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# Are Consumers Myopic?

## Evidence from handset and mobile services choices \*

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### Abstract

This paper estimates a discrete choice model for combination of mobile tariffs and handsets using a cross-section of 11,000 new customers from a European telecommunications carrier. It mainly focuses on the valuation of tariff price, handset subsidy and price of the handset. On the one hand, a significant evolution is observed over time. Indeed, important changes on the supply side are observed, mainly in the mobile service market but also in the retailing market. On the other hand, age of consumers also influences in a wide extent consumers valuation of services and handset. Accounting for this heterogeneity, the model enables to estimate a measure for myopia occurring when consumers are trading-off price of the tariff and upfront cost of the handset. If evidence of myopia is shown for the whole time period considered (Q4 of 2011- Q4 of 2014), its magnitude tends to decrease significantly since the end of 2012. This effect is mainly due to the take-off of sim-only contracts, emergence of cheaper handsets and improved quality of information provided to consumers.

**Key Words:** Handset subsidy; Consumer myopia; Heterogeneous preferences

## 1 Introduction

Behavioral biases may lead consumers to take sub-optimal decisions given their preferences. Among them, limited foresight is observed when consumers are unable to correctly assess the future costs and benefits from a decision. In the case of myopia, future payoffs are undervaluated while present ones are overvaluated, in the framework of a purchase decision which involves complementary consumables such as ink cartridges for printer. Intuitively, myopia may be seen as the result of high time preference rates of consumers. Nevertheless, the impact of the quality and accessibility of information is often highlighted. Indeed, some information might be hidden by the firm (as add-on prices described by Gabaix and Laibson, 2006), be difficult to access or too complex to be fully

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understood and taken into account. Other studies have questioned consumer's ability to correctly assess future payoffs. Early papers estimate implied discount rates on purchase of air conditioners (Hausman, 1979), heating systems (Dubin and Mc Fadden 1984) and cars (Dreyfus and Viscusi 1995). Some more recent papers focuses on measure of attention weight (Allcott and Wozny 2013, Grigolon et al 2015). This article attempts to contribute on literature of consumer's myopia arising when customers decide to purchase a combination of handset and mobile services.

When purchasing a new handset, consumers face the trade-off between handset subsidy and monthly fee. Consumers may choose a sim-only contract with a handset purchased at list price or a mobile plan with handset subsidy, involving lower upfront cost of the handset and higher monthly recurring charge. When making this decision, consumers cannot perfectly foresee their future usage and may have difficulties to correctly assess the attractiveness of both alternatives. On the one hand, in spite of a regulatory framework which constantly evolves to guarantee an easy-access and transparent information, consumer may ignore a part of it. Consumers may also be present biased. On the other hand, consumers may be influenced by budget constraint: they might choose a mobile plan with handset subsidy because they cannot pay at once at the start of the contract. The traditional financing scheme of handset subsidies has been commonly used to encourage consumers for long term commitment; more recently to help them upgrading their device. In recent years, this scheme has been facing competition of sim-only contracts. These plans include no handset subsidy: mobile handsets are offered separately, often with the possibility of financing through credit or spread repayments. Some European carriers (Vodafone, Telefonica) have decided to cut-off or fully stop subsidization of handsets (OECD, 2013). If studies on financial impact of this strategy had been led, there is no study -to the best of our knowledge- on its impact on consumer's surplus.

Together with the take-off of sim-only offers and the "bring your own device" trend, some European Regulators moved towards reducing termination fees and commitment period of contracts. Their purpose is to increase competition by reducing consumer's lock-in and switching costs. For the same purpose, some also encouraged -or enforced- operators to unbundle services and handsets or to provide more transparent information in displaying separate payments for service and repayment of the handset. Despite the enrichment of the offer and the new regulatory framework, mobile plans with handset subsidies and long commitment period (24 months) are still widespread. How do consumers value handset subsidies? In what extent commitment period has an impact on consumer's choice? Do consumers correctly value the discounted future monthly charges when choosing a tariff? Thanks to a model that combines both attributes of tariffs and handset, a more realistic framework is defined compared to what has been experimented so far to analyze this intertemporal trade-off. To estimate this model, an individual-level data consisting of new consumers observed between May 2011 and December 2014 is used. As a first step, a discrete choice model is estimated to determine consumers valuation of handset subsidies, handset and tariff prices. Heterogeneity of customers' age and the effect of time are taken into account. As a second step, a measure of

consumers' myopia is calculated thanks to estimation results from a simplified model. A method developed by Allcott and Wozny (2012) is followed. The remainder of the paper is organized as follows: in the next section, we position this paper within the related literature. In section 3, we describe the data used for the analysis of this paper. Section 4 develops the demand model. Section 5 provides details on the empirical estimations. Section 6 concludes.

## 2 Literature review

There is a large body of empirical research on consumer behavior in telecommunications markets which is focused estimating choices of tariffs plans (Ben-Akiva, Train and Mc Fadden, 1987), price elasticities (Pereira and Ribeiro, 2011), switching costs (Kim, 2006; Grzybowski, 2007), willingness to pay for service attributes (Rosston, Savage and Waldamn, 2010; Dippon, 2011; Grzybowski and Liang, 2014). There are also studies which analyze the role of handsets in consumer behavior. For instance, Kim, Sang-kyu and Park (2004) study the effects on welfare of the ban of handset subsidies in Korea and Finland. Papers by Choi, Lee, Chung (2001) and Song and Kim (2001) analyze the impact of handset subsidies on competition. Other papers estimated the role of handset subsidies in the technology adoption process (Daoud and Hammamein (2004); Han, Choi, Kim and Chung (2006); Zhang and Huang (2006)). Previously mentioned studies nevertheless do not question the ability of consumers to be forward looking: Literature focusing on it is very short and focuses on consumer learning after initial subscription decision which was suboptimal (Miravete, 2003). This paper contributes to the existing literature by developing a model in which consumers face a trade-off between handset subsidy and monthly fee, i.e. between capital costs and operating costs.

Myopic behavior of consumers facing similar trade-offs has been studied in several ways, mostly in the field of energy. Myopia was, at first, measured estimated through individual's discount rates. Hausman (1979) compute discount rate in the frame of choice of air conditioners. He finds an average rate of 20%, decreasing with household's level of income. This result gives evidence of present biased behavior. Dubin and Mc Fadden (1984) apply the same method for choice of heating and cooling systems and found similar values. They also found a level of income for which the discount rate is equal to real interest rate: below income of 22 300\$, consumers are credit constrained. In 2012, Busse, Zettelmeyer and Knittel compare the implicit change in willingness to pay to changes in expected future fuel costs for different kind of cars to order to compute implicit discount rate. Other recent studies on the car market attempt to evaluate myopia through a measure called *attention weight*. Allcott and Wozny (2012) followed by Grigolon, Reynaert and Verboven (2014) evaluate a value for attention weight, in a similar econometric framework. Instead of computing a discount rate, they assume it exogenous (taking a proxy for market interest rate) and calculate the extent of consumers'attention to it. Both account for mileage heterogeneity. Both find an

evidence of consumer’s myopia in a limited extent. This paper borrows Allcott and Wozny (2012)’s method to explore consumer’s myopia in the case of subscribing to services together with purchasing a handset. Heterogeneity in terms of age of customers is taken into account. Effect of time on variables of interest are also evaluated in order to account for the market evolution.

### 3 Data

The data set is a combination of several data sets. The main set consists in detailed individual observations of mobile customers provided by a European operator. This set is supplemented by the handsets’catalog of the operator, providing information about retailing price and amount of subsidy offered. To finish, public information from internet about handset characteristics is added.

Historical choices consist in a cross-section of customers of a European Telecommunication services operator who subscribed between October 2011 and December 2014.<sup>1</sup>The original sample consists in a panel of 132 710 customers whose are extracted 19,033 new customers. All consumers are new subscribers to post-paid contracts. The first observed period is kept so that the data set becomes a cross section. After keeping customers aged between 18 and 75 y.o, the sample consists of 15,281 observations. All tariffs with missing information are dropped. 13 515 customers constitute the sample which includes complete information about the tariff chosen (price, call allowance, data allowance, commitment period, handset subsidy option) and information about the customer (its age, gender, residential area). This data set is then merged with catalogs providing complementary information about handsets. The first catalog is provided by the operator and gathers list prices of marketed handsets. The catalog also provides information about amount of subsidy offered according to the chosen tariff. The second catalog adds information about handsets’ characteristics. It provides public information about the handset itself (year of release, operating system, screen size, autonomy, etc.). After dropping observation with missing information, the final sample consists of 11,016 customers.

Both original data<sup>2</sup> and sampling process led to existence of a selection bias. Nevertheless, no significant difference was found between customers and handsets’ characteristics from the random database -assumed unbiased- and the final sample.

Table 4 provides general statistics for each year. Average tariff price decreases of 19% between 2011 and 2014.<sup>3</sup> Average list price of handset stays stable. Nevertheless, when focusing on consumers with sim-only contract, handset’s average price decreases of 35%. Amount of subsidy granted to consumers with handset subsidy tariff

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<sup>1</sup>Sim-only contracts were first launched on October 2011 in the country the observed customers are from. We consider the available time period since contracts with handset subsidy are not the only alternative offered to consumers

<sup>2</sup>The individuals observed are from a single operator’s database. These customers may have specific tastes, in particular in terms of quality of services. Moreover, the operator may offer significant higher amounts of subsidy than its competitors, targeting customers who are the most sensitive to contract including handset subsidy.

<sup>3</sup>National price index for mobile tariffs shows a decrease of 38% between October 2011 and December 2014

decreases also of 14%. A take-off of sim-only contracts is observed between 2011 and 2014. Their share of chosen tariff goes from less than 2% in 2011 to roughly 30% in 2014. Over the same time period, share of tariff with no commitment period is multiplied by 20. Share of customers subscribing to a contract with a 12 months-commitment period has doubled between 2011 and 2014. Take-off of tariffs with no-commitment is in a large extent due to release of low-cost offers with no handset subsidy, online subscription and online customer services. On the whole time period (2011-2014), 98% of free of commitment subscribers are low cost subscribers. As a consequence, a variable for "low cost" contract is not included in the model because of strong correlation with the "0" commitment period. Table 5 presents shares of handset brands over the time. 4 brands of handsets are the most widespread in our sample: Apple, Samsung, Nokia and BlackBerry. These shares are quite stable in time, except for the brand Blackberry. Its share dropped from 14% in 2011 to 1.6% in 2014.<sup>4</sup>

## 4 Econometric Model

A discrete choice model framework is commonly used to analyze choices of telecommunication products. These models allow analyzing situations where an agent (a person, a firm) faces a choice or a series of choices over time, among a set of options. Each individual chooses with preferences depending on his characteristics (age, gender) and the product attributes (price, quality of services). A rational consumer chooses the alternative that maximizes its utility. As the data set combines alternatives specific variables and quality measure for all alternatives such as age and gender of the customer, a conditional logit model is estimated. The first step of modeling is to define an exhaustive and mutually exclusive choice set.

