# Analysis of consumer preferences for mobile telecom plans using a discrete choice experiment[☆]

João Confraria[a,b], Tiago Ribeiro[c,d], Helder Vasconcelos[a,e]

[a] *ANACOM, Av. José Malhoa, 12, 1099-017 Lisboa, Portugal*

[b] *Católica Lisbon - School of Business and Economics*

[c] *Indera - Estudos Económicos, Lda, Rua do Campo Alegre, 1346-01 4150 Porto, Portugal*

[d] *Institute for Choice - University of South Australia, Level 13, 140 Arthur Street, North Sydney NSW 2060*

[e] *Faculdade de Economia do Porto, Rua Dr. Roberto Frias, 4200-464 Porto, Portugal*

**Abstract**

In this paper, we present a study of consumer preferences for mobile telecommunications plans and operator characteristics. The objective of the study was to identify consumer preferences for the following characteristics of mobile plans: the importance of using the same provider as friends and family (calling club network effects), the market share of the provider (pure network effects), the length of the commitment period, monthly fee/recharge obligations and per minute call charges for calls made within and outside the provider network. A discrete choice experiment was used as a preference elicitation method and implemented in face-to-face interviews. We present results regarding willingness to pay for the described features as well as their relationship to socio-demographic variables. Consumers are willing to pay 1.3 Euro per month more to reduce the commitment period from 1 year to 6 months and willing to pay 2.5 euros per month more to be part of a larger network. Consumers are also twice as much more sensitive to within-network price variations than extra-network price variations. These results remain unchanged in the sub-sample of those that have internet access suggesting that a web-based surveys are capable of producing unbiased results. The implications of these results for regulatory policy are discussed.

*Keywords:*
Stated Preference survey, Discrete Choice Experiments, Network effects, Experimental design
JEL: C25, C38, C93, L96

[☆] We are grateful to the Editor and to two anonymous referees for their thorough and thoughtful reports. The views expressed in this article are those of the authors and do not necessarily reflect the official opinion of the institutions with which they are affiliated. Any errors are the sole responsibility of the authors.

*Email addresses:* joao.confraria@anacom.pt (João Confraria), tiago.ribeiro@indera.pt (Tiago Ribeiro ), helder.vasconcelos@anacom.pt (Helder Vasconcelos)

*URL:* http://www.anacom.pt (João Confraria), http://www.indera.pt (Tiago Ribeiro ), http://www.fep.up.pt/docentes/hvasconcelos/ (Helder Vasconcelos)

## 1. Introduction

In this paper, we present a study of consumer preferences for mobile telecommunications plans and operator characteristics, making use of data collected through a state preference survey which is representative of the entire Portuguese population.

The objective of this study is two-fold. First, it explores the importance of network effects in consumers' choices in mobile telecommunications markets. To this end, we empirically test whether consumers take into account global and local network effects when selecting their tariff-plans. Relatedly, we also investigate whether there are network effects that are induced by mobile operators' rate differentiation between on-net and off-net calls, by testing how do consumers react to changes in the price of the calls to the same network (on-net calls) as opposed to changes regarding the prices of calls to other networks (off-net calls). Second, this study aims at analyzing the role of switching costs in mobile telecommunications. In particular, it investigates the importance of the minimum length of subscription duration (the so called commitment period), the existence of which is usually indicated as a source of (static) market power and as an important restriction to the "natural" evolution of market dynamics as it tends to give rise to lock-in effects.[1]

With these two main objectives in mind, we identify consumer preferences for the following characteristics of mobile plans: the importance of using the same provider as friends and family (the so called calling club network effects or local network effects), the market share of the provider (so as to measure as pure or global network effects), the length of the commitment period, monthly fee/recharge obligations and per minute call charges for calls made within and outside the provider network.

A novelty of this paper is then to empirically investigate the *joint* effect of switching costs and network effects (both local network effects and global network effects) in determining consumers' preferences when selecting their mobile telecommunication plans.

Despite their increasing importance in the literature, switching costs and network effects have mainly been empirically studied separately. However, as the existing theoretical literature shows, it is the interaction between these two factors that reinforces the well known lock-in effect ( Farrell and Klemperer (2007)). Hence, in markets where both are present, as it is clearly the case in the mobile telecommunications industry, a separate analysis of these two factors may well bias in a substantial way the estimation and the interpretation of their induced effects on individual choices regarding mobile plans.

To the best of our knowledge, the two exceptions studying the joint effect of network effects and switching costs in the mobile telecommunication industry are Fuentelsaz et al. (2012) and Maicas et al. (2009).[2] These studies are, however, concerned with the induced impacts on the level of competition and on the choice of supplier, whereas the present paper is focused instead on the individual decision making process regarding the choice amongst specific mobile telecommunication plans (offered by the same firm or by different firms). By so doing and by making use of a new methodological approach, we contribute both to the extant literature and to the policy discussion by empirically demonstrating that consumers who value having friends in the same network also tend to be more sensitive to commitment periods. In addition, and perhaps more importantly, we are able to provide estimates about the cost that a firm must incur (by means

[1] See Villas-Boas (2015) and Farrell and Klemperer (2007) for surveys on the effects of switching costs on product market competition.

[2] See Section 2 for more a detailed description of these two studies.

of providing a discount in the monthly fee) so as to be able to lock in consumers for an additional six month period, controlling for the presence of network effects. These results are therefore useful both for firms, when designing their pricing strategies, and for regulators, who are certainly interested in understanding whereas those pricing strategies may (or may not) give rise to lock-in effects which prevent effective competition between existing firms in the market or deter new entry.

We use a discrete choice experiment as a preference elicitation method. We present results regarding willingness to pay for the described features as well as their relationship to socio-demographic variables. We find that consumers are willing to pay 1.3 Euro per month more to reduce the commitment period from 1 year to 6 months and willing to pay 2.5 euros per month more to be part of a larger network. In addition, our empirical results suggest that consumers are also twice as much more sensitive to on-net price variations than off-net price variations. Interestingly, this last result appears to be related to the recent findings of European Commission Special Eurobarometer 396,[3] where it is highlighted that: (**i**) roughly half of the EU respondents involved in the survey agreed that they have limited their calls to mobile or fixed phones on another network operator because they were concerned about charges; (**ii**) the proportion of respondents that agreed that they limited calls to mobile or fixed phones on another network varied significantly across EU countries; and (**iii**) Portugal was found to be the country with the highest level of agreement regarding this statement about off-net calls limitation because of concerns related to communications charges, with 86% of Portuguese respondents recognizing to have adopted such behavior.

Our results may then be of interest to regulators as they may be useful to discuss the eventual need for regulation related to commitment periods and also to discuss implications for regulating on- and off-net price discrimination.

The paper is organized as follows: Section 2 presents a review of the literature; Section 3 includes a detailed description of the data, the survey design and the estimation methods used; Section 4 presents the results of the analysis; Section 5 discusses the regulatory policy implications that can be drawn from the obtained results; and Section 6 provides final remarks.

