€
- 3000 up to 3500€
- 3500 up to 4000€
- 4000€ and more
- No answer

QUESTION 38. *What is your family status?*

- Single
- Live together with partner
- Married
- Divorced
- Widowed

QUESTION 39. *How many people live in your household?*

- 1 person
- 2 persons
- 3 persons
- 4 persons
- 5 persons
- more than 5 persons

QUESTION 40. *How many children live in your household?*

- ○ none
- ○ 1 child
- ○ 2 children
- ○ 3 children
- ○ 4 children
- ○ 5 children and more

QUESTION 41. *How would you evaluate your mathematical skills?*

very weakly pronounced						very strongly pronounced
1	2	3	4	5	6	7
○	○	○	○	○	○	○

A.1.12 Code of Honor

QUESTION 42. *Is there anything you want to tell us?*

Please allow us to ask a final question. This question does not have any impact on your payoff or your participation in future questionnaires. Your answer cannot be seen by the operating market research company.

QUESTION 43. *Have you answered all questions honestly and truthfully to the best of your knowledge?*

- ○ Yes
- ○ No

A.2 Supplementary Analysis

A.2.1 Sample Demographics

gender	#	age	#	income	#
male	365	14-19	68	[0€,500€)	16
female	381	20-29	159	[500€,1000€)	37
		30-39	128	[1000€,1500€)	54
		40-49	186	[1500€,2000€)	72
		50-59	135	[2000€,2500€)	97
		60-69	70	[2500€,3000€)	82
				[3000€,3500€)	92
				[3500€,4000€)	73
				[4000€,∞€)	113

A.2.2 Scale Development

TABLE A.1: *Multi-item scale on psychological effects*

	Taximeter
T1	I less enjoy being on the phone when costs are rising with every minute.
T2	Only if I don't have to pay per minute I'm happy to use my phone.
T3	I don't like when calling costs are rising every minute.
	Insurance
I1	For the security that my costs will never exceed a predefined amount, I'm willing to pay a bit more on average.
I2	Even though a tariff with cost ceiling is a little bit more expensive, I'm happy as my costs will never exceed this cost ceiling.
I3	The assurance that my total bill will never exceed a certain amount is more important to me than choosing the cheapest tariff.
	Overestimation
O1	I can well imagine to call more than the average.
O2	The probability of calling more than expected is higher than calling less.
O3	The risk of calling more than average is higher than the risk of calling less than average.
	Flexibility
F1	I don't want to bind myself paying a fixed fee regularly for mobile phone consumption.
F2	While choosing a tariff, I pay attention to a low fixed fee, as I phone less from time to time.
F3	It bothers me when the flat rate does not pay out in a month.

TABLE A.2: *Exploratory factor analysis: Pattern matrix*

item	factor				Cronbach's α
	1	2	3	4	
T1			0.7356		0.752
T2			0.5745		
T3			0.6835		
I1		0.6650			0.796
I2		0.7064			
I3		0.6372			
O1	0.7025				0.844
O2	0.7288				
O3	0.7224				
F1				0.5823	0.714
F2				0.6445	
F3				0.6743	
Note: Values <0.3 suppressed, varimax rotation					

A.2.3 Estimation Results

FIGURE A.1: *Draws of MCMC estimation*

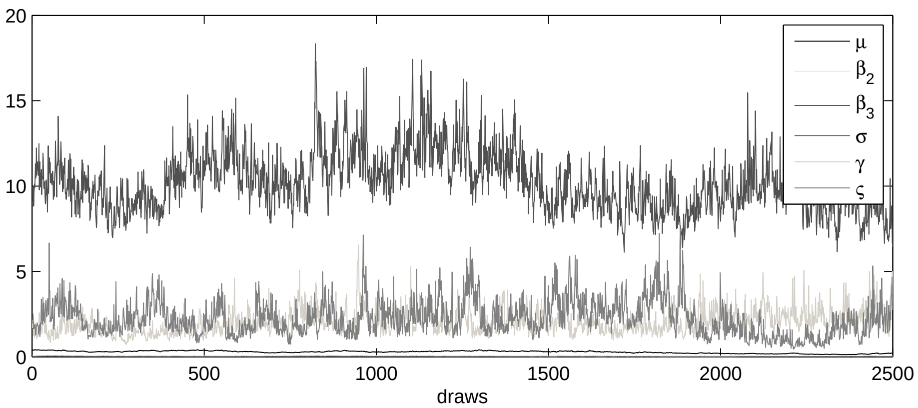


TABLE A.3: *Internal and external validity of alternative models*

	internal validity				external validity	
	SLL	Log BF	HR	MAD	HR	MAD
Model X	-8,087	-	56.06%	0.23	52.41%	0.29
Model Y	-8,167	-	65.23%	0.20	60.19%	0.27
Notes:	SLL: simulated log-likelihood, Log BF: log Bayes factor, HR: hit rate, MAD: mean absolute deviance					
Model X accounts for allowance bias						
Model Y accounts for externalities						