Consumers are assumed to choose a combination of tariff and handset among all the combinations available at current month. In the choice set, each individual has a unique identifier and face a large number of combinations. These combinations are made with a tariff from all the available carrier's tariffs and a handset from the catalog of available handsets sold by the carrier.<sup>5</sup> Customers are assumed to purchase a new handset when subscribing to a new tariff<sup>6</sup>. Constructing an exhaustive choice set would have led to computational issues as each choice set consists of 3000 alternatives and the final data set over 32 million of observations.<sup>7</sup> The number of alternatives is limited by fixing a number of tariffs and handsets randomly chosen in the catalog of available tariffs and handset available at the current month, which is a standard approach in the discrete choice literature (see Ben-Akiva *et al*, 1987).

The majority of available tariffs since October 2011 are offered with several options in terms of commitment

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<sup>4</sup>Variations in brand shares may be heavily influenced by the Operator's retailing strategy such as refund offers.

<sup>5</sup>Handsets may be bought elsewhere but its price is assumed to be equal to the Operator's list price

<sup>6</sup>Let us ignore the case when a consumer subscribe to a mobile tariff and keep its previously bought handset. Let us also assume that the handset obtained thanks to a subsidy is actually used by the subscriber. Indeed, handsets may be offered or sold.

<sup>7</sup>Taking average number of available tariffs and handsets, the final data set would consist in  $11000 \times (70 \times 42) = 32,340,000$  lines.

period and handset subsidies. Prices are different in each of these situations. Commonly, the cheapest tariff is the tariff with no handset subsidy. These tariffs are offered free of commitment or with a 12-months commitment period. In the latter case, a discount of 5-10 euros on the tariff price is granted every month. Tariffs with handset subsidy are associated with commitment period of 12 or 24 months. 24-months contracts are the cheapest among these two. In the choice set, all available options for the chosen tariff appear. 10 more random offers selected in the 95% of tariffs chosen by customers the corresponding month are added. Table 6 in appendix shows an example of choice set. Each tariff (actually chosen and random ones) appears with the chosen handset and 10 randomly selected handsets. The catalog of handset consists of the 95% of most chosen handset at the current month.<sup>8</sup> Each choice set consists in between 121 and 154 alternatives<sup>9</sup> per customer where are mixed actually chosen tariff with random handsets, actually chosen handsets with random tariffs and random offers with random handsets.

#### 4.1 Detailed model to estimates elasticities over time and age groups

A standard linear utility specification is used for individuals  $i = 1, \dots, N$  over different tariffs  $j = 1, \dots, J$  and handsets  $k = 1, \dots, K$ . Utility depends on tariffs and handset characteristics and on the observable and unobservable individuals characteristics.

The utility of individual  $i$  for tariff  $j$  and handset  $k$  be given by :

$$U_{ijk} = x'_{jk}\beta - \alpha_1 pt_j - \alpha_2 ph_k + \alpha_3 s_{jk} + \epsilon_{ijk} = V_{ijk} + \epsilon_{ijk} \quad (1)$$

where the price of tariff is denoted by  $pt_j$ , price of handset  $ph_k$  and amount of handset subsidy  $s_{jk}$ .  $\alpha_1$ ,  $\alpha_2$  and  $\alpha_3$  are average valuation for  $pt_j$ ,  $ph_k, s_{jk}$ , respectively.

$x'_{jk}$  is the vector that include the following variables: a dummy for unlimited calls, a categorical variable for commitment period (0/12/24 months), discount for 12-months commitment in the case of sim-only contract, amount of data allowance, a dummy for fixed broadband, a dummy for smartphone, a dummy for the fourth popular brands (Apple, Samsung, Nokia, Blackberry), camera quality (in Mpx), the standby autonomy in hour, the screen size in inch and the time since release of the handset<sup>10</sup> Interactions between the variable the study focus on ( $pt_j, ph_k, s_{jk}$ ),

<sup>8</sup>The historical choices data set does not provide information about the internal memory of smartphone from the manufacturer Apple. As price of models varies according to this criterion, a 16 GB internal memory model is taken as a reference for all Apple's smartphones.

<sup>9</sup>This heterogeneity is related to the difference in number of option available for a same tariff. If the chosen tariff has no alternative commitment period or subsidization, the choice set will contain 121 alternatives (11 tariffs\*11 handsets). If another option is available, the choice set will contain 132 alternatives (12 tariffs\*11 handsets). If 2 options are available, the choice set will contain 143 alternatives (13 tariffs\* 11 handsets). To finish, if there are 3 other options, the choice set will contain 154 alternatives (14 tariffs \* 11 handsets)

<sup>10</sup>A dummy variable for low cost tariff of the brand could be included. Nevertheless, the high correlation with no-commitment lead both commitment and low-cost dummy estimates to take signs that are counter-intuitive. One may also split the subsidy in two parts; a fixed part for the services associated with this kind of tariff and a proportional part, the amount of subsidy itself. Nevertheless, fixed part of subsidy estimates and commitment are strongly correlated. Some estimation results are not intuitive anymore: 24 commitment period become source of utility (with a positive sign) and the fixed part of handset subsidy is negatively valued. Moreover, extracting the financing dimension of the amount of subsidy prevent from calculating the measure of myopia  $\gamma$  the way this is calculated in the standard way. Indeed, when splitting the subsidy in two, the financing aspect of subsidy, i.e. the implicit cost of credit would probably be captured by the fixed part of subsidy. This implicit credit should be included is consumer's ratio of capital costs on operating costs.

year of subscription and ranges of customer's age are included in the model.

$\epsilon_{ijk}$  capture the unobserved variability generated, among others, from advertising, special discount or refund offers.

An individual  $i$  chooses a tariff  $j$  and a handset  $k$  if this tariff maximizes its utility among all the available alternatives, i.e. if  $U_{ijk} = \max_{n \in C_i}$  where  $C_i$  is the individual  $i$ 's available choice set. The probability that individual  $i$  chooses a tariff  $j$  and a handset  $k$  is given by:

$$P_{in} = \text{Prob}(V_{in} + \epsilon_{in}) > \text{Prob}(V_{im} + \epsilon_{im}) \quad \forall m \neq n \quad (2)$$

The closed form expression derived from the previous equation, which is the classic logit probability:

$$P_{in} = \frac{e^{V_{in}}}{\sum e^{V_{im}}} \quad (3)$$

Denote by  $\epsilon_{ijk}$  the elasticity of demand for a combination of tariff  $j$  and handset  $k$  with respect to the tariff price :

$$\epsilon = \frac{\partial P_{jk}}{\partial p_j} \frac{p_j}{P_{jk}} \quad (4)$$

$$\epsilon = -p_j(1 - P_{jk}) \quad (5)$$

## 4.2 Simplified model to compute a myopia's measure

As a second step, an alternative model is estimated. This model is slightly different from the previous one and allows for applying Allcott and Wozny's (2012) computation. Indeed, in their study, consumers trade-off future costs of energy using cars with their purchase price. They may choose either a fuel-efficient more expensive car or a cheapest and less fuel-efficient car. Analogously, consumers may choose a sim-only contract (with higher upfront cost but lower monthly recurring charges) or a mobile plan with handset subsidy (lower upfront cost but higher monthly charges). One should, as a consequence, estimates the valuation for upfront cost of the device rather than list price of handset and subsidy separately.

Back to the demand function of detailed model:

$$U_{ijk} = x'_{jk}\beta - \alpha_1 p t_j - \alpha_4 (p h_k - s_{jk}) + \epsilon_{ijk} \quad (6)$$

Both list price of the handset  $p h_k$  and amount of subsidy  $s_{jk}$  are estimated.

From equation 1, the demand function is rewritten to give a simplified model :



$$U_{ijk} = x'_{jk}\beta - \alpha_1 pt_j - \alpha_5(up_{jk}) + \epsilon_{ijk} \quad (7)$$

The variable denoted by  $up_{jk}$  replaces the list price of the handset and the amount of subsidy; it corresponds to the upfront cost of the handset.  $\alpha_5$  is its average valuation.

To compute the value of attention weight, the demand function is rewritten in order to let appear the capitalization coefficient and the attention weight. Capitalization coefficient, denoted  $\rho$ , present-discounts the monthly recurring payoffs  $pt_j$ .

$$\rho = \frac{1+r}{r}[1 - (1+r)^{-S}]$$

$r$  corresponds to the market interest rate. Two alternative assumptions on its value may be taken. On the one hand,  $r$  may take the value of consumption credit average interest rate. On the other hand,  $r$  may be an approximation of opportunity cost of capital. In a similar set-up on car choices, Allcott and Wozny (2012) choose to compute a weighted average of both with share of customers who purchase the good with a credit and customers purchasing it with cash money. They find and use in their computation  $r = 6\%$ . A similar value is chosen by Grigolon et al (2014).

Two alternative scenarios are considered in this study:

- $r$  is the average national consumer credit rate for each quarter considered. Its average value on the whole period is  $r = 6.31\%$ .
- $r$  the opportunity cost of capital. We take the average return of a risk-free national booklet on each quarter considered. Its average value on the whole period is  $r = 2\%$ .

$S$  is the time horizon considered when consumers are trading-off. In previous papers,  $S$  is commonly equal to average durability of the good. In the framework of this model,  $S$  is assumed to equal average commitment period.

The attention weight -our measure of myopia-, denoted  $\gamma$  allows computing the "subjective" weight consumers put on future payoffs.

The demand function is rewritten as follow:

$$U_{ijk} = x'_{jk}\beta - \alpha(up_{jk} + \gamma\rho pt_j) + \epsilon_{ijk} \quad (8)$$

Closer to 1  $\gamma$  is, more attentive to future payoffs consumers are. If  $\rho$  equals 1, consumer's valuation of future is very high because all the value of the ratio operating costs on capital cost will be captured by  $\gamma$ . If  $\rho$  equals  $S$ , consumers do not discount future values,  $\gamma$  equals 1.