## 2. Review of the relevant literature

This paper is related to different strands of the broad extant literature on tariff choice in mobile telecommunications markets. A first strand of this literature investigates which network is relevant to the consumer when choosing between different network operators. Is it the total number of subscribers of a particular network (global network effects) or is it rather the choice of people living in the same area (regional network effects) or belonging to a more restricted social network (local network effects)? Based on Turkish micro-data, Karaçuka et al. (2013) conclude that local network effects are significant for consumer choice: consumers are more likely to be affected by the choices of other people within their local area than by the overall size of a network. In particular, their findings suggest that regional network effects (as measured by market shares at the province level) are more important than network effects at the country level (as measured by national market shares). In addition, Birke and Swann (2006, 2010) provide some evidence that the individual choice of operator is influenced by the total number of subscribers for each operator,

[3] See European Commission Special Eurobarometer 396 (November, 2013): E-Communications Household Survey, available at: http://ec.europa.eu/public_opinion/archives/ebs/ebs_396_en.pdf.

but a much stronger effect is due to the operator choice of other household members, on the one hand, and to the operator choice of people belonging to the individual's wider social network, on the other. These findings are thus in line with Swann (2002) who argues that whilst all other users are a potential source of network effects, some users (or groups of users) matter more than others, implying that the utility derived by an individual subscriber is more heavily influenced by the composition of a network than by the size of the network per se. Similarly, Corrocher and Zirulia (2009), based on a survey involving Italian students, investigate: (*i*) to what extent consumers take into account their contacts' operators in choosing a provider; and (*ii*) which individual characteristics affect the importance consumers attach to local network effects. Their results suggest that consumers are highly heterogeneous with respect to their evaluation of the importance of their friends' and/or family members' operators in their choice of a provider, and that such heterogeneity is associated with specific characteristics such as individual innovativeness and specific mobile phone usage patterns. In particular, they find that users who ascribe importance to local network effects use voice services quite intensively and are typically more-aware users (e.g. they tend to spend a substantial amount of time screening the different options before joining an operator).

Relatedly, some recent literature has introduced the notion of calling clubs in communications networks, accounting for the fact that subscribers tend to place most calls to a limited number of other subscribers (see e.g. Gabrielsen and Vagstad (2008)). A recent contribution is that of Hoernig et al. (2014) who propose a model of telecommunications network competition with non-uniform calling patterns.[4] In particular, they assume that subscribers with similar preferences (say, friends and family, or people closely related by social links) are more likely called than those further away in the preference space. In so doing, they investigate how concentrated calling patterns, naturally involving a higher fraction of on-net calls, affect the equilibrium outcomes and also discuss implications for regulating (prohibiting) on- and off-net price discrimination. Their model is therefore in line with some empirical evidence that Sobolewski and Czajkowski (2012) present for the mobile telecommunications in Poland. In particular, by employing a choice experiment similar to the one carried out in the present paper, Czajkowski and Sobolewski (2011) find that: " *the network effect is more influential for those whom the consumer considers to be closer or maintains contacts more often (e.g. family members) than for looser relationships (e.g. friends). ...* [*In addition,*] *this effect is far stronger than the size of the total base of an operator's users (others), which did not turn out to significantly contribute to the choice of an operator.*" (p. 209). Interestingly, however, in the present paper, we find that while calling club effects are not in themselves statistically significant, Portuguese consumers are significantly more sensitive to on-net price variations than to off-net price variations. Hence, a partial network effect (a calling club network effect) is probably being captured by this price sensitivity.

Our work is thus closely related as well to another strand of the literature that explores how consumers react towards price differentiation between on-net and off-net calls in mobile telecommunications. Bolle and Heimel (2005) claim that even if a provider with a lower market share places lower on-net and off-net prices than a larger rival (i.e. even if it offers a dominant price vector), its average price might in the end be higher than that of the larger provider. The reason is simply that the average price faced by a specific consumer depends also on her personal demand structure (on-net versus off net calling frequencies). Interestingly, however, by making use of evidence from the German mobile phone market, they find that most consumers choices were primarily guided by the dominance relations in the competing price vectors. They then conclude

[4]They thus relax a standard assumption in the previous literature that each subscriber is assumed to call each other subscriber with equal probability, the so called uniform calling pattern assumption (see e.g. Armstrong (1998) or Laffont et al. (1998a) Laffont et al. (1998b) ).

that while it is true that network size matters when new subscribers choose their service providers (as shown, for example, by Kim and Kwon (2003)),[5] the large networks' advantage is not as substantial as it should be in the presence of rational consumers. Consequently, they defend that competition authorities and regulators might have less reasons to worry about the concern which was put forward by Laffont et al. (1998b) that on-net/off-net price discrimination, which leads to tariff-mediated network externalities, might be used as an effective instrument to block small scale entry.[6] Along similar lines, but using a much larger sample based on a survey involving German students, Haucap and Heimeshoff (2011) find that a large share of students does not correctly incorporate the structure of their on-net and off-net calls in their calculations to find the optimal tariff. In addition, a fair number of students also suffer from what they refer to as a "price differentiation bias", in the sense that they tend to overestimate the savings that would result from reduced on-net and/or off-net charges, since they appear not to weigh the prices with the probabilities of placing on-net or off-net calls. Their results may then help to explain why it have been the small entrants in various European mobile telecommunications markets those that initiated on-net discounts. As Zucchini et al. (2013) point out, this anecdotal evidence may seem surprising given the theoretical research cited above on tariff-mediated network effects, according to which large network operators may use one net discounts as an anti-competitive instrument so as to leverage their installed bases and force small operators out of the market or prevent them from entering. One possible explanation for why on-net discounts may be attractive for small telecommunications operators as well is given by research on marketing and consumer behavior (e.g. Lambrecht and Skiera (2006)), which suggests that small operators can use on-net discounts as an important strategic marketing tool to advertise with low on-net prices. Interestingly, however, by using German data on tariff setting in mobile telecommunications to test whether tariff-mediated network effects or strategic discounting are the dominant motivation behind on-net discounts, Zucchini et al. (2013) conclude that large operators are more likely to offer tariffs with on-net discounts. In sum, their results are consistent with theoretical models that propose large operators using tariff-mediated network effects as a competitive instrument as the main driver of on-net discounts, thereby supporting the regulation of on-net discounts by large operators while not suggesting to limit their use as a marketing instrument by small operators.

Our analysis also contributes to the empirical literature on switching costs in telecommunications by investigating consumer preferences regarding alternative lengths of the commitment period. Recent contributions regarding the impact of switching barriers (such as subscription duration or number portability procedures between mobile network operators) on customer loyalty and retention include Lee et al. (2006), Kim et al. (2004) , Kim and Yoon (2004) and Gerpott et al. (2001), to name a few.[7] Moreover, Fuentelsaz et al. (2012) analyze empirically the joint effect of switching costs and network effects in determining the level

[5]Based on a consumer survey for the Korean mobile telecommunications market Kim and Kwon (2003) show that: (*i*) consumers tend to prefer carriers with a large number of subscribers (other things being equal); and (*ii*) intra-network call discounts are one likely source of that effect.

[6]See also Lopez and Rey (2016), Calzada and Valletti (2008), and Hoernig (2007), who study whether the tariff-mediated network externality created by the on-net/off-net price discrimination can be strategically used by large networks for predatory purposes against smaller rivals. In addition, see Cabral (2011) for an investigation of the dynamic implications of alternative policies regarding termination charges, on the one hand, and network effects created by termination-based price discrimination, on the other. In particular, he highlights the importance of considering how different levels of termination charges lead to different dynamic paths of network market structure. For example, he shows that higher markups of termination charges over marginal cost, in addition to the short-run deadweight loss, imply a higher degree of market dominance (i.e. a greater tendency for larger networks to become even larger).

