Private Operators’ Entry Strategies in the FttH Market –
The Case of France
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WORK IN PROGRESS

Abstract
We estimate models of entry into local markets by broadband services providers using cross-section data of 36,107 municipalities in metropolitan France in September 2014. There are four main market players: Orange, SFR, Free and Numericable, which differ with respect to market position and entry strategies. Depending on the provider the entry strategies include: (i) deployment of xDSL services using own network or via local loop unbundling (LLU); (ii) deployment of fiber in co-investment with other operators or (iii) deployment of fiber alone. We find mixed results on the interdependence between LLU and fiber deployment. For some operators, upgrading DSL lines to VDSL2 reduces incentives to deploy fiber, while it is insignificant for others. Moreover, the impact of LLU entry on the deployment of fiber by their competitors is either positive, negative or insignificant. We also find that market characteristics significantly impact the mode of entry. Regarding the variables related to the local market size, the thresholds to be reached is higher for Free, than for SFR and finally for Orange. On average, these thresholds are higher for Investment alone, than for co-investment and finally than for LLU.

Key Words: FttH; ADSL; Market entry
JEL Classification: L13, L50, L96

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1 Introduction

“Digital technology currently represents 5.5% of the French GDP”, it share may increase by 100 billion euro by 2020.¹ In April 2015, in a speech at the very fast broadband colloquium, ARCEP President calls out that “Telecommunication networks, the Telecoms [sector] are important, but what for?”² The deployment of next generation access networks (NGA) constitutes a major stake for economic and social development. Infrastructure investments have always been regarded as a tool of economic recovery in the short-term and as a factor of competitiveness and attractiveness in the long-term. Very high speed broadband is commonly associated with growth, employment and social development.

In the last decade the European Commission has been pursuing the objective of universal broadband access to the Internet according to which all European households should have access to basic broadband by 2013. Moreover, as set out in the Digital Agenda for Europe, “by 2020, all Europeans should have access to Internet with download speed of above 30 Megabits per second (Mb/s) and 50% or more of European households have subscriptions above 100Mb/s.”³ Such download speeds can be achieved when households are connected to fiber to the home (FttH) or upgraded cable modem technologies (DOCSIS3.0 also called FttLA), while the majority of households in the EU still uses copper-based Digital Subscriber Line (DSL) to access Internet. DSL offers a much slower download speed between 8Mb/s to 52 Mb/s depending on the technology and the distance of the household from the Main Distribution Frame (MDF).

Yet, regardless how important very high speed Internet could be for a country, privates incentives to deploy are not necessarily in line with public agenda. NGA roll out, especially FttH networks, requires heavy investment from private operators. Most of the costs are sunk and profitability is of prime importance for investments to occur. Though, alternative DSL operators are aware that NGA deployment constitutes an opportunity to free themselves from the incumbent, they face high investments costs and do not have the same advantages as the incumbent. As a result, the transition from copper to fiber is due to be progressive with the coexistence of several technologies, of which xDSL, cable, FttLA and FttH.

In February 2013, the French Government launched an ambitious superfast broadband plan (Plan France très Haut Débit, THD Plan). In line with the Digital Agenda for Europe, the THD Plan aims at covering the whole French territory with superfast broadband by 2022, of which 80% through the deployment of FttH network. The plan is worth 20 billion euros, shared between private operators and public authorities over a 10-year period. According to ARCEP observatory’s figures, in the third quarter of 2014, the number of high-speed and very high speed broadband subscriptions reached 25,970 million, i.e. net growth of 4.1% within a year. The number of very high speed broadband reached 3,113 million, of which 993,000 FttH subscriptions. Within a year, the number of FttH subscriptions has increased by 67%, whereas for the first time, the number of high speed broadband has decreased by 0.1%. Since the fourth

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¹French Government’s website, March 2015 “9 things you didn’t know about France and digital technology”. Results taken from a 2012 study by McKinsey.
² ARCEP President Speech April 2015 “Accelerating copper to fiber transition and very high speed mobile broadband coverage”.
³Digital Agenda for Europe is a flagship initiative of the Europe 2020 strategy for a smart, sustainable and inclusive economy. See “A Digital Agenda for Europe - COM(2010) 245”. 
quarter of 2011 the number of high speed broadband subscription has jumped by 131% and the number of FttH subscription by 404%.

