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# Bundling, consumer retention and entry: evidence from fixed broadband market

Lukasz Grzybowski\*      Julienne Liang†      Christine Zulehner‡

**Very preliminary and incomplete. Please, do not cite**

## Abstract

This paper answers two empirical questions. First, we analyze how fixed-mobile (quadruple-play) bundling impacts retention of consumers in fixed broadband market. Second, we assess how bundling by the incumbent operator impacts the market share and number of entrants who provide broadband services using incumbent's infrastructure. To address these questions we use a complete database of about 9.5 million subscribers to incumbent fixed broadband operator in a European country between March 2014 and February 2015. This data is combined with information on the market share and number of entrants in about 36,000 municipalities in this country. We find that consumers who bundle fixed and mobile services from the same provider are less likely to churn. Without quadruple-play bundling the annual retention of fixed broadband consumers would increase from 8.4% to 9.2%. Next, we find that the share of consumers having quadruple-play bundles with the incumbent has a negative impact on the market share and number of entrants. In the absence of quadruple-play bundling, the market share of entrants would be higher by about 6.8 percentage points. Quadruple-play bundling has also negative impact on the number of LLU entrants, which is bigger in the case of small LLU operators who cannot provide bundled offers themselves. This suggests that firms which cannot sell fixed-mobile bundles are disadvantaged in competition.

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**JEL Classification:** L13, L50, L96

# 1 Introduction

Bundling multiple communication services is nowadays a common strategy in telecommunications industry. Fixed telecommunications operators typically offer so called triple-play tariffs consisting of TV, fixed-line and high-speed Internet. In the last years, in several countries including France, Spain, South Korea, Japan and others, there has been also increasing supply of quadruple-play offers, which in addition to triple-play services include mobile services. The response of consumers to these bundled offers has been positive with fast-growing penetration.<sup>1</sup> For instance, according to a report by Analysys Mason, about 42% of fixed broadband households in France and 21% in Spain bundled their mobile services with fixed broadband service at the end of 2012, which based on forecasts should increase to respectively 75% and 42% by the end of 2017.<sup>2</sup>

The economic literature suggests that bundles can be used to substantially limit competition when some firms are not able to replicate the essential products and services, such as fixed broadband infrastructure or mobile licences. In fixed broadband markets, quadruple-play bundles may be used as a tool to prevent consumers from switching to new entrants and thus foreclose competition. At the same time, quadruple-play tariffs may strengthen the position of mobile operators against competitors without fixed broadband services, and eventually enable them to charge higher prices. However, the provision of quadruple-play bundles can also increase competition if it brings more choices, higher quality, or lower prices to consumers.<sup>3</sup>

In this paper, we contribute to the literature by analyzing the role of bundling for consumer retention. We also assess the impact of bundling on market shares of entrants using data for telecommunications industry. First, we analyze the impact of quadruple-play bundles on consumer retention. We use a unique data of about 9.5 million consumers from a single telecommunications operator in a European country. The data allows us to identify consumers

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<sup>1</sup>According to Eurobarometer, the purchase of bundled communications services by EU households increased from 38% in 2009 to 50% in October 2015. See “Special Eurobarometer 438: E-Communications and the Digital Single Market.”

<sup>2</sup>See <http://www.analysismason.com/About-Us/News/Insight/Fixedmobile-bundling-Feb2013>

<sup>3</sup>See OECD (2015), “Triple and Quadruple Play Bundles of Communication Services.”

who churned fixed broadband services during one year period between March 2014 and February 2015 representing about 8.4% of total consumer base. The decision to churn may depend on the use of bundled service offers, availability of alternative offers and individual consumer preferences. This data is combined with information on presence of competition in about 36,000 municipalities in the country considered. The competition variables include the number of DSL operators in municipality, presence of upgraded cable network, percentage of population in municipality covered with cable network of at least 30 MB/s. We also use information on share of population covered by 4G mobile network. Since we lack information on consumer characteristics due to data confidentiality, in the estimation we use socio-economic data on municipality level.

We estimate a number of econometric models. First, we estimate the impact of quadruple-play bundling and competition with other providers of broadband services based on different technologies on consumer's decision to churn. We find that consumers who bundle fixed and mobile services from the same provider are less likely to churn. Without fixed-mobile bundling the retention of fixed broadband consumers would increase from 8.4% to 9.2% representing an increase by 8.9%. The estimated impact of bundling on churn is modest, which may be due to the fact that the main competitors in the provision of fixed broadband services in this country also offer quadruple-play bundles. Competition with other DSL operators, which provide broadband services using local loop unbundling (LLU), and with cable operators increase consumer retention.<sup>4</sup> But the impact is not large relative to areas without fixed broadband competition. We also find that consumer churn due to competition with 4G mobile broadband is negligible. The propensity to churn depends also on individual characteristics and differs in geographic

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<sup>4</sup>Since the opening to competition in the 1990's, the telecommunications industry has been subject to regulation to limit the exercise of market power by incumbent operators and allow competition to emerge. In particular, to foster entry and competition in the broadband market, the European Commission has implemented in the early 2000's wholesale access to the incumbents' local networks, a regulatory policy known as "local loop unbundling" or LLU. LLU requires incumbents to grant access to their physical local copper infrastructure, at regulated prices, to enable entrants to provide DSL ("digital subscriber line") broadband services.

areas.

In the second part, we analyze the impact of churn on market share of entrants which provide broadband services based on DSL technology via LLU. In the estimation, we focus on municipalities in which there are no competitors which provide broadband services using fibre or cable technologies. We find that, after controlling for attractiveness of municipalities using a set of socio-economic characteristics and regional dummy variables, the share of consumers having quadruple-play bundles with the incumbent has a negative impact on the market share of entrants. Based on our estimates, in the absence of quadruple-play bundles, the market share of entrants in all municipalities under consideration would be higher by about 6.8 percentage points on average with differences across municipalities ranging between zero and 12 percentage points. Finally, we estimate a model in which the number of LLU entrants is regressed on the share of fixed-mobile bundles. We find that the share of subscribers to incumbent operator with quadruple play offers has a negative impact on the number of LLU entrants, which is bigger in the case of small LLU operators who cannot provide bundled offers themselves. This suggests that firms which cannot sell fixed-mobile bundles are disadvantaged in competition.