To obtain  $\gamma$ , estimations from the demand function described in equation (7) are used. The value of ratio  $\frac{\alpha_1}{\alpha_5}$  is divided by  $\rho$ . This allows to withdraw the impact of market interest rate on inter-temporal decision and highlight consumer's attention weight.

Results from this model are presented in Table 9. A random coefficient model is also estimated. Theoretical model and estimation results are presented in Appendix, in Table 10. Nevertheless, this sophisticated model do not seem to provide a significant improvement of the fit. Indeed, likelihood increases of 0.2%. This may be explained by the fact that consumer's heterogeneity is well captured by the conditional logit model with time and age interactions.

## 5 Estimation results

Two conditional logit models are estimated. These models provide average coefficients of consumers valuation for tariffs and handset attributes. Estimates from the detailed model are presented in Table 7. This model is used to describe consumer's behavior and compute elasticities from tariff price, handset's list price and amount of subsidy over the time. Estimates from the simplified model are presented in Table 9 and are used to compute  $\gamma$ .

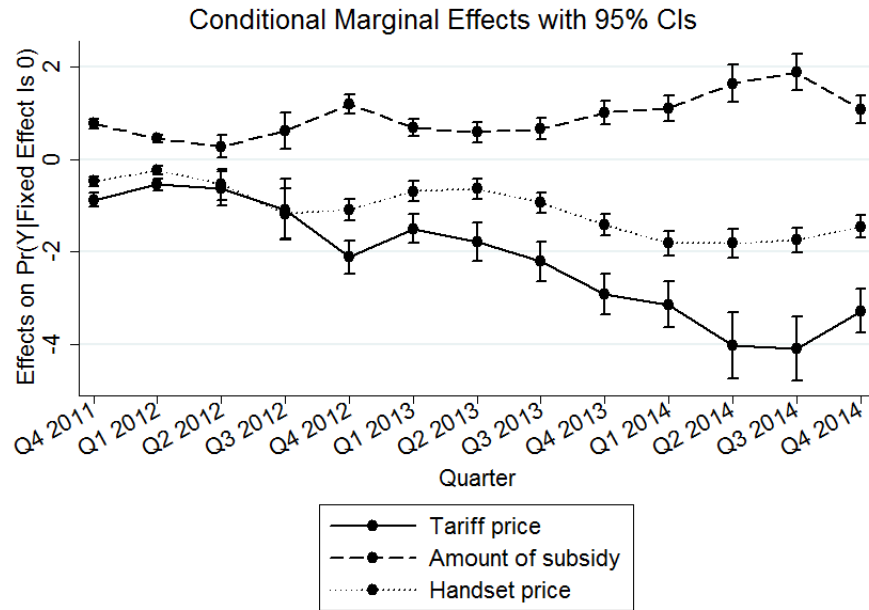
### 5.1 Estimates and elasticities from detailed model

Table 7 shows results from the detailed model. In this model, tariff price, list price of the handset and amount of subsidy are interacted with the customer age and quarter of subscription. First age group (18-25 years old) is the reference category for interaction with age. Quarter 4 of 2011 is the reference for interaction with subscription quarter of the year. Highly significant and reasonable coefficients for all variables of the model are found. As a first step, evolution in time of valuation of tariff price, handset price and subsidy are considered. As a second step, heterogeneity of these variables is compared between age groups. To finish, general results from the detailed model are presented.

**Time impact** Both coefficients for tariff price and list price of the handset are negative. These attributes have a negative impact on the probability that a combination "tariff+handset" is chosen among others. On the contrary, amount of subsidy has a positive impact on alternative's probability to be chosen. Tariff prices are interacted with the quarter of subscription to capture effects related to disturbances on the mobile Telecommunication market. Indeed, descriptive statistics show a quick fall of tariff prices between 2011 and 2014. Estimation of tariff price coefficient is divided by 3 between 2011 and 2014. Considering elasticities, sensitivity to tariff price, list price of handset and amount of subsidy has increased over the time period.

Fig.1 shows that consumers are much more sensitive to tariff price since competition has intensified and sim-only tariffs emerged. Marginal effects presented describe the variation on probability to be chosen for an alternative

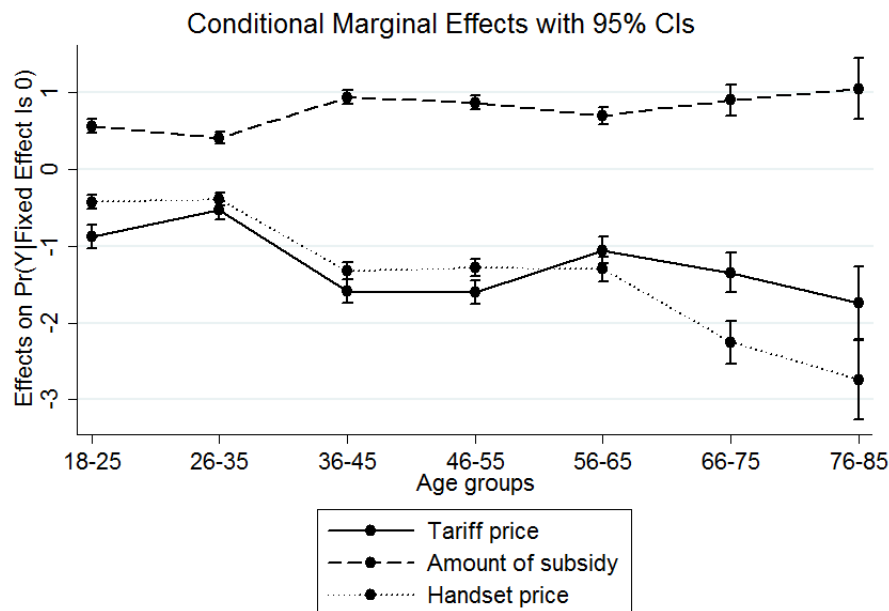
Figure 1: Marginal effects between Q4 2011 and Q4 2014



after one euro increase of tariff price, amount of subsidy or handset price, all other variables remaining at their mean. Impact of subsidy on consumer’s utility has roughly remained stable even if it tends to slightly increase since Q2 2013. Elasticity for list price of handset has increased significantly. This may be explained by the emergence of low-cost smartphones, increasing resort to the second hand mobile market and decrease of handsets’ price while ages.

**Age impact** Fig.2 shows marginal effects for tariff price, handset price and amount of subsidy according to different age groups. First, consumers’ valuation of tariff price is heterogeneous in terms of age. Youngest consumers (18-25) are more sensitive to tariff price than the 26-35 y.o. group, probably because of significant differences in purchasing power. Nevertheless, these two groups have similar level of usages and they appear less elastic compared to older consumers. Age groups 36-45, 46-55 and 76-85 have roughly similar price elasticities for tariff.

Figure 2: Marginal effects according to age groups



Second, consumers are in a smaller extent heterogeneous considering of the amount of subsidy offered. Intuitively, one may guess that amount of subsidy is particularly important to customers with high budget constraint. Younger customers are effectively more sensitive to subsidy offered compared to customers from age group 26-35. Nevertheless, both groups are less sensitive to subsidy compared to customers aged above 35 y.o. On the one hand, it may be explained by the high attractiveness of sim-only contracts targeted to young customers, in particular low cost mobile plan available online. On the other hand, added services included in contracts with handset subsidy (such as assistance, single billing) may provide high added value to consumers who are uncomfortable dealing with online customer service or who have a high search cost (for example to find a retailer).

Third, consumers are heterogeneous considering handset price. Roughly, older is the consumer, higher will be its handset price elasticity. This effect is mainly due to level of usages.

### General results

The model combines characteristics from mobile plans and handsets. On the one hand, let us describe tariff's characteristics. The dummy for unlimited calls is interacted with the year of subscription. Estimate for the dummy in 2011 has a significant negative impact. This effect is largely less important in 2012: the impact is divided by 4.5 but still negative. Since 2013, unlimited calls have a positive impact on consumer's utility. This important evolution is due to recent spread of this type of offers. Each unit of data allowance (in GB) has a positive impact on consumer's

utility. Willingness to pay for each Gb is about 14€. The dummy for fixed broadband, which is the 4P option<sup>11</sup> has also a positive impact. Willingness to pay is about 18 extra €. The estimates of commitment period are categorical and take as a reference 0 commitment. Both 12 and 24 months-commitment has negative impact on consumer's utility. Nevertheless, a 24 months-commitment tariff is preferred to a 12 months-commitment tariff. Several reasons might explain this result: First, 12 month commitment tariffs are recent<sup>12</sup>; consumers may not know them well. Indeed, these offers are not promoted as intensively as 24 months-commitment-tariff<sup>13</sup>. Second, the structure of termination fee<sup>14</sup> may influence the extent of negative valuation for 12 month commitment tariff. Indeed, for a 12 months-commitment, all the remaining periods of the commitment are charged to the customer. For a 24 months-commitment, only the 12 first months are fully charged; the 12 remaining months benefit from a lightened termination fee scheme. Third, 12 months offers probably undergo a strong competition with no-commitment contract: Customers who accept to be committed choose 24 months contracts, customers who are willing to stay free of commitment choose no-commitment contract and only a few value and choose the intermediate alternative, i.e. 12 months contracts.

On the other hand, let us describe the attributes of handsets. The coefficient for the dummy variable smartphone is significant and positive. When estimating the model, four of the most represented brands in our cross section are picked-up and included as dummies in the model for each of them. Valuation for these four dummies is the difference in valuation existing between these brands and the others brands, that is to say, all the brands for which a dummy is not estimated. Table 5 gives details about brands shares in the sample. The dummy for handset manufactured by Apple has a great positive impact on consumer's utility. The average willingness to pay to obtain a iPhone rather than, for example, a HTC handset, is, *ceteris paribus*, about 115€. This is due to a specific *premium* positioning of the brand. Blackberry handsets are also notably well valued compared to handsets from others brands. Handsets from this manufacturer have been positioned as *business* devices. Nokia and Samsung are two brands slightly more valued than the other brands.<sup>15</sup> Quality of the camera, in terms of mega-pixel capacity, has a significant and positive impact. Autonomy of the battery, expressed in stand-by hours, also increases consumer's utility. So does the screen size in inches. The number of months since handset has been released has a negative and significant impact on consumer's utility. Older the model, smaller is the utility.

