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Measuring reservation prices for bundles of fixed telecommunications services

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ABSTRACT

Bundling becomes a dominant sales strategy in telecommunications. Dual and triple-play packages are increasingly popular among subscribers. From operators' perspective, a core issue in bundling design is the knowledge about how consumers value packages. In this paper we focus on elicitation of subscribers willingness to pay for bundles of fixed telecommunication services composed of telephony, Internet and paid TV. We conduct a stated preference discrete choice experiment on a sample of subscribers in Poland, to model subscription choices over packages of fixed services. We obtain estimates of mean willingness to pay as well as entire distributions of reservation prices for single services and possible combinations of bundles.

We find that mean WTP for fixed telephony as a stand-alone service or an add-on to bundle is zero. This result suggest that fixed telephony has already become an obsolete service. Out of the three fixed services, Internet generates the biggest value for customers, driving up valuations of bundles. WTP for Internet is much higher than actually paid prices, leaving space for increase of profits. In contrast fixed telephony and pay TV seem to be overpaid which may create a pressure on operators' revenue.

HIGHLIGHTS

- We apply discrete choice experiment to model subscribers' stated preferences over bundles of fixed telecommunications services.
- We estimate MNL and MXL models and obtain distributions of mean willingness to pay for fixed telephony, fixed broadband, pay TV and their bundles, encompassing possible substitutability and complementarities between various fixed services as well as the impact of mobile services.
- We compare choice-based willingness to pay with directly self-reported valuations.

KEYWORDS

Bundling, stated choice experiment, willingness to pay, fixed telephony, fixed broadband, pay TV, dual play, triple play, fixed-to-mobile substitution

JEL CLASSIFICATION

C25; D12; L96

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1 INTRODUCTION

Bundling is defined as a sale of two or more separate products in a package at a discounted price (Stremersch and Tellis 2002). This sales strategy is popular in many markets nowadays, but perhaps it is most pervasive in telecommunications with overflow of dual, triple and sometimes quadruple play offers. According to industry reports, multiple-play offers will soon command for 70% of subscription revenues.⁴ Various data confirm increasing popularity of packages. According to latest Eurobarometer survey (European Commission 2013), 45% of EU households purchase a bundle of telecommunication services.⁵ Fixed triple play bundles (i.e. packages consisting of fixed telephony, broadband Internet and pay TV) are picked-up by 12% of households in Europe, a proportion that rises continuously over the last few years.

Theoretical literature identifies several rationales for bundling. Most importantly, under certain conditions (pure or mixed) bundling generates extra profit compared to independent sales of component products.⁶ In general, pure bundling works through reduced heterogeneity in reservation prices across consumers, thus facilitating the capture of greater part of consumer surplus. On the other hand mixed bundling can be a powerful tool for price discrimination if unit production costs are substantial, yielding even higher profit than pure bundling. There are also supply side arguments for bundling. For example, if production costs are sub-additive, bundling is a good way to explore economies of scope. In the context of telecommunication industry bundling has been proved to offer a number of additional, specific advantages to telecommunication operators: such as churn reduction (Prince, Greenstein 2014; Yang 2013) or leveraging position in the market through product tying or so called predatory bundling (Kramer 2009).

Whether potential advantages of bundling can be realized depends critically on consumer valuations for individual services and their packages. From managerial perspective, knowing the distributions of reservation prices in consumer population is an essential starting point for design and optimization of bundling strategies, as these valuations make up for the market demand. Information on subscribers' valuations is also very useful from policy perspective, given ability of bundling strategies to impact market power through altering demand elasticity or exercising price discrimination. Despite the widespread use of bundling in today telecommunications markets, almost no attention has been paid in empirical research to apply and compare various approaches towards measuring consumer valuations for bundles. Outside telecommunications, several studies confirmed that significant differences exist between results of direct and indirect methods (Wertenbroch and Skiera 2002; Backhaus, Wilken et al.

⁴ Digital TV Research (2013). Triple-Play Forecasts.

⁵ In some countries, like the Netherlands or France, this rate exceeds 60% and Triple-play revenues command 70% of total subscription revenues

⁶ Telecom operators engage in mixed bundling as consumers are not forced to choose package only (as is the case under pure bundling) but may also buy separate services.

2005). Our work compares mean WTP obtained from two different hypothetical methods: indirect, based on consumer choices and direct one based on valuations self-reported by respondents in a survey. The latter method is straightforward in implementation but sensitive to several uncontrolled measurement biases (Monroe 1990). Moreover, direct elicitation method seems to be less suitable for higher-priced, less frequently purchased product categories with significant competition (Miller, Hofstetter et al. 2011). Our interest in indirect methods is partially motivated by that evidence and also because the implementation of stated preference approach to estimate valuations of telecommunication bundles is, for a number of reasons, a challenging task.

First, telecommunications bundles contain larger number of component services than usually analyzed in different contexts. With only three services a number of potential package offerings rises from three to seven. This greatly increases complexity of a problem on different stages of modelling. Second, numerous interdependencies exist between component services, which need to be accommodated in valuations. For example, for many users, fixed broadband will be an imperfect substitute for fixed telephony, as they can use IP-based video and voice services, such as calls to mobiles and landlines. Therefore, a reservation price for the fixed telephony will be conditional on whether consumer has access to substitute services. On the other hand, multiple-play package may create additional value to consumers due to complementarities between components of the package. Complementarity might stem from various sources like: technical integration of different technologies in one service (ex. video on demand) or convenience (ex. one bill or single user account).⁷ In short, for component products being substitutes or complements, reservation price for a package typically will not be additive in reservation prices for components which has practical implications for the design and profitability of bundling. (Venkatesh and Kamakura 2003).