France has one of the highest shares of 90% of broadband connections based on DSL technology in the EU, with FttH connections representing only about 2.3%. Such distribution of technology shares is not desirable from the perspective of the objectives set out by the European Commissions and the French Government to have the majority of households connected to Internet with download speed of at least 100Mb/s. We use the case of France to analyze the incentives of firms to deploy FttH technology in different geographic areas of a country. In particular, we analyze entry and competition between fiber networks operators and operators providing broadband DSL services via the so called local loop unbundling.

We use a detailed geographic data on fiber deployment and LLU in 36,107 municipalities of metropolitan France in September 2014 to estimate how the transition from copper to fiber occurs. This paper would contribute to the literature by bringing empirical evidence to theoretical findings.

The remainder of the paper is organized as follows. Section 2 discusses the relevant literature on competition in broadband industry. Section 3 introduces the broadband industry in France. Section 4 presents the data. Section 5 introduces the econometric framework. Section 6 presents the estimation results. Finally, Section 7 concludes.

2 Literature Review

Since a fast deployment of high speed broadband became an important policy issue, there is a growing body of literature on broadband diffusion, market definition of broadband services and entry into broadband markets.

The literature on broadband diffusion is in general focused on the effects of competition and regulation on broadband penetration and relies on aggregate country-level data, with the exceptions of few studies which use a more detailed geographic data (see Dauvin and Grzybowski (2014) for the EU countries; and Nardotto et al (2015) for the UK). In general, competition is found to have a significant and positive impact on broadband diffusion but with some differences with respect to the importance of inter- and intra-platform competition. A positive impact of inter-platform competition was found in Distaso et al. (2006) for the old EU countries, Denni and Gruber (2007) for the U.S., Lee and Brown (2008) for the OECD countries. On the other hand, there are studies which find that inter-platform competition has no impact on broadband diffusion but instead emphasize the role of intra-platform competition, see for instance Lee et al (2011) for the OECD countries, and Gruber and Koutroumpis (2011) for selected countries worldwide.

Another growing body of literature analyzes competition between broadband technologies from the consumer perspective. For instance, Cardona et al. (2009) use household survey data for Austria to estimate discrete choice models and find that cable modem and mobile access are close substitutes to DSL and that they are in the same market as DSL. Srinuan et al. (2012) use discrete choice model on survey data for Sweden and find that mobile broadband and fixed broadband technologies are close substitutes when they are locally available. Finally, Grzybowski et al (2013) estimate a mixed logit model using survey data for Slovakia and find

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4As of 2014, about 58% of EU households used DSl as their main Internet connection and about 6% used FtH. Source: “Eurobarometer: E-Communications Household Surveys”, Fieldwork in January 2014.

5Local loop unbundling is the regulatory process of allowing multiple telecommunications operators to use connections from the telephone exchange to the customer’s premises.
that mobile broadband should be included in the relevant market for internet access based on fixed broadband technologies. However, they do not study the competition between broadband providers and the incentives for deployment.

The literature on modelling entry is mature and excellently reviewed by Berry and Reiss (2007). However, the number of studies which deal with entry into telecommunications markets is very short, which is due to a lack of appropriate local-level data and the fact that the opening of telecommunications industry to competition is a recent phenomenon and entry requires substantial investments in infrastructure. There are few empirical studies which focus on market entry into local telecommunications markets in the US prior to the FCC’s decision in 2004 to reverse its open access policy (Greenstein and Mazzeo, 2006; Economides et al., 2008; Xiao and Orazem, 2009; Xiao and Orazem, 2011; Goldfarb and Xiao, 2011). Since the deployment of broadband technologies took place only in the last decade, except Nardotto et al. (2015), there are no empirical studies on this subject.