A.2.4 Additional Choice Sets

TABLE A.4: *Choice sets for evaluating tariff perception for medium and high consumption group*

		T1	T2	T3
M	fixed fee (f)	0 €	0 €	15 €
	minute price (p)	0.15 €/min	0.17 €/min	0.00 €/min
	cost cap (c)	∞ €	16 €	∞ €
H	fixed fee (f)	0 €	0 €	27.50 €
	minute price (p)	0.15 €/min	0.17 €/min	0.00 €/min
	cost cap (c)	∞ €	30 €	∞ €

Note: Components in parentheses describe the second choice set.

Appendix B

Empirical Study II

B.1 Questionnaire

This questionnaire was conducted and designed with appreciated help of Kateryna Shapovalova.

Dear participant,
this questionnaire is about choosing tariffs for cell phone usage and is part of a research project of the Institute of Information Systems and Marketing at the Karlsruhe Institute of Technology.
The questionnaire will take about 15 minutes to complete.
Your data will be used for scientific purposes only and not be given to any third party.
Thank you for your participation.

B.1.1 Introduction

QUESTION 1. *What is your gender?*

- ○ male
- ○ female

QUESTION 2. *How old are you?*

- ○ 0-13 years
- ○ 14-19 years
- ○ 20-24 years
- ○ 25-29 years
- ○ 30-34 years
- ○ 35-39 years
- ○ 40-44 years
- ○ 45-49 years
- ○ 50-54 years
- ○ 55-59 years
- ○ 60-64 years
- ○ 65 years and older

QUESTION 3. *Do you own a cell phone contract or a prepaid card, which you are currently using?*

- ○ yes
- ○ no

QUESTION 4. *Do you pay for one of them?*

- ○ yes
- ○ no

QUESTION 5. *Do you use your cell phone for private or business purposes?*

privat purposes only						business purposes only
1	2	3	4	5	6	7
○	○	○	○	○	○	○

QUESTION 6. *Please state whether the following statements apply to you.*

It is important for me to be able to use my cell phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I have mainly choosen my tariff due the affiliated cell phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

My consumption pattern is significantly influenced by tariffs and usage prices.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

B.1.2 Presentation of Tariff Schemes

In this section all tariff schemes will be presented which are relevant for this questionnaire. All tariffs of this questionnaire consider only air time minutes. Other services (e.g. SMS, data, apps) are not relevant in the context of this questionnaire.

Tariff scheme 1 - pay-per-use tariff: You pay a predefined price for every minute on the phone.
Tariff scheme 2 - flat rate tariff: You pay a predefined fixed fee per month and no further costs occur, independently of your phone consumption.
Tariff scheme 3 - cost cap tariff: You pay a predefined price for every minute on the phone. However, your total costs cannot exceed a predefined cost ceiling (cost cap).
Before reaching the cost cap this tariff is comparable to a pay-per-use tariff (tariff scheme 1). After reaching the cost cap this tariff is comparable to a flat rate tariff (tariff scheme 2).

Example: You use a cost cap tariff with a usage price of 0.10€/min and a cost cap of 30€. Assuming you have had 100 minutes of air time, you have to pay 100min x 0.10€ = 10€. If you have 500 minutes of air time, you would have exceeded the cost cap of 30€: 500min x 0.10€ = 50€. You only pay 30€.

QUESTION 7. *Please imagine you have been on the phone for exactly 300 minutes. Please calculate the total bill of the following tariffs:*

Consumption of 100 min	Tariff 1	Tariff 2	Tariff 3
Fixed fee	0 €	0 €	20 €
Usage price	0,10 €	0,15 €	0,00 €
Cost cap	none	25 €	none
Total bill in €			

B.1.3 Note

For the following questions, please assume your personal mobile phone consumption (outgoing calls only). Furthermore, assume that you have to pay for all calls by yourself. Please note: There is no "right" or "wrong" answers in the following questions. Answer all questions according to your personal assessment. Your assessment does not have to be dead on time.

B.1.4 Evaluation of Your Calling Pattern

QUESTION 8. *Please estimate how many minutes you are on your phone per month (only outgoing calls).*

I'm calling minimal ___ minutes per month.
I'm calling on average ___ minutes per month.
I'm calling maximal ___ minutes per month.

