

# Mobile-only consumers arise from heterogeneous valuation of fixed services\*

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## Abstract

Mobile-only users are usually perceived as a consequence of fixed-mobile substitution. This study uses a unique dataset based on a survey in France, combined with interviewee's telecommunications billing data, to reveal heterogeneous consumer preferences for fixed services. With the same mixed logit model we estimate the willingness to pay (WTP) for fixed communications services and fixed-mobile relationship. Results show a very large heterogeneity of WTP for fixed services among consumers. In addition, we show that fixed and mobile data are complement for all consumers. Mobile-only consumers have a much lower but non-zero WTP, and higher price sensitivity compared to fixed-mobile consumers. Consequently, an increase in the fixed offer price would reduce the demand for fixed service. Heterogeneous preferences for fixed services constitute an alternative explanation for the existence of mobile-only users, despite the complementary nature of fixed and mobile broadband. Counter-factual simulations show that the share of mobile-only could also be driven by the way to subsidize mobile handset. For instance, making the handset subsidy only available to fixed-mobile quadruple play subscribers could reduce the share of mobile-only by half.

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All errors are our own.

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# 1 Introduction

Fixed-mobile substitution on voice services is well documented, whereas the literature regarding the relation between fixed and mobile broadband is still relatively scarce. The aim of this paper is to contribute to the understanding of this very relation.

Today's electronic communication usage is much more data driven than it was several years ago, which places traditional voice and SMS services in the near off-side. In a society with a steep rise in data usage, the substitution pattern between fixed and mobile services may be impacted, or even reversed. The question arises whether data consumption underlies an equivalent substitution as observed in voice or SMS services, or, alternatively, if there is complementarity. Using a data set on French consumption behavior, the first aim of this paper is to assess whether fixed and mobile broadband usage (or subscription) are complementary or substitutes.

Intuitively, it could be assumed that fixed and mobile broadband are complementary, especially when today's rise in data usage is considered in relation to the specificities of the different subscriptions. Indeed, mobile broadband subscriptions differ from their fixed counterparts in speed and volumes. Whereas mobile broadband subscriptions primarily offer limited monthly allowances at higher costs, fixed broadband offers are often characterized by virtually unlimited volumes at much lower prices. For instance, a typical fixed broadband offer in France costs around €30 per month, offers unlimited volumes and guarantees a relatively high average download speed. For the same price, a mobile offer allows for an average download volume of 10 GB without a guarantee on speed.<sup>1</sup>

However, this intuition is confronted with the existence of mobile-only consumers. If fixed and mobile broadband are supposedly complementary, why is 10 % of the French market still made up of people using only a mobile subscription to satisfy their need for electronic communications? A similar question can be asked for the US market, where according to NCHS data,

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<sup>1</sup>It should be kept in mind that a given cell in a mobile network is shared by a potentially large number of users, which impacts the performance perceived by each user connected to that cell. Although, fixed lines may be shared by all the members of a household, the impact on the performance of the Internet access service is much less.

the share of mobile-only consumers is almost fourfold. Given the increasing and ubiquitous Internet usage, the question arises regarding the explanation of this phenomenon. This paper attempts to address this issue by analyzing the potential heterogeneity of French consumers willingness to pay (WTP) for both fixed and mobile broadband subscriptions. Given the above, the consumers preferences for fixed broadband are too heterogeneous, resulting in diverging subscription patterns.

When analyzing WTP, market dynamics must be considered. Among such dynamics, the most apparent to the consumer is the price they pay for their service(s). The French communication services market has shown impressive dynamics in terms of prices, mostly driven by competition in the market. For instance, some quadruple play offers, launched in 2009, provided consumers with a strong incentive to combine their fixed and mobile offers since the quadruple offer was cheaper than the sum of the stand-alone service prices<sup>2</sup>. The other market players naturally followed this trend to stay competitive and maximize the number of new customers.

Besides highly competitive pricing, market dynamics are also driven by technological developments. The replacement of traditional voice networks with data networks, led to the adoption of IP technology on the fixed and mobile core network, as well as the deployment of optical fiber for mobile base stations backhaul traffic. This technological transformation, which occurred on the fixed network in the early 2000s, allows operators to provide voice over IP (VoIP) as a basic, generic component of triple play offers. On the mobile market, voice and SMS services account for a declining share of the price of mobile plans, which is increasingly dominated by mobile data. Despite the recent arrival of LTE technology with better spectral efficiency improving the capacity of mobile networks, the usage of mobile data has also increased exponentially. Because of this, the higher mobile network capacity still appears to be relatively limited and therefore the added value of fixed networks compared to mobile services in terms of data volumes can still be forward. This may explain the large percentage of consumers who use both networks.