[7]Nakamura (2010), following an empirical approach similar to Lee et al. (2006), examines which factors give rise to switching costs in the Japanese mobile telecommunications market. In particular, he examines empirically users' preferences regarding

of competition and market dynamics in the European mobile communications industry. By so doing, they find that the differences observed among market structures in the different European countries are partially determined by the levels of both switching costs and network effects: the higher the magnitude of switching costs and network effects, the lower the competition in the market (their simultaneous presence tends to favor the emergence of the well-known lock-in effect). They then suggest that regulators and policy makers should strengthen their efforts to reduce the negative consequences of switching costs and network effects, especially in those countries where operators seem to enjoy privileged positions. Along related lines, Maicas et al. (2009) analyze the joint effect of what they refer to as personal network effects (related to the individual's social network), on the one hand, and switching costs, on the other, in explaining customer choice in the Spanish mobile telecommunications industry. Their results reveal that the probability that a customer selects a mobile phone company increases especially with the number of members of her social network already subscribed to that provider, and that switching costs are significantly present in the mobile phone market making switching providers costly.

Our methodological approach draws on the discrete choice analysis literature, represented by, e.g., McFadden (1974), McFadden and Train (2000), Train (2003) and on the literature related to direct elicitation of preferences.

Stated preference surveys have been used in and are widely accepted in some fields, such as transportation economics (Hensher (1994)), environmental economics (Mitchell and Carson (1989)), marketing ( Louviere et al. (2000)), and health economics ( Flynn et al. (2007)). Among sociologists stated preference surveys have been used to study social norms ( Rossi and Nock (1982); Finch and Mason (1990)).

They are an important tool to enable the forecasting of choices of various agents operating in a market (or hypothetical markets where none exist in the real world), as well as to obtain estimates of behavioral outputs of interest, such as marginal rates of substitution and willingness to pay measures.

Differences in terminology used in various fields are common when referring to the methods employed here. References to vignette methods or fractional factorial surveys appear in the sociology literature (Rossi and Nock (1982) ), in relation to the use of carefully constructed realistic hypothetical situations as a context for studying and measuring attitudes with respect to social norms. In marketing the term conjoint analysis is often used to refer to a wide set of techniques some of which are consistent with the ones employed here (Carson and Louviere (2011)) and the term choice based conjoint is sometimes used to distinguish the techniques from the more general conjoint analysis. In economics, "contingent evaluation" ( Mitchell and Carson (1989)) is sometimes used to describe one form of stated choice survey and choice based conjoint (CBC) (McFadden (2015)) is often used when describing the techniques used here.

More recently, the terms used in this paper - stated-choice methods and more concretely discrete choice experiments (DCE) have been proposed in an attempt to promote a common vocabulary (Carson and Louviere (2011)).

As used in this paper a DCE has two essential elements: (1) a respondent is asked to make a discrete choice between two or more alternatives in a choice set, and (2) the alternatives presented for choice are constructed by means of an experimental design that varies one or more attributes within- and/or between-respondents to be able to estimate economic quantities tied to preference parameters (Carson and Louviere (2011)).

an hypothetical SIM unlock situation.

In some fields, the use of stated-choice methods is met with skepticism by researchers regarding the validity of studies of hypothetical behavior as predictors of actual behavior. The validity check is whether this behavior in fact matches market behavior Past evidence permits the identification of some of the necessary conditions under which this occurs (see Green et al. (2001), Cameron et al. (2013) and McFadden (2014)).

For a summary of the theoretical, statistical, and behavioral underpinnings of methods for direct preference elicitation see McFadden (2015).

## 3. Method

We implemented a stated preference survey to elicit preferences regarding mobile telecommunications plans and operator characteristics. Survey respondents are presented with concrete hypothetical situations in which they are asked to choose between a selection of different alternatives. The alternatives are defined by a set of attributes. These attributes can assume different levels which are varied to produce different alternatives. Therefore answers, in the form of selected preferred alternatives, embody information about respondents' preferences with respect to the attributes that define the alternatives.

Variation of features mobile telecommunications plans and operator characteristics is seldom present in observational data to an extent that allows identification of preferences and willingness to pay for the characteristics of interest. A DCE generates this variation experimentally. Whilst most survey approaches involve capturing data from respondents both in terms of the dependent and independent variables to be used in subsequent modeling, data from DCEs differ from other survey data in that aside from covariate information, the independent variables are supplied by the analyst in the form of choice scenarios, and the respondent provides data only related to the dependent variable, via the choices they are observed to make. It is therefore necessary for the analyst to generate the choice scenarios shown to each of the sampled respondents. Conceptually, an experimental design is simply a matrix of values that is used to determine what goes where in a DCE survey. These values may be either numbers or labels depending on how the analyst wishes to relate the information of the experiment to the respondents.

### *3.1. Survey design and data collection*

The choice scenarios were constructed using a low resolution design, more specifically an orthogonal main effects plan (OMEP). An OMEP imposes restrictions on the functional form one is able to identify however it reduces substantially the number of questions required of a given respondent. This was a necessary trade-off in the present case as the overall survey had several goals and the total number of questions had to be kept at a minimum. The technology available to implement the survey was face-to-face interviews showing cards for each scenario which limited substantially the possibility of using different versions of the survey which would have allowed for more complex designs to have been implemented.

There are a total of 8 scenarios per respondent. In each scenario there are 3 alternatives and each alternative is defined using 6 attribute dimensions (i.e. variables) the levels of which are varied systematically according to our design matrix. Our goal is to study how consumers choose different plans and the relevance of both network effects and commitment periods in this choice process. Consequently the attribute dimensions considered were: i) Network characteristics regarding family and friends - this attribute attempts to capture the importance of using the same provider as friends and family which we identify with calling club network

effects; ii) network size as defined by the market share of the provider which we identify as pure network effects; iii) commitment period which captures a switching cost component ; iv) monthly payment v) on-net per minute price, vi) off-net per minute price. Table 7.1 details these attributes and levels they assume.

An example of a scenario is given in table 7.2. After being presented with a scenario the respondent was asked the following three questions[8]:

> Suppose that your commitment period with your current mobile operator has expired, that is, you can change mobile operator without incurring any extra charges. You are contacted by other operators and/or by your current operator and you encounter the following options regarding the choice of a mobile phone plan.

1. Please tell us which option you find the **most** attractive.
2. Please tell us which option you find the **least** attractive.
3. Of the three sentences that follow please tell us which one best reflects your opinion about the different options:
   (a) I would consider purchasing any of the options presented.
   (b) I would consider purchasing some of the options presented but not others.
   (c) I would never consider purchasing any of the options presented.

The elicitation technique just described, which asks for the most and the least preferred option, is know as a best-worst choice question (Marley and Louviere (2005), Louviere et al. (2015)). This format increases the number of implied binary comparisons (which convey the information content of the response). Besides increasing statistical efficiency, a rationale for this elicitation technique is that the easiest choices for respondents are likely to be their most and least favorites, particularly as the number of options increases. Further, indicating the least favorite choice may involve less strategic behavior and reveal more statistical information than indicating another choice like a respondent's second favorite (Carson and Louviere (2011)). The third question explicitly allows for an outside option, that is the option of not purchasing any of the presented alternatives. The respondent has therefore 4 options in total and partial order information is collected on every set of 4 alternatives.

Data collection was done by Universidade Católica Portuguesa. The fieldwork took place from the 21st of June to the 6th of July, 2014 between 10am and 7pm. The sample size was 1029.