Importantly, this is the first paper which relies on a complete consumer database from incumbent operator to provide evidence on the impact of bundling on entry. Our results suggest that bundling reduces consumer retention and leads to lower market shares of entrants in local broadband market. But these effects do not seem to be sufficiently large to foreclose entry and competition locally. Our results contribute to the literature on bundling in telecommunications markets and shed light on the impact of bundling on consumer behaviour and competition. There is a large body of theoretical literature on the effects of bundling. Bundling may foreclose entry of a single-product provider (see Whinston, 1990; Nalebuff, 2004). In telecommunications markets, quadruple-play bundles may be used to deter entry of fixed broadband providers, which do not own a licence to operate mobile services. Thus, an oligopolistic mobile operator with market power may leverage its position into fixed broadband market. Market power may be also leveraged in the other direction from fixed broadband to mobile services. A dominant fixed

broadband operator can reinforce its share in mobile market by reducing consumer churn. Bundles may also enable firms to enjoy economies of scale and scope, thus reducing their transaction and production costs, which can strengthen their competitive position. Moreover, firms may introduce quadruple-play bundles to price discriminate.<sup>5</sup>

The remainder of the article is organized as follows. Section 2 discusses relevant literature. Section 3 presents the data which we use in the estimation. Section 4 introduces the econometric framework. Section 5 presents the estimation results. Finally, Section 6 concludes.

## 2 Literature

The empirical literature on bundling is scarce due to limited data availability. In general, individual-level panel data is required with information on bundling and switching tariffs and providers over time. Moreover, quadruple-play tariffs are a recent development in telecommunications and there are essentially no empirical studies on fixed-mobile bundling. One exception is Grzybowski and Liang (2015) who estimate demand for fixed-mobile bundles and switching costs between tariffs.

The empirical literature focused so far on bundling communications services and television on fixed networks. For instance, Prince and Greenstein (2014) analyze the impact of triple-play bundling of TV, telephone, and high-speed Internet and consumers' switching behavior using survey data of U.S. households. Since their original data is not a panel of the same households, they build a pseudo-panel data using nearest-neighbor matching methods. They find that households with triple-play bundles are less likely to switch service providers. In another paper, Burnett (2014) uses a survey of UK households to analyze the impact of bundling of communication services on the probability that a household changes supplier. He finds that bundling reduces the probability to switch. But the data used in his study is a cross-section. Also Lee (2016) uses

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<sup>5</sup>For this strategy to be effective, consumers who choose a bundle should have negatively correlated preferences for fixed and mobile components (see Bakos and Brynjolfsson, 1999). Crawford (2008) shows that bundling of cable channels within tiers rather than “a la carte” is an effective way of second degree price discrimination.

a survey data of Korean consumers to analyze whether bundling of telecommunications services makes individuals less likely to switch their service provider. He finds that Internet subscribers who previously bundled are less likely to switch their Internet service provider than are those who did not bundle. Again, his estimation relies on cross-sectional data with consumer declarations about past behaviour. In another paper, Pereira et al. (2013) use Portuguese consumer-level data of invoices to analyze whether bundles of subscription television, fixed broadband and fixed voice are a relevant product market in the sense of competition policy. But this paper does not analyze the impact of bundling on switching service providers. The papers mentioned above, with the exception of Pereira et al. (2013), do not use consumer panel data obtained from a firm. In this paper, we observe consumers' decisions to bundle and churn on monthly basis for the period of one year.

There are also papers focused on strategic decisions of firms in telecommunications markets when bundling is possible. Chang (2012) studies the impact of mixed bundling on a multi-product supplier's entry decision in the high-speed Internet market in the U.S. She concludes that provision of mixed bundling by the incumbent implies market demand for mixed bundling and thus increases the probability of entry by a firm which also provides mixed bundling. On the other hand, lower retention of consumers due to bundling has a negative effect on entry. Macieira et al. (2013) use data on Portuguese consumers who choose from assortments of different types of telecommunications products to analyze incentives of firms to offer bundles. In another paper, Crawford and Yurukoglu (2012) use firm-level data to estimate the welfare effects of unbundling in the retail cable television industry in the US. They find that unbundling channels would increase input costs and consequently prices paid by consumers thus offsetting consumer surplus benefits from purchasing individual channels.

### **3 The Data**

In this analysis we combine four data sets from different sources: (i) customer data from a large European fixed broadband incumbent operator, which includes individual-level information on



use of fixed-mobile bundles and decision to churn within one year period; (ii) municipality-level data on the number of active copper lines from the incumbent operator and entrants which offer broadband services via LLU and bitstream; (iii) municipality-level information on the number of competitors providing broadband services via LLU, coverage of cable network and share of population with access to 4G mobile services; (iv) municipality-level socio-economic statistics.

First, we use a complete database of 9,951,650 subscribers to fixed broadband services who were active in March 2014, which was made available to us by the incumbent telecommunications operator. Among these consumers, 852,408 churned within 12 months between March 2014 and February 2015, which represents 8.6% of customer base. We have monthly information on the type of subscriptions used by each consumer which can be: (i) a ‘naked’ Internet access offer; (ii) ‘double play’ offer which includes Internet access and fixed telephony over IP (IP Telephony); (iii) ‘triple play’ offer which includes Internet access with IP Telephony and television over IP (IPTV); or (iv) ‘quadruple play’ offer which includes IP Telephony, IPTV and access to mobile services. Thus, we know whether in March 2014 each consumer used bundled fixed-mobile offer (quadruple play tariff) or not. Moreover, for each consumer we know whether in March 2014 he was eligible to have FttH (Fibre to the Home) access and, in case of eligibility, whether he subscribed to FttH services.<sup>6</sup> For consumers who in March 2014 used DSL broadband services, we know whether they also kept fixed-line connection for voice calls (PSTN), in which case there is extra charge for it. We also know the number of years passed since first subscription with our operator. For each consumer we also have information on the postal code, which can be linked uniquely to one from about 36,000 municipalities in this country.

Second, we use municipality-level data on the number of active copper lines operated by the incumbent and its competitors, who rely on incumbent’s network using bitstream or LLU access. We also use information on the number of years which passed since the installation of Internet broadband services in each municipality, which approximates the economic importance

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<sup>6</sup>In case FttH access, fibre reaches the boundary of the living space, such as a box on the outside wall of a home.

of municipalities and how long is experience of consumers in using Internet services.<sup>7</sup> Moreover, we use information on average copper line loss which approximates quality of copper network.<sup>8</sup> This data was also provided to us by the incumbent operator.