Consumption behaviors constitute the central point of this study, which introduces a micro-

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<sup>2</sup>According to Eurobarometer, the French market has a significant level of quadruple play penetration, 24% in 2015, putting it second in Europe after Belgium (27%).

econometric model. Survey data on French interviewees combined with their detailed billing data is fitted in a mixed logit model. Individuals have three different consumption choices: i) only using a mobile offer; ii) purchasing a stand-alone fixed offer in addition to their mobile offer; or iii) subscribing to a quadruple play offer.

The remainder of the article is organized as follows. Section 2 discusses the relevant literature. Section 3 presents the data used in the estimation. Section 4 introduces empirical model. Section 5 presents the main results. Finally, Section 6 concludes the paper.

## 2 Literature Review

The relevant literature reviewed here focuses on the characteristics of demand for telecommunications services. Early academic literature on this issue, published in the 1970s, mainly focused on estimating demand elasticity with respect to prices, in an era marked by high inflation and upward pressure on call rates (Taylor, 2002). Later, with the increasing popularity of mobile services and thus the emerging replacement of fixed services with mobile services, the literature integrated non-price factors, such as socio-demographic factors, to profile consumers based on the services they use.

Rodini, Ward and Woroch (2003) used a logit model to estimate cross-price elasticities between fixed and mobile voice services. Their study was based on microlevel data from 2000-2001 in the US. In addition to the significant impacts of usage, access and prices, the authors found that socio-demographic variables such as income, education and household size have a positive impact on the probability of taking out a mobile subscription, to the detriment of a second fixed line subscription. In contrast, the older the person surveyed, the lower their probability of subscribing to a mobile voice service.

Similarly, Ward and Woroch (2004) analyzed substitution patterns in the US in 1999-2001 and concluded that non-price factors like mobile network coverage and quality also play a major role in mobile subscription take-off. Using data from 2004 to 2006, Schejter et al. (2010) performed separate cluster analysis on the wireline and wireless market segments to identify the

characteristics of the consumers in each segment. Their results revealed that wireless users are predominantly young and low-income. Moreover, home owners are more likely to be fixed line users. The authors also concluded that mobile-only consumers are newcomers to the markets, reflecting the emergence of a new type of consumer rather than a shift among existing consumers. Macher et al. (2012) empirically estimated a consumer choice model using household-level observations from 2003-2010 and found that fixed and mobile voice line subscriptions are replacements, rather than complements. Grzybowski & Verboven (2016) found significant fixed-mobile voice substitution with substantial heterogeneity across households and EU regions. Their paper also revealed that the decline in fixed telephone lines has slowed due to the high degree of complementarity between the fixed-line and mobile connections offered by the fixed-line incumbent operator.

With the emergence of broadband Internet access, several studies have focused on estimating the demand for the different Internet access technologies and deriving consumers' willingness to pay for different components of the available offers. For instance, Savage and Waldman (2005) provided evidence that high income households and individuals with higher education are more likely to subscribe to a high-speed broadband connection. They also showed that consumers' online experiences are another influential factor.

Rosston, Savage and Waldman (2010) designed a discrete choice experiment to show consumers willingness to pay for Internet service improvements like increased Internet connection speeds. Their results revealed that US citizens are willing to pay \$3 more to enjoy very fast Internet rather than fast Internet. This is an interesting result, as it raises the question of whether deploying a nationwide fiber optic network is economically justifiable or not.

Estimates of broadband access demand in Europe also identified variables that influence the consumer decision-making process, including income, education and household size. For instance, Srinuan, Srinuan and Bohlin (2012) illustrated these findings for Sweden using data from 2009 and Cardona et al. (2009) analyzed the Austrian market with 2006 data. The former showed that in Sweden low-income people have a higher probability of using mobile broadband

instead of fixed broadband (fiber or DSL), while the same probability is lower in rural areas. A similar result was found for the Austrian market: residents of Vienna are more likely to subscribe to a mobile broadband offer. Level of education, however, seems to play a less important role in Sweden than in Austria.

The relevant literature also includes reports issued by government agencies including the various national regulatory authorities, consulting agencies and national research centers. For instance, a report issued by DotEcon (2001) studied fixed-mobile substitution in 2001 and drew consumer profiles for mobile-only consumers, fixed-only consumers, and fixed and mobile consumers in the UK. Similar studies were produced in France by CREDOC (2014) and at the European level as part of the Eurobarometer surveys.

Both studies provided essentially the same insights: single-service usage is favored by low income (for mobile-only usage) or higher age (for fixed-only usage). However, they essentially provide inventories and descriptive statistics on these phenomena rather than econometric analysis.