There is also a broad range of theoretical literature on the impact of regulation on private incentives to invest in NGA network. In particular, there are few studies on the trade-off faced by National Regulatory Authorities between the promotion of competition and the promotion of investment (Guthrie 2006). Some of these studies focus on the relation between copper access regulation and fiber access regulation and its impact on fiber deployment and migration (among others: Bourreau et al (2011b), Nitsche et al (2009), Briglauer et al (2011), Brito et al (2010)). Bourreau et al (2011a) and (2011b) have carried out an in-depth analysis of the migration from copper to NGA networks. They identify three contradictory effects influencing operators’ incentives to invest: a replacement effect, a wholesale revenue effect and a business migration effect. In addition, they highlight the existence of economies of scale in fiber network roll-out and the importance of investment decisions timing. The second operator to invest could benefit from the procedures already engaged by the first operator.

3 Broadband Industry in France

In France, broadband services are provided using five different technologies: DSL, cable modem, FttH, Fixed Wireless Access (or briefly WiFi) and mobile broadband. DSL converts the standard copper telephone line into a high speed digital line by transmitting data at higher frequencies than those used for voice. It allows for simultaneous use of voice telephony and data services. Cable modem uses access lines for cable television (CATV). Although traditional CATV networks need to be upgraded with a separate voice line to provide interactive communication services like telephony and Internet access, new networks use the same coaxial cable to provide simultaneous transmission of data, television and voice. FttH is an optic technology similar to standard cable. Fiber optic cables are rolled out up to the consumers’ home and can carry video, data, voice and interactive video-telephone services. WiFi uses radio links between a base station and a receiving antenna located in the consumer’s premises. It allows for simultaneous transmission of voice and data. Finally, mobile broadband uses the ‘third and fourth generation’ mobile network (3G and 4G).6

As of 2014, the French broadband market was characterized by the following shares of different technologies used as households’ primary Internet connection: DSL (88%), FttH (3.6%), cable modem (6.6%), other high speed subscription, such as WiFi, mobile broadband

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6There is an ongoing deployment of a new high-speed mobile data network in HSUPA standard, which is currently supporting data transfer speed rates up to 14.4 Mbps for download and 1.46 Mbps for data upload.
and satellite (1.8%). According to our data, DSL is accessible in all 36,107 municipalities in France. However, not all households in the municipality may be able to connect to copper network. FttH is available in 456 municipalities which represent 31% of population, and upgraded cable is available in 1,057 of municipalities also representing 31% of population. We do not have in the data information about the coverage of WiFi but according to official statistics in France there is only 8,377 hotspot in France located in restaurants, coffee places, hostels, public institutions, train station, airport, etc. According to ARCEP observatory, in 2014 mobile broadband was available in 99% and 70% of the French territory via, respectively, the 3G and the 4G networks of four mobile operators: Orange, SFR, Bouygues Telecom and Free. Even though mobile broadband is becoming increasingly popular due to expanding coverage and improving technical performance it is still not commonly used as the main households’ Internet connection. Hence, among these five technologies only DSL, and FttH have significant market shares. We focus on these technologies in our further analysis.

3.1 Digital Subscriber Line

The copper network in France is owned by the previous monopolist France Telecom, which currently operates under the name of Orange. This network is used by Orange to provide voice and DSL broadband services. Apart from that Orange is obliged to provide wholesale access to its copper network to independent operators on the basis of Local Loop Unbundling (LLU), for which it sets the wholesale access price. LLU is the regulatory process of allowing multiple telecommunications operators to use connections from the Main Distribution Frame (MDF) to the customer’s premises, passing through a first network aggregation point or street cabinet. In order to access the physical copper lines and provide Internet services, the alternative operator builds its own backhaul connection and core network down to the incumbents MDF. Then, it connects its customers to its own broadband equipment, DSLAM (Digital Subscriber Line Access Multiplexer) located within the MDF, next to the incumbents DSLAM. There are two types of unbundled access available in France: full unbundling which allows accessing to the entire copper line; and shared unbundling which involves accessing only to the upper bandwidth of the line while the incumbent keeps providing the telephone service to the public. In this paper, due to a lack of more detailed information on the type of unbundling we ignore this distinction.