Please assume in the following, that you have to phone under a pay-per-use tariff and that there is no alternative tariff to choose. You only have to pay for each air time minute according to the usage price. This tariff does not include any fixed fee, allowance or cost cap.

QUESTION 9. *Please state how many minutes you would on average be on the phone with the given usage prices (outgoing calls only).*

0.40€/min	___ minutes
0.20€/min	___ minutes
0.10€/min	___ minutes
0.05€/min	___ minutes
0.01€/min	___ minutes
free of charge	___ minutes

QUESTION 10. *How sure are you about your consumption pattern?*

very uncertain						very certain
1	2	3	4	5	6	7
○	○	○	○	○	○	○

B.1.5 Tariff Choice (1/2)

Apart from your current tariff, imagine you have to choose one of the following tariffs. Please assume that you are choosing the tariff for your personal consumption in the following choice tasks.

QUESTION 11. *State the minimal, average and maximal number of minutes you would call with your cell phone for each tariff (only outgoing calls).*

	pay-per-use tariff	cost cap tariff	flat rate tariff
Fixed fee	0 €	0 €	25 €
Usage price	0.13 €	0.15 €	0.00 €
Cost cap	none	30 €	none
Minimal consumption			
Average consumption			
Maximal consumption			

QUESTION 12. *Please state how you rate each tariff.*

	not attractive at all 1	2	3	4	5	6	very attractive 7
Pay-per-use tariff	○	○	○	○	○	○	○
Flat rate tariff	○	○	○	○	○	○	○
Cost cap tariff	○	○	○	○	○	○	○

QUESTION 13. *Please state in which order you would choose these tariffs (state the most attractive tariff as number 1, the second most attractive as number 2 and so on)*

Your ranking: 1) ______ 2) ______ 3) ______

B.1.6 Tariff Choice (2/2)

In the following, prices have been changed. How would you choose now?

QUESTION 14. *State the minimal, average and maximal number of minute you would call with your cell phone for each tariff (only outgoing calls).*

	flat rate tariff	pay-per-use tariff	cost cap tariff
Fixed fee	20 €	0 €	0 €
Usage price	0.00 €	0.10 €	0.12 €
Cost cap	none	none	25 €
Minimal consumption			
Average consumption			
Maximal consumption			

QUESTION 15. *Please state how you rate each tariff.*

	not attractive at all 1	2	3	4	5	6	very attractive 7
Pay-per-use tariff	○	○	○	○	○	○	○
Flat rate tariff	○	○	○	○	○	○	○
Cost cap tariff	○	○	○	○	○	○	○

QUESTION 16. *Please state in which order you would choose these tariffs (state the most attractive tariff as number 1, the second most attractive as number 2 and so on)*

Your ranking: 1) ______ 2) ______ 3) ______

B.1.7 Note

You have already finished half of the questionnaire.

For the second part of the questionnaire, please imagine apart from your actual consumption that you use your cell phone for 200 minutes per month on average for outgoing calls and that you have to pay the costs for yourself. You monthly consumption varies between 0 and 400 minutes, while every number of minutes is equally likely.

B.1.8 Cost Cap Tariff

Please choose in each case between the given cost cap tariff and a flat rate tariff with a monthly fixed fee of 20€. Please take into account, that the cost cap tariff practically becomes a flat rate tariff after a specific amount of air time. The corresponding number of minutes are given respectively.

Please imagine apart from your actual consumption that you use your cell phone for 200 minutes per month on average for outgoing calls and that you have to pay the costs for yourself. You monthly consumptions varies between 0 and 400 minutes, while every number of minutes is equally likely.

QUESTION 17. *Which of these tariffs would you choose in each case?*

Flat rate tariff	Cost cap tariff	Flat rate tariff	Cost cap tariff
20 €/month	0.05 €/min 25 €/month cost cap above 500min	○	○
20 €/month	0.10 €/min 25 €/month cost cap above 250min	○	○
20 €/month	0.15 €/min 25 €/month cost cap above 166min	○	○
20 €/month	0.20 €/min 25 €/month cost cap above 125min	○	○
20 €/month	0.25 €/min 25 €/month cost cap above 100min	○	○

B.1.9 Payback Tariff

Now we would like to introduce you to a brand new tariff scheme: the payback tariff. Similar to a flat rate tariff you pay a fixed fee per month which includes all calling costs.

However, if you use less than a predefined number of minutes, you get money back for every unused minute.

Example: You pay 25€ under a payback tariff. For every minute you call less than 500 minutes, you get 0.05€ back. You can get back a maximum of 25€.

Please choose in each case between the given payback tariff and a flat rate tariff with a monthly fixed fee of 20€.

Please imagine apart from your actual consumption that you use your cell phone for 200 minutes per month on average for outgoing calls and that you have to pay the costs for yourself. You monthly consumption varies between 0 and 400 minutes, while every number of minutes is equally likely.