The major contribution of this paper is the usage of an original dataset of more than 1,000 consumers for the period spanning January to December 2012, in which we combine survey data with the interviewees telecommunications billing data. The results are different from those described in the existing literature. Few papers use a random coefficient to explain mobile-only existence. There are two reasons driving mobile-only consumers: higher price sensitivity and lower valuation of fixed services. Each consumer must decide either to buy two complementary goods or to select only one of them. However, one of them is less valued and some consumers exhibit high price sensitivity. Therefore, consumers who are not willing to pay the monthly fee for the fixed component in addition to the mobile fee, especially low-income individuals, prefer to become mobile-only users.

### 3 The Data

The data, provided by the GFK Institute for surveys, covers the period from January to December 2012. During this period, 1,069 consumers<sup>3</sup> were contacted on their mobile phone and asked to indicate which means of electronic communications they use for their personal needs.<sup>4</sup> The present study uses these indications to determine whether a given consumer is mobile-only. Respondents are considered mobile-only if they only use a mobile plan to meet their consumption needs.

Among the 1,069 respondents there are three types of consumers in December 2012: mobile-only (15%), fixed-mobile with separate fixed and mobile service subscriptions (60%) and quadruple play (25%). Respondents who have separate fixed and mobile service subscriptions can be divided into two groups: i) fixed-mobile users who have PSTN services without broadband access and ii) fixed-mobile users who have (in most cases) a triple-play offer and a stand-alone mobile offer.

The GFK survey collected data on certain consumer characteristics, including age, number of children living at home, occupational status, and municipality of residence.

By using the survey respondents mobile phone numbers and the operators billing database, we also collected 12 monthly observations (01/2012-12/2012) about the respondents monthly bills, characteristics of their mobile and/or quadruple play offer and the type of handset used during the period in question. With 12 months of data, we can observe when a consumer changes his mobile plan and determine the value of our switching dummy. The value of switching dummy equals one if a consumer switches from an old mobile plan to a new plan, and zero otherwise.

The monthly fees for mobile services and quadruple play offers were exactly observed in the dataset. For consumers with a mobile offer combined with a separate fixed offer, a monthly fee of €30 was added, reflecting the most popular triple-play price observed on the French market.

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<sup>3</sup>GFK randomly selects 3472 mobile phone numbers among the French population. We have collected the billing data for 1069 consumers from a single operator.

<sup>4</sup>Since all respondents were called on their cellphone, every respondent had at least a mobile. Consequently, the survey does not include fixed-only users.



Table 1 shows variables used in our data and summary statistics compared to averages representative of the French population.

Table 1: Descriptive statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max	FrenchPop
Mobile-only	0/1: 1 for mobile only users	11776	0.14	0.35	0	1	0.12
price	list price	11776	55.46	19.56	0	170.3	58.50
terminalsubsidy	mobile handset option	11776	0.93	0.25	0	1	0.87
comit12	commitment length of 12months	11776	0.18	0.39	0	1	0.13
comit24	commitment length of 24months	11776	0.78	0.41	0	1	0.84
TriplePlay	VoIP, TV and Internet access	11776	0.87	0.34	0	1	
unlimited	0/1: 1 for unlimited mobile voice	11776	0.12	0.32	0	1	
voice	limited mobile voice allowance	11776	82.91	58.14	0	360	
datamobile	mobile data allowance in GB/m	11776	0.56	0.71	0	3	
switching	0/1: 1 for switching to a newtariff	11776	0.05	0.23	0	1	
leaving	0/1: 1 for leaving operator	11776	0.00	0.04	0	1	
smartphone	0/1: 1 for smartphone owners	11776	0.58	0.49	0	1	0.59

Source: operator except 'Mobile-only' is provided by the GFK survey

Our dependent variable, i.e. the choice decision of each consumer, is constructed by combining the dummy variable Mobile-only in Table 1 and the mobile plan owned by each consumer at each month. The other variables are used as explanatory variables of consumer decisions among all available alternatives: keep current offer, leave operator and switch to a new offer in the operators catalog. We expect that the consumer choice decision will reveal their valuation for each attribute of a fixed and/or mobile offer, such as their willingness to pay for a fixed service, the utility (or disutility) of owning both a fixed and a mobile service.

Based on the descriptive statistics, mobile-only consumers are more common among low-income households, jobseekers, young people, and people without children (see Table in Appendix A- 1)

As in all choice models, consumers must be confronted with a set of possible choices. This study’s choice set was built similarly to Grzybowski & Liang (2015). For each month from January to December 2012, consumers had the option to choose one of the following options:

(i) keep the same offer as in the previous month; (ii) switch to a new mobile offer from the list of offers available that month; (iii) switch to a new mobile offer and combine it with a stand-alone fixed offer <sup>5</sup> (iv) switch to a new quadruple play offer; (v) for fixed-mobile consumers, leave for another mobile operator but keep the same fixed service.