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<sup>11</sup>A bundled offer with a mobile line + a fixed line including broadband internet access, TV and fixed national calls

<sup>12</sup>These offers has been marketed since 2008 as a follow-up of a new regulatory obligations

<sup>13</sup>According to a study led by the National Regulatory Agency of Telecommunication.

<sup>14</sup>Termination fee is the monetary amount charged to customers when quitting before the end of a contractual commitment. It may be framed by a national rule, what is the case in the concerned country.

<sup>15</sup>Nevertheless, valuation for handset brand is probably heterogeneous in time.

## 5.2 Method to compute the measure of Myopia

Thanks to tariff price and upfront cost of the handset's estimates (that gives the ratio  $\rho\gamma$ ) and assumptions about  $r$  and  $S$ , the market interest rate and the time horizon respectively, the myopia measure  $\gamma$  is computed.

Following the method described by Allcott and Wozny (2012), the following expression is obtained with the estimates from simplified model.

$$\gamma\rho = \frac{\alpha_{\text{tariff price}}}{\alpha_{\text{upfront cost of the handset}}}$$

For each customer, we compute  $\gamma\rho$  using the average coefficients for tariff price and upfront cost of the handset. We use the estimates from interaction between tariff price and year and upfront cost of handset and quarter. For example, we obtain for a customer of 20 years old who subscribed in November 2011:

$$\gamma\rho = \frac{-0.0321}{-0.0060} = 5.20$$

Table 1 presents the values obtained for  $\gamma\rho$ .

As a reminder, we have to withdraw from the previously found value  $\rho\gamma$  the market impact captured by the capitalization coefficient. It is calculated as follows:

$$\rho = \frac{1+r}{r} [1 - (1+r)^{-S}]$$

$r$  is a measure of the capital cost in the market. Two opposed situations are considered. On the one hand, if  $r$  equals the opportunity cost of funds, the national non-risky saving booklet interest rate is considered. In this case,  $r$  takes varies from 1 to 2.25% to during the period considered. On the other hand, if  $r$  is assumed equal to the average interest rate of consumer credit on the period considered,  $r$  takes its values from 5 to 6.3%<sup>16</sup>. Quarterly values of both booklet interest rate and consumer credit rate are obtained from the website of the National Bank of the country.

$S$  is the time horizon consumer takes into account when taking its decision. This could be interpreted in the framework of this study as the number of months the customer anticipates to keep its tariff. Literature sets up this value as the durability of the good, its life time. Indeed, in the case of heating, cooling system or cars, goods may be sold at any moment; no contractual relationship bounds the customers with the retailer who sold the good. In the

<sup>16</sup>Allcott and Wozny (2012) and Grigolon *et al* (2014) use 6% as a "market interest rate" to compute the valuation of future payoffs in automobile market. They use a weighted average of discount rate in the case of financed payment and cash payment. The value is calculated as follow: 37% of the vehicles of the Allcott and Wozny's panel is financed at a real interest rate of 6.9% in average. 63% are purchased cash. In this case, the cost opportunity of funds is assumed to be equal to S&P 500 (Standard and Poors index) returns, i.e. at the time they did the study 5.8%. The weighted average is equal to 6.2. They use 6% for more convenience. Rather than mixing the two types of rates, the two situations are explored

Table 1: Average values of coefficients and  $\rho\gamma$

<b>Quarter</b>	$\alpha_{tariff\ price}$	$\alpha_{upfront}$	$\rho\gamma$
Q4 2011	-0.0321 (0.0103)	-0.0060 (0.0014)	5.20 (0.96)
Q1 2012	-0.0253 (0.0109)	-0.0045 (0.0015)	5.44 (1.32)
Q2 2012	-0.0359 (0.0107)	-0.0051 (0.0015)	7.07 (0.99)
Q3 2012	-0.0452 (0.0107)	-0.0070 (0.0014)	6.43 (0.63)
Q4 2012	-0.0536 (0.0104)	-0.0067 (0.0016)	8.15 (0.70)
Q1 2013	-0.0490 (0.0110)	-0.0054 (0.0017)	9.30 (1.10)
Q2 2013	-0.0567 (0.0112)	-0.0048 (0.0017)	12.34 (1.88)
Q3 2013	-0.0731 (0.0108)	-0.0061 (0.0015)	12.20 (1.35)
Q4 2013	-0.0838 (0.0109)	-0.0075 (0.0016)	11.43 (1.05)
Q1 2014	-0.0910 (0.0117)	-0.0086 (0.0017)	10.73 (0.81)
Q2 2014	-0.0949 (0.0114)	-0.0087 (0.0015)	11.03 (0.74)
Q3 2014	-0.0902 (0.0106)	-0.0088 (0.0014)	10.35 (0.70)
Q4 2014	-0.0888 (0.0108)	-0.0074 (0.0014)	12.22 (1.08)

Standard deviation in parentheses

framework of this study, the contrary is often the case. For instance, customers willing to switch service supplier will be charged of a termination fee. Previously developed models in the field of energy took the average lifetime of the good as a reference for  $S$ . Ignoring the significant differences between configurations of bundles considered, one might take the average time period before handset is replaced. In this case,  $S$  would take a value between 22.4 and 51.5 months.<sup>17</sup> This alternative does not make sense as the monthly recurring charge may vary over life time of the device.

The best approximation of  $S$  in the framework of this study appears to be the commitment period. One may assume that, when subscribing, customers are perfectly aware to be bounded to their carrier for their commitment period. One may also add that, when contracting, customers anticipate to stick to their tariff for the whole commitment period. Indeed, in the case they would not, termination fee is charged. This fee is proportional to the remaining months in the contract. It is reasonable to assume the number of consumers terminating before the end of the commitment period is negligible.

Nevertheless, this approximation does not have any sense for free-of-commitment customers (basically customers with sim-only contracts). In this case, we take  $S = 19$  which is the average 'life-time' of free-of-commitment customers obtained with the full data set provided by the operator.

### 5.3 Results for the measure of Myopia

Table 2 and Fig.3 present average values of  $\gamma$  over time. Results are computed with  $r$  equal to the quarterly average national credit interest rate. Table 12 in Appendix presents results with an alternative assumption, i.e.  $r$  equal to average interest rate of a national non-risky booklet. Results are very close.

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<sup>17</sup>According to a study from Recon Analytics published in 2012, the average length of handset replacement cycle in 2010 was (1)30.8 months in France (2) 45.7 months in Germany (3) 51.5 months in Italy (4) 22.4 months in United Kingdom.

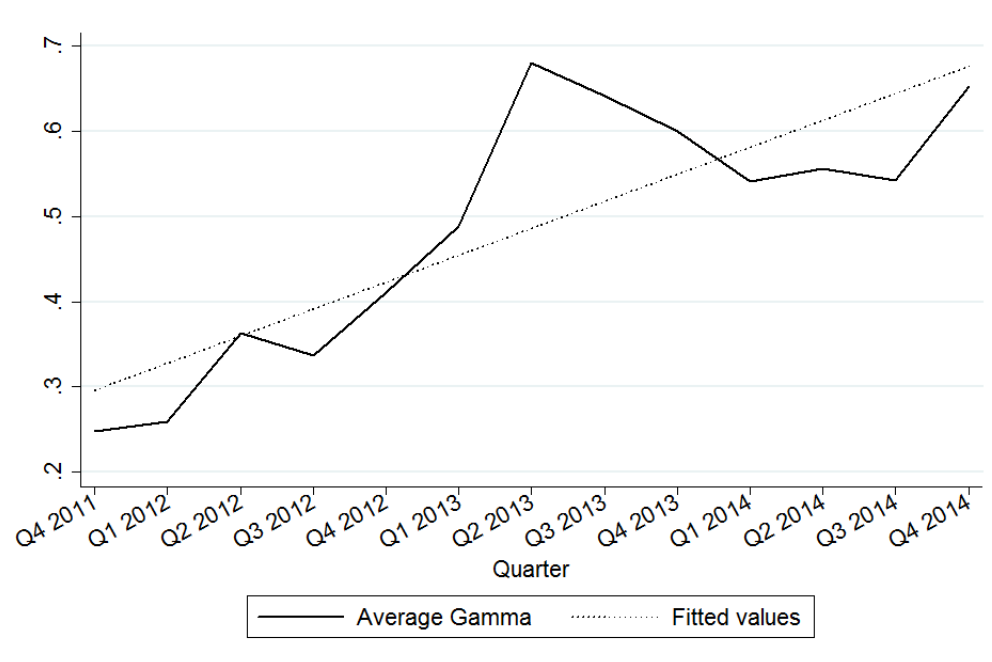


Table 2: Average values for  $r$ ,  $S$  and  $\gamma$

Quarter	Annual $r$	$S$ in months	$\gamma$
Q4 2011	0.005 (0.000)	22.984 (3.259)	0.25 (0.072)
Q1 2012	0.006 (0.000)	22.825 (2.866)	0.26 (0.079)
Q2 2012	0.005 (0.000)	21.629 (4.273)	0.36 (0.107)
Q3 2012	0.005 (0.000)	21.448 (4.549)	0.34 (0.102)
Q4 2012	0.005 (0.000)	22.007 (4.156)	0.41 (0.117)
Q1 2013	0.005 (0.000)	21.268 (4.502)	0.49 (0.148)
Q2 2013	0.005 (0.000)	20.545 (4.967)	0.68 (0.235)
Q3 2013	0.005 (0.000)	21.157 (4.515)	0.64 (0.185)
Q4 2013	0.005 (0.000)	21.175 (4.429)	0.60 (0.173)
Q1 2014	0.005 (0.000)	21.796 (4.010)	0.54 (0.135)
Q2 2014	0.005 (0.000)	21.776 (4.099)	0.56 (0.139)
Q3 2014	0.004 (0.000)	21.225 (4.606)	0.54 (0.156)
Q4 2014	0.004 (0.000)	20.928 (4.776)	0.65 (0.202)

Standard deviation in parentheses

Figure 3: Average values of  $\gamma$  over time



An evidence of consumers becoming less myopic over time is found. Recall that closer to 1  $\gamma$  is, more correct is consumer's valuation of future. Over 1, consumers overvalue future expected return on savings. Important decrease of consumer's myopia is mainly due to emergence of sim-only contracts and cheaper handsets, improvement of quality of information provided to customers but also an increase of attention paid to mobile contract choice. At the origin of these changes is a major event: the entry of a new MNO on the national market. The aggressive strategy of the new player was based on cheap web-only plans with no bundled handset. This led existing MNOs to mimic the outsider's strategy by launching their low-cost brand. These brands were exclusively offering cheap sim-only plans. Hegemonic till then, the handset subsidy financing scheme was now competing with others, because of structural changes on the mobile market. Indeed, new options to finance the handsets have been offered since then: consumer credit, spread repayment with no extra charge, leasing. In front of an expanding field of possibilities, consumer is probably encouraged to give extra attention when making its choice

The outsider firm also generated a significant debate about handset subsidy, courting one of the existing MNO, denouncing handset subsidies as source of unfair competition and disguised consumption credit with usurious interest rate. This case raised public' opinion on handset subsidy's concern. Even if the court case ended in favor of the existing MNO, handset subsidies suffered from a negative image in the national press. This last event probably increased in a wide extent consumer's attention when choosing a contract.

