Empirical Evaluation of Fair Use Flat Rate Strategies for Mobile Internet

Tariffs constitute important decision making parameters in the marketing mix of mobile phone companies. Flat rates, as an example of such a pricing model, are decoupling the customers' usage and the generated revenue. This leads to commercial risks for telecommunication providers. The current price level for a data flat rate in conjunction with current technologies and usage patterns leads to high production costs and negative contribution margins. As an alternative concept, fair use flat rates lead to a limitation of use while also satisfying the typical customer usage patterns. Therefore, they are preferable to traditional flat rates. New production technologies such as LTE will not change this situation since they do not make customers more willing to pay. Instead, the motivation for the introduction of LTE is based on an improved cost situation for the telecommunication provider.

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1 Introduction

With yearly revenues of almost 150 billion Euros, the information and telecommunication sector is one of the largest industries in Germany (BMWI 2010). The availability of broadband Internet access over the mobile telephone network is especially seen as a pillar of hope within this market. These services known as "mobile Internet" are supposed to open up new sources of revenue and as a result will compensate for the difficult situation in the voice communication segment, which has been affected by saturation and price competition.

However, the demand for mobile Internet initially fell short of the service providers' expectations for a while. One particular reason for this was the price skimming strategy used by network operators as well as the low data transfer rates in relation to the fixed-line network (Delaney 2009). These adoption barriers were only overcome with the introduction of flat rate tariffs, a decline in the price level, and the roll-out of more efficient transmission technologies. The demand for mobile Internet is now increasing rapidly. For the period from 2008 to 2013 an average yearly growth of 46.8% in the number of users is expected. An average growth of 89.3% a year is predicted in data traffic and thus network load for the same period of time (Informa 2009).

This worldwide observed trend creates a fundamentally new situation for the network operators: Based on the limited capacity of the network infrastructure and mobile phone frequencies, the satisfaction of additional demand nowadays also requires a constant expansion of the network capacity. As a result the network operator faces direct production costs that depend on the consumed data volume. The postulate of "marginal costs near to zero" (Shapiro and Varian 1998) from Internet Economics is therefore no longer given in the case of the mobile Internet.

In order to account for these production costs and to offer mobile Internet profitably, the creation of a tariff portfolio (i.e., a menu of pricing plans) as a regulator between demand and costs is of central importance. Recently network operators are rising to the challenge, especially with the offer of so-called fair use flat rates. In this article, we understand fair use flat rates as a tariff with a fixed monthly price, but for which the transfer speed is restricted after a specified volume limit ("cap") is exceeded. As a result, there are no extra charges for exceeding the volume limit, but frequent usage and the cost risk to the provider is restricted. Thus, at present the monthly price of a leading German telecommunication company is €39.95 for a 5 GB volume limit and a speed of 7.2 Mbit/s.

The determination of price, volume, and speed of a fair use flat rate is a very complex economic problem (Marn et al. 2004). For example, a decrease in the volume limit leads to a lower usage on average, but also to a decrease in the number of customers and revenue. With regard to the international introduction of the next generation of mobile networks, Long Term Evolution (LTE), further central questions are how the added value to consumers due to the increased network speed as well as the improvement in the operators' cost situation should ideally be reflected in the price.

This paper aims to identify the optimal price structure for fair use flat rates. For this purpose, we suggest the use of a simulation model which demonstrates quantitatively the effect of different strategies on the contribution margin as an aid to decision making. Unlike the existing and, in most cases, purely analytical work on the determination of optimal prices (e.g., Schade et al. 2009; Png and Wang 2010), which assumes that customer preferences are known, this paper uses discrete choice experiments to empirically estimate consumers reaction to the offer of fair use flat rates.

Section 2 first presents the state of scientific research in the fields considered in this paper. Section 3 investigates the technological changes of mobile Internet providers due to the introduction of LTE. Section 4 presents the data collection and simulation study as the core of the paper. Section 5 concludes the work with a critical discussion of the results as well as an outlook for further research questions.

2 State of Research

The theories relevant for this paper are derived from the interpretation of mobile broadband access as a form of an information and communication system (ICS) which is designed to be offered as a product on the market. Mobile broadband access, as well as Software-as-a-service or other digital value-added services, therefore constitutes an instance of the class "ICS as a service on the market". With the introduction of such ICS, problems with acceptance often become apparent which point to methodical deficiencies in the design (GI 2010). In order to eliminate these acceptance problems, business information systems engineering (BISE) generally focuses on the development and implementation of methods for requirement analysis or requirement engineering and ultimately also on being able to early measure and test the perceived benefit of the product from the viewpoint of the user before its launch onto the market (GI 2010).

Based on this understanding, the following three scientific areas are of particular relevance: (1) Interdisciplinary explanation approaches of the Internet Economy, (2) the discussions about business models led by business administration and BISE, and (3) the methods for collecting data on customer preferences and their willingness to pay as developed in the fields of marketing and psychology.

2.1 Internet Economy

The Internet economy deals with the economic implications of the commercial use of the Internet, i.e. the production, distribution, and consumption of information goods (Shapiro and Varian 1998). The focus is typically on the non-access business, which is the provision of services and content. However, the optimal pricing strategy of mobile Internet access is also an elementary component of the information system "Internet" and thus is to be analyzed in this context. The fundamental works of Shapiro and Varian (1998) and Zerdick et al. (2001) identify the central questions for this purpose. These include not only technical aspects of implementation but also microeconomic discussions about its distribution and consumption. The objective, in terms of requirements engineering, is the theory-based analysis and formulation of more appropriate business models as a design pattern for use by market participants in the Internet economy.