Next, we collect municipality-level data on the presence of competition in year 2014, which includes information on the number of competitors providing DSL broadband services via LLU. Moreover, for each municipality we know whether in 2014 there was a cable operator providing broadband services, which was upgraded to FttLA (Fiber to the Last Amplifier) and the percentage of population which was eligible to have cable broadband connection with speed of at least 30 MB/s.<sup>9</sup> We also use information on the percentage of population covered with 4G mobile network by different operators at the end of 2014. This information can be used as a proxy for competition with mobile broadband service. This information was extracted from different sources including the websites of broadband providers and the website of the regulator of telecommunications.

Finally, we collect from the website of the statistical office municipality-level socio-economic information for year 2014, or for year 2013 when information for 2014 is not available, which includes: (i) the number of households; (ii) density of population (number of households divided by the surface of municipality); (iii) the percentage change in population size; (iv) the number of deaths per population; (v) the number of kids per population; (vi) the number of students per population; (vii) median income (in 2013); and (viii) the unemployment rate. The last variable is reported for 322 employment areas and it is assumed to be the same for all municipalities

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<sup>7</sup>The start of broadband Internet in a municipality is marked by the installation of the first broadband equipment (DSLAM) in the main distribution frame (MDF) which covers the municipality.

<sup>8</sup>Broadband signals from the exchange suffer attenuation as they travel along the copper line from the exchange to customer's house, which reduces the speed of DSL access. In general, the longer is the distance from customer's house to the exchange, the higher is the copper line loss. The copper line loss was measured in decibel in December 2010 or December 2013 and ranges from 1.5dB to 75dB with a mean value of 27dB.

<sup>9</sup>FttLA replaces the coaxial cable all along the line to the last amplifier (towards the subscriber) with optical fibre. It retains the existing most expensive part of the access network, the coaxial cables for the last mile connected with the subscriber.

within the same employment area. This data should control for socio-economic factors, which may affect consumer decision to churn but which are not available on individual-level in the first database.

The consumer-level data was merged with municipality-level data using unique post codes. Table (1) shows summary statistics for municipality-level information. The number of individuals used in the estimation is about 9.5 million, a bit smaller than the initial number, which is due to data cleaning and merging of individual- and municipality-level data sets.

## 4 Econometric Model

### 4.1 Churn decision

We analyze consumer decision to churn fixed broadband services. We do not know where churning consumers are going but they have essentially three options, they may: (i) switch to another fixed broadband operator, if available at consumer’s location; (ii) switch to mobile broadband operator, if there is 3G or 4G network coverage at consumer’s location; (iii) give up using broadband Internet. It is rather unlikely that consumers give up Internet access but it may still happen in situations in which the consumer moves household or dies.

We can model the decision to churn by means of a binomial logit (or probit) model, where the consumer makes a 0-1 decision to leave our fixed broadband operator or not. For this purpose we specify the following latent variable for consumer  $i$  living in municipality  $m_i$ :

$$U_i = C_{m_i}\alpha + \beta B_i + X_i\gamma + Z_{m_i}\delta + \epsilon_i = V_i + \epsilon_i \quad (1)$$

The price of alternative to which consumers switch is not observed but it varies across municipalities due to differences in presence of alternative fixed broadband operators and differences in coverage by 4G mobile networks, which variables are denoted by vector  $C_{m_i}$ . We may anticipate that the price of alternative operators is lower than the price of our operator in municipalities in which they are present because new entrants typically charge less than the incumbent operator. We expect a positive impact on the utility of churn of the following variables: (i) the number of

LLU operators in municipality, (ii) the presence of cable operator in municipality and greater share of population covered with cable network of at least 30 MB/s; (iii) the percentage of population covered by 4G networks of competitors. The impact of the percentage of population covered by 4G network of our operator is ambiguous. On the one hand, consumers may be more willing to use fixed-mobile bundles and continue using fixed broadband subscription with our operator when 4G coverage is higher. On the other hand, they may be willing to switch to separate mobile broadband services with our operator, which we do not observe in the data.

The variable  $B_i$  is a dummy variable which denotes that a consumer has a quadruple-play bundle, in which case he is expected to have higher switching costs and disutility from churning. We expect a negative coefficient  $\beta$ , which is estimated relative to the choice of continuing subscription with our operator, in which case consumers do not incur switching costs. The vector of variables  $X_i$  represents consumer characteristics which include: (i) number of years passed since first subscription with our operator; (ii) having active PSTN line; (iii) eligibility to use FttH broadband; (iv) having FttH broadband connection instead of DSL. These consumer characteristics may influence the utility derived from subscription with our operator, and thus also the utility derived from churning relative to continued subscription. In particular, the length of subscription indicates loyalty and should have negative impact on churn. Households with PSTN line are typically older and more attached to the incumbent operator. Also, there are additional switching costs to transfer or give up PSTN line, which should have a negative impact on churn. Households who are eligible to FttH connection typically live in wealthier urban areas with more competition. On the one hand, they may be less price sensitive and willing to churn. On the other hand, they may be better informed and have more options and to do so. Finally, consumers having FttH connection have already switched at least once and it may be easier for them to do it again. Also, fibre connection is often deployed as co-investment, it may be easier to switch to other fibre providers.

The vector of variables  $Z_{m_i}$  represents socio-economic characteristics of the municipality in which consumer  $i$  resides. These characteristics approximate missing consumer-specific charac-

teristics which may influence the utility derived from our or alternative broadband operator. The characteristics included in the estimation are: (i) the number of households (in logarithm); (ii) density of population defined as number of households per surface area (in logarithm); (iii) increase (or decrease) in population; (iv) number of deaths per population; (v) number of kids under 18 per population; (vi) number of students per population; (vii) median income (in logarithm); (viii) unemployment rate; (ix) average copper line loss; (x) set of dummy variables for the year in which the municipality is connected to broadband Internet.

The number of households in the municipality and density of population should be correlated with the accessibility of services of competitors, for instance there should be more points of sale which are located closer to consumers. We may expect that there is higher churn rate in municipalities with greater population size and density of population. There may be higher churn in municipalities with declining population, which is because households give up connections when moving away. Also greater number of deaths naturally contributes to higher churn. The higher number of kids and students per population suggests a greater share of young households which may be more willing to churn. Households based in municipalities with lower average income and higher unemployment rate may be more willing to churn due to higher price sensitivity. Also, in municipalities with a greater average copper line loss, which approximates quality of copper network, churn may be higher since people may want to switch to other technologies including 4G mobile network. Finally, churn may be higher in municipalities which are connected to broadband Internet for a longer time because consumers may be more experienced with use of Internet and aware of their needs and other services available on the market.