### *3.2. Econometric Model*

The data collected is analyzed assuming that in each choice task respondents behave according to a random utility maximization procedure (McFadden (1974)).

Specifically an alternative $i$, from a choice set $c$ has an indirect utility for respondent $n$ denoted by $U_{icn}$ which is:

$$U_{icn} = V_{icn} + \varepsilon_{icn}$$

[8]Translated from Portuguese.

where

$$V_{icn} = \sum_j X_{ic}^j \beta_{nj}$$

The systematic component of the indirect utility is denoted by $V_{icn}$ and the preference parameters are given by the vector $\beta_n$ with generic element $\beta_{nj}$ where $j$ indexes attributes and $\varepsilon_{icn}$ is an unsystematic component of the utility function. We have estimated multinomial logit models and mixed logit models. These models are standard and extensibly described in the literature (see for example Train (2003)).

The notation just employed captures all the models analyzed in this paper. If $\beta_n$ is common to all respondents, i.e. $\beta_n = \beta$, the standard MNL model is obtained. We also allow each $\beta_{nj}$ to be a function of observed individual characteristics ($Z_{nk}$) and we have $\beta_{nj} = \beta_j^0 + \sum_k Z_{nk}\beta_j^k$. Alternatively $\beta_{nj}$ can be thought of as being composed of a mean term and an unobserved component ($\xi_{nj} \sim$ N(0,1)) and we have $\beta_{nj} = \beta_j^0 + \sigma_j \xi_{nj}$ giving rise to a mixed logit model .

Standard maximum likelihood methods were used to estimate multinomial logit models. Mixed logit models were estimated using hierarchical Bayesian techniques implemented in the R-STAN statistical package (Stan Development Team (2015))[9].

## 4. Results

Table 7.3 presents the descriptive statistics of the collected data. The dataset is representative of the Portuguese population aged 15 or older and matches census data on standard socio-demographic variables.

The estimation results of a multinomial logit model applied to the data is presented in table 7.4 showing the estimates of the previously defined $\beta$ coefficients. The expected effects were obtained for all variables and except for the calling club network effect (as measured by the coefficient associated to the variable relating to friends and family in the same network), all were statistically significant. The columns labeled WTP present results normalized by the price coefficient, thereby representing a willingness to pay measure for each attribute. They are therefore expressed in euros.

Consumers are willing to pay 1.3 euros per month more to reduce the commitment period from 1 year to 6 months and willing to pay 2.5 euros per month more to be part of a larger network. We note however that whilst calling club-type network effects are not in themselves significant, consumers are more sensitive to on-net price variations than off-net price variations. It is possible that club-type network effects are already being captured by this differential sensitivity. An increase of 10 cents per minute in on-net calls is equivalent to a 5.6 euro increase in monthly payments. On the other hand an increase of 10 cents per minute in off-net calls is equivalent to a smaller 2.9 euro increase in monthly payments, i.e. nearly half as much.

This survey was conducted using face-to-face interviews, however surveys of this type can be implemented effectively, inexpensively and with much greater complexity via the web. Information was concurrently

[9] In hierarchical Bayesian estimation we used non-informative normal priors for the mean parameters, non-informative half-Cauchy priors for the scale parameters and the LKJ correlation distribution as a prior for the correlation between coefficients (see Stan Development Team (2016)).

collected as to who has internet access. Critiques of the substitution of non web-based interviews with web-based surveys frequently point out that the sample obtained from respondents who have internet access is distorted in comparison to the wider population. Whilst this is true, for example, the population with internet access is typically characterized by a greater proportion of young people, this does not mean that an appropriately weighted sample will fail to produce meaningful results. Columns 6 to 9 present the results for the sub-population of those that have internet and a re-weighed sample of these to match overall socio-demographic statistics. The results in these columns are not statistically different from the results presented in columns 4 and 5 which use the whole sample. This suggests that a web-survey is capable of producing unbiased results.

Analysis of interaction of demographic covariates with product attributes does not produce, for the most part, statistically significant results with the following exceptions reported in table 7.5: i) younger respondents are more prone not to choose the outside alternative and to have as the most preferred option one of the packages selected and ii) the less educated respondents (primary education or less) are responsible for the lack of significance of the network club effects - this sub-population is not willing to pay any additional amount to be in the same network with other relatives or friends. Also in this case the divergence between the valuations of on-net and off-net prices is much smaller. A similar effect in unobserved heterogeneity is commented on below in the context of the mixed logit model.

The estimation results of a mixed logit model with a diagonal variance covariance matrix are presented in table 7.6. Tables 7.7 and 7.8 present the results of a mixed logit model with a full variance covariance matrix.

The magnitude of the mean coefficients related to on-net is qualitatively unchanged in comparison with the MNL model with the exception of the outside option coefficient. The outside option $\sigma$ coefficient reveals significant heterogeneity as will be discussed below. The significance of most of the standard deviation coefficients also reveals significant heterogeneity in preferences across respondents however the mean effect is qualitatively unchanged.

Table 7.8 reports correlation coefficients of attribute preferences within a respondent. Respondents who are more sensitive to monthly payments end up to be more sensitive to both on-net and off-net per minute prices. Likewise respondents who care about commitment periods also care about both monthly payments and on-net tariffs. It is also the case that respondents that value having friends in the same network also tend to be sensitive to commitment periods and monthly payments. We also note that stronger preferences for having friends in the same network are not associated with higher price sensitivity to either on-net or off-net tariffs. Finally respondents who have a stronger preference choosing any of the options presented and not delaying a decision also prefer being a part of a large network and are less sensitive to off-net tariffs.

In table 7.9 results of a mixed logit where coefficients are expressed in WTP space (i.e they are normalized by the monthly payment coefficient) are reported and figure 1 reports posterior densities individual WTP measures.

The magnitude of the mean coefficients related to on-net/off-net pricing and commitment periods are of the same orther of magnitude of values calculated from the multinomial logit model. The calling club variable is now significant albeit at the expense of an almost equality between the on-net and off-net price coefficients. This same effect was noted above in the sub-population of less educated respondents. The contrast with the results obtained in the multinomial logit model reveals that it is difficult to separately

identify 'club' network effects from on-net/off-net price differentials. Also the density estimates reveal important disparities regarding the heterogeneity of valuations of the outside option. Essentially a mixture of three distinct sub-populations of respondents emerges regarding the valuation of the outside option (the value of not purchasing the package proposed and continue searching). One sub-population rarely finds the proposed packages attractive, one sub-population almost always finds one proposal attractive and a third one is indifferent between the packages offered and the option of postponing a decision. Socio-demographics variables have little power in explaining these disparities except, to some extent, the age variable as described before. Finally regarding the remaining attributes figure 1 depicts some heterogeneity around mean valuation amounts but no distinct populations emerge.

## 5. Regulatory implications

Our results suggest that a discount of 1.3 euro per month, was needed for a subscriber to accept an additional commitment period of 6 months. Considering the monthly ARPU at the end of 2013, €12.6, as a reference price, a subscriber would be willing to pay at most €11.3 per month under a 6-month commitment period. The problem is then to know if operators were willing meet consumers' preferences and ensure commitment.