In order to describe business models, the works of Stähler (2001) and Gordijn et al. (2005) develop suitable technical terminology. There is widespread agreement on the fact that the central areas of a business model represent the architecture of the added value, the range of benefits, and the revenue models. While the first is necessary to describe the production of information goods, the merging of the offered benefits and the revenue model is a critical factor for the purchase and utilization decision of customers. In the telecommunications industry, direct revenue models have prevailed over indirect revenue models funded by advertising, so that customers have to choose between different types of tariffs.

2.2 Revenue Models of ISPs

Until now fair use flat rates, as relevant tariff concepts of the telecommunications industry, have been largely neglected in research. Skiera (1999) investigates the use of flat rates, pay-per-use, and multi-part tariffs consisting of a fixed fee and a price per unit. These tariffs are aimed at customers with varying demand patterns – for example, frequent and infrequent users – so that the paid marginal price eventually depends on the usage and the chosen tariff. Lambrecht and Skiera (2006) show that customers have different preferences for these types of tariffs and that they prefer flat rates rather than multi-part tariffs even if they pay a higher price for the same service. On the one hand, the price payable at the end of the month remains constant so that the costs for the service can be planned. On the other hand, customers are unsure about the extent of usage (Delaney 2009) and flat rates can more easily be compared than multi-part tariffs. Customers also mentally record the cost of a flat rate at the beginning of the period. Since then no marginal costs are incurred at the time of consumption, the consumption that has already been paid for can be enjoyed to a greater extent (Lambrecht and Skiera 2006).

In the case of high variable costs, the flat rate proves to be problematic because the customer has no incentive to limit their use, which leads to a massive increase in network load in the mobile Internet, loss of service quality, and hence also costs for the service provider.

Fair use flat rates combine the benefits of classical flat rates as perceived by customers with the possibility for the provider to restrict user behavior. The tariffs proposed by Altmann and Chu (2001) are closest to these as they are differentiated by price and quantity as well as quality of service (QoS) – thus in the case of the mobile Internet they are differentiated by the data transfer speed. However, the authors distinguish a free version of the service with a very low QoS and a paid for version with a high QoS, and it remains unclear how tariffs can be aligned with the heterogeneous demand behavior.

2.3 Measurement of Customer Demand Behavior

We distinguish three empirical approaches to determine customer behavior (Völckner 2006): The use of (1) expert opinion, (2) transaction data (e.g., Lambrecht et al. 2007), and (3) survey data (e.g., Iyengar et al. 2008). Expert opinion is an important source of information obtained from people who have extensive expertise and experience on a particular subject. However, accuracy is not guaranteed and results are often subjective. Expert opinion does nevertheless offer considerable benefits if the data are used synergetically to evaluate the recommendations from other data sources.

In contrast, transaction data have a high external validity because they are based on real purchase decisions. However, the price usually varies only slightly and non-purchase decisions are not observed (Swait and Andrews 2003). Furthermore, they do not exist at the time of launch of a service and the effects of a slightly higher or lower price are hard to measure on demand. This in turn results in the fact that the customers' true willingness to pay remains unknown.

If transaction data are not available, it is advisable to use survey data, e.g., using discrete choice experiments (see Sect. 4.1). Survey data have the advantage over transaction data that the research subject being analyzed does not have to exist in reality and observations can be collected at low costs (Swait and Andrews 2003). In addition, the analyst may exert greater influence on the data generating process of the studies and can investigate important central problems in a more targeted manner. Survey data are frequently criticized due to their lower external validity since participants only make hypothetical decisions which have no direct consequences on their actions (Völckner 2006). Researchers currently face this criticism by combining incentive-compatible mechanisms, such as the Becker-DeGrot-Marschack mechanism (Wertenbroch and Skiera 2002), with the survey or they do not directly ask the participants about their willingness to pay (e.g., Ding 2007). Instead, they make choice decisions, such as in discrete choice experiments, which are comparable to real purchasing situations. Multi-part tariffs have only been investigated in the study by Iyengar et al. (2008), which evaluates tariffs with the help of survey data.

3 Technological Conditions for the Mobile Internet

The simulation study presented in Sect. 4 is used as decision support in order to bring technology-related costs and tariff-moderated demand for mobile Internet access in line with each other. The technological aspects relevant to this are presented in the following.

3.1 Established Technological Environment: UMTS and HSPA

The foundation for the currently available mobile Internet access was laid down with the roll-out of UMTS in 2003. The initial maximum possible data transfer rate with UMTS of 384 Kbit/s was still well below the speed of comparable fixed lines. This adoption barrier was finally overcome with the worldwide initiated roll-out of the technological standard High Speed Packet Access (HSPA) in 2007. It enables transfer rates of up to 7.2 Mbit/s, comparable to a DSL fixed line (Dahlman et al. 2008).

German network operators are already planning the launch of the next mobile generation. First of all, a double in the possible transfer rates to 14.4 Mbit/s is expected with the upgrade from HSPA to HSPA+. All the aforementioned technologies encompass the principles of resource sharing and packet-based data transfer. This means that the resources required for data transfer are not reserved exclusively for one connection, but rather all the information packets are processed in parallel according to the best-effort principle. Consequently, the available data rate per customer decreases with each addition to the network load. Thus, the current average transmission performance achieved with the use of HSPA is about 1 Mbit/s and therefore well below the theoretical maximum of 7.2 Mbit/s.

In line with the decreases in capacity and speed, costs incur for the network operator when providing mobile Internet access. These costs can be directly attributed to the individual units of service. In the short term, opportunity costs include the reduction in service quality and customer satisfaction. In the medium to long term, investments for capacity expansion of the radio access, backhaul, or core network should be considered as step-fixed costs. In addition to these congestion-related network costs (capacity costs), electricity and maintenance costs for the signal transfer (network-related operating costs) are recognized. In total, it is assumed that the production costs for the transfer of one megabyte of data volume over a mobile network in Germany in 2009 amount to 2 to 3 cents and are therefore ten times higher than in the fixed line network (Informa 2009).