LLU has played a critical role in promoting broadband diffusion in France by enabling competition between the incumbent and the alternative operators which do not possess developed telecommunications infrastructure. There are in total 16,315 MDFs distributed across metropolitan France, excluding Corsica, with about 33 million copper line connections, all of which as of 2014 are eligible to a DSL technology. As of December 2014, more than half of the MDFs have been unbundled, i.e., at least one alternative operator has installed its own active equipment inside. Hence, almost 90% of the metropolitan population has access to unbundling offers.

Apart from Orange, broadband services based on DSL technology are provided by 5 main alternative operators: SFR, Free, Bouygues Telecom and Completel (Numericable’s business subsidiary), OVH Telecom (also web provider) and a broad range of small private or public

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7. Source: ARCEP observatory - High and very-high speed Internet » Retail market; SFR-NumÃ©ricable 2014 annual results
8. Source: hotspot wifi directory in France.
local operators. The biggest alternative DSL operator for long has been SFR but at the end of January 2015 it was surpassed by Free with 6,980 unbundled MDFs as compared to 6,764 for SFR as of March 2015. Unlike SFR and Free, the third biggest alternative DSL operator, Bouygues Telecom, favoured DSLAM renting. It subscribes to the bitstream offers proposed by the incumbent or the unbundling operators. As of March 2015, Bouygues Telecom had only unbundled 985 MDFs.

In order to increase the speed delivered through the copper network, a faster technology, VDSL (very high bit rate digital subscriber line), has been implemented. This technology is also called Fiber to the Neighbourhood (FttN). It requires deploying fiber downstream to the sub local loop or street cabinet, where the DSLAM will then be located. In October 2013, the French telecommunications regulator ARCEP authorised the use of a second generation of VDSL, called VDSL2, which can deliver speed superior or equal to 30MB/s. But the authorization concerned only lines in direct distribution, i.e., only the lines which are directly connected to a MDF.

Since October 2014, ARCEP generalised the use of VDSL2 to all eligible lines, i.e., all lines connected to a street cabinet. VDSL2 is cheaper to deploy than FttH network because the copper local loop last mile is still used, i.e., between the street cabinet and the customer’s premises. According to ARCEP in the fourth quarter of 2014, approximately 8,500 MDFs, covering 91% of the population, have been equipped with VDSL2. Another solution which has been implemented by Orange to improve broadband speed in rural areas, where some lines were not eligible to ADSL, was the creation of MDF shadow zones. The idea was to reduce the line distance by creating a new MDF next to the street cabinet, where the DSLAM would be placed. However, this solution has been stopped with the development of VDSL.

3.2 Fiber to the Home

From 2010 onward, French telecommunication operators have started deploying next generation network access (NGA). Orange and SFR are the most active in the FttH deployment. They deploy not only in very high density areas, but also in less densely populated areas. In January 2010, Orange and SFR signed a co-investment agreement, mostly to deploy FttH in areas which are less densely populated. Yet in November 2014, Numericable bought SFR threatening the viability of the 2010 co-investment agreement since some areas are also covered by the cable network of Numericable.

Numericable is at present the biggest operator in the high speed segment of the broadband market in terms of the number of customers. Unlike the other operators, it does not deploy a new network but upgrades its cable network using DOCSIS 3.0 standard. It actually brings the fiber downstream, until the last amplifier (fiber to the last amplifier, FttLA) and keeps exploiting its cable access network. Therefore, it deploys fiber at a lesser cost than the operators investing in FttH network. However, Numericable’s network has a smaller footprint than the copper network, since it covers only 30% of the French households mostly located in urban areas.

Free deploys its own FttH network in very high density areas and co-invests in less densely populated areas. In July 2011, Free signed a co-investment agreement with Orange to deploy FttH fiber in 60 agglomerations located in less densely populated areas. In 2014, another 20 municipalities have been added to the list. In frame of the co-investment agreement, whereas Orange deploys the FttH network, Free participates to the financial cost in proportion of the market share it wants to obtain, i.e., Free subscribes to Orange’s FttH access.
offer. However, we could not get information on the local market share targeted by Free. We also do not have information on the municipalities covered by the agreement. Since August 2012, Free has almost stopped deploying its optical distribution frames. In December 2014 it had deployed its optical distribution frames (ODF) in 230 sites as compared to 226 in August 2012. At the same time Free has intensified its unbundling strategy and transfers its DSL subscriber towards the VDSL2 protocol.