For operators, avoiding uncertainty over future revenues is one advantage of having committed subscribers. By the end of 2013 there were 2.375 million post paid subscribers[10] . Assuming an average contract length of 18 months, there would be 0,132 million contracts for renewal every month and 0.792 million over a 6-month period. In 2014, the churn rate among all mobile subscribers was 9.1%. Assuming this value also for post paid subscribers, on average, every 6 months a mobile operator would lose 0.108 million subscribers among those at the term of their contracts. The probability that a contract up for renewal would not be renewed was then 13.6%, and the probability of renewal, 86.4%. The expected value of a contract up for renewal would be €65.2 over 6 months, or €10.9 per month, if the monthly ARPU of €12.6 is used to calculate the expected revenue of a subscriber in new contracts. If so, in new contracts, a risk neutral operator would be willing to make offers with prices in the range €10.9-€11.3 per month to keep subscribers committed over 6-month periods, and avoid churning. Or, to put it in another way, to pay in the range €1.3- €1.7 to have a committed subscriber, thereby including the value required by the subscriber to accept commitment, according to our estimates.

Another argument about the opportunities to offer subscribers attractive packages with commitment periods is related to the cost of consumer credit. During 2014 maximum interest rates on credit cards were in the range 20%-23% per year and on consumer credit 16-17% [11]. A subscriber might borrow paying a 6-month interest rate in the range 8%-11,5%. A smartphone acquisition of e.g. €150 would imply an interest payment after 6 month in the range €12-€17,25, that is €2,0-€2,9 per month. Our results suggest that subscribers were willing to accept a 6-month commitment period if an operator reduced this payment by at least €1,3 per month. The operators cost of capital was much lower than the cost of consumer credit. The cost of capital of Portugal Telecom, was 10,42% in 2014, per a decision of the national regulatory authority, Anacom. If

[10] Data on subscribers, churn, revenues and cost of capital in Portuguese mobile markets are published by the national regulatory authority, Anacom. See `http://www.anacom.pt/render.jsp?contentId=1339156#.WEn994XXKUk` , `http://www.anacom.pt/render.jsp?categoryId=385370#.WEoHLPCLSU1` and `http://www.anacom.pt/render.jsp?contentId=1358845#.WEoUioXXKUk`.

[11] Central bank data, available at `http://clientebancario.bportugal.pt/pt-PT/TaxasJuroCambio/TaxasdeJuro/Creditoconsumidores/Paginas/Taxasmaximas.aspx`.

the cost of capital of the other operators was similar, this suggests that, in the previous case, they could provide consumer credit (or equivalent pricing packages) in exchange for a payment of €1.3 to cover the cost of capital – and acceptance of a commitment period. Subscribers borrowing at higher interest rates, with monthly payments of €2.9, would be willing to accept such an offer. However, the offer would not be attractive for subscribers borrowing at lower rates, with monthly payments of €2. For these subscribers, acceptance of a commitment period would require monthly payments not higher than €0.7. To have a committed subscriber for 6 months, the operator would not be able to recover completely the cost of capital, charging just €0.7 per month. However, this charge might still be interesting for the operator, considering the benefits of reduced uncertainty over revenues in exchange for a loss of just €0.6.

Summing up, these examples suggest that operators would be interested in paying at least the amount of €1.3 per month, required by subscribers to accept a 6-month commitment period. In a sense there was some lock in, over the commitment period. However, every operator was engaged in these pricing policies, that were part of the competitive process and subscribers got lower prices as part of this process[12].

The pricing policies adopted by firms involved some type of price discrimination, between subscribers at the end of their contracts, and negotiating their renewal, and the other subscribers. They were associated with the imposition of high penalties on subscribers willing to switch to a different operator before the commitment period was over. This suggests that each firm was offering pricing policies attractive to committed subscribers of the other firms and, at the same time, it was trying to lock in its own subscribers using high penalties for early termination of contracts.

The value of these penalties has been a source of policy concerns, because of lock in effects. Arguably, a market failure argument has been implicitly accepted by Portuguese authorities, as legislation has been enacted to impose limits on them. Following a report by the Portuguese competition authority, where it was considered that lack of consumer mobility was a major barrier to competition, ceilings on penalties in mobile services were imposed by law in 2010. Additional restrictions, applicable to all electronic communications services, were enacted in 2016 by Parliament, following proposals submitted by Anacom. The objective of state intervention in these cases was to impose constraints on pricing practices that implied unduly increases on switching costs, rather than prohibiting commitment discounts. This seems sensible, given the arguments above. History based price discrimination is not necessarily a source of market failure[13]. Prices may be lower than prices resulting from uniform pricing, at least for subscribers switching suppliers. The final outcome on prices depends on the sets of information available to operators, dominance, availability of retention strategies and switching costs. Moreover, lower prices do not imply higher welfare, as operators' losses may be larger than subscribers' gains (Gehrig et al. (2012) ; Esteves (2014)).

Our results also suggest that although network effects are statistically significant, club effects, unmediated by price differentials, are not. It seems that subscribers are more interested in the size of the network than in the number of family and friends that subscribe a given network. It was also noted that a possible interpretation is that club effects are being captured by the revealed differential sensitivity to on-net an off-net prices. As mentioned above, subscribers are willing to pay more 2.5 euro per month to subscribe a

[12] A different question would be to ask about price changes under alternative pricing policies, without commitment periods. This is outside the scope of this paper.

[13] History based price discrimination (or behavior-based price discrimination) is a variant of price discrimination which occurs when firms have information about consumers' past behavior and use this information to offer different prices to consumers with different purchasing histories (for a comprehensive survey, see Fudenberg and Villas-Boas (2006)).

larger network, that is, double the amount that they are willing to pay to reduce their commitment period from 1 year to 6 months. The role played by network size in consumer choice can be explained by tariff mediated network externalities or by quality signaling (Kim and Kwon (2003)). In the first case network externalities are the source of costs to be incurred by the entrants that were not incurred by (at least) the largest incumbents. Regulation may contribute to solve the problem. It has been usually assumed that this is the case of EU that regulation of mobile termination services, setting prices adjusted to long run marginal costs (EC (2009)). No additional regulations were imposed, although that was a source of complaints of the third mobile operator. The problem is likely to be reduced by the adoption of all net prices, eliminating the differences between on net and off-net prices. In any case, if consumer preference for a larger network is the consequence of some form of quality signaling there may be no strong rationale for ex ante regulation. The informational role of market shares may even be pro-competitive (Caminal and Vives (1996)).

## 6. Concluding remarks

A DCE was designed to study of consumer preferences for mobile telecommunications plans and operator characteristics. Consumers are willing to pay 1.3 Euro per month more to reduce the commitment period from 1 year to 6 months and willing to pay 2.5 euros per month more to be part of a larger network. Consumers are also twice as much more sensitive to on-net price variations than off-net price variations.

Regulatory implications of these findings have been discussed.