After having had overcome different adoption barriers the mobile Internet has been able to report a huge growth in demand in Germany. In particular the use of mobile computers such as laptops or netbooks has also greatly increased. Here, mobile access is used either as a supplement or as a complete replacement for the domestic fixed line. With the increasing dispersion, though, the established mobile technologies are moving evermore towards their limits, in both technological and commercial terms.

3.2 The Pillar of Hope: LTE

While HSPA technology is based largely on UMTS, the transition towards Long Term Evolution (LTE) developed by the 3rd Generation Partnership Project as an international standard (Dahlman et al. 2008)[1] causes significant technological changes. Although LTE is designed to coexist with the previous technologies, there are still vast differences both in the architectural approach and in central radio interfaces for mobile technologies. As

[1] See also http://www.3gpp.org/-Industry-White-Papers.

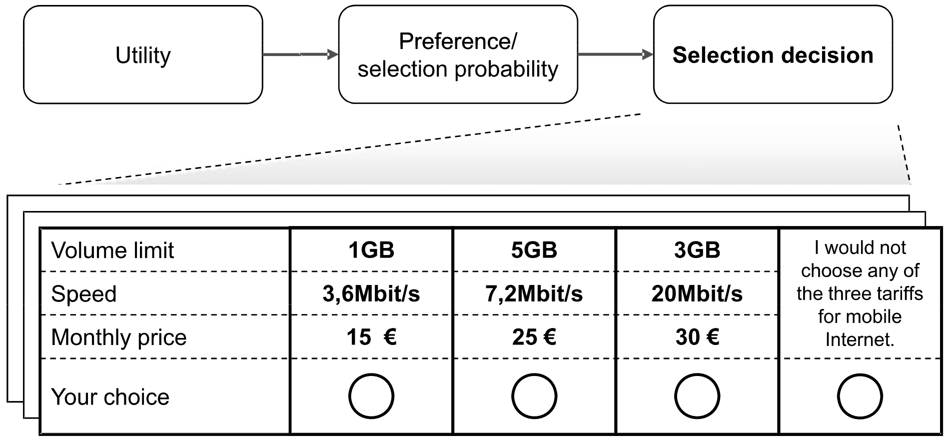

Fig. 1 Relationship between utility and selection decision

a consequence and opposed to its predecessors, LTE allows both a more flexible spectrum allocation and also better spectrum efficiency. Thus, the capacity of transmission towers equipped with LTE increases by a factor of three compared to HSPA. Capacity constraints can thus be resolved cost-effectively and for the time being by technologically upgrading existing transmission towers. It should be added that a simpler, more flexible architecture reduces administrative expense of an LTE network, compared to HSPA. Taken together, these effects are considered to cause a reduction in production costs of LTE-based mobile Internet access.

Besides these advantages in terms of costs, improvements also arise from a customer perspective. With the maximum data transfer rate, it is expected that there will be initial values of around 20 Mbit/s with an increase in subsequent years. Additionally, with LTE the latency, which is the waiting time between a call to Internet content and its transmission, is also decreased and thus the user experience is brought closer to the one of a DSL fixed Internet line.

Since the auctioning of spectrums for LTE has already been conducted in many European countries, mobile operators are currently carrying out network expansion. It is likely that the commercial availability of LTE in Germany will be announced by the end of 2011 at the latest. While sufficient transparency can be assumed with regard to the achievable cost savings with LTE, the question remains how much customers are willing to pay for LTE and what the impact is on the tariff design. This question is followed up in the next section.

4 Data Collection and Simulation Study

After having described the real market for the mobile Internet in the preceding section, this section is devoted to the model construction and analysis. For this purpose, first the methodology for the collection of customer preferences is presented and the results are explained. Following this, the preferences will be used in a simulation study to identify the effects of differently structured fair use flat rates on economic success.

4.1 Discrete Choice Experiments

The discrete choice experiment (Louviere et al. 2000) has established itself as an important data collection method for measuring the customer preferences in a variety of disciplines, such as marketing, psychology, or health care. Discrete choice experiments have a firm foundation in sociology and behavioral research and are known for being able to explain actual purchasing behavior very well (Swait and Andrews 2003).

The participants repeatedly choose their preferred alternative in a choice set (see **Fig. 1**), which is modeled on real decision-making situations (such as tariff selection). A choice set consists of several profiles which are described by features and their characteristics. Thus, in every choice set trade-off decisions must be made; this means choosing between different attractive combinations of feature characteristics which in turn allow to draw conclusions about the preferences of participants.

We employ random utility theory (Louviere et al. 2000) to analyze consumers' choices: it assumes that a participant h decides for the profile i that provides him with the highest latent – i.e., not directly observable – utility $u_{h,i}$. The term utility is used here as a quantitative measure of the satisfaction of needs and consists of a deterministic component $v_{h,i}$ and a stochastic component, the error term $\varepsilon_{h,i}$. The deterministic component is calculated from the subjective utility $\beta_h \cdot X_i$ (vector of utility parameters of the participant h multiplied with the design vector of the i-th product) minus the perceived costs $\varpi_h \cdot p_i$ (price parameter multiplied with price).

$$\begin{aligned} u_{h,i} &= v_{h,i} + \varepsilon_{h,i} \\ &= \beta_h \cdot X_i - \varpi_h \cdot p_i + \varepsilon_{h,i} \\ &(h \in H, i \in I). \end{aligned} \tag{1}$$