Bouygues Telecom does not deploy its own FttH network, but rather proposes a retail fiber offer by subscribing to Numericable’s bitstream offer on its FttLA network. In addition, in December 2010, Bouygues Telecom has signed a co-investment agreement with SFR to cover few agglomerations in very high density areas. In January 2012, it has also signed a co-investment agreement with Orange concerning FttH deployment in both less densely populated areas and very high density areas. As of December 2014, Bouygues Telecom fiber offers were commercially available in 6 agglomerations, namely Paris, Lyon, Marseille, Toulouse, Bordeaux, and Nice. Bouygues Telecom keeps also unbundling Orange’s MDFs. However, due to a lack of data on the municipalities concerned by Bouygues Telecom FttH co-investment and FttLA bitstream access, it has been excluded from the scope of the study.

Other smaller private operators concentrate their investments in large municipalities or medium municipalities located in less densely populated areas. Many municipalities or departments across the country deploy FttH network or a mix of technologies, such as FttH, VDSL2, satellite or wireless local access to provide high speed Internet connection into rural areas. However, the analysis of public investment or its impact on private investment is out of the scope of the paper.

The roll-out of the horizontal segment of FttH networks is well undergone. According to ARCEP observatory, in September 2014, 3,411,000 housings were eligible to FttH and 311,000 households had subscribed to an FttH offer. In December 2014, there were 4,064,000 eligible housing and 356,000 subscriptions, i.e. a rise of 37% and 91% respectively compared to December 2013. Besides, 8,707,000 households were eligible to Numericable’s FttLA offer. All fiber operators have chosen to apply a 5 euros mark up on the retail market compared to the price of broadband offers. As such, customer’s migration toward FttH or FttLA Internet offers is enhanced.

### 3.3 Regulatory Framework

Legal certainty is of prime importance for private investments to occur. Onward 2008, with the adoption of the Law on Modernising the Economy, public authorities have adopted a series of measures to facilitate the roll-out of next generation access network, especially fiber network and achieve full coverage of the French territory by 2022.

ARCEP has contributed to define a secure and clear regulatory framework which include both symmetrical obligations, i.e., which apply to all operators, and asymmetrical obligations, i.e. which apply only to Orange. In this respect, in its 2008 market analysis of markets 4 and 5, ARCEP has compelled Orange to provide access to its civil engineering, ducts and poles, under transparent, non-discriminatory and cost-oriented conditions and to publish a reference offer. Access to existing infrastructures is seen as a prerequisite to ensure dynamic competition in the deployment of FttH network. Civil engineering represents the highest

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9Market 4 of Wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location. Market 5 of Wholesale broadband and ultra-fast broadband network access including bitstream’ access at a fixed location.
deployment costs. The FttH council has estimated in 2014 that “about 2.5 billion Euros was saved over five years by eliminating civil works for new cables in France, and similar savings could be made in the coming five years. The huge cost savings from duct sharing can dramatically improve the return on investment for FTTH projects”.

In addition, to avoid the pitfall of monopolisation, ARCEP has imposed symmetrical access obligations to all operators deploying a fiber optical network. Hence, any operators deploying an FttH network must grant access to its network, access prices are defined commercially by the operators and a public offer shall be published. Besides, to take account of geographical differentiation and promote investment, France has been segmented in two zones: the very high density areas and the other areas, in which the access obligations to the vertical network differ.

First, concerning horizontal deployment, ARCEP promotes infrastructure-based competition in very high density area, where dynamic competition already exists. In these areas, it is economically feasible for several operators to deploy their own network until the consumers’ premises. On the contrary, in less densely populated areas, ARCEP promotes mutualisation of the last mile of the network from the optical distribution frame to alleviate the costs of FttH roll out. In these areas, it is not economically feasible for several operators to deploy their own fiber network, however, network mutualisation between two or more operators leads to cost-cutting and improve profitability.