The third issue which adds complexity to the elicitation of subscribers valuations for fixed telecommunication bundles is an impact of cellular services, known as fixed-to-mobile substitution (FMS). Numerous recent studies (Barth and Heimeshoff 2012; Grzybowski 2014) confirmed ongoing substitution using subscription or revenue data. Shrinking relates mostly to those fixed lines which operate (naked) voice telephony. On the other hand, fixed-to-mobile substitution is not that strong in case of lines operating broadband Internet, as this service offers some premium to consumers due to higher transfer speeds and unlimited transfer (Vogelsang 2010).⁸ Our study contributes to ongoing FMS debate with an microeconomic evidence on the distribution of reservation prices for both fixed-line

⁷ Stremersch and Tellis (2002) list many ways in which integration creates value added, such as: compactness seamless interaction, reduced risk, interconnectivity and enhanced performance. It seems that integrated ICT-based products and services (such as smart TV and VOD) gained much on importance since they wrote their paper.

⁸ A bundle of fixed broadband internet and mobile telephony might slow down FMS for the time being, but the future of fixed-line services looks vague with an advent of fully reliable and unlimited mobile internet based on LTE.

services conditional on having mobile phone. Our results strongly suggest that subscribers, who consider price of mobile calls to be low, already evaluate fixed telephony as an obsolete service.

The objective of the paper is to apply stated preference discrete choice experiment to obtain willingness to pay distributions for three most popular fixed telecommunication services, namely telephony, broadband internet and pay TV. Our framework encompasses a number of challenging issues stemming from the specificity of telecommunications services, namely: possible substitutability and complementarities between bundle components as well as the impact of mobile services on WTP. To our knowledge, this is the first attempt to model choices over three-component bundles in telecommunications. Existing studies on this topic are very scarce and deal with much simpler case of two-item bundles, mainly outside telecommunications market.

The rest of the paper is organized as follows. In section 2 we provide a short literature view. In section 3 we describe details of our empirical study. Section 4 sets up modelling framework and presents estimation results. Finally, section 5 provides summary and conclusions.

2 LITERATURE REVIEW

Over recent years there is a growing practical interest in bundling on various markets including airlines, financial services and telecommunications. Various properties of bundling and especially conditions under which it generates more profit than separate sales have been studied in economics since the seminal works of Stigler (1963) and Adams and Yellen (1976). Venkatesh and Mahajan (2009) provide an overview of existing research and identify elements which determine dominance of (pure or mixed) bundling over separate sales of components. In general, pure bundling works through reduced heterogeneity in reservation prices across consumers, thus facilitating the capture of greater part of consumer surplus. On the other hand, mixed bundling can be a powerful tool for price discrimination if unit production costs are substantial, yielding even higher profit than under pure bundling. Mixed bundling enables monopolist to sell a bundle to a large mass of customers in a central segment of total value distribution and, at the same time, capture higher mark-up from consumers in the left tail, who are mainly interested in one of the goods (Schmalensee 1984). The idea of reduced heterogeneity of reservation prices for a bundle is linked to the issue of negative correlation of component reservation prices. Schmalensee (1984) has shown that for joint bivariate normal distribution bundling might be optimal even if correlation between reservation values is moderately positive. McAfee, McMillan et al. (1989) establish general sufficient condition for mixed bundling to dominate separate sales for any atomless joint distribution of reservation prices and show that this condition holds also for independently distributed reservation prices. Recently, Chen and Riordan (2013) utilized copula approach to generalize sufficient and necessary conditions of McAfee, McMillan et al. for bundles of size larger than two.

Empirical contributions in the field of telecommunications focus mainly on factors determining adoption of bundles by consumers. Srinuan, Srinuan et al. (2014) find that apart from the size of bundle discount, also socio-demographic profiles of subscribers, such as income or household size and service characteristics influence the probability of buying multiple services. Another contribution from Üner, Güven et al. (2015) uses logit regression to model probability of bundling adoption for Turkish customers. They find that probability of bundling adoption increases for young and well educated people pointing to customer preference heterogeneity for different telecommunications packages.

Literature related to the measurement of consumers' willingness-to-pay for multiple telecommunication services is scarce. Klein and Jakopin (2014) estimate willingness-to-pay for mobile telecommunication service bundles. They focus on several attributes of plain voice service such as free minutes, type of handset and added services and calculate part-worth utilities in a conjoint study. They conclude that text messaging has lower relative value (as a % of basic fee) than the volume of free minutes and Internet access. Ben-Akiva and Gershensfeld (1998) is the first study to apply stated preference discrete choice to model of large number of possible bundles composed of fixed telephony service with several add-ons such as call forwarding, number presentation, and other customizable calling features. They evaluate preselected packages and test how the size of price discounts increases demand. The most relevant study to our work is a paper by Jedidi, Jagpal et al. (2003). They develop a stated choice experiment, which captures heterogeneity in reservation prices for bundles with two components. They find that reservation prices for component products and bundles are sub-additive and that bundling reduces heterogeneity of reservation prices. Our work adopts similar framework as proposed in Jedidi, Jagpal et al. (2003), namely discrete choice experiment, but makes several points of departure in order accommodate bundles with three component services.

3 EMPIRICAL STUDY

Researchers in economics have two main data sources for analyzing consumer preferences: revealed and stated preference data. Stated preference data refer to situations where choices are hypothetical although typically made under incentive-compatible conditions. The use of stated-preference data is currently a fast-growing technique used in a broad range of fields, including the economics of transportation, environment, health, marketing, and policy (Carson 2012; Hess and Daly 2014). Importantly, the stated preference methods allow for the systematic and simultaneous study of the influence of multiple factors that influence choice behavior.