Together with the take-off of sim-only plan, regulatory framework encouraged MNOs and independent retailers to

display list price of the handsets, even when selling a bundled offer. This improvement of information transparency also contributed to myopia's decreasing. Indeed, the handset subsidy financing scheme often led to occult the actual value of the handset to consumers.

Take-off of sim-only contracts also led to expansion of the handset supply. On the one hand, since then, consumers are free to purchase their handset from any retailer. They can compare prices from different retailers. Consumers were also free to choose brands that were not sold by MNOs. As consumers are now facing the list price of the handset as upfront cost when choosing a sim-only contract, their elasticity for this amount increased. As a reaction of this demand evolution, cheap handsets and new brands emerged. In the country the data are from, a low cost brand created in 2011 selling exclusively unbundled smartphones represents, mid 2014, a market share of 10-15% of national unbundled sales according to GfK, climbing to the second rank, just after Samsung.

Major changes on the supply side led to significant changes in demand. Among them, increased attention paid to contract choice.

At the beginning of the period studied, the computed value for  $\gamma$  is 0.25. Attention weight appears to be very low in this case, compared to a car purchase. As suggested in Strotz(1956), consumers are more impatient when making short-run trade-offs than making long-run trade-offs. Both replacement cycle and magnitude of investment are different and could explain the difference in values of  $\gamma$  found. Nevertheless, the significant increase of attention weight since Q4 2012 shows that the relatively quick replacement cycle of handsets and magnitude of investment are no longer robust reasons for consumers to neglect future payoffs. Indeed, computed  $\gamma$  for the two last years of observation is about 0.60, a value getting closer and closer to Grigolon et al's (2014) one. Indeed, Grigolon *et al* who worked on purchase of cars in Europe found  $\gamma = 0.88$  and concluded that consumers have a modest undervaluation of future payoffs.

Estimates from a more sophisticated model are show in Table 10. If the quality of the model is slightly better, results are very close to estimates from the standard conditional logit. Mixed logit model provides weak additional information about consumers' heterogeneity as the previous model already captured the two major sources of heterogeneity, i.e. year of subscription and age of subscriber. The only significant adding of mixed logit is showing heterogeneity of valuation of commitment.

Some limitations emanate from both data and assumptions of the model. First, the selection bias quickly described in the data section might have a limited but still worth-noting impact on results. Indeed, estimations are based on historical choices from a single operator. This operator has a marketing positioning based on high quality of services and, as a consequence, offers in a large share premium tariffs. Most price-elastic consumers are probably not observed as they have subscribed to an operator with a different positioning. Excluding rare, low end smartphones and elders-targeted brands may also left out specific consumers. Second, consumers are assumed to choose simultaneously a tariff and a handset. In a realistic framework, consumer probably chooses one after the

other. A nested logit model would allow for constructing a sequential decision: as a first step, consumer would choose a handset; as a second step, consumer would choose a tariff, knowing the list price of the chosen handset. An alternative model could be estimated with the inverse sequence: the tariff is chosen first; then the handset is picked up. Nevertheless, the complexity of consumer's choice in our framework and consequently the size of the choice set does not technically allow to estimate such a sophisticated model. To finish, handsets are assumed to be new handsets when observed. Actually, handsets may have been purchased before or given by a relative. The architecture of the decision is different in this case. Nevertheless, this doubt only exists for customers who choose sim-only contracts (1.8% in 2011, 13.7% in 2012, 30.1% in 2013 and 28.8% in 2014). In the national market, the share of sim-only contracts is about 20% at the end of 2011, 33% at the end of 2012, 44% at the end of 2013 and 51% at the end of 2014. The cross section is specific in the sense that its share of sim-only contract is significantly lower than the national average. This carrier may offers contracts with attractive handset subsidies.

## 6 Conclusion

The paper analyses to which extent mobile Telecommunication services subscribers undervalue future payoffs when making their decision to bundle or unbundle mobile tariff and handset.

To estimate the demand model, a detailed cross section of new subscribers is used. This data set gathers information of both tariff and handset chosen in the month of subscription. Thanks to discrete choice models, valuation of tariff price, handset subsidy and list price of handset are estimated. Heterogeneity in terms of year of subscription and consumer's age are taken into account. The first source of heterogeneity captures effects of major changes of both supply and demand side on the time period observed. The second source captures the main variability of preferences.

If consumers undervalue in a large extent future payoffs until end of 2012, their behavior seems to have evolved significantly over time. Indeed, since Q4 of 2012 average attention weight increased sharply. It is mainly due to sim-only tariff spreading, availability of cheaper smartphones and improved quality of information provided to consumers.

## 7 Appendix

### 7.1 General statistics

Table 3: **Summary Statistics**

<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
Age of the customer	41	13.87	18	85
Female	0.49	0.5	0	1
Commitment period	20.59	7.59	0	24
Tariff price	40.34	21.75	4.9	175
Data Allowance	1.11	1.22	0	10
List price of the handset	388.19	179.43	25	800
Option handset subsidy	0.87	0.34	0	1
Unlimited call	0.23	0.42	0	1
Amount of subsidy	210.59	124.14	0	590
Voice consumption in minutes	88.79	285.32	0	11691.07
Data consumption in Gb	0.31	1.12	0	56.68
Number of customers observed	10 666			

Table 4: **Statistics according to year**

	2011	2012	2013	2014
Tariff price	39.7	43.9	33.5	32.3
List price of handset	384.7	401.2	365.2	359.8
- For customers with handset subsidy	382.8	398.2	378.1	377.3
- For customers with no handset subsidy	491.3	419.9	335.2	316.7
Amount of subsidy (if sub>0)	235.6	259.3	221.1	202.8
Upfront cost of handset	153.4	177.4	210.6	215.4
-For customers with handset subsidy	147.1	138.9	157.0	174.4
-For customers with no handset subsidy	491.3	419.9	335.2	316.7
Share of sim-only contracts (%)	1.8	13.7	30.1	28.8
Commitment period				
- 0 months	1.6	12.6	16	14.3
- 12 months	7.8	5.6	18.1	16
- 24 months	90.6	81.8	65.9	69.7
Share of observations	30.02	48.95	12.95	8.88

Table 5: Shares of handset brands (in %)

Brands	2011	2012	2013	2014
Acer	0.25	0.27	0.00	0.00
Alcatel	0.69	1.13	1.77	3.27
Apple	32.32	33.84	29.17	33.58
Blackberry	13.99	9.12	6.94	1.58
HTC	2.84	2.64	2.39	2.01
Huawei	0.00	0.00	0.08	0.21
LG	3.59	3.16	5.40	4.44
Motorola	1.94	2.01	0.85	0.32
Nokia	9.96	9.27	12.42	12.57
Carrier's Brand	0.00	0.13	0.15	0.00
Samsung	29.92	33.77	29.71	28.93
Sony	0.00	0.33	9.49	12.67
Sony-Ericsson	4.50	4.33	1.62	0.42
Total	100	100	100	100

Table 6: Example of choice set: details

id	alt	tariff id	tariff price	data	commitment period	handset	upfront cost handset	y
22	1	ABC	54	0.5	24	Galaxy S5	100	1
22	2	ABC	60	0.5	12	Galaxy S5	100	0
22	3	ABC	34	0.5	0	Galaxy S5	400	0
22	4	DEF	35	1	24	Galaxy S5	190	0
22	5	GHI	21	1	0	Galaxy S5	400	0
22	6	JKL	66	3	24	Galaxy S5	85	0
22	1	ABC	54	0.5	24	iPhone 5C	210	0
22	2	ABC	60	0.5	12	iPhone 5C	210	0
22	3	ABC	34	0.5	0	iPhone 5C	450	0
22	4	DEF	35	1	24	iPhone 5C	350	0
22	5	GHI	21	1	0	iPhone 5C	450	0
22	6	JKL	66	3	24	iPhone 5C	110	0

*id* is an unique identifier for a customer. *alt* is the identifier of the alternative, i.e. a combination of tariff and handset attributes. *tariff id* is the identifier for a tariff. As several options may exist for a same tariff, it is commonly found with different commitment period associated. *data* refers to the data allowance of the tariff. *commitment period* refers to the commitment period associated with the tariff. It could take the value 0, 12 or 24.