We define  $y_i = 1$  if the consumer  $i$  decides to churn by the end of our period and  $y_i = 0$  otherwise. The probability that consumer  $i$  decides to churn in logit model is given by:

$$P_i(Y_i = 1) = \frac{\exp(V_i)}{1 + \exp(V_i)} \quad (2)$$

and the probability of not churning is denoted by  $P_i(Y_i = 0) = 1 - P_i(Y_i = 1)$ . Assuming that the decisions of individuals  $i = 1, \dots, N$  are independent, the probability that each individual in

the sample chooses the observed option can be written as the log-likelihood function:

$$\mathcal{L}(\theta) = \sum_{i=1}^N [y_i \log(P_i) + (1 - y_i) \log(1 - P_i)] \quad (3)$$

The maximum likelihood estimator is the value of the parameter vector  $\theta$  that maximizes the likelihood function  $\mathcal{L}$  given by equation (8).

## 4.2 Market share

The second analysis is based on a simple Ordinary Least Squares (OLS) estimation on municipality level, in which we analyze the impact of churn on market share of entrants which provide broadband services based on DSL technology via LLU. Since we do not have information about the number of active fibre or cable connections of competitors, we focus on municipalities in which there are no competitors that provide broadband services using fibre or cable technologies. Thus, we drop from the estimate the most populous and economically attractive municipalities. The estimated equation takes the following form:

$$Y_m = \alpha S_m + Z_m \gamma + \varepsilon_m \quad (4)$$

in which we regress the total market share of entrants in municipality  $m$  taking values between 0 and 1 on the share of customers of the incumbent in the municipality who have quadruple play tariff plans  $S_m$ , which also takes values between 0 and 1 in percentage. We control for other possible determinants of entrants' share using a set of municipality characteristics  $Z_m$  which are similar to the previous estimation. In particular, the characteristics included in the estimation are: (i) the number of households (in logarithm); (ii) density of population (in logarithm); (iii) increase (or decrease) in population; (iv) number of deaths per population; (v) number of kids under 18 per population; (vi) number of students per population; (vii) median income (in logarithm); (viii) unemployment rate; (ix) share of flats in total number of premises; (x) average copper line loss; (xi) share of population covered by incumbent's 4G network; (xii) share of population covered by competitors' 4G networks; (xiii) set of dummy variables for the year in

which the municipality is connected to broadband Internet. Finally, the error term denoted by  $\varepsilon_i$  follows normal distribution.

The set of variables included in the estimation can be divide into demand factors and cost factors which determine entry and competition. The share of entrants may be higher in more populous municipalities with growing population since new comers may opt for subscriptions to cheaper services of entrants. Also, demand for entrants' services may be higher in municipalities with younger population which is approximated by the number of kids and students in population. In municipalities with a greater number of deaths per population the market share of incumbent may erode. Moreover, market share of entrants may be higher in municipalities with lower average income and higher unemployment rate due to higher price sensitivity of consumers who live there. The average copper line loss indicates the overall quality of copper network. The year in which the municipality was connected to broadband Internet is a proxy for attractiveness of the municipality. Municipalities with a higher share of population covered by 4G services of the incumbent and competitors may be also more attractive, but they may be also cheaper to cover. The density of population and share of flats in total number of premises also approximate the cost of coverage by broadband networks.

### 4.3 Entry

We estimate the determinants of equilibrium number of LLU entrants in municipalities. As in the regression of entrants' market share, we focus on municipalities in which there are no competitors that provide broadband services using fibre or cable technologies. The number of LLU entrants in municipality  $i$  is denoted by  $N_{it} = n \in \{0, 1, 2, 3+\}$ , where 3+ refers to a market with at least three entrants.<sup>10</sup> Following earlier literature on entry into local broadband markets, including Xiao and Orazem (2011) and Nardotto et al. (2015), in presence of  $n - 1$  competitors, the expected discounted future profits of the  $n^{th}$  firm in market  $i$  can be written

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<sup>10</sup>Since there is only a small number of markets with more than three entrants, we truncate the number of entrants to three. We dropped from the estimation most populous and economically attractive municipalities in which firms deployed fibre or cable networks and there was at the same time a greater number of LLU competitors.

as:

$$\pi_i^n = \alpha \ln S_{it} + X_i \beta - \mu^n I(N_i = n) + \epsilon_i \equiv \bar{\pi}_i^n + \epsilon_i, \quad (5)$$

where  $S_i$  is the potential market size approximated by the number of households and  $X_i$  is a vector of characteristics of municipalities, which are potential determinants of profits as discussed in the previous subsection. Finally,  $\mu^n$  represents the negative effect on profits from the presence of the  $n^{\text{th}}$  firm, and  $\epsilon_{it}$  is the error term.

The reduced-form profit specification (5) does not allow us to distinguish how the number of competitors affects the variable profits and the fixed costs, as in Bresnahan and Reiss (1991). The profits  $\pi_{it}^n$  include the non-sunk part of fixed costs but firms may also incur sunk cost to enter a local market, which cannot be recouped when they exit. We estimate the model using cross-sectional data for a single period which does not allow us estimating sunk costs, as in Hasbi et al. (2017). Since profits are not observed,  $\pi_{it}^n$  is a latent variable. We draw inferences on the determinants of profits assuming free entry equilibrium. Firms are present in the local market if, and only if, their expected stream of future profits is positive.

We should observe that in market  $i$  there are  $N_i = n$  active firms if for the  $n^{\text{th}}$  marginal firm, the expected discounted benefits from market presence are greater than zero, and at the same time for the  $(n + 1)^{\text{th}}$  marginal firm, the benefits from market presence are negative, as follows:

$$N_i = n \text{ if } \pi_i^n \geq 0 \text{ and } \pi_i^{n+1} < 0. \quad (6)$$

The probability of observing  $N_i = n$  entrants in market  $i$  is given by:

$$Pr(N_i = n) = \Phi(\bar{\pi}_i^n) - \Phi(\bar{\pi}_i^{n+1}), \quad (7)$$

where  $\Phi(\cdot)$  denotes the cumulative normal distribution function. The parameter vector  $\theta = (\alpha, \beta, \mu^n)$  is estimated by maximizing the following log-likelihood function:

$$LL(\theta) = \sum_{i=1}^M \sum_{n=1}^N y_{it} \ln(Pr(N_i = n|\theta)), \quad (8)$$

where  $y_i$  takes value of 1 if  $N_i = n$ , and 0 otherwise.