One of the preference elicitation formats widely used in stated preference studies is a discrete choice experiment (Ben-Akiva and Lerman 1985; Louviere, Hensher et al. 2006; Train 2009). Potential consumers are asked to make choices from mutually exclusive sets of alternatives in a hypothetically constructed scenario. In each choice situation, the choice alternatives are described in terms of different levels of attributes describing the good in question (Lancaster 1966). By observing respondents' choices

in the choice situations, the effects of the attributes on the choices can be derived. In essence, this allows us to estimate the parameters of consumers' utility functions which makes it possible to simulate their market behavior, calculate welfare changes in case a new product is introduced, and estimate respondents' willingness to pay for each level of each attribute.

In this paper we present the results of a discrete choice experiment study conducted on a non-representative sample of consumers in Poland in 2015. Our study focuses on estimation of willingness to pay for dual and triple-play bundles of telecommunication services in order to (i) check for additivity at sample level, (ii) capture the impact of mobile services and (iii) compare choice-based WTP estimates with self-reported valuations.

3.1 CHOICE EXPERIMENT QUESTIONNAIRE

A dedicated questionnaire has been developed and tested for the purposes of our research. It contained a block dedicated to the actual use of telecommunication services - both fixed and mobile. We have asked about details of tariff plans for voice telephony and pay TV. For currently used broadband services, respondents reported transfer speeds and monthly data limits. We have also collected information on providers, adoption of bundling offers and monthly costs of services.

In the main part of choice experiment questionnaire, respondents were introduced to the hypothetical situation of moving into a new apartment in another town. They were instructed that their current fixed services cannot be ported to a new place, but they can choose new package from an offer presented by telco supplier operating exclusively in the area. All three component services (TEL, TV, INT) had the same set of technical parameters listed in the questionnaire. Those parameters corresponded to actual 'average' market conditions and were invariant over respondents and choice situations. Putting aside technical differences was our deliberate choice as we wanted to focus entirely on the relations between reservation prices for different fixed packages and also the impact of mobile services. Consequently, we could describe choice alternatives with only 2 attributes:

- (1) type of bundle,
- (2) monthly subscription fee for that package.

Levels of the 'type' attribute reflected all possible combinations of packages that can be formed out of three component services. Levels of subscription fee attribute, corresponded with actual expenses reported by subjects in the preliminary qualitative analysis. Both attributes are summarized in Table 1.

Table 1. The list of attributes and attribute levels used to describe choice alternatives

Type of bundle	<ul style="list-style-type: none"> • only [TV] • only [TEL] • only [INT] • [TV+INT] • [TV+TEL] • [INT+TEL] • [TV+TEL+INT]
Monthly subscription fee (PLN)	<ul style="list-style-type: none"> • A number from [10,100] on continuous scale

At the choice experiment design stage we had to address two practical problems. Both resulted from having bundle size greater than two. With only two items in the bundle it is possible to prepare an experiment using minimal orthogonal plan for main effects with three possible levels of ‘type’ attribute, three levels of ‘fee’ and three levels of bundle discount, as in Jedidi, Jagpal et al. (2003). Such plan has only 27 choice situations which can be conveniently split into 3 blocks. However this cannot be done when the number of items is three, as this implies seven levels for the bundle attribute: three single-component offers, three dual-play and one triple-play bundle. Even for minimal number of levels of price attribute, full factorial plan has 2187 combinations – definitely too many for implementation in any survey. Another problem is related to the fact that choice tasks with more than 4 alternatives are not recommended, because they impose too heavy cognitive burden on respondents leading to unreliable results (Louviere, Hensher et al. 2006). To accommodate for the above restrictions one could use fractional factorial design which includes only some combinations of attribute levels in alternatives, and maintain attribute level balance. It is preferable however to use non-orthogonal efficient design which is optimized to extract more information from respondent choices, yielding parameters with as low as possible standard errors (Street and Burgess 2007). Standard errors are determined in AVC matrix based on the underlying experiment and some prior information about the parameter estimates (Sándor and Wedel 2001).⁹ We have generated efficient design optimized for calculating willingness-to-pay, which minimizes C-Error – the sum of variances of the ratio of two parameters (Scarpa and Rose 2008).

Our design had 36 choice situations split into 3 blocks. Each respondent was randomly assigned to one of the blocks with 12 choice tasks, each with four alternatives. In single choice situation respondent was presented with four alternatives to choose from: three variants of fixed packages with corresponding prices and the no-choice alternative. Respondents were instructed that: (i) they can choose only from the presented subset of three fixed packages or choose not to buy; (ii) picking-up no-choice alternative implies, that in the new apartment they will use only currently subscribed mobile services and (iii) picking-up one of fixed bundle alternatives does not preclude them from using currently subscribed mobile services at home. We wanted to ensure that the framing of our choice experiment resembles as

⁹ We obtained priors from pilot study conducted at an earlier stage of the research.

much as possible real-life choice situation, where fixed services can be partially or entirely substituted with mobile services. In our experiment consumer could decide not to buy fixed telephony or broadband Internet if he felt that mobile services within his current plan are sufficient. An example of a choice card shown to respondents is given in Figure 1.

Figure 1. Example of a choice card (translation)

You are presented with the following offers of fixed services for your new apartment. Which of the following package would you consider the best for yourself?

Offer	A	B	C	D
Type of package	TV+Internet	TV+Telephony	TV	None. I will use only my current mobile services
Monthly subscription fee (PLN)	95	41	31	
Your choice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Besides declared experimental choices, respondents provided us with an information about their subjective valuations of particular services. This gave us an opportunity to compare reservation prices provided directly by respondents with those obtained with indirectly from discrete choice.

3.2 SAMPLE DATA

We have collected data from 272 respondents by means of internet survey. The survey was administered on a platform Profitest.pl developed by our colleague from Faculty of Economics. Respondents were incentivized with a promised contribution to a charity for submitting complete set of answers.¹⁰ Average duration of an interview in the whole sample was 16 minutes (with standard deviation of 5.5 min.) and complied with the expected duration time indicated in the instruction to the questionnaire (15-20 min.).