## 7.2 Detailed model

Table 7: Results from detailed model

	Conditional Logistic Regression	
Tariff price	-0.0336***	(0.00219)
Amount of subsidy	0.00716***	(0.000341)
List price of the handset	-0.00254***	(0.000274)
Discount for 12 months commitment	0.156***	(0.0164)
Commitment period= 12	-1.776***	(0.0567)
Commitment period= 24	-0.249***	(0.0455)
Unlimited call	-1.484***	(0.114)
Unlimited calls in 2012	1.182***	(0.122)
Unlimited calls in 2013	1.687***	(0.138)
Unlimited calls in 2014	1.725***	(0.151)
Data Allowance	0.483***	(0.0165)
Fixed broadband	0.611***	(0.0398)
Dummy smartphone	0.151***	(0.0403)
Dummy Apple	3.882***	(0.0684)
Dummy Samsung	0.903***	(0.0337)
Dummy Nokia	0.523***	(0.0431)
Dummy Blackberry	1.624***	(0.0580)
Camera Quality	0.109***	(0.00732)
Standby autonomy in hour	0.000660***	(0.0000964)
Screen size	0.286***	(0.0300)
Time since handset release	-0.0291***	(0.00140)
Q4 2011 $\times$ Tariff price	0	(.)
Q1 2012 $\times$ Tariff price	0.00959***	(0.00167)
Q2 2012 $\times$ Tariff price	0.0117*	(0.00538)
Q3 2012 $\times$ Tariff price	0.00175	(0.00827)
Q4 2012 $\times$ Tariff price	-0.0255***	(0.00412)
Q1 2013 $\times$ Tariff price	-0.0114**	(0.00380)
Q2 2013 $\times$ Tariff price	-0.0176***	(0.00492)
Q3 2013 $\times$ Tariff price	-0.0255***	(0.00489)
Q4 2013 $\times$ Tariff price	-0.0408***	(0.00516)
Q1 2014 $\times$ Tariff price	-0.0453***	(0.00590)
Q2 2014 $\times$ Tariff price	-0.0666***	(0.00855)

Q3 2014 × Tariff price	-0.0689***	(0.00816)
Q4 2014 × Tariff price	-0.0491***	(0.00547)
Q4 2011 × Amount of subsidy	0	(.)
Q1 2012 × Amount of subsidy	-0.00242***	(0.000271)
Q2 2012 × Amount of subsidy	-0.00483***	(0.000977)
Q3 2012 × Amount of subsidy	-0.00276*	(0.00136)
Q4 2012 × Amount of subsidy	0.000931	(0.000634)
Q1 2013 × Amount of subsidy	-0.00212***	(0.000606)
Q2 2013 × Amount of subsidy	-0.00313***	(0.000734)
Q3 2013 × Amount of subsidy	-0.00290***	(0.000721)
Q4 2013 × Amount of subsidy	-0.000903	(0.000758)
Q1 2014 × Amount of subsidy	-0.000404	(0.000830)
Q2 2014 × Amount of subsidy	0.00277*	(0.00123)
Q3 2014 × Amount of subsidy	0.00432***	(0.00116)
Q4 2014 × Amount of subsidy	-0.000538	(0.000909)
Q4 2011 × List price of the handset	0	(.)
Q1 2012 × List price of the handset	0.00110***	(0.000181)
Q2 2012 × List price of the handset	-0.0000323	(0.000657)
Q3 2012 × List price of the handset	-0.00221*	(0.000915)
Q4 2012 × List price of the handset	-0.00165***	(0.000399)
Q1 2013 × List price of the handset	-0.000317	(0.000386)
Q2 2013 × List price of the handset	0.0000317	(0.000396)
Q3 2013 × List price of the handset	-0.000923**	(0.000350)
Q4 2013 × List price of the handset	-0.00245***	(0.000378)
Q1 2014 × List price of the handset	-0.00373***	(0.000421)
Q2 2014 × List price of the handset	-0.00370***	(0.000515)
Q3 2014 × List price of the handset	-0.00348***	(0.000427)
Q4 2014 × List price of the handset	-0.00250***	(0.000384)
18-25 × Tariff price	0	(.)
26-35 × Tariff price	0.0116***	(0.00215)
36-45 × Tariff price	-0.0105***	(0.00212)
46-55 × Tariff price	-0.0106***	(0.00214)
56-65 × Tariff price	0.00382	(0.00253)
66-75 × Tariff price	0.000409	(0.00345)
76-85 × Tariff price	-0.00794	(0.00599)
18-25 × Amount of subsidy	0	(.)



26-35 × Amount of subsidy	-0.00104**	(0.000364)
36-45 × Amount of subsidy	0.00105**	(0.000362)
46-55 × Amount of subsidy	0.000444	(0.000364)
56-65 × Amount of subsidy	-0.000414	(0.000454)
66-75 × Amount of subsidy	0.000173	(0.000704)
76-85 × Amount of subsidy	0.000783	(0.00127)
18-25 × List price of the handset	0	(.)
26-35 × List price of the handset	-0.000111	(0.000234)
36-45 × List price of the handset	-0.00301***	(0.000226)
46-55 × List price of the handset	-0.00279***	(0.000225)
56-65 × List price of the handset	-0.00323***	(0.000285)
66-75 × List price of the handset	-0.00604***	(0.000457)
76-85 × List price of the handset	-0.00733***	(0.000854)
<hr/>		
Observations	1468207	
Log Likelihood	-44078.5	
<hr/>		

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 8: **Elasticities over time**

	ey/ex	Std. Err.	[95% Conf.	Interval]
<b>Tariff price</b>				
Q4 2011	-0.88	0.08	-1.03	-0.72
Q1 2012	-0.55	0.06	-0.67	-0.43
Q2 2012	-0.64	0.19	-1.01	-0.26
Q3 2012	-1.09	0.33	-1.74	-0.43
Q4 2012	-2.11	0.18	-2.47	-1.76
Q1 2013	-1.50	0.16	-1.82	-1.18
Q2 2013	-1.80	0.21	-2.21	-1.38
Q3 2013	-2.21	0.21	-2.63	-1.79
Q4 2013	-2.92	0.22	-3.36	-2.48
Q1 2014	-3.14	0.25	-3.64	-2.64
Q2 2014	-4.02	0.37	-4.74	-3.30
Q3 2014	-4.09	0.35	-4.79	-3.40
Q4 2014	-3.28	0.24	-3.75	-2.81
<b>Amount of subsidy</b>				
Q4 2011	0.77	0.06	0.66	0.87
Q1 2012	0.45	0.04	0.36	0.53
Q2 2012	0.28	0.13	0.03	0.52
Q3 2012	0.62	0.20	0.22	1.01
Q4 2012	1.19	0.10	0.98	1.39
Q1 2013	0.69	0.09	0.51	0.87
Q2 2013	0.58	0.11	0.36	0.80
Q3 2013	0.65	0.12	0.43	0.88
Q4 2013	1.01	0.13	0.76	1.25
Q1 2014	1.10	0.14	0.83	1.38
Q2 2014	1.64	0.21	1.23	2.04
Q3 2014	1.88	0.20	1.50	2.26
Q4 2014	1.08	0.15	0.78	1.37
<b>List price of handset</b>				
Q4 2011	-0.48	0.05	-0.59	-0.38
Q1 2012	-0.24	0.04	-0.33	-0.15
Q2 2012	-0.54	0.17	-0.88	-0.21
Q3 2012	-1.18	0.28	-1.72	-0.64
Q4 2012	-1.09	0.12	-1.32	-0.86
Q1 2013	-0.69	0.11	-0.91	-0.48
Q2 2013	-0.64	0.12	-0.87	-0.42
Q3 2013	-0.94	0.11	-1.16	-0.73
Q4 2013	-1.42	0.12	-1.66	-1.19
Q1 2014	-1.82	0.13	-2.08	-1.56
Q2 2014	-1.82	0.16	-2.14	-1.50
Q3 2014	-1.75	0.14	-2.02	-1.48
Q4 2014	-1.45	0.12	-1.69	-1.22

Elasticities are elasticities at representative values of *quarter*

Other variables are computed at their mean.

### 7.3 Simplified model

Table 9: Results from simplified model

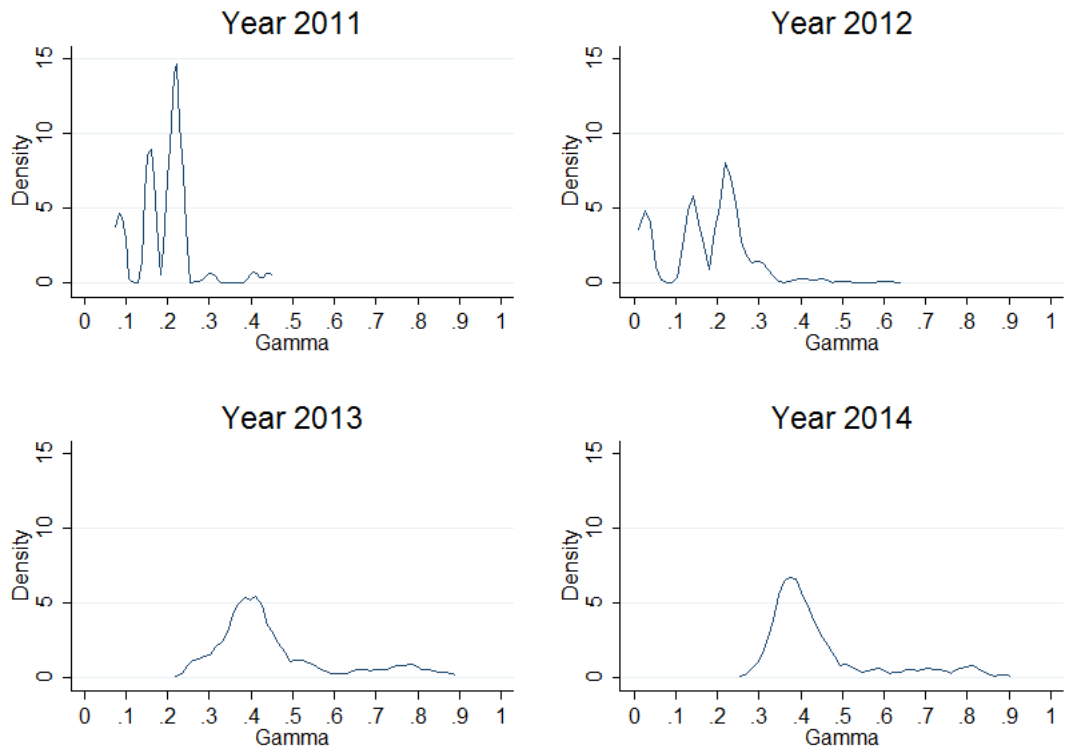
	Conditional Logistic Regression	
Tariff price	-0.0213***	(0.00183)
Upfront cost of the handset	-0.00423***	(0.000222)
Discount for 12 months commitment	0.138***	(0.0164)
Commitment period= 12	-1.688***	(0.0553)
Commitment period= 24	-0.165***	(0.0436)
Unlimited call	-1.536***	(0.114)
Unlimited calls in 2012	1.242***	(0.122)
Unlimited calls in 2013	1.797***	(0.137)
Unlimited calls in 2014	1.797***	(0.150)
Data Allowance	0.485***	(0.0165)
Fixed broadband	0.644***	(0.0396)
Dummy smartphone	0.141***	(0.0403)
Dummy Apple	4.162***	(0.0581)
Dummy Samsung	0.929***	(0.0333)
Dummy Nokia	0.576***	(0.0423)
Dummy Blackberry	1.801***	(0.0524)
Camera Quality	0.129***	(0.00644)
Standby autonomy in hour	0.000682***	(0.0000963)
Screen size	0.376***	(0.0268)
Time since handset release	-0.0238***	(0.00115)
Q4 2011 $\times$ Tariff price	0	(.)
Q1 2012 $\times$ Tariff price	0.00517***	(0.00139)
Q2 2012 $\times$ Tariff price	-0.00410	(0.00470)
Q3 2012 $\times$ Tariff price	-0.0154*	(0.00754)
Q4 2012 $\times$ Tariff price	-0.0263***	(0.00328)
Q1 2013 $\times$ Tariff price	-0.0202***	(0.00312)
Q2 2013 $\times$ Tariff price	-0.0297***	(0.00382)
Q3 2013 $\times$ Tariff price	-0.0424***	(0.00363)
Q4 2013 $\times$ Tariff price	-0.0552***	(0.00369)
Q1 2014 $\times$ Tariff price	-0.0636***	(0.00434)
Q2 2014 $\times$ Tariff price	-0.0674***	(0.00555)
Q3 2014 $\times$ Tariff price	-0.0595***	(0.00496)