## 4 Empirical model and identification strategy

A discrete choice model was used in this study. In this type of model, a decision maker faces a finite set of mutually exclusive alternatives, from which he or she chooses one and only one. There were up to 69 different alternatives available to consumers each month in the period considered.

We determine the set of 69 different alternatives each month using the subscriptions database. We consider a tariff to be new whenever in a given month there was at least one consumer who switched to this tariff, proposed in operator’s catalog. Depending on the month, the number new tariffs ranges between 50 and 68. By adding the alternative of leaving operator, the choice set of each consumer ranges between 51 and 69 tariffs depending on the month.

Certain types of discrete choice models can be based on a logistic distribution of choice probabilities. These models can be divided into multinomial logit models, where the exogenous variables vary with the individuals (e.g. age, occupational status, etc.), and conditional logit models, where the exogenous variables vary with the alternatives in the choice set. Prices are the archetypal variable in a conditional discrete choice model, but the data allowance in mobile subscriptions (which may differ between offers) is another example.

Multinomial and conditional models can also be combined. In this case, the set of exogenous variables contains both alternative-specific and individual-specific variables. However,

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<sup>5</sup>Same mobile offer list as in (ii)

these models should not be confounded with a mixed logit model, which can take into account unobserved heterogeneity of individuals. This study uses both alternative-specific and individual-specific variables.

We use a standard linear utility specification for individuals  $i = 1, \dots, N$  over the different offers  $j = 1, \dots, J$ . Utility depends on offer characteristics and on the observable and unobservable individual characteristics. The utility of individual  $i$  for offer  $j$  in month  $t$  be given by:

$$U_{ijt} = V_{ijt}^f + V_{ijt}^m + \gamma_{fm}FMint + s'_{ijkt}\gamma_i + \epsilon_{ijt} \quad (1)$$

$$= x'_{jt}\beta_i^m + \delta_f\beta_i^f - \alpha_i(p_{jt}^m + p_{jt}^f) + \gamma_{fm}FMint + s'_{ijkt}\gamma_i + \epsilon_{ijt} \quad (2)$$

The observed utility of a mobile offer is  $V_{ijt}^m = x'_{jt}\beta_i^m - \alpha_i p_{jt}^m$  and of a fixed offer and its interaction with mobile services is  $V_{ijt}^f + \gamma_{fm}FMint = \delta_f\beta_i^f + \gamma_{fm}FMint - \alpha_i p_{jt}^f$ , where the price of mobile offer and fixed component are respectively denoted by  $p_{jt}^m, p_{jt}^f$ ,<sup>6</sup> and  $\alpha_i$  is the individual-specific valuation of price.  $\delta_f$  is the indicator for alternatives including a fixed component. Note that each consumer faces the same list prices of offers which are independent of consumption. All mobile offers include a mobile voice and data allowance. The individual-specific valuations of mobile offer attributes are denoted by  $\beta_i^m$  and the vector  $x'_{jt}$  includes the following variables: (i) a dummy for handset subsidy; (ii) a dummy for unlimited mobile voice allowance; (vi) mobile data allowance; (vii) mobile voice minutes included in the offer in case the mobile voice allowance is not unlimited.

We thus included interaction terms for a dummy for fixed component with a dummy for unlimited mobile voice allowance, as well as with variables for mobile data and mobile voice minutes included in the offer. The aim of these interactions is to estimate potential substitution or complementarity between usage of mobile data and voice and fixed components.

The vector of switching dummies is denoted by  $s'_{ijkt}$ , as in Grzybowski & Liang (2015), and the coefficients  $\gamma_i$  represents disutility from switching which approximates switching costs. We consider two types of switching dummies. The first one, "switching", takes value of zero if

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<sup>6</sup>For quadruple play offer, the list price, is precisely collected in dataset, is the sum of mobile offer price and triple play price decreased by a bundle discount.

consumer  $i$  in the previous month  $t - 1$  used alternative  $k = j$  and one otherwise when  $k \neq j$ . The second one, "leaving", takes value zero for the choice of any tariff and one for the choice of outside option, which is to leave the mobile offer.

Finally,  $\epsilon_{ijt}$  is a non observed utility component of alternative  $j$  for individual  $i$  at time  $t$ .

The vector of coefficients  $\theta_i = (\alpha_i, \beta_i^m, \beta_i^f, \gamma_{fm}, \gamma_i)'$  depends on unobserved consumers' heterogeneity, i.e.  $\theta_i = (\alpha_i, \beta_i^m, \beta_i^f, \gamma_{fm}, \gamma_i)' + \nu_i \sim N(0, \Sigma)$ , where  $(\alpha_i, \beta_i^m, \beta_i^f, \gamma_{fm}, \gamma_i)$  refers to a vector of mean valuations,  $\nu_i$  is a randomly drawn vector from joint normal distribution with  $\Sigma$  represents a diagonal matrix with the diagonal elements being standard deviations around the mean valuations.