Our sample was not representative for any group of users of fixed telecommunication services in Poland, however, we use it for the illustration of how stated preference elicitation and modeling techniques can be used for the analysis of bundling with three components. In addition, some of our findings remain valid irrespective of the representativeness of the sample. In particular this refers to the impact of mobile

¹⁰ Given a short duration of the interview, a fair level of contribution was set to 5 pln (1,25 eur), based on pilot testing. Respondents could choose from a preselected list of public benefit organizations and charity trusts representing wide range of activities, like: environment conservation, children or disabled medical and educational support. Data collection was finished in May 2015 and took only one week. This indicates that charity incentive was effective, however apparently it attracted mostly women possibly causing auto selection bias in our sample.

services on the valuation for the fixed-line telephony. In Table 2, we present descriptive statistics for the most important characteristics of our sample respondents.

Table 2. Definition of variables used to model respondents' mobile operator choice

A. SERVICES - respondents using:		%	N						
[1] pay TV [TV]		59%	161						
[2] Fixed-line BB Internet [INT]		85%	231						
	out of which: cable	68%	158						
	out of which: xDSL	32%	73						
[3] Fixed-line telephony [TEL]		39%	106						
[4] Mobile telephony		99%	270						
	out of which: voice+data plan	62%	167						
[5] mobile internet for home use (extra sim)		12%	33						
				F. Demographics					
				age (min/max/mean/median)	21/84/32/28				
				women/men [%]	73%/27%				
B. BUNDLES - respondents having		%	N	monthly expenses [PLN]				bundle discount	
				min	max	mean	median		
only [TV]		13%	36	10	130	52,97	50	-	
only [TEL]		3%	8	10	119	42,53	37	-	
only [INT]		31%	85	15	89	52,21	50	-	
[TV+INT] dual play		19%	51	20	188	92,98	86	13%	
[TV+TEL] dual play		1%	3	60	65	63,33	65	51%	
[INT+TEL] dual play		9%	24	35	150	78,71	80	20%	
[TV+TEL+INT] triple play		26%	71	30	200	112,4	110	31%	
C. Transfer speeds at home		N	0-2 Mb/s	2-5 Mb/s	5-10 Mb/s	10-20 Mb/s	20-50 Mb/s	more than 50	do not know
fixed-line BB Internet		231	1%	4%	13%	21%	15%	19%	27%
mobile internet for home use (extra sim)		33	6%	6%	6%	27%	15%	3%	36%
D. Transfer limit		N	1 GB	2 GB	3 GB	4-10 GB	more than 10 GB	unlimited	do not know
monthly data limit for mobile Internet		167	35%	26%	9%	9%	2%	5%	15%
E. monthly expenses on mobile phone		N	0-20 PLN	20-40	40-60	60-80	80-100	more than 100	do not know
[pln]		270	6%	6%	6%	27%	15%	3%	36%

A couple of interesting observations can be drawn from Table 2. First, looking at figures showing adoption rates of particular services (part A) we observe that mobile phone and Internet are the two most popular telecommunications services (with penetration of 99% and 97%), followed by pay TV (59%) and fixed telephony (39%). Fixed broadband still remains a prevailing type of Internet access, yet 12% respondents already access Internet from home, using 3G/4G modem with separate sim. Cable remains a dominant technology for fixed-access, which is characteristic for Poland and other Central European countries because of underdeveloped copper infrastructure. Broadband transfer speeds, shown in part C, look quite satisfactory both for fixed and mobile type of access. Only 18% of our sample respondents (excluding unaware), have transfer speeds less than 10Mb/s. An important difference between fixed and mobile access to Internet is caused by monthly data limits (part D). While fixed-line Internet is generally unlimited, mobile Internet has quite tight capacity constraints: 51% of respondents has a limit of 2GB per month, while only 5% uses unlimited offers. For this reason we expect that the valuations for fixed-line Internet will be quite substantial given that mobile access, albeit widespread, is still a very weak substitute.

Second, telephony is the least popular among fixed services in our sample, which is expected, given ongoing technological trend of fixed-to-mobile substitution. Interestingly, fixed telephony is bought almost entirely as a component of a dual-play bundle with internet (TEL+INT) or triple-play package with internet and pay TV (TV+TEL+INT). Another dual-play combination (TEL+TV) is quite unpopular despite the largest discount offered by the operators – 51% down from the sum of mean prices of standalone services. Third observation refers to frequency of bundling adoption and pricing, shown in part B. Around 55% of our sample respondents use some form of bundling, which is fairly close to the figures known from other sources, like already mentioned Eurobarometer survey. Triple-play and a dual-play with TV+INT are two the most popular type of bundles, adopted respectively by 26% and 19% of respondents. Pricing data reveals a clear discount pattern, according to which more popular packages are priced with much smaller discounts than the less popular ones.

4 RESULTS

In this section, we use discrete choice experiment data to formally model respondents' utility function, i.e., to quantify the extent to which each attribute influences choices and determine on what terms they are willing to trade one attribute for another. In addition, we calculate respondents' willingness to pay, i.e., the rate at which they are willing to exchange their money for the different package of fixed telecommunication services.