## 5 Estimation Results

### 5.1 Churn decision

Table 2 shows estimation results for consumer decision to churn fixed broadband services between March 2014 and February 2015. The first estimation includes only consumer-level information: (i) a dummy variable for a quadruple-play bundle; (ii) a dummy variable for having PSTN connection; (iii) a dummy variable for eligibility to use FttH broadband services; (iv) a dummy variable for current subscription to FttH broadband services with the other option being subscription to DSL broadband services; (v) number of years as a subscriber with our operator. The second estimation in addition includes variables related to competition with other broadband providers and technologies. Finally, the third regression also includes socio-economic characteristics of municipalities.

We can conclude that consumers having quadruple-play bundles are less likely to churn. This remains unchanged after inclusion of additional control variables. Our finding is in line with results from previous empirical studies. Consumers may benefit from having fixed-mobile bundles through lower transaction costs and they may end up paying lower price than when buying services separately. But they may also have higher switching costs. We are not able to identify the reasons for lower churn. Table (3) shows predicted churn in the consumer population for different scenarios, as compared to the base case. We find that in the absence of quadruple-play tariffs, annual consumer churn would increase from 8.4% to 9.2%, which represents an increase by 8.9%. The estimated impact of bundling on churn is modest, suggesting that quadruple-play bundles do not represent a constrain to competition in fixed broadband market. This may be due to the fact that the main competitors providing fixed broadband services in this country also offer quadruple-play bundles.

The other results also confirm intuition. We find that churn is lower for consumers who keep PSTN connection. The share of such consumers is about 27%, as compared to the share of consumers having quadruple-play tariff of 36%. The reason for this may be that consumers with PSTN are older and unwilling or unable to make voice calls over IP. Moreover, some

consumers may still value having fixed-line number. We observe that the share of households with PSTN connection declines over time, which results in a higher churn. The model predicts that when PSTN lines were not available and used by consumers, churn would increase from 8.4% to 9.3% which is an increase by 11.0%. Moreover, consumers who are eligible to use FttH broadband services are less likely to churn but, once they adopt FttH connection, their likelihood to churn increases. This may be because consumers eligible to use fibre are targeted by marketing campaigns trying to convince them to make a switch from DSL to FttH connection. Thus, instead of leaving the operator they may just change tariff and technology staying with out operator. But once they decide to switch to FttH, since the fibre connection is often deployed as co-investment, it may be easier for them to switch to other fibre providers. Finally, consumers who are longer with our operator are less likely to churn. Typically these are older households. Their higher loyalty may be explained by satisfaction with services, lack of information or higher switching costs.

The number of DSL competitors which provide broadband services via LLU increases the likelihood to churn. Also, the presence of cable operator in a municipality increases the likelihood to churn and also more consumers churn in municipalities with a greater share of population having access to cable connection with speed of at least 30 MB/s. Moreover, the propensity to churn is higher in municipalities in which DSL broadband was available since a longer period of time. These are typically more attractive municipalities with intense competition and consumers being better informed about available offers. The likelihood to churn is lower in municipalities in which a greater share of population is covered by 4G network of the operator but higher when a greater share of population is covered by the 4G networks of competitors. These two variables say something about the attractiveness of potentially complementary services of the our and competing operators but they are also highly correlated.

These results confirm the positive impact of competition with other DSL and cable competitors on churn. We predict the impact of competition on churn in the following scenarios. We assume that either cable has not been deployed at all or it is fully deployed and covers whole

population with speed of at least 30 MB/s. In the first case consumer churn drops by 5% to 8.0%, and in the second case it increases by 19.2% to 10.0%. Furthermore, we consider that either there are no LLU entrants at all or there are 5 entrants in every municipality in the country. In the first case, consumer churn drops by 23.7% to 6.4% and in the second case it increase by 17.2% to 9.8%. Thus, LLU has a bigger impact on churn than cable, but competition with both technologies relatively modest impact on consumer retention. Finally, we consider the impact of 4G mobile broadband, where in the first case there is no coverage at all, and in the second case 4G has full country coverage. The impact of 4G on churn is negligible, which suggests that at this point of time there competition between fixed and mobile broadband is limited.

The inclusion of municipality-level control variables does not impact the estimates discussed above. We find that in municipalities with a higher median income churn is lower. There is also more churn in municipalities with a higher unemployment rate. Thus, richer consumers may be less price responsive. More consumers churn in more densely populated municipalities. There is more churn in municipalities which either increase or decline in population size. A higher death rate increases churn. Thus, we can also observe churn in municipalities in which there is no competition which may be due to migration and natural changes in population size. In municipalities with more kids per household churn is lower and in municipalities with a greater number of students churn is higher. The estimation results are overall intuitive and show that the likelihood to churn depends on observable characteristics of individual consumers, which are approximated by municipality-level statistics.

## 5.2 Market share

Table (5) shows OLS regressions for equation (4) for a sample of 34,273 municipalities in which the only mean of accessing fixed broadband services is via copper network (Model IV). We focus on these municipalities because we do not have information about the number of active fibre and cable lines. The total market share of entrants in considered municipalities is represented by the number of fully or partially unbundled lines and bitstream lines divided by the total number of

active copper lines.

In the first estimation, we regress the share of entrants' copper lines in municipality on the share of incumbent's customers who have quadruple play tariffs and on a set of municipality characteristics discussed in the previous section. In the estimation we use the number of households as weights. The reason for this is that there is a large number of municipalities with small population size, e.g., there are 12,895 municipalities with less than 100 households. In these municipalities every household represents a significant percentage of the market. Due to small sample size the computed entrants' market share and the share of bundled contracts may contain large error, which cannot be explained by the model. In the second regression, we also include a set of regional dummy variables for 93 administrative regions. In the third regression, we restrict the sample to 21,831 municipalities in which there was at least one LLU entrant. These are in general more populous and attractive municipalities. In the fourth regression, we restrict the sample to 21,357 municipalities with population of at least 100 households. In all four regressions, we find that there is a highly significant and negative impact of bundling on entrants' market share. The negative impact of bundling is lower in Model II when regional dummy variables are included. The effect is then a bit higher for the estimations with regional dummies when the sample is restricted to municipalities with at least one LLU entrant (Model III) and to larger municipalities (Model IV).

Our result implies that bundling fixed and mobile services makes it harder for LLU entrants to acquire market share. The effect however does not seem to be very large. We use our model estimate how big is the impact on total market share of entrants. Based on the estimates of Model II for all municipalities including regional variables, in the absence of quadruple play bundling by the incumbent, predicted market share of entrants in all municipalities considered in this analysis would be higher by about 6.8 percentage points.