#### 4.1 Choice Probabilities

An individual  $i$  chooses a tariff  $j$  in month  $t$  if this tariff maximizes the utility among all available alternatives, i.e., if  $U_{ijt} = \max_{n \in C_{it}} U_{int}$ , where  $C_i$  is individual  $i$ 's available choice set. Hence, the probability that individual  $i$  with given random coefficients  $\beta$ ,  $\alpha$  and  $\gamma$  makes a sequence of tariff choices  $j = \{j_1, j_2, \dots, j_T\}$  is given by:

$$\begin{aligned} l_{ij}(\theta_i) &= \prod_{t=1}^T \Pr \left( U_{ijt} = \max_{n \in C_{it}} U_{int} \right) \\ &= \prod_{t=1}^T \frac{\exp \left( x'_{j_t t} \beta_i^m + \delta_f \beta_i^f - \alpha_i (p_{j_t t}^m + p_{j_t t}^f) + \gamma_{fm} F M_{int} + s'_{i j_t k t} \gamma_i \right)}{\sum_{n \in C_{it}} \exp \left( x'_{n_t t} \beta_i^m + \delta_f \beta_i^f - \alpha_i (p_{n_t t}^m + p_{n_t t}^f) + \gamma_{fm} F M_{int} + s'_{i n_t k t} \gamma_i \right)} \end{aligned}$$

where the second line follows from the distributional assumptions of the unobserved utility term  $\epsilon_{ijt}$ .

A mixed logit model allows for unobserved consumer heterogeneity and requires integration of the conditional choice probability  $l_{ij}(\theta_i)$  over the joint distribution of  $\theta_i$ :

$$P_{ij}(\theta, \Sigma) = \int_{\theta_i} l_{ij}(\theta_i) f(\theta_i) d\theta_i. \quad (3)$$

where  $\theta$  and  $\Sigma$  are the parameters to be estimated. This is mixed logit or random coefficients logit choice probability.

## 4.2 Identification strategy

Interaction variables are used to study fixed-mobile dependence for fixed services. In particular, we focus on the interaction terms involving the dummy for fixed components included in fixed-mobile combined offers <sup>7</sup>.

The interaction between fixed and mobile only makes sense if a consumer owns a smartphone which enables the use of mobile data services. However, smartphone ownership is endogenous due to its correlation with unobserved characteristics of each individual that can influence their decision. To deal with this endogeneity, the dummy variable smartphone is instrumented with the density of the respondent's residential municipality. To benefit from Smartphone features, 3G or 4G mobile network coverage is essential. High density municipalities are better covered than low density municipalities. Therefore, the adoption of a smartphone is positively correlated with the density. The relevance of the instruments is tested in the first-stage regression reported in the appendix Table A- 2. A control variable is included in both conditional logit and mixed logit regressions using a control function approach (Petrin and Train 2010). To introduce variability into the choice sets, the dummy variable smartphone is interacted with the handset subsidy option associated with each alternative.

## 5 Main results

The main results are based on a mixed logit specification whose parameters  $\theta$  and  $\Sigma$  are estimated and reported in Table 2 below. The variables included are: (i) characteristics of the mobile offer in each alternative, namely the list price, handset subsidy option, dummies for 12- and 24-month contract length, dummy for unlimited mobile voice allowance, number of mobile voice minutes when the voice allowance is not unlimited, mobile data allowance in GB, (ii) dummy variable

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<sup>7</sup>A quadruple play is a special tariff designed by operators which bundle fixed and mobile services with attractive discount. But at the same time, a consumer can freely combine a fixed service component with a mobile offer without benefiting in return from price reductions.

for fixed broadband triple play, (iii) dummy for leaving which corresponds to an outside option, and (iv) dummy for switching representing the situation when a consumer switches from an old offer to a new one.