4.1 ECONOMETRIC MODEL

Formally, discrete choice modeling is based on the random utility model (McFadden 1974). The utility function of consumer i from the choice of alternative j can be expressed as:

$$U_{ij} = \boldsymbol{\beta}'\mathbf{x}_{ij} + \varepsilon_{ij}, \quad (1)$$

where $\boldsymbol{\beta}$ is the vector of parameters, \mathbf{x} is the vector of the levels of attributes specific for the consumer and the alternative, and ε is the random component, stemming from the inability to observe all of the important characteristics of respondents' different decision-making mechanisms (Manski 1977). By assuming that the random component is extreme value type I distributed, the multinomial logit (MNL) model is obtained with the following convenient closed-form expression of the probability of choosing alternative j from a set of J available alternatives (Greene 2011):

$$P(j | J) = \frac{\exp(\boldsymbol{\beta}'\mathbf{x}_{ij})}{\sum_{k=1}^J \exp(\boldsymbol{\beta}'\mathbf{x}_{ik})}. \quad (2)$$

The state-of-the-art DCE models allow us to take the respondents' preference heterogeneity into account. In the random parameters (mixed) logit (MXL) model, the parameters of the utility function are random variables following a priori specified distributions $-\beta_i \square f(\mathbf{b}, \Sigma)$, where \mathbf{b} is the vector of the mean values of parameters in a population and Σ is their variance-covariance matrix. Although each consumer has specified stable parameters of the utility function, the parameters may have a specific distribution in the consumer population, reflecting their preference heterogeneity. The MXL model typically yields a much better fit to the data, and at the cost of a more complicated estimation procedure, avoids some of the rigid assumptions of the MNL model (Train 2009).

4.2 WILLINGNESS TO PAY

A consumer's willingness to pay (WTP) for a marginal change in one of the attributes can be computed as marginal rate of substitution between the quantity expressed by the attribute, and income, at a constant utility level (Meijer and Rouwendal 2006). In choice experiments, as income is often missing from the indirect utility function, the marginal rate of substitution is calculated with respect to minus the cost variable, which is usually included as one of the attributes characterizing alternatives (Jara-Díaz 1991). With linear in parameters and attributes utility function, point WTP measure for an attribute k is defined as the ratio between the parameter of interest and the minus cost attribute (Bliemer and Rose 2013):

$$WTP_k = \frac{\beta_k}{\beta_{price}} \quad (3)$$

In MNL model both coefficients are fixed, but uncertain, thus mean WTP given in equation 3 is in fact a random variable, rising an interest for confidence intervals. This might be a nontrivial problem as the ratio of two random variables has unknown distribution, possibly with undefined moments. For example, if β_k, β_{price} are normally distributed, their ratio has Cauchy distribution which has undefined mean and variance, making it difficult to obtain statistical properties of WTP. In practice, confidence intervals for the mean WTP in MNL model are obtained using either normal approximation (Delta method) or Krinsky and Robb simulation. Delta method makes use of the fact that parameters of MNL model in large sample are asymptotically normally distributed, hence their ratio will be also asymptotically normally distributed with a mean given in equation (3) and variance which can be obtained analytically from asymptotic variance-covariance matrix of the parameters, as shown in Scarpa and Rose (2008). On the other hand, Krinsky and Robb method uses Monte Carlo simulation, taking simulated draws from a multivariate normal distribution with means given by the estimated coefficients and covariance given by the estimated covariance matrix of the coefficients. Then, based on R draws taken from the joint distribution simulated values of WTP are calculated. Both methods produce similar results if the standard error of β_{price} parameter to its mean is low (Hole 2007).

In MXL model both coefficients might be random, often correlated, variables following specific distribution assumed by the modeler. Several simulation approaches to estimating confidence intervals for willingness to pay measures have been proposed in this case (Hensher and Greene 2003; Hu, Veeman et al. 2005; Bliemer and Rose 2013). In this study we have adopted Krinsky Robb method in which instead of fixed coefficients, parameters of their assumed distributions are accounted for (Hensher and Greene 2003). More specifically, let now $\beta = (\beta_{k_\mu}, \beta_{k_\sigma}, \beta_{price_\mu}, \beta_{price_\sigma})$ be parameters describing mean and standard deviation of random attribute k and price. In the first step, the procedure generates R random draws for each element of β according to the process given by:

$$\tilde{\beta} = \beta + c'u \quad (4)$$

Where matrix c' is *Cholesky* factor of variance-covariance matrix for β and u is the vector of standard normal variates. For each draw of $\tilde{\beta}$, simulated WTP mean can be calculated as:

$$\widetilde{WTP}_{k_\mu} = \frac{\tilde{\beta}_{k_\mu}}{\tilde{\beta}_{price_\mu}} \quad (5)$$

With R values of \widetilde{WTP}_{k_μ} one can derive estimate of mean WTP distribution with corresponding standard errors. At the expense of increased calculation, it is possible to simulate the entire distribution of WTP in the sample by taking S draws of WTP for each realization of $\tilde{\beta}$, constructed as:

$$\widehat{WTP}_k = \frac{(\tilde{\beta}_{k_\mu} + \tilde{\beta}_{k_\sigma}u)}{(\tilde{\beta}_{price_\mu} + \tilde{\beta}_{price_\sigma}u)} \quad (6)$$

4.3 ESTIMATION RESULTS

The final dataset consisted of 3264 choices made by 272 respondents. We used these data to estimate both MNL and MXL models. For mixed logit we have assumed that all of the preference parameters were random, following normal distributions. In what follows, we assumed the following general form of the utility function of respondent i from choosing alternative r :

$$U_{ir} = \beta_{TEL}TEL + \beta_{TV}TV + \beta_{INT}INT + \beta_{TELV}TELV + \beta_{TELINT}TELINT + \beta_{TVINT}TVINT + \beta_{TELVINT}TELVINT + \beta_{PRICE}PRICE + \beta_{ONLYMOB}ONLYMOB + \epsilon_{ir} \quad (1)$$

where β is the vector of parameters associated with their respective variables and ϵ_{ir} is random component of utility associated with the choice. The interpretation of variables in the choice model is given in Table 3 below.

Table 3. Definition of variables used to model respondents' choice of bundled offers.