Q4 2014 × Tariff price	-0.0603***	(0.00372)
Q4 2011 × Upfront cost of the handset	0	(.)
Q1 2012 × Upfront cost of the handset	0.00142***	(0.000167)
Q2 2012 × Upfront cost of the handset	0.00102	(0.000655)
Q3 2012 × Upfront cost of the handset	-0.00124	(0.000913)
Q4 2012 × Upfront cost of the handset	-0.00121**	(0.000379)
Q1 2013 × Upfront cost of the handset	0.000314	(0.000370)
Q2 2013 × Upfront cost of the handset	0.000749	(0.000389)
Q3 2013 × Upfront cost of the handset	-0.000295	(0.000346)
Q4 2013 × Upfront cost of the handset	-0.00179***	(0.000374)
Q1 2014 × Upfront cost of the handset	-0.00306***	(0.000420)
Q2 2014 × Upfront cost of the handset	-0.00320***	(0.000508)
Q3 2014 × Upfront cost of the handset	-0.00296***	(0.000417)
Q4 2014 × Upfront cost of the handset	-0.00179***	(0.000380)
18-25 × Tariff price	0	(.)
26-35 × Tariff price	0.00718***	(0.00168)
36-45 × Tariff price	-0.0177***	(0.00165)
46-55 × Tariff price	-0.0191***	(0.00167)
56-65 × Tariff price	-0.00911***	(0.00203)
66-75 × Tariff price	-0.0192***	(0.00294)
76-85 × Tariff price	-0.0293***	(0.00532)
18-25 × Upfront cost of the handset	0	(.)
26-35 × Upfront cost of the handset	0.000120	(0.000214)
36-45 × Upfront cost of the handset	-0.00259***	(0.000210)
46-55 × Upfront cost of the handset	-0.00230***	(0.000209)
56-65 × Upfront cost of the handset	-0.00256***	(0.000274)
66-75 × Upfront cost of the handset	-0.00527***	(0.000460)
76-85 × Upfront cost of the handset	-0.00647***	(0.000862)
Observations	1468207	
Log Likelihood	-44238.0	

Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Figure 4: Densities of average  $\gamma$  according to year of subscription



## 7.4 Simplified model with random coefficients

### Theoretical model adapted from Grzybowski and Liang (2015)

A standard linear utility specification is used for individuals  $i = 1, \dots, N$  over the tariffs  $j = 1, \dots, J$ . Utility depends on tariffs characteristics and on observable and unobservable individuals characteristics. Let the utility of individual  $i$  for tariff  $j$  be given by

$$U_{ij} = z_j' \tilde{\beta}_i - \tilde{\alpha}_i p_j + \epsilon_{ij}$$

$z_j$  denotes a vector of non-price tariff characteristics and  $\tilde{\beta}_i$  is a vector of individuals specific valuations of these characteristics. Price paid for a tariff  $j$  is denoted by  $p_j$  and  $\tilde{\alpha}_i$  is the individual specific valuation of price.  $\epsilon$  is the individual specific valuation for tariff  $j$ , the error term. It is identically and independently distributed across tariffs according to the type I extreme value distribution. Vectors  $\tilde{\beta}_i$  and  $\tilde{\alpha}_i$  depend on unobserved heterogeneity.

$$\begin{pmatrix} \tilde{\beta}_i \\ \tilde{\alpha}_i \end{pmatrix} = \begin{pmatrix} \beta_i \\ \alpha_i \end{pmatrix} + \begin{pmatrix} \sigma_\beta \\ \sigma_\alpha \end{pmatrix} \nu_i$$

where  $(\beta, \alpha)$  refers to a vector of mean valuations.  $\nu_i$  is a randomly drawn vector from the standard normal distribution capturing unobserved individual heterogeneity regarding tariff attributes and price, and  $\sigma = (\sigma_\beta, \sigma_\alpha)$  refers to a vector of standard deviations around the mean valuation.

An individual  $i$  chooses a tariff  $j$  if this maximizes its utility among all alternatives, i.e. if  $U_{ij} = \max_{k \in C_i} U_{ik}$  where  $C_i$  is individual  $i$ 's available choice set. Hence the probability that individual  $i$  with given random coefficients  $\tilde{\beta}_i$  and  $\tilde{\alpha}_i$  chooses tariff  $j$  is given by :

$$l_{ij}(\tilde{\beta}_i, \tilde{\alpha}_i) = Pr(U_{ij} = \max_k U_{ik}) = \frac{e^{x_j' \tilde{\beta}_i - \tilde{\alpha}_i p_j}}{\sum_k e^{x_k' \tilde{\beta}_i - \tilde{\alpha}_i p_k}}$$

In the case when  $\sigma$  is a vector of zeros, there is no unobserved individual heterogeneity and the conditional logit model is obtained. More generally, a mixed logit model allows for unobserved heterogeneity among individuals and requires integration of the conditional choice probability  $l_{ij}(\tilde{\beta}_i, \tilde{\alpha}_i)$  over the distribution of  $\tilde{\beta}_i$  and  $\tilde{\alpha}_i$ .

$$s_{ij}(\theta) = \int_{\tilde{\alpha}_i} \int_{\tilde{\beta}_i} l_{ij}(\tilde{\beta}_i, \tilde{\alpha}_i) f(\tilde{\alpha}_i) f(\tilde{\beta}_i) d\tilde{\alpha}_i d\tilde{\beta}_i$$

where  $\theta$  is the vector of all parameters to be estimated. This is the random coefficients logit choice probability.

Individual  $i$ 's probability of choosing the actual alternative is expressed as  $\prod_j s_{ij}^{y_{ij}}$  where  $y_{ij} = 1$  if individual  $i$  chose alternative  $j$  and  $y_{ij} = 0$  otherwise. Assuming that each individual's choice is independant of that of other individuals, the probabilitu of each individual in the sample choosing the alternative that it was observed to choose

can be rewritten as the log-likelihood function :

$$\mathcal{L} = y_{ij} \sum \sum \log(s_{ij}(\theta))$$

To approximate the integral entering the choice probabilities  $s_{ij}$  in (3), a simulation method is used. Following Train (2003),  $R$  draws for  $\nu$  are taken from the joint normal distribution to obtain the average choice probability per individual:

$$\hat{s}_{ij}(\theta) = \frac{e^{x_j' \beta} - \alpha p_j}{\sum e^{x_k' \beta - \alpha p_k}}$$

Table 10: Results from simplified model (random coeff.)

Mixed Logistic Regression		
Mean		
Tariff price	-0.0199***	(0.00191)
Upfront cost of the handset	-0.00395***	(0.000239)
Discount for 12 months commitment	0.170***	(0.0268)
Data Allowance	0.481***	(0.0171)
Commitment period= 12	-1.769***	(0.119)
Commitment period= 24	1.640***	(0.346)
Dummy Apple	4.176***	(0.0625)
Unlimited call	-1.613***	(0.117)
Unlimited calls in 2012	1.212***	(0.125)
Unlimited calls in 2013	1.852***	(0.144)
Unlimited calls in 2014	1.906***	(0.159)
Fixed broadband	0.615***	(0.0409)
Dummy smartphone	0.136***	(0.0405)
Dummy Samsung	0.931***	(0.0336)
Dummy Nokia	0.577***	(0.0426)
Dummy Blackberry	1.801***	(0.0533)
Camera Quality	0.129***	(0.00664)
Standby autonomy in hour	0.000680***	(0.0000969)
Screen size	0.376***	(0.0271)
Q4 2011 $\times$ Tariff price	0	(.)
Q1 2012 $\times$ Tariff price	0.00707***	(0.00146)
Q2 2012 $\times$ Tariff price	-0.00250	(0.00489)
Q3 2012 $\times$ Tariff price	-0.0139	(0.00803)
Q4 2012 $\times$ Tariff price	-0.0259***	(0.00341)
Q1 2013 $\times$ Tariff price	-0.0211***	(0.00336)
Q2 2013 $\times$ Tariff price	-0.0302***	(0.00407)
Q3 2012 $\times$ Tariff price	-0.0421***	(0.00385)
Q4 2012 $\times$ Tariff price	-0.0531***	(0.00391)