Table 2: Main results

VARIABLES	conditional logit	mixed logit	
	Mean	Mean	SD
price	-0.063*** (0.004)	-0.077*** (0.005)	0.019*** (0.004)
terminalsubsidy	0.549*** (0.169)	0.899*** (0.269)	0.692* (0.367)
comit12	0.711*** (0.187)	0.806*** (0.196)	0.003 (0.133)
comit24	1.029*** (0.202)	1.128*** (0.212)	0.017 (0.138)
TriplePlay	<b>2.846***</b> (0.128)	<b>7.587***</b> (1.173)	<b>4.933***</b> (1.079)
unlimited	1.892*** (0.222)	2.081*** (0.282)	0.185 (0.234)
voice	0.005*** (0.001)	0.006*** (0.001)	0.004*** (0.001)
datamobile	0.187*** (0.071)	0.131 (0.089)	0.005 (0.083)
switching	-6.816*** (0.055)	-6.550*** (0.066)	0.004 (0.202)
leaving	-6.901*** (0.315)	-7.099*** (0.421)	0.409 (0.641)
TriplePlay_unlimited	-0.154 (0.180)	-0.195 (0.246)	0.001 (0.224)
TriplePlay_datamob_smartphone	0.443*** (0.066)	0.593*** (0.087)	0.006 (0.092)
control_function	0.711*** (0.191)	0.788*** (0.221)	0.695 (0.502)
Log likelihood	-4951.357	-4865.896	
Observations	538,418	538,418	

Standard errors in parentheses.  
Significant at 1%(\*\*\*),5%(\*\*),10%(\*)

Table 2 displays conditional logit and mixed logit estimates of the fixed and random coefficients. The random coefficients of the mixed logit estimation demonstrate the heterogeneity in consumer valuation. As expected the worst performing model is the standard conditional logit model which does not allow for any preference heterogeneity. This result is confirmed by the higher log likelihood value of mixed logit regression (-4865.896 vs -4951.357).

All coefficients are statistically significant, except 'datamobile' and 'TriplePlay\_Unlimited' interaction. The price coefficient is significant and negative, consistent with economic theory. The coefficient of 'terminalsubsidy' is positive which means that the option of a mobile handset subsidy included in a mobile offer is positively and highly valued by consumers. The commitment length of 24 months is more positively valued than 12 months as the operator subsidizes a more advanced handset with 24 months commitment. The coefficients for the 'unlimited' and 'voice' variables are also positive, which suggests that the mobile voice allowance yields positive utility to consumers. The coefficients for the 'switching' and 'leaving' variables are significant and negative, representing the consumers costs for switching to a new offer or for leaving the operator. The standard deviations of coefficients are statistically significant for three variables: 'price', 'TriplePlay' and 'voice'. The standard deviations are particularly significant for TriplePlay, with SD equal to 4.933 for a mean value of 7.587. This result indicates that consumer valuation of fixed services is highly heterogeneous. The interaction between the fixed broadband and mobile data components (Triple Play\_Mobile Data\_Smartphone) has a significant positive coefficient. This suggests that fixed and mobile data are complementary, provided that the consumer owns a smartphone. The insignificance of 'datamobile' and the significance of fixed-mobile interaction 'TriplePlay\_datamob\_smartphone' suggest that mobile data yields utility to consumers who own smartphone and subscribe to triple play offer. The insignificance (yet negative) of interacted variable between triple play and unlimited mobile voice allowance suggests that these two attributes are independent.

Our finding about heterogeneity is different from other papers such as Grzybowski & Verboven (2016). Our paper uses the characteristics of tariffs, eight attribute-specific variables (list price included), to estimate the heterogeneity while Grzybowski & Verboven (2016) use only the price and demographic variables which are individual-specific. Adding the attributes of tariffs collected in our data such as the triple play option made it possible to obtain a different estimate of the random coefficients.

We also estimate the price elasticity of demand to be on average -0.85 with standard deviation

of 0.21, which is in line with estimates of other papers in the literature such as Madden et al. (2004). As expected, mobile-only consumers are more price sensitive with a mean value of -1.45 against -0.75 for fixed-mobile consumers.

The estimated coefficient of the exogeneity control variable is statistically significant. The endogeneity correction of the dummy variable indicating smartphone ownership is justified by the control function.

We will discuss the distribution of 'price' and 'TriplePlay' below in more detail, using individual-level parameters (Train 2009). As reported in Table 2 the estimate of price coefficient ( $-\alpha_i$ ) is negative and statistically significant both for the mean value and its standard deviation. The distribution of the price coefficient was specified to be normal. Table 3 illustrates the distribution of the price coefficient for mobile-only consumers and fixed-mobile consumers by using individual level parameters.

Table 3: comparison of mobile-only and fixed-mobile consumers for the random coefficient of price, TriplePlay, WTP, FM inteaction

	Mobil-only consumers	Fixed-mobile consumers
mean price coefficient (standard deviation)	-0.079 (0.008)	-0.076 (0.006)
mean TriplePlay coefficient (standard deviation)	0.7 (2.1)	8.8 (0.5)
mean WTP for TriplePlay (standard deviation)	8 (28)	116 (11)
mean FM interaction coefficient (standard deviation)	0.593 (0.002)	0.593 (0.001)



## Price coefficient distribution

The price coefficient for mobile-only users is significantly more negative than for fixed-mobile consumers which suggests higher price sensitivity among the former. Consequently, an increase in the fixed offer price would reduce the utility for fixed services among mobile-only users.