QUESTION 18. *Which of these tariffs would you choose in each case?*

Flat rate tariff	Payback tariff	Flat rate tariff	Payback tariff
20 €/month	25 €/month 0.05 €/min payback below 500min	○	○
20 €/month	25 €/month 0.10 €/min payback below 250min	○	○
20 €/month	25 €/month 0.15 €/min payback below 166min	○	○
20 €/month	25 €/month 0.20 €/min payback below 125min	○	○
20 €/month	25 €/month 0.25 €/min payback below 100min	○	○

B.1.10 Your Opinion on Tariff Schemes (1/3)

QUESTION 19. *Please state by the use of the following scale, whether the following statements apply to you.*

It is important for me to be able to use my cell phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

For the security that my costs will never exceed a predefined amount, I'm willing to pay a bit more on average.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It's great when the monthly costs cannot exceed a defined amount, because I don't have to think about costs every minute.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I don't like when calling costs are rising every minute.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It bothers me when the flat rate does not pay out in a month.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I can well imagine to call more than the average.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It's important to me to call enough so that my tariff has paid off afterwards.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

B.1.11 Your Opinion on Tariff Schemes (2/3)

QUESTION 20. *Please state by the use of the following scale, whether the following statements apply to you.*

I feel way loose and impartial to use my cell phone, when the fixed fee includes already all running costs.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I less enjoy being on the phone when costs are rising with every minute.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

The probability of calling more than expected is higher than calling less.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Even though a tariff with cost cap is a little bit more expensive, I'm happy because my costs will never exceed this cost cap.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

It's important to me to exhaust the flat rate.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Payback and cost cap tariff are equally attractive to me.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

B.1.12 Your Opinion on Tariff Schemes (3/3)

QUESTION 21. *Please state by the use of the following scale, whether the following statements apply to you.*

There is no difference between the payback and the cost cap tariff.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

The risk of calling more than average is higher than the risk of calling less than average.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I don't want to commit myself to pay regularly a fixed fee for mobile calling.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

I don't like when costs are higher than originally anticipated.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Only if I don't have to pay per minute I'm happy to use my phone.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

The assurance that my total bill will never exceed a certain amount is more important to me than choosing the cheapest tariff.

does not apply at all						fully applies
1	2	3	4	5	6	7
○	○	○	○	○	○	○

B.1.13 Details on Your Consumption Pattern

QUESTION 22. *Please state all components your current tariff includes.*

- ○ Monthly fixed fee
- ○ Usage price
- ○ Flat rate for calling in any network (including fixed line)
- ○ Flat rate for calling in specific networks (e.g. only to fixed line)

- ○ Allowance
- ○ Cost cap
- ○ Minimum turnover
- ○ Data packet
- ○ SMS packet
- ○ Further components

QUESTION 23. *How much is your average monthly total bill (including all services such as SMS or data consumption)?*

___ €

QUESTION 24. *Do you have a monthly budget for your mobile total bill?*

- ○ Yes
- ○ No

QUESTION 25. *How much is this budget?*

___ €

QUESTION 26. *How do you pay for your mobile services?*

- ○ Prepaid (by cash before delivery)
- ○ Postpaid (by bill)

B.1.14 Thought Experiment

Imagine you could participate in the following described free lotteries. Each lottery has two possible outcomes, which occur with equal probability. Your payoff depends on a) which lottery you choose and b) which outcome occurs.

Example: If you choose lottery 4 and outcome A occurs, you get 40€. If outcome B occurs, you get 4€.

QUESTION 27. *Please choose one of the following five lotteries, which you would like to play.*

Lottery	Outcome	Payoff	Probability	Your choice
1	A	16€	50%	○
	B	16€	50%	
2	A	24€	50%	○
	B	12€	50%	
3	A	32€	50%	○
	B	8€	50%	
4	A	40€	50%	○
	B	4€	50%	
5	A	48€	50%	○
	B	0€	50%	

B.1.15 Questions about Yourself

QUESTION 28. *What is your profession?*

- ○ High school student
- ○ University student
- ○ Apprentice
- ○ Employee
- ○ Freelancer

- Housewife/ househusband
- Seeking work
- Retired
- Other

QUESTION 29. *What is the net income of all persons living in your household?*

- smaller or equal to 500€
- 500 up to 1000€
- 1000 up to 1500€
- 1500 up to 2000€
- 2000 up to 2500€
- 2500 up to 3000€
- 3000 up to 3500€
- 3500 up to 4000€
- 4000€ and more
- No answer

QUESTION 30. *How many people live in your household?*

QUESTION 31. *How many children live in your household?*

QUESTION 32. *How would you evaluate your mathematical skills?*

very weakly pronounced						very strongly pronounced
1	2	3	4	5	6	7
○	○	○	○	○	○	○

QUESTION 33. *Is there anything you want to tell us?*

B.1.16 Code of Honor

Please allow us to ask a final question. This question does not have any impact on your payoff or your participation in future questionnaires. Your answer cannot be seen by the operating market research company.