## 7. Tables

Table 7.1: Attributes

| **Attribute** | **Levels** |
|---|---|
| Friends and family (network effects) | Most friends and family are in this network; I know few people in this network |
| Market share of the provider (pure network effects) | 15%; 40% |
| Length of the commitment period | 6 months; 1 year |
| Monthly fee/recharge obligations | 0€; 15€; 25€ |
| On-net per minute call charges | 0 cents; 15 cents; 30 cents |
| Off-net per minute call charges | 15 cents; 30 cents; 42 cents |

Table 7.2: Sample scenario

| **Attribute** | **Option A** | **Option B** | **Option C** |
|---|---|---|---|
| Friends and family (network effects) | I know few people in this network | Most friends and family are in this network | Most friends and family are in this network |
| Market share of the provider (pure network effects) | 40% | 40% | 15% |
| Length of the commitment period | 6 months | 1 year | 6 months |
| Monthly fee/recharge obligations | 15€ | 15€ | 25€ |
| On-net per minute call charges | 15 cents | 30 cents | 30 cents |
| Off-net per minute call charges | 30 cents | 30 cents | 42 cents |

Table 7.3: Descriptive statistics

| | Mean | S.D. | Min | Max | N |
|---|---|---|---|---|---|
| **Gender** | | | | | |
| Male | 0.44 | 0.50 | 0.00 | 1.00 | 1029 |
| Female | 0.56 | 0.50 | 0.00 | 1.00 | 1029 |
| **Age** | | | | | |
| 15-24 | 0.15 | 0.36 | 0.00 | 1.00 | 1027 |
| 25-34 | 0.14 | 0.34 | 0.00 | 1.00 | 1027 |
| 35-44 | 0.20 | 0.40 | 0.00 | 1.00 | 1027 |
| 45-54 | 0.18 | 0.38 | 0.00 | 1.00 | 1027 |
| 55-64 | 0.17 | 0.38 | 0.00 | 1.00 | 1027 |
| 65 + | 0.16 | 0.37 | 0.00 | 1.00 | 1027 |
| **Education** | | | | | |
| Primary | 0.40 | 0.49 | 0.00 | 1.00 | 1029 |
| Secondary | 0.31 | 0.46 | 0.00 | 1.00 | 1029 |
| Tertiary | 0.30 | 0.46 | 0.00 | 1.00 | 1029 |
| **Marital status** | | | | | |
| Single | 0.32 | 0.47 | 0.00 | 1.00 | 1027 |
| Married | 0.50 | 0.50 | 0.00 | 1.00 | 1027 |
| de facto | 0.04 | 0.20 | 0.00 | 1.00 | 1027 |
| Divorced | 0.08 | 0.27 | 0.00 | 1.00 | 1027 |
| Widower | 0.06 | 0.23 | 0.00 | 1.00 | 1027 |
| **Employment status** | | | | | |
| Self employed | 0.09 | 0.28 | 0.00 | 1.00 | 1026 |
| Employed | 0.45 | 0.50 | 0.00 | 1.00 | 1026 |
| Student | 0.13 | 0.34 | 0.00 | 1.00 | 1026 |
| Unemployed | 0.11 | 0.31 | 0.00 | 1.00 | 1026 |
| Retired | 0.20 | 0.40 | 0.00 | 1.00 | 1026 |
| Other | 0.03 | 0.17 | 0.00 | 1.00 | 1026 |
| **HH size** | | | | | |
| 1 | 0.10 | 0.31 | 0.00 | 1.00 | 1020 |
| 2 | 0.29 | 0.46 | 0.00 | 1.00 | 1020 |
| 3 | 0.30 | 0.46 | 0.00 | 1.00 | 1020 |
| 4 | 0.21 | 0.41 | 0.00 | 1.00 | 1020 |
| 5+ | 0.10 | 0.30 | 0.00 | 1.00 | 1020 |
| **HH monthly income** | | | | | |
| <500€ | 0.14 | 0.35 | 0.00 | 1.00 | 821 |
| [500€; 800€[ | 0.20 | 0.40 | 0.00 | 1.00 | 821 |
| [800€; 1250€[ | 0.27 | 0.44 | 0.00 | 1.00 | 821 |
| [1250€; 2000€[ | 0.23 | 0.42 | 0.00 | 1.00 | 821 |
| >2000€ | 0.16 | 0.37 | 0.00 | 1.00 | 821 |
| | | | | | |
| Has internet access | 0.82 | 0.38 | 0.00 | 1.00 | 1011 |

Table 7.4: Estimation results: MNL

| | MNL | | WTP | | WTP - internet | | WTP - internet weighted | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **Coef** | **S.E.** | **Coef** | **S.E.** | **Coef** | **S.E.** | **Coef** | **S.E.** |
| Outside option | -0.027 | 0.084 | -0.365 | 1.137 | -1.231 | 1.164 | -0.608 | 1.356 |
| Most of my friends | 0.044 | 0.050 | 0.602 | 0.689 | 0.925 | 0.711 | 1.413$^{*}$ | 0.785 |
| 40 % mkt shr | 0.189$^{***}$ | 0.051 | 2.567$^{***}$ | 0.667 | 2.904$^{***}$ | 0.690 | 2.709$^{***}$ | 0.784 |
| 6 months | 0.097$^{**}$ | 0.047 | 1.313$^{**}$ | 0.629 | 1.633$^{**}$ | 0.647 | 1.538$^{**}$ | 0.731 |
| On-net price | -0.041$^{***}$ | 0.003 | -0.558$^{***}$ | 0.035 | -0.564$^{***}$ | 0.036 | -0.590$^{***}$ | 0.040 |
| Off-net price | -0.021$^{***}$ | 0.003 | -0.288$^{***}$ | 0.046 | -0.260$^{***}$ | 0.047 | -0.249$^{***}$ | 0.052 |
| Monthly payment | -0.074$^{***}$ | 0.003 | -1.000 | 0.000 | -1.000 | 0.000 | -1.000 | 0.000 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$;

Table 7.5: Estimation results: MNL with demographic covariates

| | WTP | |
|---|---|---|
| **Variable** | **Coef** | **S.E.** |
| Outside option : Age [15-24] | -3.592*** | 1.342 |
| Outside option : Age [25-34] | 0.871 | 1.451 |
| Outside option : Age [35-44] | -4.599*** | 1.275 |
| Outside option : Age [45-54] | 0.258 | 1.369 |
| Outside option : Age [55-64] | 3.687** | 1.456 |
| Outside option : Age 65+ | 2.762* | 1.472 |
| Most of my friends : Primary school | -1.750* | 1.055 |
| Most of my friends : Secondary school | 3.294*** | 1.151 |
| Most of my friends : > Secondary school | 1.353 | 1.228 |
| 40 % mkt shr | 2.550*** | 0.675 |
| 6 months | 1.255** | 0.636 |
| On-net price : Primary school | -0.423*** | 0.048 |
| On-net price : Secondary school | -0.614*** | 0.053 |
| On-net price : > Secondary school | -0.676*** | 0.058 |
| Off-net price | -0.296*** | 0.046 |
| Monthly payment | -1.000 | 0.000 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$;

Table 7.6: Mixed Logit - Diagonal Covariance

| | $\beta$ | | $\sigma$ | |
|---|---|---|---|---|
| **Variable** | **Coef** | **S.E.** | **Coef** | **S.E.** |
| Outside option | 0.925*** | 0.256 | 4.888*** | 0.266 |
| Most of my friends | 0.059 | 0.083 | 0.978*** | 0.095 |
| 40% mkt shr | 0.030 | 0.072 | 0.259 | 0.166 |
| 6 months | 0.082 | 0.066 | 0.479*** | 0.145 |
| On-net price | -0.056*** | 0.004 | 0.028*** | 0.006 |
| Off-net price | -0.038*** | 0.005 | 0.021** | 0.010 |
| Monthly payment | -0.101*** | 0.006 | 0.049*** | 0.006 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$;