Based on the commonly used assumption of the Gumbel-distributed error term (Louviere et al. 2000), the Logit model can be formed. According to Train (2009), the differences compared with alternative distributions, such as the normal distribution, are negligibly low. The strength of the Logit model as opposed to, for example, the Probit model resulting from the normal distribution, is that it is mathematically simple and easy to interpret. This allows the selection probability $\Pr_{h,i}$ of the person h for profile i in choice set C_a to be described by:

$$\begin{aligned} \Pr_{h,i} &= \exp(v_{h,i}) \\ &\quad \times \Big(\exp(v_{h,0}) + \sum_{j \in C_a} \exp(v_{h,j})\Big)^{-1} \\ &(h \in H, i \in I), \end{aligned} \tag{2}$$

Equation (2) also takes into account a non-purchase option $v_{h,0} = 0$, in case a customer h decides against all the tariffs offered. The individual parameter distributions for each participant that explain the observed behavior can be estimated with the help of the Hierarchical Bayes model. The fact that this is

Table 1 Characteristics of the features of mobile Internet access

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Volume limit (in GB)	0.5	1.0	3.0	5.0	10.0	Unlimited		
Speed (in Mbit/s)	3.6	7.2	20.0					
Monthly price (in €)	10	15	20	25	30	35	40	45

Table 2 Results of the estimation

	Value						Importance weight
Constants							
Average	3.18						
Std. deviation	(3.86)						
Volume limit (in GB)	0.5	1.0	3.0	5.0	10.0	Unlimited	45.22%
Average	−6.72	−2.39	1.16	1.77	2.55	3.63	
Std. deviation	(3.04)	(1.68)	(0.96)	(1.06)	(1.57)	(2.57)	
Speed (in Mbit/s)	3.6	7.2	20.0				13.99%
Average	−1.88	0.55	1.33				
Std. deviation	(1.32)	(0.47)	(1.03)				
Monthly price							40.79%
Average	0.27						
Std. deviation	(0.17)						

possible despite the low number of observations (16 in the following study) is one of the main advantages of Hierarchical Bayes compared to alternative methods (see Online Appendix). For this purpose, more than several thousand iterations of behavior patterns of the population of participants are identified which serve to enrich the data of an individual participant. Hierarchical Bayes is therefore extremely computationally intensive and has only been used since a few years because of the increased performance capability of modern computers. A detailed description of the computation can be found in Gensler (2003) and the related assumptions are made in Chandukala et al. (2007).

4.2 Construction of the study

In order to develop the survey design, the most important characteristics of mobile Internet were identified (see **Table 1**) using a market analysis and a preliminary study, which applied the "dual questioning" technique (Myers and Alpert 1968). While the speeds 3.6 Mbit/s and 7.2 Mbit/s already exist on the market today with HSPA, 20 Mbit/s can be achieved solely through the introduction of LTE. The questionnaire of the main study consisted of four sections: The first section collected information on the Internet usage patterns of the participants, in particular the average monthly data consumption, but also the number of hours spent, for example, for surfing on websites, movies, online games, or music. In the second section, the choice decisions in the choice sets were made. In the third section, we asked how much participants expected to exceed or fall below the monthly volume limit for two offers with a speed of 7.2 Mbit/s and a volume limit of 1 GB and 5 GB. In the last section, we collected demographic and socio-economic information.

A major challenge is the creation of an efficient choice design (Street and Burgess 2007). For this purpose, the techniques in Street and Burgess (2007) were applied and a D-optimal $(6 \cdot 3 \cdot 8)$ full factorial design with 18 choice sets was generated. These designs are known for their high efficiency and their suitability for a diverse range of research designs. Each choice set shows three different tariffs for mobile Internet and a non-purchase option (see **Fig. 1**). The observations from 16 of 18 choice sets are included in the estimation and the remaining two choice sets are used to test the predictive validity.

4.3 Survey Results

An online survey conducted in September 2009 generated 270 completed questionnaires. The sample was collected by an online panel provider so that the composition of the sample is representative for the German population with respect to age and sex (see Online Appendix). The respondents showed moderate to strong interest in mobile Internet and 37.02% chose one of the top two categories on a 5-point Likert scale.

According to the respondents' self-assessment, usage is strongly oriented towards the consumption of the offered volume limit. 74.39% (87.54%) of participants claimed that they would not exceed the volume limit of a fair use flat rate with a 1 GB (5 GB) cap. Within this group, 44.64% (34.60%) of participants said they would align their usage exactly with the limit. 20.76% (33.22%) would make use of up to 200 MB (1 GB) less and 9.00% (19.72%) would use considerably less.

For the simulation, the customer preferences are estimated on an individual level with the Hierarchical Bayesian method. All features are effect-coded, except the price, which is subject to a vector model. A burn-in phase of 20,000 iterations was chosen for the estimation so that the system converges in the relevant field of information. The estimated parameters are based on the analysis of a further 20,000 iterations.

The results of the estimation and the importance weightings (see e.g., Gensler 2003) of the properties are listed in **Table 2**. All values are plausible and have the expected sign. The strictly monotonous mode in which utility in the volume limits and speeds increases, indicates high face validity. The most important feature for the participants is the volume limit (importance weight of 45.22%), almost equivalent to the price (importance weight of 40.79%). The speed has the lowest importance weight (13.99%). It is noteworthy that an unlimited monthly volume limit only offers an insignificant added value compared to the 10 GB limit. It is even more remarkable that the increase in benefit between the speed of 3.6 Mbit/s and 7.2 Mbit/s is valued much higher than that between 7.2 Mbit/s and 20 Mbit/s.