The other variables included in the estimation are significant with intuitive signs. In particular, entrants' market share is positively influenced by the number of households in municipality and by higher density of population, as well as by higher population growth rate. The mar-

ket share of entrants is also higher in municipalities with a greater number of students and kids. Thus, the municipalities which are attractive for entrants and easier to gain market share are more populous, with higher density of population and growing. Also, municipalities with younger population are more attractive to enter and easier to gain market share. Interestingly, it is easier for entrants to gain market share in municipalities with lower average income and higher unemployment rate, which may be because their brands are not established and therefore not preferred by better-off consumers. Higher share of flats in total number of premises and higher copper line loss make it also harder for entrants to gain market share. The latter variable impacts quality of copper broadband connections for both the incumbent and entrants' using its infrastructure via LLU or bitstream. The market share of entrants is also positively influenced by 4G coverage by the incumbent and competitors and by time passed since Internet is present in a municipality. The municipalities which were connected to broadband early on are more attractive for entrants who were able to gain higher market share.

### **5.3 Entry**

Finally, we use maximum likelihood estimation for ordered logit model specified by equation (8). The number of LLU entrants is regressed on the same set of explanatory variables as in the estimation of entrants' market share. The model is estimated using the number of households as weights. As shown in Table (4, the number of LLU entrants ranges between 0 and 5. But among LLU entrants there are two major competitors to the incumbent who own mobile licences and deploy fibre networks. These two operators also offer quadruple play contracts and may not be negatively affected by fixed-mobile bundling by the incumbent. It is therefore reasonable to consider impact of bundling on the number of entrants who cannot offer quadruple play contracts, i.e., smaller local LLU operators. We estimate two models. In the first one, we consider all LLU entrants including firms which can offer bundles with mobile services (Model V). Since there were only 321 municipalities with more than three entrants, we truncated these municipalities by three. In the second one, we consider only the number of LLU entrants which

cannot offer quadruple play bundles (Model VI). We also truncated 393 municipalities with more than one entrant by one.

In both models, we find that the share of subscribers to incumbent operator with quadruple play offers has a negative impact on the number of LLU entrants, which is in line with our estimates of the impact of bundling on entrants' market share. The effect is greater in absolute terms in the case of small LLU entrants which cannot offer bundles. This suggests that firms which cannot sell fixed-mobile bundles are disadvantaged in competition.

The estimates of other variables broadly confirmed the results from the estimation of entrants' market share. There is more entry in more populous municipalities with higher density of population and in municipalities with younger population, i.e., with a greater number of students and kids. There is also more entry in municipalities with higher average income. The entry is also positively influenced by 4G coverage by the incumbent and competitors and by time passed since Internet is present in a municipality. The municipalities which were connected to broadband early on are more attractive for entrants.

## 6 Conclusion

We use a database of about 9.5 million subscribers to fixed broadband services of a single telecommunications operator in a European country between March 2014 and February 2015 to answer two empirical questions. First, we estimate the impact of fixed-mobile bundling and competition with other providers of broadband services based on different technologies on consumer decision to churn. We find that consumers who bundle fixed and mobile services from the same provider are less likely to churn. Without fixed-mobile bundling the retention of fixed broadband consumers would increase from 8.4% to 9.2%, which represents an increase by 8.9%. The estimated impact of bundling on churn is modest. We also find that competition with other DSL operators, which provide broadband services using LLU and with cable operator increase consumer retention.

Second, we also analyze the impact of fixed-mobile bundling on market share of entrants

which provide broadband services based on DSL technology via LLU. In the estimation, we focus on municipalities in which there are no competitors which provide broadband services using fibre or cable technologies. We find that, after controlling for attractiveness of municipalities using a set of socio-economic characteristics and regional dummy variables, the share of consumers having quadruple-play bundles with the incumbent has a negative impact on the market share of entrants. Based on the model estimates, in the absence of quadruple-play bundles, the market share of entrants in all municipalities under consideration would be higher by about 6.8 percentage points on average, with differences across municipalities ranging between zero and 12 percentage points.

We also estimate two models in which the number of LLU entrants is regressed on the share of fixed-mobile bundles. In the first one, we consider all LLU entrants including firms which can offer bundles with mobile services. In the second one, we consider only the number of LLU entrants which cannot offer quadruple play bundles. In both models, we find that the share of subscribers to incumbent operator with quadruple play offers has a negative impact on the number of LLU entrants. The effect is greater in absolute terms in the case of small LLU entrants which cannot offer bundles. This suggests that firms which cannot sell fixed-mobile bundles are disadvantaged in competition.

Our paper provides important and unique evidence on the impact of bundling on competition. This is the first paper which relies on a complete consumer database from incumbent operator to provide evidence on the role of bundling for consumer retention and entry into local broadband markets.

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## Appendix

Table 1: Summary statistics

churning consumers	35809	24.603	135.724	0	11123
churn share (%)	35809	0.072	0.054	0	1
quadruple-play share (%)	35809	0.340	0.116	0	1
year since with the firm	35809	6.669	1.218	0.938	44
share FttH eligible (%)	35809	0.006	0.047	0	0.840
share having FttH (%)	35809	0.001	0.018	0	0.810
share having PSTN (%)	35809	0.276	0.142	0	1
unemployment rate	35809	0.100	0.020	0.048	0.178
coverage with 4G	35809	0.251	0.389	0	1
max coverage with 4G by competitors	35809	0.269	0.399	0	1
years since Internet in municipality	35809	10.512	2.012	-1	15
cable dummy	35809	0.030	0.171	0	1
cable 30mbps	35809	0.022	0.135	0	1
VDSL 30mbps	35809	0.126	0.239	0	1
LLU dummy	35809	0.648	0.478	0	1
median income	35809	19.913	3.327	4	47
surface	35809	14.969	14.997	0.04	770
households	35809	0.664	3.640	0.001	199
nb of children/population	35809	3.081	0.429	1	9.750
nb of students/population	35809	0.171	0.073	0	1.786
nb of ULL operators	35809	1.257	1.176	0	7
Population density	35809	67	443	0.170	22103
change in population	35809	-0.004	0.053	-1.740	0.7
nb of death/population	35809	0.010	0.009	0	0.5