## Fixed component coefficient and consumers' WTP

The estimate of the coefficient of the dummy variable for fixed component Triple play  $\beta_i^f$  is also statistically significant for both the mean value and its standard deviation. Table 3 indicates that the mean value of the fixed component coefficient is lower for mobile-only consumers ( $\sim 0.7$ ) than for fixed-mobile consumers ( $\sim 8.8$ ). This result provides the main explanation of mobile-only consumption behavior which implies that mobile-only users do not value fixed broadband highly enough to be inclined to subscribe to an additional fixed broadband offer.

The analysis of the respondents' willingness to pay provides the same insight. You will recall that WTP is calculated by dividing the valuation of a given service by the price coefficient. In this paper, we use `mixlbeta` (cf. Hole 2007) to calculate individual-level parameters corresponding to the variables in the specified varlist based on the method proposed by Revelt and Train (2000). So, the price coefficient in the denominator to generate WTP distribution is individual-level. As Table 3 shows, mobile-only users have a far lower WTP for fixed broadband than fixed-mobile users. Calculations on the individual-level parameters for Price and Triple Play coefficients reveal that mobile-only users have an average WTP for fixed broadband of €8 per month, whereas their fixed-mobile counterparts have a WTP of €116.

It should also be noted that fixed broadband serves the whole household, while a mobile subscription is usually used only by the subscriber. In the present study, average household is made up of three people for fixed-mobile consumers. Hence, on an individual basis, fixed-mobile

users have a WTP for fixed broadband that is higher than mobile-only users.<sup>8</sup>

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<sup>8</sup>According to CREDOC (2014), mobile-only consumers (10% of the population in 2014) are on average younger: 55% are under 40 years while they only make up 41% of the general population. It is interesting to note that males are overrepresented (53%, +5 points compared to the general population). Mobile-only consumers are also more often people living alone (45%, against 24% in the overall population) and on low incomes (37% against 22% on average). Employees (22%, +6 points) and workers (18%, +7 points) are over-represented in this category. These socio-demographic characteristics may help explain the difference in WTP for a fixed component which is shared among more users in a multi-person household than a one-person household.

## Fixed mobile data interaction

The model specification includes an interaction term between the fixed broadband and mobile data components ('TriplePlay\_datamob\_smartphone'). Its purpose is to study the substitution versus complementarity between both broadband components.

The main results in Table 2 show that the mean value of the relevant variable is statistically highly significant and positive. Table 3 indicates that the coefficient of the fixed-mobile data interaction variable is positive and has a similar value for mobile-only consumers and fixed-mobile consumers. Both broadband components are thus complementary. This result contradicts the results found for voice services, since several studies have revealed a pattern of substitution for voice.

The results indicate a statistically insignificant standard deviation, implying that both mobile-only and fixed-mobile users see fixed and mobile broadband as complementary. It can thus be deduced that the existence of mobile-only users is due to the factors described above, namely higher price sensitivity and a lower fixed broadband valuation by mobile-only users.

The complementarity between the broadband components also has a positive impact on respondents' WTP for fixed broadband. Since both components are complementary, consumers with increasing data usage could be motivated to subscribe to an additional fixed offer in order to meet their consumption needs. This aspect is reflected in the WTP per GB included in the mobile plan. Dividing the 'TriplePlay\_datamob\_smartphone' coefficient by the price coefficient yields a WTP per GB included in the mobile offer of €7.7 (cf. Table 2  $7.7 = 0.593 / 0.077$ ). An increase in the mobile data allowance could thus lead some mobile only users to subscribe to an additional fixed broadband service. To this end, increasing the mobile data allowance by approximately 3 GB would suffice. Given that mobile-only users' basic WTP for fixed broadband is approximately €8, and given a potential increase of €7.7 per GB, it can be inferred that mobile-only users' WTP for fixed broadband could exceed the most popular fixed service price of €30 if the mobile data allowance were increased by 3 GB.

## Simulations with handset subsidy only available for quadruple play offers

This subsection studies the effect of mobile handset subsidy on the consumer's choice by performing some simulations. We used the estimated model to conduct some counterfactual simulations. The aim is to identify the variation in the share of mobile-only consumers when a mobile handset subsidy is only available for quadruple play offers.