Variable name and definition	Measurement
<i>TEL</i> – fixed telephony standalone	Dummy: 1 = TEL; 0 = otherwise
<i>TV</i> – pay TV standalone	Dummy: 1 = TV; 0 = otherwise
<i>INT</i> – fixed Internet standalone	Dummy: 1 = INT; 0 = otherwise
<i>TELV</i> – telephony + TV dual-play	Dummy: 1 = TEL+TV; 0 = otherwise
<i>TELINT</i> – telephony + internet dual-play	Dummy: 1= TEL+INT; 0 = otherwise
<i>TVINT</i> – tv + internet dual-play	Dummy: 1= TV+INT; 0 = otherwise
<i>TELVINT</i> – telephony + tv + internet triple-play	Dummy: 1= TEL+TV+INT; 0 = otherwise
<i>ONLYMOB</i> – only mobile services at home	Dummy: 1= if no choice alternative was selected; 0 = otherwise
<i>PRICE</i> – monthly subscription fee	Continuous from range [10,100]

The estimation results – coefficients for MNL and means and standard deviations of the normally distributed preference parameters for MXL – are reported in Table 3. In both models we have set ONLYMOB as a baseline utility level. The parameters describe the relative importance (utility) associated with the attribute levels that were used in the DCE. Their absolute values do not have an interpretation, but their sign, relative values and statistical significance can be used to illustrate the characteristics to which the respondents paid the greatest attention.

While all coefficients are significant in both models, MXL performs much better as can be seen from values of Log-likelihood and pseudo R² statistics. Looking at MNL estimates, we see negative utility of fixed-telephony compared to the baseline alternative of using solely mobile services. Apparently, for those who already have mobile subscription, fixed telephony is unwanted service – mainly because it is additionally paid, but also due to inconvenience from receiving extra bills. This situation is not surprising, given that fixed telephony is functionally inferior to mobile voice service. Thus for those who already use mobile services, additional paid subscription for fixed telephony, makes no economic sense. Interestingly, fixed telephony is neutral for consumer utility if it is included in the package together with other fixed services. This observation holds for all pairs of bundles which differ only with TEL component. All those pairs have nearly equal utility levels, which suggest that subscribers do not view packages with TEL component as in any respect better than the bundles without it. This result points to the limited effectiveness of upsell strategies based on fixed telephony service.

Table 4. The results of the MNL and MXL models of respondents' mobile operator choices

Variables	Parameters		
	MNL	MXL	
	Coefficient (s.e.)	Mean (s.e.)	Standard deviation (s.e.)
<i>TEL</i> – fixed telephony standalone	- 1.3856*** (0.1836)	- 0.5422* (0.3257)	0.8511*** (0.3751)
<i>TV</i> – pay TV standalone	0.3705*** (0.1401)	1.1757*** (0.2984)	2.2381*** (0.2351)
<i>INT</i> – fixed Internet standalone	2.7295*** (0.1865)	4.7530*** (0.3376)	2.2506*** (0.1903)
<i>TELV</i> – telephony + TV dual-play	0.3806*** (0.1284)	1.4387*** (0.2853)	2.3712*** (0.2971)
<i>TELINT</i> – telephony + internet dual-play	2.5717*** (0.2309)	5.2554*** (0.4025)	2.3803*** (0.2332)
<i>TVINT</i> – tv + internet dual-play	4.2799*** (0.2614)	8.3483*** (0.4520)	2.3045*** (0.2034)
<i>TELVINT</i> – telephony + tv + internet triple-play	4.3300*** (0.2927)	8.4609*** (0.5011)	2.0820*** (0.2097)
<i>PRICE</i> – monthly subscription fee	- 0.047*** (0.0031)	- 0.082*** (0.0005)	0.0430*** (0.0025)
Model characteristics			
Log-likelihood	-3812.709	-2750.962	
McFadden's pseudo R ²	0.1433	0.3920	
AIC/n	2.341	1.695	
<i>n</i> (observations)	3264	3264	
<i>k</i> (parameters)	8	16	

***, **, * Significance at 1%, 5%, 10% level

Contrary to *TEL*, both fixed Internet and pay TV have positive utility as separate services. Consumers prefer to use them together with current mobile services from using solely mobile services at home. Coefficient for *INT* is largely positive, reflecting the fact that mobile Internet available within currently subscribed mobile services is only a weak substitute of the fixed Internet – not so much due to transfer speeds, but rather due to severe monthly transfer limits. With larger limits for mobile data transmission, utility from fixed Internet would drop in comparison to the baseline.

TVINT is the most preferred one among dual-play bundles. This is not surprising as other dual-play bundles contain fixed telephony. Finally, triple-play bundle has nearly the same utility as dual-play composed of TV and Internet which shows neutrality of fixed telephony as an add-on component to bundles. The results of MXL model, regarding means of parameter distributions, are not qualitatively different from the ones obtained with MNL. Large estimates of the standard deviations (relative to the means) associated with choice characteristics indicate the presence of substantial unobserved preference heterogeneity in our sample. Given our main objective, we will not investigate sources of this heterogeneity, albeit this can be done in MXL framework by adding a set of covariates around mean of selected parameters. Instead we turn to the results of willingness to pay estimation.

In table 5 we present the estimates of mean WTP based on MNL and MXL models, obtained with Krinsky and Robb method (as explained in section 4.2). Together with mean WTP we provide lower and upper bounds of 95% confidence interval and also means of direct valuations self-reported by our respondents.

Table 5. Mean WTP based on MNL and MXL and means of self-reported valuations in PLN.