QUESTION 34. *Have you answered all questions honestly and truthfully to the best of your knowledge?*

- ○ Yes
- ○ No

B.2 Supplementary Analysis

B.2.1 Sample Demographics

gender	#	age	#	income	#
male	154	14-19	10	[0€,500€)	12
female	176	20-24	37	[500€,1000€)	24
		25-29	41	[1000€,1500€)	35
		30-34	34	[1500€,2000€)	39
		35-39	28	[2000€,2500€)	61
		40-44	40	[2500€,3000€)	34
		45-49	44	[3000€,3500€)	27
		50-54	39	[3500€,4000€)	22
		55-59	31	[4000€,∞€)	43
		60-64	26		

B.2.2 Scale Development

TABLE B.1: *Multi-item scale on psychological effects*

	Taximeter
T1	I less enjoy being on the phone when costs are rising with every minute.
T2	Only if I don't have to pay per minute I'm happy to use my phone.
T3	I don't like when calling costs are rising every minute.
	Insurance
I1	For the security that my costs will never exceed a predefined amount, I'm willing to pay a bit more on average.
I2	Even though a tariff with cost ceiling is a little bit more expensive, I'm happy as my costs will never exceed this cost ceiling.
I3	The assurance that my total bill will never exceed a certain amount is more important to me than choosing the cheapest tariff.
	Overestimation
O1	I can well imagine to call more than the average.
O2	The probability of calling more than expected is higher than calling less.
O3	The risk of calling more than average is higher than the risk of calling less than average.
	Flexibility
F1	It bothers me when the flat rate does not pay out in a month.
F2	It's important to me to exhaust the flat rate.
F3	It's important to me to call enough so that my tariff has paid off afterwards.

TABLE B.2: *Exploratory factor analysis: Pattern matrix*

item	factor				Cronbach's α
	1	2	3	4	
T1			0.7367		0.705
T2			0.4506		
T3			0.6839		
I1	0.3130	0.6511			0.755
I2		0.5980			
I3	0.3261	0.6177			
O1	0.6872	0.3472			0.852
O2	0.7072				
O3	0.7537				
F1				0.4447	0.567
F2				0.5751	
F3				0.5738	

Note: Values <0.3 suppressed, varimax rotation

Appendix C

Experimental Instructions

Dear participant,

you will take part in an experiment designed for determining emotions. This experiment will take about 1.5 hours. The data obtained during this experiment is anonymized and will be used for scientific purposes only.

During the experiment your heart rate will be measured and recorded. Therefore, we ask you politely to keep the hand that is attached to the equipment still during the procedure.

During the experiment you can earn money. We guarantee a minimum payment of 5€ at the end of the experiment.

C.1 Procedure

General remarks In the course of the experiment you will make several telephone calls to a hotline that gives out voucher codes to the callers. You can redeem your voucher code right away and hereby earn money. Before you receive a valid voucher code at the end of the call, you will be placed in the waiting loop first. From this time on you will be charged connection costs.

Preliminary information Previous to each call, you will receive a budget to cover your expences. During a call the budget will be reduced by the connection costs. If the budget exceeds the resulting connection costs you will get the difference as a payoff in the end of the session. If the connection costs exceed your budget, the final payment at the end of the session will be reduced by this negative amount. Previous to each call your budget and the connection costs, which depend on the usage, will be displayed. The duration of the call and the actual costs are not known in advance. You can make a call by clicking on the button "Start call". After this action the call will be established.