Figure 1: Percentage of churning consumers by municipality

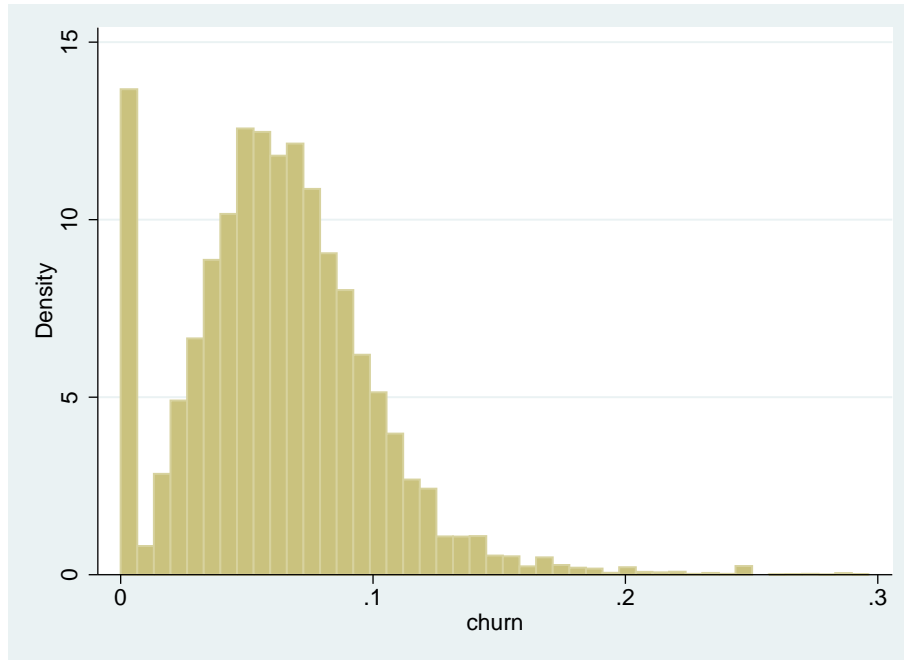


Figure 2: Percentage of consumers with quadruple-play bundle by municipality

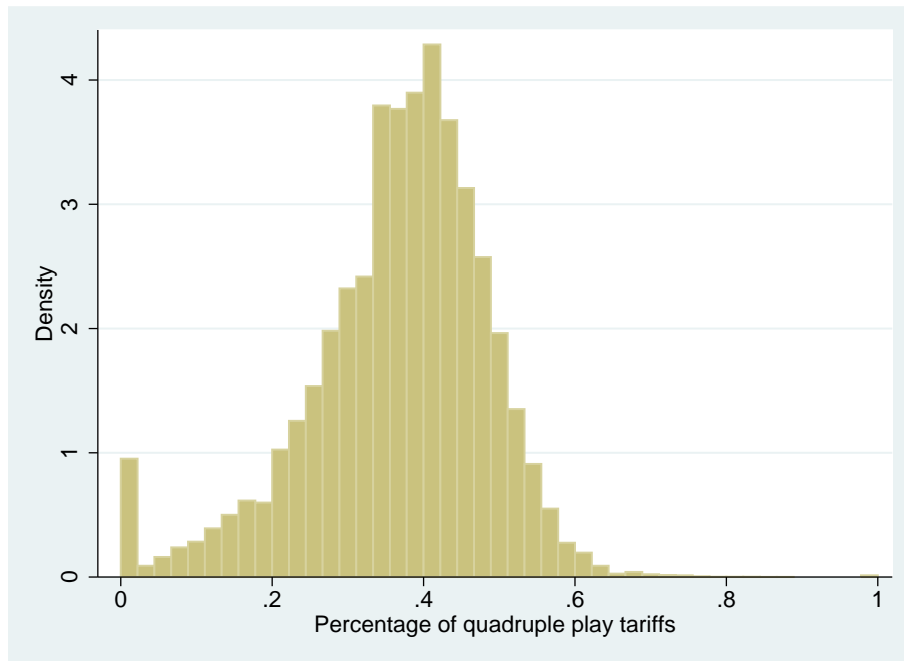


Figure 3: Percentage of consumers with PSTN connection by municipality

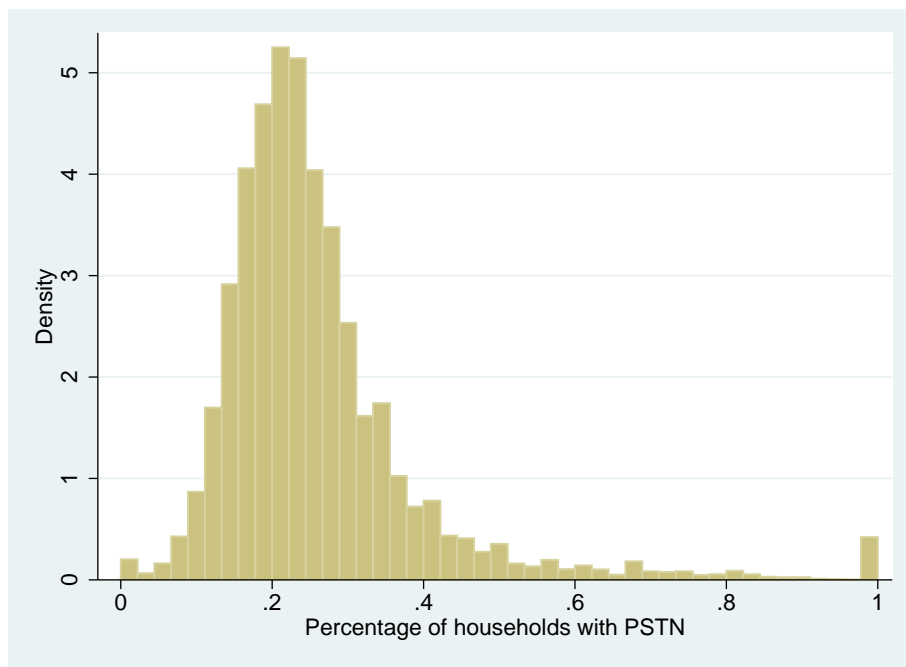


Table 2: Determinants of consumer retention

	Mod I	Mod II	Mod III	Mod IV
bundle quadruple play	-0.020*** (0.000)	-0.019*** (0.000)	-0.019*** (0.000)	-0.019*** (0.000)
year since with the firm	-0.003*** (0.000)	-0.003*** (0.000)	-0.003*** (0.000)	-0.003*** (0.000)
eligible to FTTH	-0.162*** (0.000)	-0.177*** (0.000)	-0.183*** (0.000)	-0.183*** (0.000)
having FTTH	0.099*** (0.001)	0.092*** (0.001)	0.087*** (0.001)	0.087*** (0.001)
having PSTN	-0.042*** (0.000)	-0.042*** (0.000)	-0.041*** (0.000)	-0.041*** (0.000)
years since Internet in municipality	0.009*** (0.000)	0.001*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
nb of ULL operators		0.011*** (0.000)	0.007*** (0.000)	0.007*** (0.000)
presence of cable		0.013*** (0.001)	0.010*** (0.001)	0.011*** (0.001)
cable 30mbps		0.032*** (0.001)	0.011*** (0.001)	0.010*** (0.001)
VDSL 30mbps		0.008*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
median income of the commune			-0.001*** (0.000)	-0.001*** (0.000)
nb of households/surface			0.000*** (0.000)	0.000*** (0.000)
population growth			0.251*** (0.005)	0.249*** (0.005)
population decline			0.057*** (0.005)	0.056*** (0.005)
nb of death/population			0.308*** (0.022)	0.305*** (0.022)
nb of children/population			-0.035*** (0.000)	-0.035*** (0.000)
nb of students/population			0.128*** (0.002)	0.128*** (0.002)
unemployment rate			0.076*** (0.008)	0.072*** (0.008)
coverage with 4G				-0.002*** (0.000)
max coverage with 4G by competitors				0.003*** (0.000)
Constant	0.013*** (0.001)	0.077*** (0.001)	0.180*** (0.002)	0.181*** (0.002)

Table 3: Model predictions

	Churn	% Change
Base	8.4%	
No bundle	9.2%	8.9%
No PSTN	9.3%	11.0%
Full cable coverage	10.0%	19.2%
No cable	8.0%	-5.0%
No LLU	6.4%	-23.7%
Full Nb LLU = 5	9.9%	17.2%
No 4G	8.3%	-0.9%
Full 4G	8.5%	0.6%

Table 4: Number of LLU entrans in municipalities

Nb LLU	All municipalities	Without cable and fibre	
		with mobile firms	without mobile firms
0	12,484	12,419	26,605
1	6,668	6,597	7,258
2	13,933	13,477	377
3	1,941	1,452	16
4	617	301	0
5	28	10	0
6	1	0	0
Total	35,672	34,256	34,256

Table 5: Entrants' market share and number of entrants

	Market share				Number of entrants	
	Model I	Model II	Model III	Model IV	Model V	Model VI
quadruple-play share (%)	-0.345*** (0.007)	-0.156*** (0.006)	-0.191*** (0.007)	-0.188*** (0.007)	-0.565*** (0.171)	-1.169*** (0.179)