Q1 2014 × Tariff price	-0.0629***	(0.00464)
Q2 2014 × Tariff price	-0.0718***	(0.00607)
Q3 2014 × Tariff price	-0.0602***	(0.00543)
Q4 2014 × Tariff price	-0.0617***	(0.00408)
Q4 2011 × Upfront cost of the handset	0	(.)
Q1 2012 × Upfront cost of the handset	0.00124***	(0.000186)
Q2 2012 × Upfront cost of the handset	0.000634	(0.000695)
Q3 2012 × Upfront cost of the handset	-0.00160	(0.000967)
Q4 2012 × Upfront cost of the handset	-0.00130**	(0.000398)
Q1 2013 × Upfront cost of the handset	0.000375	(0.000395)
Q2 2013 × Upfront cost of the handset	0.000493	(0.000409)
Q3 2013 × Upfront cost of the handset	-0.000488	(0.000360)
Q4 2013 × Upfront cost of the handset	-0.00207***	(0.000390)
Q1 2014 × Upfront cost of the handset	-0.00336***	(0.000438)
Q2 2014 × Upfront cost of the handset	-0.00333***	(0.000528)
Q3 2014 × Upfront cost of the handset	-0.00317***	(0.000434)
Q4 2014 × Upfront cost of the handset	-0.00201***	(0.000394)
18-25 Tariff price	0	(.)
26-35 Tariff price	0.00758***	(0.00175)
36-45 Tariff price	-0.0186***	(0.00173)
46-55 Tariff price	-0.0200***	(0.00174)
56-65 Tariff price	-0.00928***	(0.00211)
66-75 Tariff price	-0.0194***	(0.00305)
76-85 Tariff price	-0.0301***	(0.00549)
18-25 Upfront cost of the handset	0	(.)
25-35 Upfront cost of the handset	-0.0000388	(0.000229)
36-45 Upfront cost of the handset	-0.00277***	(0.000228)
46-55 Upfront cost of the handset	-0.00248***	(0.000227)
56-65 Upfront cost of the handset	-0.00281***	(0.000294)
66-75 Upfront cost of the handset	-0.00557***	(0.000487)
76-85 Upfront cost of the handset	-0.00691***	(0.000904)
Time since handset release	-0.0244***	(0.00130)

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**Standard Deviation**

Tariff price	0.000305	(0.00145)
Upfront cost of the handset	0.0000680	(0.000189)
Discount for 12 months commitment	0.0515	(0.0813)
Data Allowance	0.00506	(0.0213)
Commitment period= 12	-0.767**	(0.258)
Commitment period= 24	-3.313***	(0.422)
Dummy Apple	0.467*	(0.218)
Time since handset release	0.00790	(0.00749)
Observations	1468207	
Log Likelihood	-44151.8	

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Standard errors in parentheses

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Table 11: Comparison of results clogit/mixlogit

Quarter	$\alpha_{tariff\ price}$	$\alpha_{tariff\ price}$	$\alpha_{upfront}$	$\alpha_{upfront}$	$\rho\gamma$	$\rho\gamma$	$\gamma$	$\gamma$
	clogit	mixlogit	clogit	mixlogit	clogit	mixlogit	clogit	mixlogit
Q4 2011	-0.0321 (0.0103)	-0.0312 (0.0108)	-0.0060 (0.0014)	-0.0059 (0.0015)	5.2003 (0.9661)	5.1367 (1.0937)	0.25 (0.0724)	0.24 (0.0758)
Q1 2012	-0.0253 (0.0109)	-0.0224 (0.0114)	-0.0045 (0.0015)	-0.0045 (0.0016)	5.4399 (1.3178)	4.6297 (1.6162)	0.26 (0.0787)	0.22 (0.0871)
Q2 2012	-0.0359 (0.0107)	-0.0334 (0.0112)	-0.0051 (0.0015)	-0.0054 (0.0015)	7.0685 (0.9918)	6.1549 (1.1435)	0.36 (0.1073)	0.32 (0.0988)
Q3 2012	-0.0452 (0.0107)	-0.0427 (0.0112)	-0.0070 (0.0014)	-0.0072 (0.0015)	6.4330 (0.6291)	5.8660 (0.7312)	0.34 (0.1018)	0.31 (0.0955)
Q4 2012	-0.0536 (0.0104)	-0.0521 (0.0108)	-0.0067 (0.0016)	-0.0066 (0.0017)	8.1505 (0.7041)	8.0159 (0.8076)	0.41 (0.1165)	0.40 (0.1159)
Q1 2013	-0.0490 (0.0110)	-0.0488 (0.0115)	-0.0054 (0.0017)	-0.0052 (0.0018)	9.2970 (1.0981)	9.6750 (1.3658)	0.49 (0.1475)	0.51 (0.1574)
Q2 2013	-0.0567 (0.0112)	-0.0560 (0.0117)	-0.0048 (0.0017)	-0.0050 (0.0018)	12.3443 (1.8802)	11.8830 (1.9018)	0.68 (0.2353)	0.65 (0.2290)
Q3 2013	-0.0731 (0.0108)	-0.0718 (0.0113)	-0.0061 (0.0015)	-0.0062 (0.0016)	12.2021 (1.3482)	11.8762 (1.3963)	0.64 (0.1851)	0.62 (0.1811)
Q4 2013	-0.0838 (0.0109)	-0.0806 (0.0114)	-0.0075 (0.0016)	-0.0076 (0.0016)	11.4296 (1.0498)	10.7828 (1.0297)	0.60 (0.1729)	0.57 (0.1647)
Q1 2014	-0.0910 (0.0117)	-0.0892 (0.0122)	-0.0086 (0.0017)	-0.0088 (0.0017)	10.7301 (0.8147)	10.3138 (0.8261)	0.54 (0.1347)	0.52 (0.1304)
Q2 2014	-0.0949 (0.0114)	-0.0982 (0.0119)	-0.0087 (0.0015)	-0.0087 (0.0016)	11.0298 (0.7357)	11.4293 (0.8627)	0.56 (0.1391)	0.58 (0.1437)
Q3 2014	-0.0902 (0.0106)	-0.0899 (0.0111)	-0.0088 (0.0014)	-0.0089 (0.0015)	10.3494 (0.6961)	10.2381 (0.7576)	0.54 (0.1563)	0.54 (0.1542)
Q4 2014	-0.0888 (0.0108)	-0.0891 (0.0113)	-0.0074 (0.0014)	-0.0075 (0.0015)	12.2205 (1.0791)	12.1464 (1.1620)	0.65 (0.2023)	0.65 (0.2018)

Standard deviation in parentheses

## 7.5 Alternative assumptions

Table 12: Comparison of  $\gamma$  according to alternative value for  $r$

Quarter	$r_1$	$r_2$	$S$	$\gamma_1$	$\gamma_2$
Q4 2011	0.005	0.002	22.984	0.247	0.239
	0.000	0.000	3.259	0.072	0.072
Q1 2012	0.006	0.002	22.825	0.259	0.249
	0.000	0.000	2.866	0.079	0.077
Q2 2012	0.005	0.002	21.629	0.364	0.351
	0.000	0.000	4.273	0.107	0.107
Q3 2012	0.005	0.002	21.448	0.336	0.326
	0.000	0.000	4.549	0.102	0.102
Q4 2012	0.005	0.002	22.007	0.411	0.398
	0.000	0.000	4.156	0.117	0.117
Q1 2013	0.005	0.001	21.268	0.488	0.472
	0.000	0.000	4.502	0.148	0.147
Q2 2013	0.005	0.001	20.545	0.681	0.660
	0.000	0.000	4.967	0.235	0.234
Q3 2013	0.005	0.001	21.157	0.641	0.619
	0.000	0.000	4.515	0.185	0.185
Q4 2013	0.005	0.001	21.175	0.600	0.579
	0.000	0.000	4.429	0.173	0.173
Q1 2014	0.005	0.001	21.796	0.541	0.521
	0.000	0.000	4.010	0.135	0.135
Q2 2014	0.005	0.001	21.776	0.556	0.537
	0.000	0.000	4.099	0.139	0.140
Q3 2014	0.004	0.001	21.225	0.542	0.525
	0.000	0.000	4.606	0.156	0.157
Q4 2014	0.004	0.001	20.928	0.653	0.633
	0.000	0.000	4.776	0.202	0.202

$r_1$  is the national quarterly average consumption credit rate.  $r_2$  is the national quarterly average interest rate of a non-risky saving booklet.  $S$  is the average time horizon. We take commitment period for committed consumers (12 or 24 months) and 19 months for free-of-commitment customers. As a reminder, it is the average life-time of a customer who is not committed, computed on the operator's database.  $\gamma_1$  is the attention weight computed with  $r_1$  and  $\gamma_2$  the value computed with  $r_2$

Table 13: **Alternative interpretations of  $\rho\gamma$** 

<b>Attention Weight with fixed interest rate</b>							
Year	$r$ year	$S$ year	$r$ months	$S$ months	$\rho\gamma$	$\rho$	$\gamma$
2011	6.29%	1.92	0.52%	22.98	5.20	21.71	0.24
2012	6.60%	1.89	0.55%	22.72	5.68	21.42	0.27
2013	5.78%	1.75	0.48%	21.05	11.28	20.07	0.56
2014	5.41%	1.78	0.45%	21.39	11.13	20.44	0.54
2011	2.25%	1.92	0.19%	22.98	5.20	22.51	0.23
2012	2.25%	1.89	0.19%	22.72	5.68	22.26	0.26
2013	1.49%	1.75	0.12%	21.05	11.28	20.79	0.54
2014	1.11%	1.78	0.09%	21.39	11.13	21.19	0.53
<b>Discount rate if perfect attention <math>\gamma = 1</math></b>							
Year	$r$ year	$S$ year	$r$ months	$S$ months	$\rho\gamma$	$\rho$	$\gamma$
2011	283.00%	1.92	23.58%	22.98	5.20	5.20	1
2012	252.50%	1.90	21.04%	22.72	5.68	5.68	1
2013	88.80%	1.76	7.40%	21.05	11.28	11.28	1
2014	92.30%	1.78	7.69%	21.39	11.13	11.13	1
<b>Required payback time if <math>r</math>=market rate and <math>\gamma = 1</math></b>							
Year	$r$ year	$S$ year	$r$ months	$S$ months	$\rho\gamma$	$\rho$	$\gamma$
2011	6.29%	0.44	0.52%	5.26	5.20	5.20	1
2012	6.60%	0.48	0.55%	5.75	5.68	5.68	1
2013	5.78%	0.96	0.48%	11.57	11.28	11.28	1
2014	5.41%	0.95	0.45%	11.39	11.13	11.13	1

As described in Grigolon et al (2014), estimation of  $\rho\gamma$  may be interpreted in several ways. One can assume a market interest rate  $r$  and time horizon of the decision  $S$  to compute  $\gamma$ . That is the assumption we explore in this paper. Results are shown in the first part of the table. One can use estimation of  $\rho\gamma$  to compute individual discount rates  $r$  as in Hausman (1979). We allow for a similar computation assuming  $S$  and  $\gamma = 1$ . To finish, one may compute  $S$  as the payback time. In this case,  $r$  is the market interest rate and attention is assumed perfect, i.e.  $\gamma = 1$ . The payback time is the length of time required to recover the cost of an investment. For example, in 2014, choosing a sim-only contract and paying the full price of the handset is more profitable compared to a contract with handset subsidy 11 months after subscription.

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