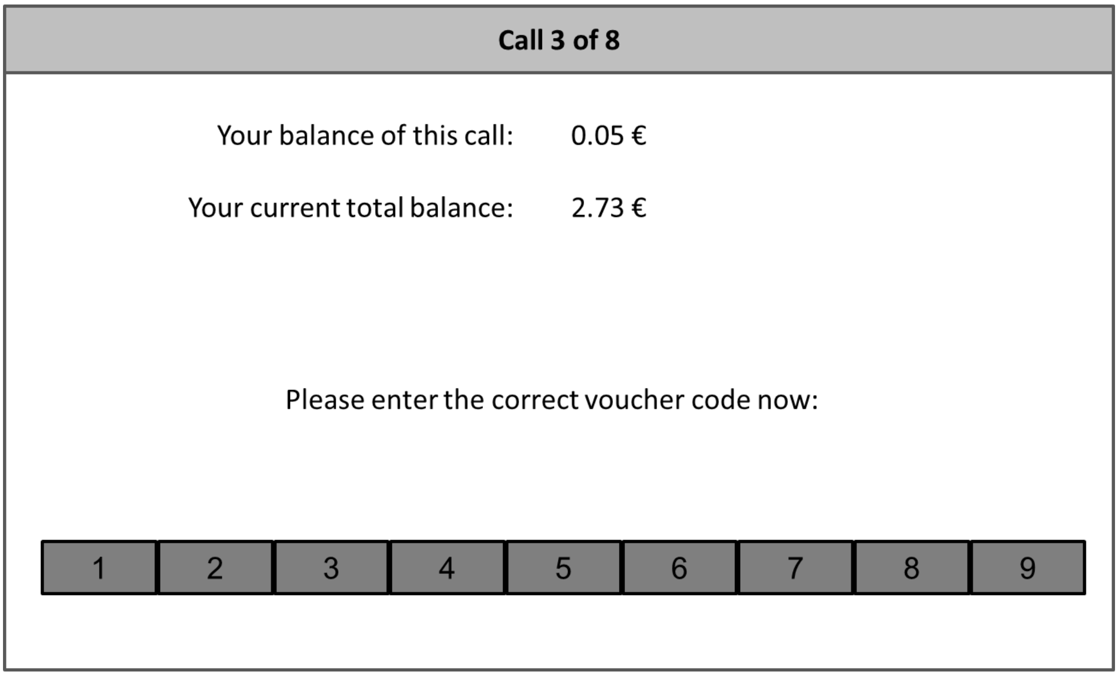
Waiting loop After the call is established you will be forwarded to a waiting line and be put on hold. At this point of time you cannot terminate the call on your own. During your call certain information will be displayed on your monitor:

Call 3 of 8		
Elapsed time:	0 min	34 sec
Your current budget:	6.50 €	
Your ongoing costs:	2.58 €	
Your current balance:	3.92 €	

On the top of your screen you will be informed about the number of your current call. The elapsed time informs you about the time you have already spent in the waiting loop. Your current budget is always determined for a certain call beforehand and does not change over its duration. In contrast, the ongoing costs reflect the currently accumulated connection costs. Furthermore, the difference between your budget and ongoing costs of the call is displayed as the current balance.

During the time in the waiting loop you will hear some background music. It will be regularly interrupted by a notice, asking you to be patient for some more time. Additionally there will be an acoustic signal, notifying a rise in costs.

Voucher code After an indefinite period of time you will be released from the waiting loop. You will then be shown a screen on which you have to enter the voucher code. From this moment on there are no further connection costs for this call.



This screen shows information about your current total balance of the entire experiment up to this point of time. In addition, the balance of the just terminated call is displayed.

At that time you will also hear a recorded message with your voucher code. This code has to be entered using the buttons numbered from one to nine. Your voucher is directly redeemed by clicking on a numbered button. If your input was correct, the value of the voucher will immediately be added to your overall balance.

To conclude this call, press the button "Terminate call" which will appear subsequently. After a pause of one minute the next call will be placed. During the entire experiment a total number of eight calls will be established.

Finally, after conducting eight calls, we kindly ask you to answer a concluding questionnaire.

C.2 Payment

The payment after each call consists of two parts. First, you get 1.50€ for each time entering the correct voucher code. Second, you get the balance of your current call added to you overall payment.

The balance is calculated as the difference between your budget for this call and the ongoing costs of this call. In this experiment you will get a budget of 6.50€ for each call. The variable costs of a call are calculated in units of 30 seconds each. Thereby you pay 1.29€ for each unit of 30 seconds. Additionally, there is a varying cost cap, which is assigned a value of 3.87€ or 6.45€ . This means you pay the variable costs of 1.29€ per unit only until the cost cap is reached. As soon as your ongoing costs have reached the cost cap, no further cost accrue. The beginning of a new 30 seconds unit is communicated to you by an acoustic signal as well as by a red highlighting of the displayed ongoing costs.

Example You are equipped with a cost cap of 3.87€. A call lasts 1 minute and 49 seconds and therefore consists of 4 commenced units of 30 seconds each. For the first three units you pay 1.29€ per unit. Afterwards the cost cap is in effect and as a result you do not pay for the fourth unit. The balance of this call is calculated as follows:

Budget:	6.50€
Ongoing costs:	3x1.29€ = 3.87€
Remaining balance:	6.50€ - 3.87€ = 2.63€

Assume you had an overall balance of 3.00€ up to this call. After this call the remaining balance of the call will be added to your overall payoff: 3.00€ + 2.63€ = 5.63€.