	MNL			MXL			Self-reported valuations
	Mean	95% lb	95% ub	Mean	95% lb	95% ub	Mean
TEL	-29.11	-37.91	-21.56	-0.04	-6.58	13.59	16.47
TV	7.78	3.25	11.71	14.33	8.94	19.36	32.61
INT	57.33	55.16	59.53	57.80	53.45	62.39	51.5
TELTV	7.99	3.91	11.56	17.50	12.46	22.36	34.64
TELINT	54.02	50.69	56.97	63.88	59.67	68.15	49.43
TVINT	89.90	87.77	92.21	101.48	96.59	107.10	68.93
TELTVINT	90.95	88.93	92.94	102.85	98.48	107.75	72.99

Mean WTP based on MXL are strictly larger than the ones obtained from MNL parameters. The only exception is Internet service for which both means are very similar. For MXL, mean WTP of fixed-telephony based on MXL is close to zero. We take this value as more sensible than negative estimate for MNL. It is coherent with other results indicating that TEL as component service is neutral for the valuation of bundle. Consequently further on, we focus on MXL-based WTP values as more reliable. Indirect WTP estimates reveal complementarity of Internet and pay TV. The sum of mean WTP for INT and TV is smaller (72.13) than WTP for dual play bundle composed of those two services (101.48). At first glance this result is striking. Large popularity of free video content available online from streaming services or file sharing sites would suggest at least weak substitutability of TV with INT. One possible explanation accounts for the large share of direct broadcast satellite (DBSTV) in our sample. DBSTV contrary to IPTV does not offer any customized premium video content unless set top box is connected to the Internet. Thus for DBSTV users, dual-play TVINT likely enhances value of plain TV service by enabling access to large video-on-demand libraries.¹¹ Other dual-play bundles are close to additivity in component valuations, which is caused by zero mean WTP for fixed telephony.

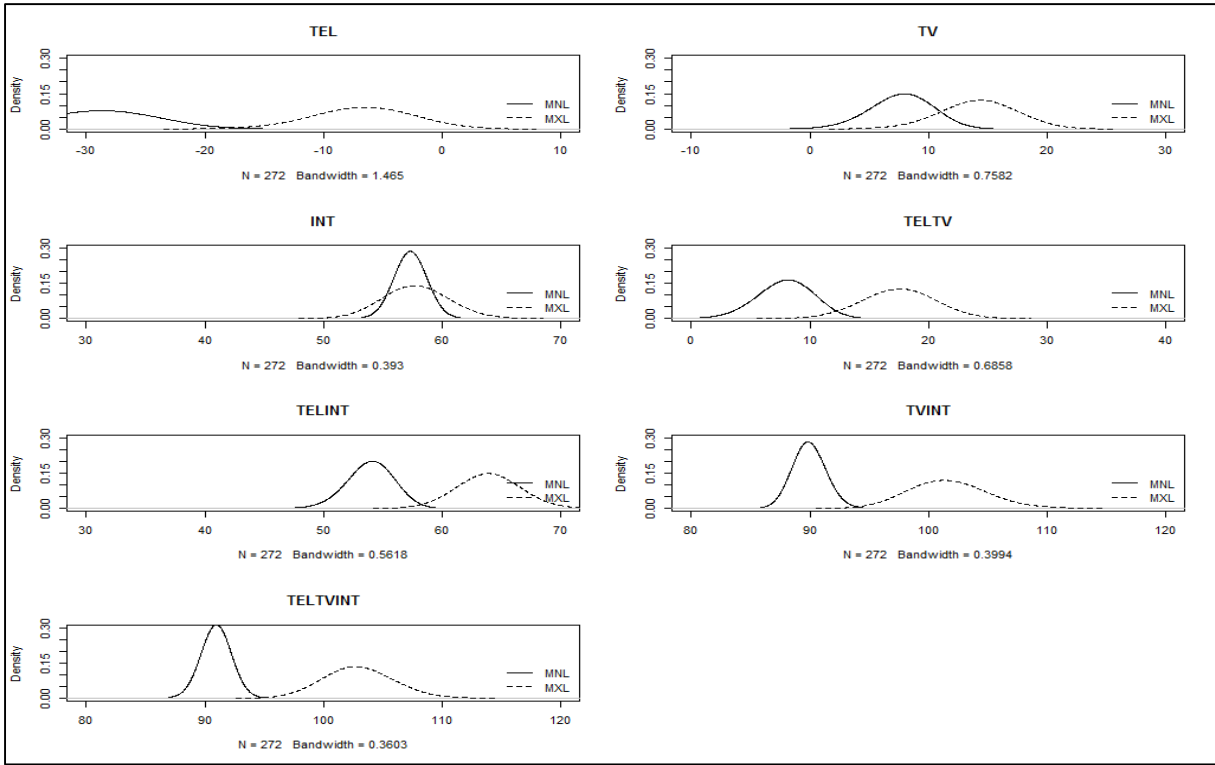
Table 5 reports also means of direct valuations. Compared to MXL WTP, self-reported valuations are greater for TEL, TV and also TELTV, but smaller for stand-alone INT service and all packages containing Internet access. This is an interesting observation which suggest that people underestimate the value of Internet when self-reporting but overestimate the values of TV and TEL. Another discrepancy between direct and indirect valuations concerns subadditivity of self-reported valuations

¹¹ In the description of pay TV service we have not mentioned any underlying technology but we have deliberately excluded VOD. Thus large part of respondents might have assumed that the offer is DBSTV.

which for services like TEL and TV cannot be easily explained. It may suggest that when self-reporting their valuations, consumers implicitly apply discounts offered for bundles. Thus direct valuation may indeed indicate how much a consumer would like to pay or what is his perception of a fair price level rather than actual reservation price which is an abstract concept. Altogether our results undermine credibility of direct valuations.