To assess the validity of the results, we consult the share of choices which were individually correctly predicted with an imputed first-choice model. The choice decisions are correctly forecasted in

Table 3 Tariffs and data consumption

	Tariff A_0 (Reference)	Tariff A_1	Tariff A_2	Tariff A_3	Tariff A_4	Tariff A_5	Tariff A_6	Tariff B	Tariff C
Simulated tariffs									
Volume limit (in GB)	5.0	1.0	1.0	3.0	5.0	10.0	Unlimited	5.0	5.0
Speed (in Mbit/s)	7.2	3.6	20.0	7.2	20.0	7.2	20.0	7.2	3.6
Monthly price (in €)	40	20	30	30	40	50	60	40	25
Estimated data consumption									
Average (in GB)	1.82	0.62	0.73	1.26	1.98	2.29	2.71		
Std. deviation	(1.33)	(0.24)	(0.26)	(0.76)	(1.42)	(2.15)	(3.13)		

86.40% of all choice sets used for the estimation and in 71.63% of the two remaining choice sets not considered in the estimation. Therefore, both values are well above the 25% chance criterion of random choice. Therefore, we conclude that our model is an adequate one (e.g., Figge and Theysohn 2006; Schlereth and Skiera 2009) and that the data are suitable for the following simulation.

4.4 Set-up of the Simulation

For demonstration purpose, different strategies for using fair use flat rates shall be investigated on the basis of the collected customer preferences. In addition, the extent to which the reduction of variable costs, caused by innovations such as LTE, affects the optimal design of the tariff offer is to be analyzed as important information for an investment decision.

For this purpose, a simulation model is applied which integrates information about the major factors that influence price determination: Customer benefit, competitive prices, and costs of the company (see Simon and Fassnacht 2009). The decision alternatives are therefore valued while taking into account all direct price-relevant information at the same time. Simulations of this kind in price research are considered to be particularly powerful, but at the same time extremely challenging (see Wiltinger 1998).

Formally, the model is described as the functional relationship $E = f(X, Y)$ between objective criteria (E), decision alternatives (X), and environmental parameters (Y) (see Hanssmann 1993). The starting point of the model is telecommunications provider A who wants to maximize the contribution margin (E) by adjusting their currently offered fair use flat rate A_0. As a secondary objective, efforts will be made to increase the number of customers. The pricing strategies (X), which are exemplary evaluated, are listed in **Table 3** in the form of tariffs A_1 to A_6 (X).

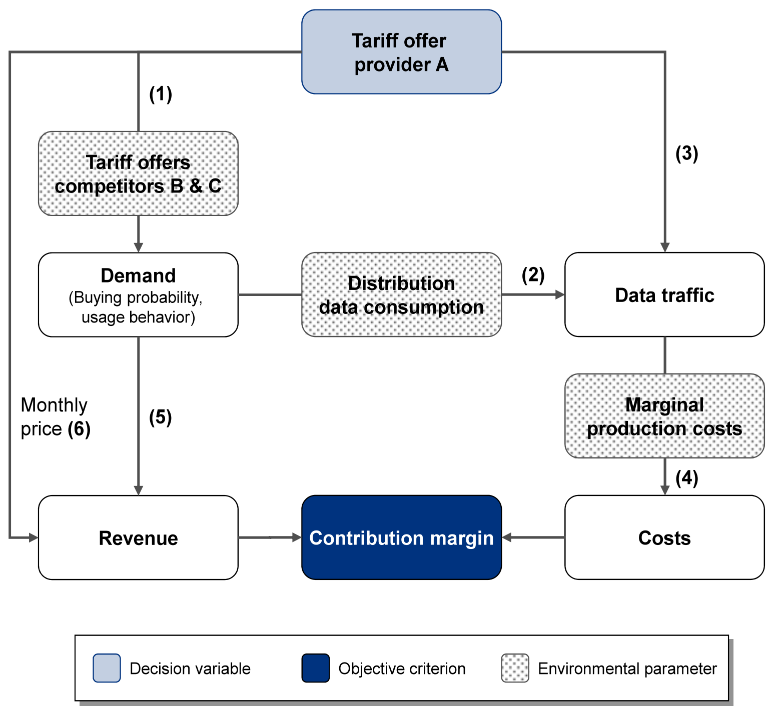

Fig. 2 System relationships

The environmental parameters of the model are the marginal production costs of the supplier, competitive offers, and the distribution of data consumption to consumers. The competitive situation in Germany is reflected more simply by considering two static competing offers B and C. The distribution of data consumption is parameterized by the position ("average per capita consumption") and shape ("asymmetry") of a log-normal distribution in the model.

The relationship between these model parameters is illustrated in **Fig. 2** (based on Skiera (2010); for more complex structural models see, for example, Reiss and Wolak 2007). The offer of service provider A determines the customer benefit and thus the demand according to the tariff offered by competitors (1). The set-up of the tariff factors influences both the amount of customers and their Internet usage behavior (Iyengar et al. 2008). The latter occurs in two different ways: First, different tariffs address different types of users (for example, frequent or infrequent users). Second, the tariff ex post moderates the usage behavior of customers as they adjust the amount they use to fit the tariff they have purchased.