Table 7.7: Mixed Logit - Full Covariance

| | $\beta$ | | $\sigma$ | |
|---|---|---|---|---|
| **Variable** | **Coef** | **S.E.** | **Coef** | **S.E.** |
| Outside option | 0.702** | 0.322 | 5.072*** | 0.372 |
| Most of my friends | -0.041 | 0.168 | 1.156*** | 0.111 |
| 40 % mkt shr | -0.169 | 0.145 | 0.454*** | 0.174 |
| 6 months | 0.212 | 0.131 | 0.706*** | 0.117 |
| On-net price | -0.074*** | 0.008 | 0.040*** | 0.006 |
| Off-net price | -0.031*** | 0.008 | 0.033*** | 0.008 |
| Monthly payment | -0.117*** | 0.010 | 0.068*** | 0.007 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$;

Table 7.8: Mixed Logit - Full Covariance - Correlation coefficients

| S.E. of $\rho$ / $\rho$ | Outside option | Most of my friends | 40 % mkt shr | 6 months | On-net price | Off-net price | Monthly payment |
|---|---|---|---|---|---|---|---|
| Outside option | | 0.126 | 0.211 | 0.163 | 0.158 | 0.186 | 0.132 |
| Most of my friends | -0.162 | | 0.209 | 0.135 | 0.137 | 0.173 | 0.115 |
| 40 % mkt shr | -0.550*** | 0.168 | | 0.235 | 0.236 | 0.253 | 0.211 |
| 6 months | -0.041 | 0.390*** | 0.059 | | 0.149 | 0.203 | 0.131 |
| On-net price | -0.059 | -0.150 | -0.014 | -0.470*** | | 0.207 | 0.104 |
| Off-net price | 0.483*** | -0.247 | -0.266 | -0.224 | 0.325 | | 0.146 |
| Monthly payment | 0.128 | -0.263** | -0.167 | -0.363*** | 0.714*** | 0.604*** | |

Lower triangular matrix contains estimated correlation coefficients; Upper triangular matrix contains s.e. of estimated correlation coefficients; $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$;

Table 7.9: Mixed Logit - WTP Space

| | $\beta$ | | $\sigma$ | |
|---|---|---|---|---|
| **Variable** | **Coef** | **S.E.** | **Coef** | **S.E.** |
| Outside option | 10.436*** | 2.847 | 2735.943*** | 408.747 |
| Most of my friends | 1.748** | 0.835 | 86.379*** | 20.574 |
| 40 % mkt shr | 0.296 | 0.672 | 3.970 | 4.522 |
| 6 months | 1.829*** | 0.642 | 18.087 | 11.877 |
| On-net price | -0.589*** | 0.036 | 0.044* | 0.025 |
| Off-net price | -0.443*** | 0.053 | 0.034 | 0.028 |

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$;

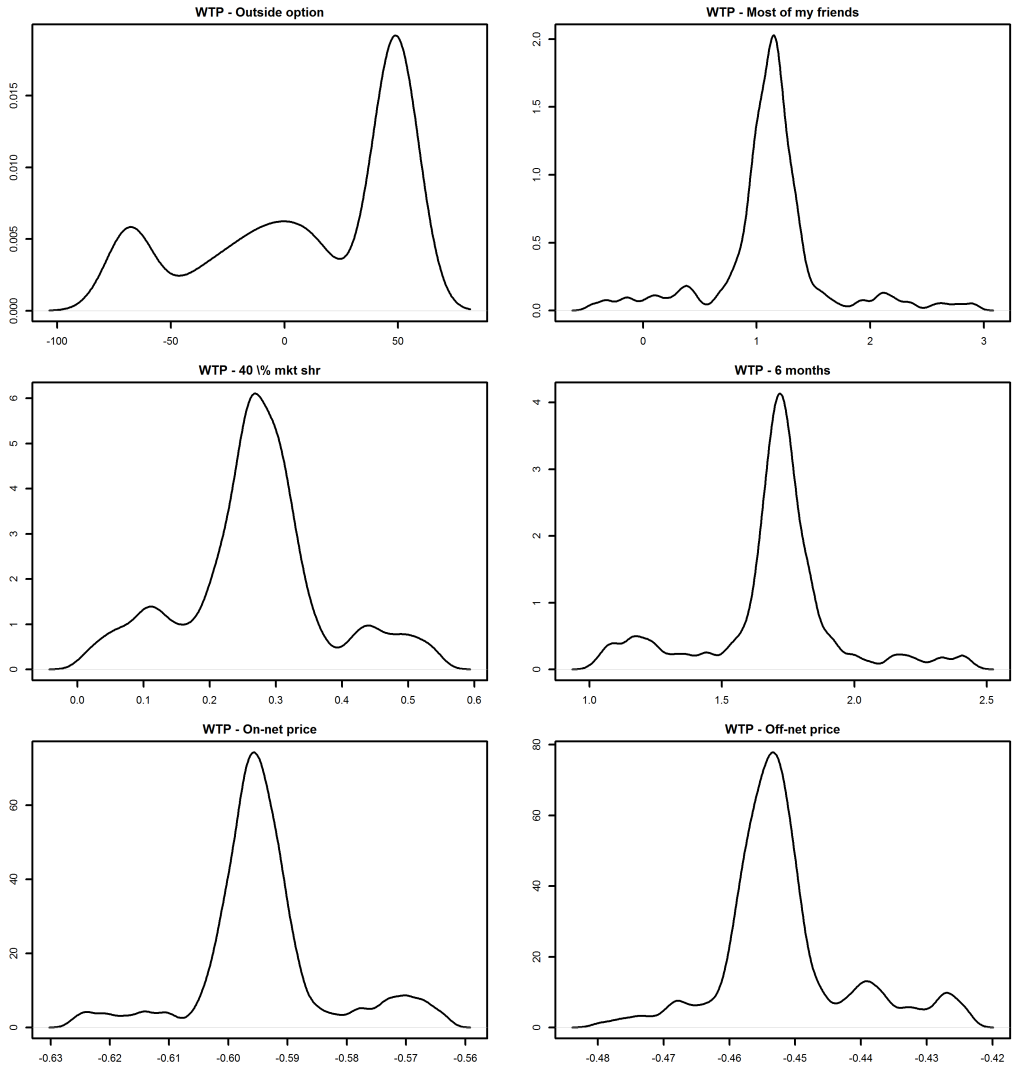


Figure 1: WTP posterior density

## 8. References


Armstrong, M., 1998. Network interconnection in telecommunications. Economic Journal, 545–564.

Birke, D., Swann, G., Apr. 2006. Network effects and the choice of mobile phone operator. Journal of Evolutionary Economics 16 (1), 65–84.

Birke, D., Swann, G. P., 2010. Network effects, network structure and consumer interaction in mobile telecommunications in europe and asia. Journal of Economic Behavior & Organization 76 (2), 153–167.

Bolle, F., Heimel, J., 2005. A fallacy of dominant price vectors in network industries. Review of Network Economics 4 (3).

Cabral, L., 2011. Dynamic price competition with network effects. The Review of Economic Studies 78 (1), 83–111.

Calzada, J., Valletti, T. M., 2008. Network competition and entry deterrence*. The Economic Journal 118 (531), 1223–1244.

Cameron, L., Cragg, M., McFadden, D., October 2013. The role of conjoint surveys in reasonable royalty cases. Law360.

Caminal, R., Vives, X., 1996. Why market shares matter: an information-based theory. The RAND Journal of Economics, 221–239.

Carson, R. T., Louviere, J. J., 2011. A common nomenclature for stated preference elicitation approaches. Environmental and Resource Economics 49 (4), 539–559.