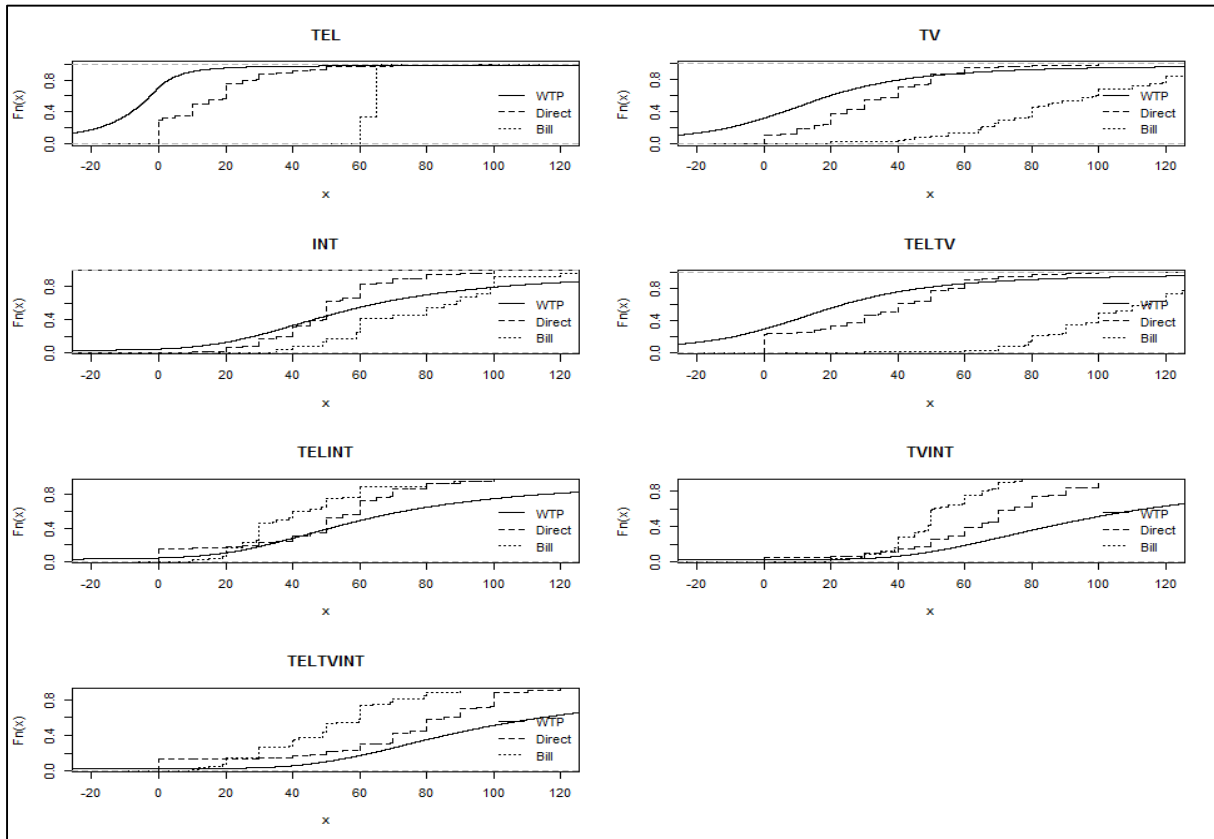
Figure 2 presents simulated distributions of mean WTP for both models. Variances of mean WTP distributions are greater for MXL – a result known from literature (Hensher, Greene et al. 2006).

Figure 2. Simulated densities of mean WTP based on MNL and MXL. Kernel density estimator.



In Figure 3, we show simulated cumulative distributions of MXL WTP in our sample, obtained with Krinsky and Robb method together with distributions of valuations self-reported in the survey. Looking at the behavior of WTP and direct valuations in the whole range of distribution and not only around means provides additional insights. Direct valuations of TEL seem to be overstated in the whole range of values, while for TV and more importantly INT this is true only for smaller valuations. Valuations for dual-play bundles with Internet: TELINT and TVINT as well as triple-play bundle seem to be underestimated by direct elicitation in the whole range of valuations. Figure 3 shows some potential for increasing profits from bundles composed of Internet. Internet seems to be the main driver of value of telecommunication bundles. Our results indicate that people might in fact be willing to pay more than they indicate with self-reported valuations and much more than they actually pay. On the other hand TEL and TV are the two services which are overpaid by consumers and whose value can be expected to decline creating a pressure on operators revenues.

Figure 3. Simulated cumulative distributions of WTP and direct valuations in our sample.



5 SUMMARY AND CONCLUSIONS

In this paper we have applied a discrete choice experiment to model subscriber preferences over bundles of telecommunication services. If a number of component services is greater than two as is the case in telecommunications, application of the method is challenging, especially at experimental design stage. We have estimated MNL and MXL discrete choice models and applied Krinsky and Robb procedure to obtain means and simulated cumulative WTP distributions in the whole sample. The indirect WTP elicitation method seems to provide more credible results than direct elicitation of valuations. One reason for this is that MNL and MXL model correctly account for possible complementarities and substitutability between bundle components as well as for an impact of mobile services which are available for home use. We have accounted for that impact with no-choice alternative in choice tasks.

Self-stated valuations show a number of discrepancies compared to MXL based WTP estimates. The main problem which undermines credibility of direct valuations is the fact that they are embedded in actual prices paid by respondents. For example consumers seem to implicitly apply discounts offered for bundles when reporting their valuations. This implies subadditivity of direct valuations – a property which was not observed for indirect WTP measures. Thus direct valuation may indeed indicate how

much a consumer would like to pay or what is his perception of a fair price level rather than actual reservation price which is an abstract concept.

Indirectly elicited valuations indicate correctly that a value of fixed telephony is close to zero regardless of whether it is a standalone service or a component of any dual or triple play bundle. With this result we provide a direct support for the main point of fixed-to-mobile substitution literature according to which the widespread use of mobile services already made fixed telephony an obsolete service. WTP valuations for bundles containing Internet and pay TV clearly indicate that fixed Internet is the biggest value generating service, while standalone TV will decline in value if not integrated with Internet based functionalities offering customized premium video content. According to our results a value of an integrated TVINT offer is super-additive in component valuations.

Our result bring two practical conclusions for telecommunication operators. First, there is potential for increasing profits from bundles composed of Internet as subscribers might in fact be willing to pay more than they indicate with self-reported valuations and much more than they actually pay. On the other hand TEL and TV are the two services which are overpaid by consumers and whose values can be expected to decline creating a pressure on operators revenues.

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