The data traffic (2) is derived from the amount of customers and their usage behavior, and it is moderated by the expected distribution of the data consumption (Skiera 2010). Furthermore, the data traffic is directly affected by the tariff features volume limit and speed (3): The speed in the tariff moderates the indi-

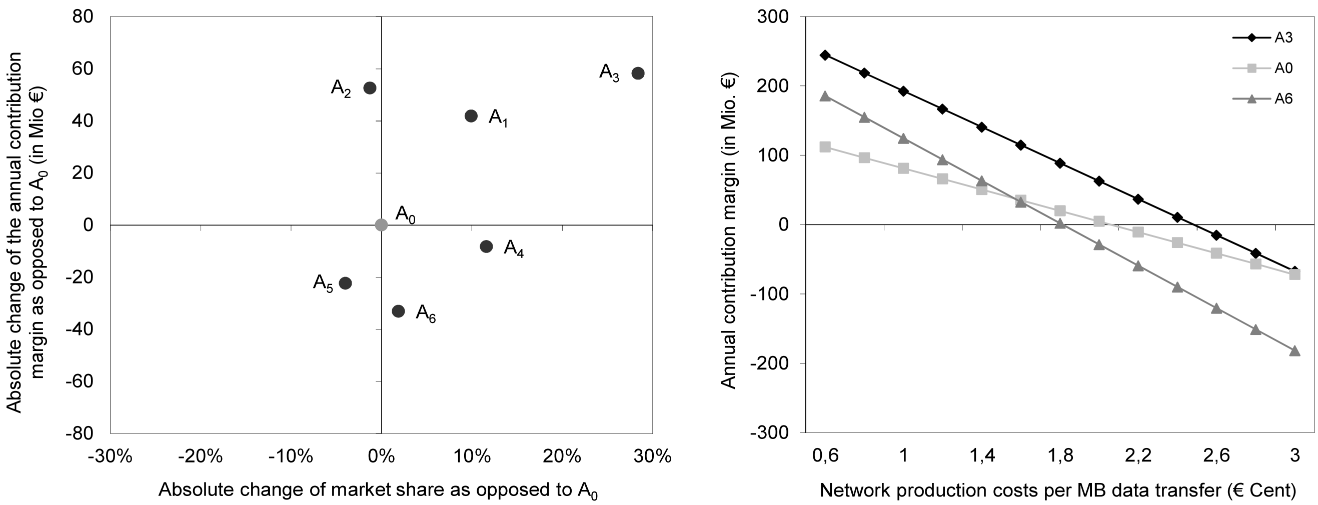

Fig. 3 Simulation results

vidual data consumption per month, and the volume determines its monthly upper limit.[2] The price-induced costs result from the product of data traffic and production costs per unit volume (4). The product of the number of customers (5) and the price (6) provides the achieved revenue (Reiss and Wolak 2007).

The specific modeling of the revenue side and cost side is explained in the following: The selection probability of the customer h for tariff A_i is calculated in (3) taking into account competitors B and C (Draganska et al. 2010) by:

$$\Pr_{h,A_i} = \exp(v_{h,A_i}) \times \big(\exp(v_{h,0}) + \exp(v_{h,A_i}) + \exp(v_{h,B}) + \exp(v_{h,C})\big)^{-1} \quad (h \in H, A_i \in I). \tag{3}$$

The revenue is the product of the probability of that tariff A_i is chosen and the monthly price: $U_{A_i} = \sum_{h \in H} \Pr_{h,A_i} \cdot p_{A_i}$. An overall market potential of 10 million consumers was taken in order to scale the sample to the size of the total German market (Informa 2009).

To model the cost side, the subjects were first arranged into an ordinal ranking according to the estimated consumption data on the use of fixed Internet on the basis of their statements in the first part of the questionnaire. Then, the data consumption was determined by drawing random numbers from a log-normal distribution using the principle of inversion of the probability transformation (Liebl 1995) and assigned to the subjects. The parameters of the log-normal distribution were estimated as $\mu = 0.7$ and $\sigma = 1.6$. The resulting distributions correspond to previous empirical studies on Internet usage (Hatton 2008; Persson 2010). In the third step, the data consumption of a subject concerning their use of mobile Internet was determined as an individual percentage of their use of fixed Internet for each case. For this, we used the answers in the first and third part of the questionnaire. In addition, we assumed that a tariff with a speed of 3.6 Mbit/s (20 Mbit/s) leads to data consumption being ten percent lower (higher) than with 7.2 Mbit/s.

4.5 Simulation Results

The simulation results are summarized in **Fig. 3**. The left half of the figure illustrates the simulation results for the case of variable costs of 2 cents per MB. The right half of the diagram shows the sensitivity of the simulation results when the variable costs are altered.

Figure 3 shows that the starting tariff of operator A is not optimal and only achieves a slightly positive contribution margin. Starting from the basic rate A_0, the maximum contribution is achieved through a price reduction while reducing the tariff volume at the same time (tariffs A_1, A_2, and A_3). Thus, for example, by reducing the monthly price from €40 to 30 in conjunction with a reduction in the volume limit from 5 GB to 3 GB, the observed operator increases their contribution to €60 million per annum, while achieving a 30 percent higher market share (tariff A_3).

The introduction of a higher transmission speed of 20 Mbit/s will only lead to improved results in the model if the factors price and volume are adjusted at the same time. Otherwise, the achieved contribution margin decreases (tariff A_4), since consumers' additional willingness to pay for the higher transmission speed is not sufficient to compensate for the extra data consumption. The offer of a true flat rate (tariff A_6) proves to be particularly insufficient in the simulation.

The right half of **Fig. 3** shows the sensitivity of the achieved contribution margin to the marginal cost of production for basic rate A_0, as well as the tariffs with the highest (tariff A_3) and lowest (tariff A_6) contribution margin in the scenario of variable costs of 2 cents per MB. This shows that tariff A_3 achieved the highest contribution margin of the three observed rates, almost independently of the level of the variable costs. Furthermore, it is evident that the unlimited flat rate (tariff A_6) will be profitable at production costs below 1.6 cents per MB. With variable cost of less than 1.4 cents per MB it leads to a higher contribution margin than the base strategy (tariff A_0).