Table 4: simulated mobile-only subscription rate in different scenarios

	Mobil-only rate (end 2012)
observed	15%
model prediction	17%
simulation if no handset subsidy	12%
simulation if no handset subsidy & switching costs=0	8%
simulation if pf=0	8.5%
simulation if pf=0 & switching costs=0	7.5%
simulation if pf=150	24%
simulation if pf=150 & switching costs=0	89%

As shown in the main results of Table 2, the option of a mobile handset subsidy ('terminal-subsidy') included in a mobile offer is positively and highly valued by consumers. This option is often included in mobile offers with 12 or 24 months commitment in order to increase customer loyalty. Table 4 shows the simulation results in the case where the mobile handset subsidy is only granted for quadruple play offers. The share of mobile-only users therefore drops by nearly 25% (from 15% in the baseline scenario to 12% in December 2012). Otherwise, if consumers were exempt from any kind of switching costs, the percentage of mobile-only users would be divided by two. This simulations results suggest that a higher handset subsidy with a quadruple offer helps to effectively reduce the share of mobile-only.

## Simulations with zero or very high fixed component price

The aim of the simulations is to identify the variation in consumers' choices when facing significant variations in the price of fixed broadband<sup>9</sup>.

To that end, the focus is on the direct utility of the fixed component from equation 1 (that is,  $U_f = \delta_f \beta_i^f + \gamma_{fm} FMint - \alpha_i p^f$ , relative to the fixed component and its positive interaction with mobile data). The remaining components of equation 1 are left unchanged. Two extreme scenarios are considered: either fixed broadband is offered for free, or the price for fixed broadband is €150. Each scenario is analyzed with and without switching costs. This approach allows us to identify the additional utility that the fixed broadband component can potentially bring to mobile-only consumers.

In the first scenario, the fixed broadband price is equal to 0. The percentage of mobile-only users therefore drops by nearly 50 % (from 15 % in the baseline scenario to 8 % in December 2012). Moreover, as shown in Table 4, if consumers were exempt from any kind of switching costs, the number of mobile-only users would decrease further.

Then consider the second scenario, with a fixed broadband price of €150. If the price is prohibitively high, the additional utility of fixed broadband would be negative for nearly 100 % of the respondents. In this case, the percentage of mobile-only users would be 9 points higher compared to the baseline scenario. Table 4 also reveals that switching costs have a considerable impact on the simulated mobile-only subscription rate. If switching costs are set to 0, nearly 90 % of respondents would switch their communications services provider.

## 6 Conclusions

In this paper, we focus on the factors which determine the choice of consumers between staying on mobile-only or subscribing to fixed-mobile offers. Mobile-only consumers are often said to be

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<sup>9</sup>These simulations are only indicative because we use extreme values for the price

the result of the ongoing fixed-mobile substitution process. The existing literature has, in fact, consistently shown that consumers can satisfy their voice service consumption needs with their mobile offer alone. When it comes to broadband, however, this finding could be reversed. Our empirical study uses a unique dataset based on a survey in France, combined with interviewee's telecommunications billing data, to reveal heterogeneous consumer preferences for fixed services. The random coefficients of the mixed logit estimation demonstrate the heterogeneity in consumer valuation. We find a very large heterogeneity of WTP for fixed services among consumers. The latter is, in our view, the main factor determining the consumer's choice. Mobile-only consumers have a much lower but non-zero WTP, and higher price sensitivity compared to fixed-mobile consumers. Consequently, an increase in the fixed offer price would reduce the demand for fixed service. In addition, we show that fixed and mobile data are complementary for all consumers. Counter-factual simulations show that the share of mobile-only could also be driven by the way to subsidize mobile handset. For instance, mobile handset subsidies affect consumers choice decisions. The share of mobile-only consumers could be significantly decreased if the handset subsidy was only included in quadruple play offers.

These results suggest that policy makers should support fixed-mobile convergence rather than promote competition between fixed and mobile players. Our results hold for France which, due to extensive coverage of its fixed and mobile networks, does not face the same circumstances as, for instance, Sweden, Austria or the USA. We have used a database from a single operator on a monthly basis between January and December 2012.

The next step could be to study choice and consumption by taking into account of the existence of mobile-only consumers of other French operators. It would also be relevant to extend the study to other countries such as the USA with a higher mobile-only adoption in order to examine whether the same determinants of consumer' choice are found as in France.

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## Appendix

Table A- 1: Mobile-only consumers are more common among people with a low-income, job-seekers, young people and people without children

	Mobile-only	Fixed-mobile
low-income	<b>22%</b>	78%
high-income	14%	86%
unemployed	<b>24%</b>	76%
employed	14%	86%
young (under 30yo)	<b>20%</b>	80%
not young	13%	87%
no children	<b>17%</b>	83%
with children	12%	88%

Table A- 2: First stage estimation of the control function

VARIABLES	smartphone
density	14.5777*** (0.765)
Constant	0.5457*** (0.005)
Observations	11,716
R-squared	0.017
Standard errors in parentheses.	
Significant at 1%(***),5%(**),10%(*)	