Corrocher, N., Zirulia, L., 2009. Me and you and everyone we know: An empirical analysis of local network effects in mobile communications. Telecommunications Policy 33 (1), 68–79.

Czajkowski, M. C., Sobolewski, M., 2011. Measuring network effects in mobile telecommunications markets with stated-preference valuation methods. International Journal of Management and Network Economics 2 (2), 197–215.

EC, May 2009. Regulatory Treatment of Fixed and Mobile Termination Rates in the EU. Commission Recommendation of 7 May 2009 2009/396/EC, European Commission.

Esteves, R.-B., 2014. Behavior-based price discrimination with retention offers. Information Economics and Policy 27, 39–51.

Farrell, J., Klemperer, P., 2007. Coordination and lock-in: Competition with switching costs and network effects. Handbook of industrial organization 3, 1967–2072.

Finch, J., Mason, J., 1990. Divorce, remarriage and family obligations. The Sociological Review 38 (2), 219–246.

Flynn, T. N., Louviere, J. J., Peters, T. J., Coast, J., 2007. Best-worst scaling: What it can do for health care research and how to do it. Journal of Health Economics 26, 171–189.

Fudenberg, D., Villas-Boas, J. M., 2006. Behavior-based price discrimination and customer recognition. Handbook on economics and information systems 1, 377–436.

Fuentelsaz, L., Maicas, J. P., Polo, Y., 2012. Switching costs, network effects, and competition in the european mobile telecommunications industry. Information Systems Research 23 (1), 93–108.

Gabrielsen, T. S., Vagstad, S., 2008. Why is on-net traffic cheaper than off-net traffic? access markup as a collusive device. European Economic Review 52 (1), 99–115.

Gehrig, T., Shy, O., Stenbacka, R., 2012. A welfare evaluation of history-based price discrimination. Journal of Industry, Competition and Trade 12 (4), 373–393.

Gerpott, T. J., Rams, W., Schindler, A., 2001. Customer retention, loyalty, and satisfaction in the german mobile cellular telecommunications market. Telecommunications policy 25 (4), 249–269.

Green, P. E., Krieger, A. M., Wind, Y., 2001. Thirty years of conjoint analysis: Reflections and prospects. Interfaces 31 (3_supplement), S56–S73.

Haucap, J., Heimeshoff, U., 2011. Consumer behavior towards on-net/off-net price differentiation. Telecommunications Policy 35 (4), 325–332.

Hensher, D. A., 1994. Stated preference analysis of travel choices: the state of practice. Transportation 21 (2), 107–133.

Hoernig, S., 2007. On-net and off-net pricing on asymmetric telecommunications networks. Information Economics and Policy 19 (2), 171–188.

Hoernig, S., Inderst, R., Valletti, T., 2014. Calling circles: network competition with nonuniform calling patterns. The RAND Journal of Economics 45 (1), 155–175.

Karaçuka, M., Çatık, A. N., Haucap, J., 2013. Consumer choice and local network effects in mobile telecommunications in turkey. Telecommunications Policy 37 (4), 334–344.

Kim, H.-S., Kwon, N., 2003. The advantage of network size in acquiring new subscribers: a conditional logit analysis of the korean mobile telephony market. Information Economics and Policy 15 (1), 17–33.

Kim, H.-S., Yoon, C.-H., 2004. Determinants of subscriber churn and customer loyalty in the korean mobile telephony market. Telecommunications policy 28 (9), 751–765.

Kim, M.-K., Park, M.-C., Jeong, D.-H., 2004. The effects of customer satisfaction and switching barrier on customer loyalty in korean mobile telecommunication services. Telecommunications policy 28 (2), 145–159.

Laffont, J.-J., Rey, P., Tirole, J., 1998a. Network competition: I. overview and nondiscriminatory pricing. The RAND Journal of Economics, 1–37.

Laffont, J.-J., Rey, P., Tirole, J., 1998b. Network competition: Ii. price discrimination. The RAND Journal of Economics, 38–56.

Lambrecht, A., Skiera, B., 2006. Paying too much and being happy about it: Existence, causes, and consequences of tariff-choice biases. Journal of marketing Research 43 (2), 212–223.

Lee, J., Kim, Y., Lee, J.-D., Park, Y., 2006. Estimating the extent of potential competition in the korean mobile telecommunications market: Switching costs and number portability. International Journal of Industrial Organization 24 (1), 107–124.

Lopez, A. L., Rey, P., 2016. Foreclosing competition through access charges and price discrimination. The Journal of Industrial Economics.Forthcoming.

Louviere, J., Hensher, D., Swait, J., 2000. Stated Choice Methods, Analysis and Application. Cambridge University Press.

Louviere, J. J., Flynn, T. N., Marley, A., et al., 2015. Best-worst scaling. Cambridge Books.

Maicas, J. P., Polo, Y., Sese, F. J., 2009. The role of (personal) network effects and switching costs in determining mobile users' choice. Journal of Information Technology 24 (2), 160–171.

Marley, A., Louviere, J., 2005. Some probabilistic models of best, worst, and best-worst choices. Journal of Mathematical Psychology 49, 464–480.

McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In: Zarembka, P. (Ed.), Frontiers in econometrics. Academic Press: New Yo, Ch. 4, pp. 105–142.

McFadden, D., 2014. The new science of pleasure: consumer choice behavior and the measurement of well-being. In: Hess, S., Daly, A. (Eds.), Handbook of Choice Modelling. Edward Elgar, pp. 7–48.

McFadden, D., July 2015. Direct elicitation of indirect preferences. Society for Economic Measurement Annual Conference (Paper 144).
URL http://repository.cmu.edu/sem_conf/2015/full_schedule/144

McFadden, D., Train, K., Dec 2000. Mixed mnl models for discrete response. Journal of Applied Econometrics 15 (5), 447–470.

Mitchell, R. C., Carson, R. T., 1989. Using surveys to value public goods: the contingent valuation method. Resources for the Future.

Nakamura, A., 2010. Estimating switching costs involved in changing mobile phone carriers in Japan: Evaluation of lock-in factors related to Japan's SIM card locks. Telecommunications Policy 34 (11), 736–746.

Rossi, P. H., Nock, S. L., 1982. Measuring social judgments: The factorial survey approach. SAGE Publications, Incorporated.

Sobolewski, M., Czajkowski, M., 2012. Network effects and preference heterogeneity in the case of mobile telecommunications markets. Telecommunications Policy 36 (3), 197–211.

Stan Development Team, 2015. RStan: the R interface to stan, version 2.8.0. http://mc-stan.org/rstan.html, Stan Development Team.
URL http://mc-stan.org/rstan.html

Stan Development Team, 2016. Stan modeling language users guide and reference manual, version 2.9.0. http://mc-stan.org/rstan.html, Stan Development Team.
URL http://mc-stan.org

Swann, G. P., 2002. The functional form of network effects. Information Economics and Policy 14 (3), 417–429.

Train, K., 2003. Discrete Choice Methods with Simulation. Cambridge University Press.

Villas-Boas, J. M., 2015. A short survey on switching costs and dynamic competition. International Journal of Research in Marketing 32 (2), 219–222.

Zucchini, L., Claussen, J., Trüg, M., 2013. Tariff-mediated network effects versus strategic discounting: Evidence from german mobile telecommunications. International Journal of Industrial Organization 31 (6), 751–759.