5 Conclusion

5.1 Discussion of Results

Based on the simulation results, three strategic recommendations for telecommunications providers can be derived. First, the model confirms that traditional flat rates with unlimited usage cannot

[2] In the model we abstract from data traffic which is caused by the use of a reduced speed (64 kbps).

Abstract

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Empirical Evaluation of Fair Use Flat Rate Strategies for Mobile Internet

The fair use flat rate is a promising tariff concept for the mobile telecommunication industry. Similar to classical flat rates it allows unlimited usage at a fixed monthly fee. Contrary to classical flat rates it limits the access speed once a certain usage threshold is exceeded. Due to the current global roll-out of the LTE (Long Term Evolution) technology and the related economic changes for telecommunication providers, the application of fair use flat rates needs a reassessment. We therefore propose a simulation model to evaluate different pricing strategies and their contribution margin impact. The key input element of the model is provided by so-called discrete choice experiments that allow the estimation of customer preferences.

Based on this customer information and the simulation results, the article provides the following recommendations. Classical flat rates do not allow profitable provisioning of mobile Internet access. Instead, operators should apply fair use flat rates with a lower usage threshold of 1 or 3 GB which leads to an improved contribution margin. Bandwidth and speed are secondary and do merely impact customer preferences. The main motivation for new mobile technologies such as LTE should therefore be to improve the cost structure of an operator rather than using it to skim an assumed higher willingness to pay of mobile subscribers.

Keywords: Mobile Internet, Discrete choice experiments, Fair use flat rates

be provided profitably at current market prices and the current cost level of HSPA. Therefore, the cancellation of these tariff models is advisable for every telecommunication provider and respective tariff decisions have already taken place on the market. With a reduction in production costs to below 1.6 cents per MB, as would be possible through the use of LTE, the simulation model shows a change in this situation. Based on such a cost level, higher contribution margins can be achieved with an unlimited flat rate than with the reference tariff A_0.

With regard to the current high variable costs, a second recommendation can be made. That is to differentiate flat rate tariffs more than in the past with the help of the segmentation of different usage levels. This statement is based on the simultaneous improvement of the contribution and market share in tariff A_1 and tariff A_3 (see **Fig. 3**) which address completely different types of users. Tariff A_1 with a competitive price point and a lower transfer volume addresses the sporadic users of the mobile Internet who only access information through mobile access to a limited extent. Consequently, the offered data transfer performance is of secondary importance and 3.6 Mbit/s is sufficient for this segment. Tariff A_3 addresses the frequent users of mobile Internet. Here, the model shows that maximum data volumes and data transfer services are not absolutely necessary. The model also shows that 3 GB already addresses the data volume requirements of most frequent users. The additional offer of Internet access at speeds of 7.2 Mbit/s and with a 3 GB volume limit thus promises the best way to increase market share and also contribution margin. Despite the general homogeneity of mobile Internet service, the simulation results support the finding that a differentiation of the services positively affects the achieved contribution margin.

The third recommendation relates to the low importance weighting of the data transfer speed. In the study, it was found that the availability of an LTE enabled 20 Mbit/s speed least impacted the preference of customers. At the same time the increase in speed from 7.2 Mbit/s to 20 Mbit/s offers a much smaller added value than the jump from 3.6 Mbit/s to 7.2 Mbit/s enabled by the introduction of HSPA (see **Table 2**). Hence, the value of LTE is caused by the technological cost benefits for the telecommunications provider rather than by a possible increase in revenue due to a higher proportion of customer preferences related to data transfer speed. With the emergence of new mobile application fields with higher demands on the data transfer speed, a change in this situation is likely. Possible candidates for such preference changing applications are, for example, cloud computing services, mobile interactive TV, and video calls.

This raises the general question of the temporal and geographic transferability of the results. In a temporal sense, this is limited by the fact that customer preference structures are instable and depend on the current establishment level of the examined good (Teichert 2001). In geographical terms, the benefit awarded to consumers varies depending on the local market situation, for instance the price level or availability of substitute goods. Due to very similar development histories of the respective telecommunications markets, it can be assumed that the results can be transferred to the European, and to a certain extent, the North American markets.

For the three recommendations stated it is also to be considered that simplifying assumptions were made, which should be resolved gradually in future research. For example, static prices were assumed for competing service providers. However, in reality competition is expected to be more dynamic (Draganska et al. 2010), with the competition adjusting its prices to newly introduced tariffs until a Bertrand-Nash price equilibrium (Draganska et al. 2010) is achieved. Nevertheless, this is not a trivial method of modeling, particularly in the context of services, since tariff choice and quantity decisions have to be considered simultaneously and also because perceptions of the benefit can change over time. Another limitation arises from the simplified model of the cost side. For example, we abstracted from a possible cost reduction with an increasing output quantity, we exclusively considered volume-based network costs, and omitted the existence of purely customer-related costs, such as for sales commissions, in order to provide a clearer presentation.

5.2 Outlook

The aim of this study is to identify the optimal pricing strategy for fair use flat rates taking into account new technologies such as LTE. Although fair use flat rates are currently mainly applied in the context of mobile Internet, they are also suitable for many other Internet-based services which have variable costs and can be differentiated on the basis of QoS. One example are commercial Web services that use and combine fee-based Web services themselves as a way of creating a mash-up service. These services could be offered at attractive flat rate prices. However, the reduction of certain QoS characteristics at high utilization will ensure that the variable costs do not exceed the achieved revenue.