log households	0.012*** (0.001)	0.025*** (0.001)	0.012*** (0.001)	0.023*** (0.001)	0.447*** (0.019)	-0.021 (0.019)
log households/surface	0.050*** (0.001)	0.039*** (0.001)	0.041*** (0.001)	0.044*** (0.001)	0.676*** (0.019)	0.410*** (0.019)
population growth (%)	0.564*** (0.025)	0.391*** (0.023)	0.293*** (0.035)	0.333*** (0.034)	0.871 (0.645)	-0.441 (0.639)
population decline (%)	-0.202*** (0.023)	-0.107*** (0.021)	0.017 (0.023)	-0.085*** (0.025)	-6.803*** (0.627)	0.118 (0.654)
death/population	-0.632*** (0.106)	-0.042 (0.091)	-0.163 (0.101)	-0.106 (0.107)	3.000 (2.739)	1.317 (2.981)
students/population	0.552*** (0.033)	0.579*** (0.029)	0.358*** (0.036)	0.404*** (0.039)	10.913*** (0.873)	1.819** (0.870)
children/population	0.439*** (0.009)	0.357*** (0.008)	0.255*** (0.009)	0.333*** (0.010)	2.390*** (0.228)	-0.004 (0.236)
log median income (tsd Euros)	0.012** (0.005)	-0.115*** (0.005)	-0.069*** (0.008)	-0.065*** (0.007)	2.596*** (0.139)	0.138 (0.137)
unemployment (%)	0.004*** (0.000)	0.002*** (0.000)	0.001*** (0.000)	0.002*** (0.000)	0.015*** (0.004)	-0.032*** (0.004)
share of flats (%)	-0.031*** (0.004)	-0.080*** (0.004)	-0.019** (0.008)	-0.051*** (0.007)	0.107 (0.094)	0.394*** (0.093)
copper line loss (decibel)	-0.001*** (0.000)	-0.001*** (0.000)	-0.002*** (0.000)	-0.001*** (0.000)	0.029*** (0.001)	0.010*** (0.001)
coverage with 4G (%)	0.023*** (0.002)	0.023*** (0.001)	0.021*** (0.002)	0.020*** (0.002)	0.398*** (0.042)	-0.061 (0.039)
max coverage with 4G by competitors (%)	0.026*** (0.001)	0.032*** (0.001)	0.029*** (0.002)	0.032*** (0.002)	0.576*** (0.037)	0.283*** (0.035)
Adsl 2000	0.037*** (0.006)	0.061*** (0.005)	0.028*** (0.006)	0.053*** (0.006)	2.951*** (0.156)	1.003*** (0.165)
Adsl 2001	0.030*** (0.006)	0.046*** (0.005)	0.016*** (0.006)	0.043*** (0.005)	2.240*** (0.154)	0.185 (0.163)
Adsl 2002	0.045*** (0.006)	0.057*** (0.005)	0.020*** (0.006)	0.050*** (0.006)	1.846*** (0.155)	-0.022 (0.165)
Adsl 2003	0.034*** (0.006)	0.048*** (0.005)	0.013** (0.006)	0.043*** (0.005)	1.908*** (0.153)	-0.019 (0.164)
Adsl 2004	0.003 (0.006)	0.026*** (0.005)	-0.006 (0.006)	0.022*** (0.005)	1.142*** (0.151)	0.047 (0.163)
Adsl 2005	-0.001 (0.006)	0.017*** (0.005)	-0.009 (0.006)	0.010* (0.005)	0.249 (0.154)	-0.183 (0.167)
Adsl 2006	0.012* (0.006)	0.020*** (0.005)	0.004 (0.007)	0.009 (0.006)	0.502*** (0.168)	0.130 (0.180)
Constant	0.024 (0.053)	1.283*** (0.052)	1.029*** (0.077)	0.832*** (0.076)		
Cut off 1					32.261*** (1.425)	3.487** (1.404)
Cut off 2					33.671*** (1.427)	
Cut off 3					38.642*** (1.432)	
Regional dummies		yes	yes	yes		
R-squared	0.672	0.765	0.517	0.636		
Observations	34,234	34,234	21,831	21,357	34,234	34,234