Entering the correct voucher code will add another 1.50€ to you overall payoff.

Example (contd.) The voucher code in this round is seven, which is correctly provided by you to the system. Afterwards, your overall payment is updated by adding 1.50€, so that your current total balance is: 5.63€ + 1.50€ = 7.13€.

The remaining balance as well as the value of voucher is added to the overall payoff after each call.

C.3 Concluding Remarks

At the beginning of the experiment a test call will be conducted. During this call you should become acquainted with the experimental situation of a call. Payoffs of this round are not taken into account in the final payment.

Afterwards there will be a rest period of 5 minutes, which is necessary for the physiological measurement. Please relax and stay calm during this period. Focus on the cross that is displayed on the screen. After 5 minutes have elapsed, the main part of the experiment will start with the first of eight calls.

If you have any questions considering the procedure of this experiment, please remain silent and signal to experiment supervisor. Please wait until the supervisor approaches you and then ask your question as quietly as possible.

Please use only your free hand to interact with the experimental system. The hand connected to the measurement equipment has to be kept still during the whole experiment. Try to avoid any kind of movement which could distort the measurement. Please remain seated after the experiment has finished and wait until the supervisor has removed the measurement electrodes. These instructions remain at your desk after the experiment.

Appendix D

Detailed Simulation Results

FIGURE D.1: *Profit of 2PT under different usage prices and fixed fees*

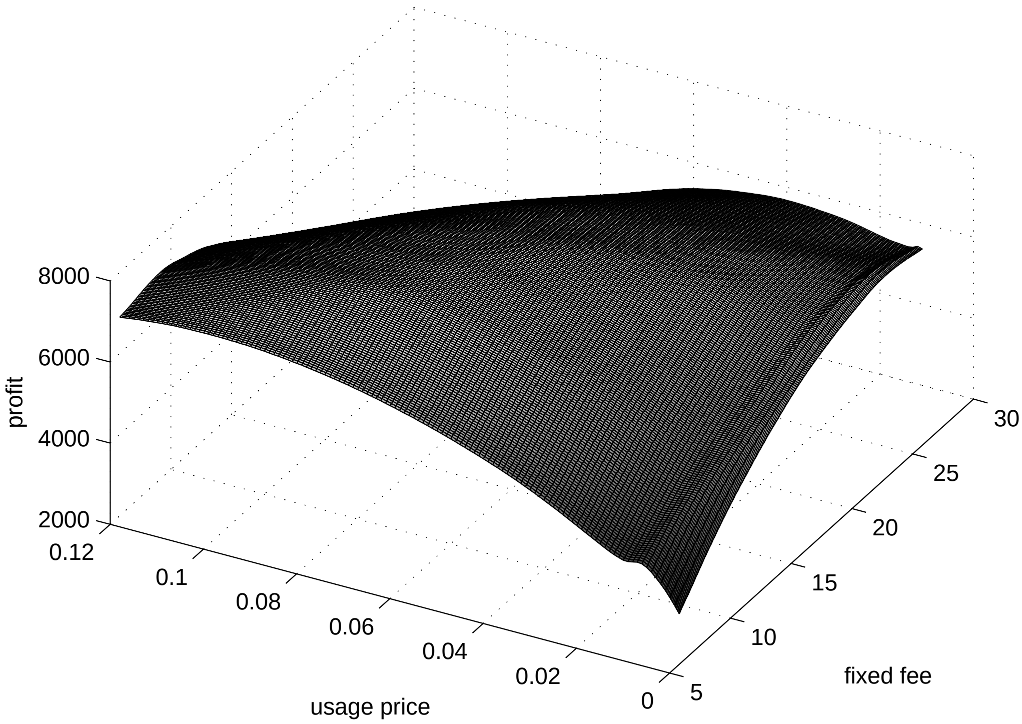


FIGURE D.2: *Profit of 3PTCC under different usage prices and fixed fees*

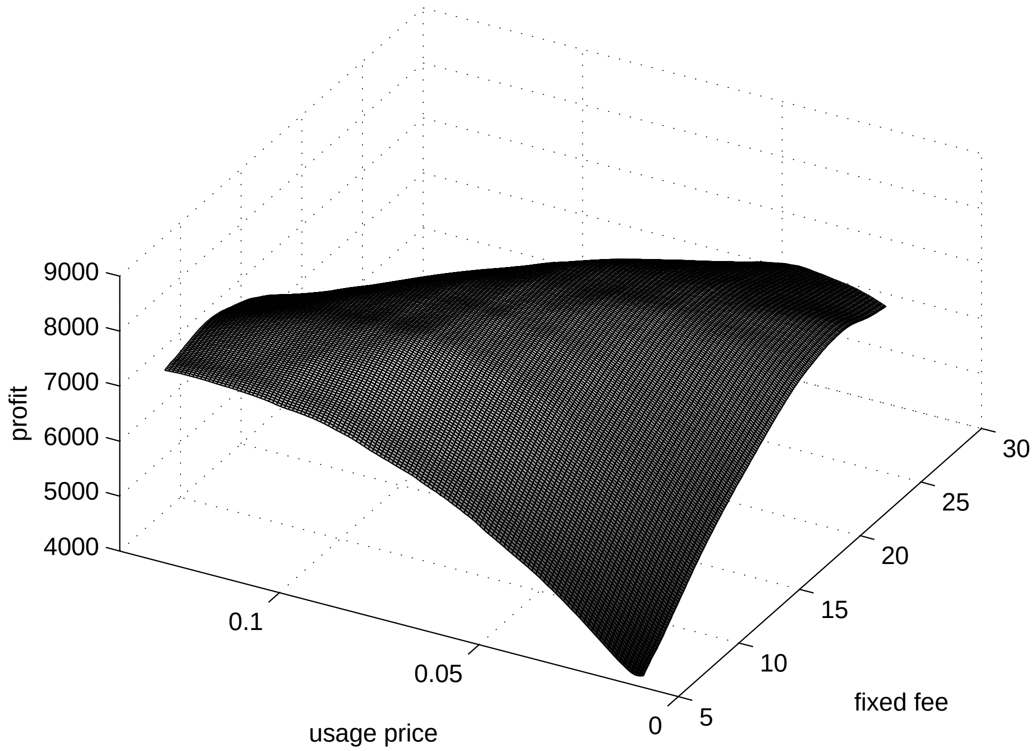


TABLE D.1: *Optimal tariffs under monopoly with varying marginal costs*