The use of empirically-supported simulation models can assist in finding the best possible service and tariff portfolios and provide additional knowledge for investment decisions. The study sees itself as a contribution to answering the question of private financing of the infrastructure necessary for an information society. The problem of intense price competition in the marketing of homogeneous information and communication services, which is postulated through economic theory and can be observed on the market, presents telecommunication providers with the challenge of developing robust revenue sources for financing. Market mechanisms can only make sure that the necessary investments are made for the development of new information infrastructure if adequate answers to these problems are found. Initial problems of market mechanisms running the risk of failure can already be observed. For example, experts understand that the Italian telecommunication network is close to collapsing because of the lack of investment in capacity expansion. The same applies to Great Britain and the U.S. (Kort 2010).

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Appendix (available online via http://springerlink.com)

Appendix 1 – Evaluation of the Assumptions for the Estimation

The assumptions which are frequently made for the data analysis of discrete choice experiments are summarized in various papers and books, for example, in Chapter 2 of Chandukala et al. (2007). In the following, we critically examine the assumptions and summarize briefly the extent to which we consider the assumptions to be fulfilled. For a detailed discussion we refer to Chandukala et al. (2007).

Tab. A-1 Assumptions regarding the estimation und their critical evaluation

Assumptions	Critical evaluation
(i) Choices are conditionally independent.	The D-efficient design of the discrete choice experiment ensures that the choice alternatives are independent. Thereby, we neglect potential dynamic cognitive processes (e.g., learning or fatigue effects when providing responses in each choice set).
(ii) Choice probabilities are driven by parameters that do not change over time.	Due to the fact that the discrete choice experiment is answered in a relatively short period of time (e.g., within 5 minutes), it can be assumed that preferences remain constant. Again, we abstract from dynamic cognitive. This assumption has to be critically questioned in the analysis of transaction data with actually made decisions over a much longer period of time.
(iii) Demand is represented by zero's and one's, indicating no choice and choice.	This assumption has already been ensured when developing discrete choice experiments. The integration of a non-purchase option in every choice set also allows that consumers are not forced to make a decision if all the alternatives are unattractive.
(iv) There is an explicit set of choice alternatives included in the analysis.	This assumption has also already been ensured by the carefully constructed design of discrete choice experiments.
(v) There is an explicit function form for covariates.	The estimation carried out in this work omits the inclusion of covariates (e.g., age, gender, or income). For the attributes and levels shown in the selection alternatives an additive functional relationship is assumed.
(vi) Some of the coefficients are unique to the choice alternatives, while others are constant across choice alternatives.	The utility function used in this study includes both a constant (which is identified through the non-purchase option) and coefficients which depend on the characteristics of a tariff.
(vii) The independence of irrelevant alternatives property is valid.	This assumption is discussed critically in the literature, and there are plenty of counter examples in which this property is not fulfilled (see for example the red bus, blue bus discussion in Train 2009). In this paper, this property should be fulfilled, because only one service category (mobile Internet) is considered and the tariffs in the choice sets are clearly distinguished by the design.

Appendix 2 – Comparison of Estimation Methods

This section compares two alternatives to the Hierarchical Bayesian method, which has been employed in the study: the maximum likelihood and latent class estimation techniques. The difference consists in the aggregation level at which the parameter values are determined. In the case of discrete choice experiments, maximum likelihood methods are only able to accurately determine a vector of parameter values which describes the preferences of all respondents (aggregated level estimates). Therefore, the method is suitable if the respondents are largely homogeneous in terms of their preferences. In contrast, finite mixture models assume that there are several segments with different preferences, and that respondents belong to one of these segments (latent segment level). The membership of a respondent to a segment as well as the parameter values that describe them are estimated simultaneously in this approach. Individual parameters for each respondent can mostly only be estimated with Hierarchical Bayes (individual level). A detailed overview of the functionality of the estimation is provided by Gensler (2003).

The differences in model quality of the different aggregation levels are shown in the following comparison applying all three methods of estimation. Thereby, we make use of the commonly applied first choice hit rate (percentage of the correctly predicted choices with the estimated parameters) and the mean absolute deviation (MAD) between the predicted probability of the selected and actually observed choices (e.g., Gensler 2003). These two ratios are used to predict both the choice sets considered in the estimation (internal validity) and the two holdouts (predicted validity). In the case of the finite mixture model, a discrete number of segment classes, i.e., a number of groups with different selection behavior, must be specified in advance. As an example, we have chosen the segment classes 4 and 8 in the following comparison. The results of the comparison are reported in **Table A-2**.

Table A-2 Quality of the estimations

	Internal validity		***Predicted validity***	
	First choice rate	**MAD**	**First choice hit rate**	**MAD**
Maximum likelihood	52%	0.61	57%	0.58
Finite mixture (4 segment classes)	70%	0.42	66%	0.46
Finite mixture (8 segment classes)	75%	0.36	62%	0.44
Hierarchical Bayes	86%	0.22	76%	0.27

The model that considers the largest degree of heterogeneity, i.e., Hierarchical Bayes, yields the highest model quality. The differences with respect to the maximum likelihood estimates are large (e.g., 86% vs. 52% and 76% vs. 57% hit rate). It can be concluded that the preferences of respondents are very heterogeneous and that a consideration of these preferences during the estimation substantially improves the results’ internal and predictive validity.

Appendix 3 – Representativeness of the Survey Participants Regarding the German Population

In cooperation with a German survey panel provider a representative sample of the population was collected. This sample consists of 49.83% male participants (49.00% share of men in Germany) and an average age of 44.50 years (average age 42.10 years in Germany). A detailed comparison by age groups can be found in **Table A-3**.

Table A-3 Comparison of age groups

Share \ Age	**18-21**	**22-40**	**41-65**
Population	5.7%	37.1%	57.1%
Survey	4.8%	28.7%	66.4%

* Population shares are taken from the Federal Statistical Office. Only the age groups between 18-65 years were considered.