0¢ marginal costs		PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
usage price	¢/min	11.90		21.20	6.49	6.48	7.01	7.02
fixed fee	€		23.48		15.79	15.79	15.41	15.41
allowance	min					0		0
cost cap	€			40.32			61.98	62.03
profit	€	5,181	7,304	6,148	7,987	7,987	8,163	8,163
consumer share	%	84.52	39.89	80.59	39.35	39.37	39.52	39.50
total consumption	10^4min	4.35	13.46	5.17	5.17	5.17	6.13	6.13
profit per consumer	€/con	8.22	23.48	10.23	27.21	27.20	27.69	27.70
consumption per consumer	min/con	69.05	449.68	97.45	175.97	176.07	208.04	207.93

1¢ marginal costs		PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
usage price	¢/min	12.67		21.59	7.00	7.01	7.95	7.95
fixed fee	€		24.04		15.57	15.56	14.69	14.70
allowance	min					0		0
cost cap	€			40.70			66.22	66.21
profit	€	4,759	5,965	5,565	7.483	7,483	7,576	7,576
consumer share	%	83.97	40.69	80.35	38.92	38.92	39.92	40.48
total consumption	10^4min	4.08	13.33	5.81	4.94	4.94	5.75	5.75
profit per consumer	€/con	7.60	19.65	9.28	25.77	25.77	25.85	25.90
consumption per consumer	min/con	65.09	439.15	96.86	170.03	196.32	170.00	190.53

5¢ marginal costs		PU	FR	2PT CC	2PT F	3PT A	3PT CC	4PT
usage price	¢/min	15.68		17.93	8.79	8.79	8.79	8.79
fixed fee	€		36.14		14.38	14.38	14.38	14.38
allowance	min					0		0
cost cap	€			85.71			369.11	411.83
profit	€	3,321	2,006	3,523	5,659	5,659	5,659	5,659
consumer share	%	81.71	23.57	80.44	37.98	37.98	37.98	37.98
total consumption	10^4min	3.11	8.70	3.99	4.18	4.18	4.18	4.18
profit per consumer	€/con	5.45	11.41	5.87	19.97	19.97	19.97	19.97
consumption per consumer	min/con	51.01	494.69	66.49	147.59	147.59	147.59	147.59

Acronyms

2PTCC	cost cap tariff	17
2PTF	traditional two-part tariff	16
3PTA	three-part tariff with allowance	19
3PTCC	three-part tariff with cost cap	20
ADHRR	average deceleratory heart rate response	128
BF	Bayes factor	75
CC	cost cap tariff	18
CS	consumer surplus	24
DSL	digital subscription line	88
ECG	electrocardiogram	135
FR	flat rate tariff	15
HF	high-frequency	129
LF	low-frequency	129
MAD	mean absolute deviation	75