Yet, in some sparsely populated areas, despite mutualisation, private investment is unlikely to occur. In some of those non-profitable areas, where a lack of private incentive to invest has been assessed, local governments can deploy their own public network. We do not address the question of public intervention in this analysis.

In December 2009, ARCEP had identified 148 municipalities located in very high density areas, representing 5.54 million households. In 2013, taking into account practical considerations and the technical and financial conditions surrounding fiber deployment, ARCEP removes 43 municipalities, corresponding to 547,000 households from the list of very high density areas. This, in turns, strengthens the principle of mutualisation on these municipalities facilitating fiber network roll-out. On the contrary, one municipality, Poitier, has been added to the list of the very high density area, based on the deployment that had already happened in the municipality. The 2013 Decision brings also a modification inside the definition of the very high density areas, by identifying low-density pockets. Inside the low-density pockets, the localisation of the mutualisation point and the condition of vertical deployment differs from the other areas.

Second, concerning vertical deployment, the Law on Modernising the Economy imposes to mutualise the last mile of the network deployed in-building. Only one operator, the building operator deploys fiber in the building. In its 2009 decision, ARCEP imposes to building

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10Source: White Paper: Innovative FTTH Deployment Technologies By the Deployment & Operations Committee
11ARCEP is enabled to define general obligations which apply uniformly to all stakeholders as soon as these obligations have been homologated by the Minister in charge of telecommunications
12ARCEP Decision Nr 2009-1106 from the 22nd December 2009
13Call for manifestation of incentive to invest 2009
14The list of very high density area has been defined following a socio-economic approach (instead of an administrative one) starting from the agglomeration level (instead of the municipality level). Only the principal French agglomerations densely populated, whose urban units count more than 250,000 inhabitants and where buildings of more than 12 flats represent at least 20% of housing (single houses included). 20 agglomerations representing 148 municipalities have been identified as very high density zone in 2009.
operators to deploy in very high density areas a dedicated fiber for their competitors, if they asked for and co-finance it. This solution aims at reducing the deployment costs and remedies to the inconvenience of having multiple interventions in the same building. This regulation comes with the creation of a right of access or right of use of the vertical fiber network by commercial operators. Therefore, customers have the choice between different competing high broadband offers. The question that arose was relative to the localisation of the shared access point, i.e. the mutualisation point (PM) or concentration point. ARCEP has defined specific rules depending on the type of area concerned and on the number of flats comprised in a building. Table 1 below sums up ARCEP’s 2013 Decision. Besides, to prevent operators from making false statement about their intention of deploying an FtTH network in an area, ARCEP imposes to building operator, in its 2010 decision, to deploy, in less densely populated areas, within 5 years the whole service area of a mutualisation point, which covers 1,000 housing.

4 The Data

The main data on optical fiber deployment constitutes a snapshot of fiber deployment in metropolitan France (Corsica excluded) as of September-October 2014. They have been extracted from Orange’s Information System for September 2014 and from SFR’s website for October 2014. Both databases provide information at the municipality level with each municipality identified by a unique INSEE code. We have information on 36,107 French municipalities out of the 36,192 municipalities counted in metropolitan France in 2014. The Corsican region and the French overseas territories are excluded from the database due to a lack of information. For each municipality, we know whether Orange and/or SFR has deployed an FtTH network. In the original dataset from Orange’s Information System, we had information on the deployment state of each mutualisation point. The data have been extracted only when the mutualisation point was declared as “deployed”. The two other states “in deployment” and “planned” have been excluded as no timeline was given for their actual deployment. However, their exclusion does not lessen the relevance of the final dataset. Indeed, for each municipality in which an FtTH network is deployed, there is at least one mutualisation point declared as “deployed”.

Regarding the data extracted on SFR’s website, two sources have been used. First, SFR has published on its website a map of France and a list of the municipalities where it has deployed or will deploy an FtTH network. For each municipality, we know whether SFR has planned to deploy its network alone or in co-investment with another operator. However, no timeline was provided for the deployment. As a result, to determine whether SFR has effectively deployed an FtTH network in the municipality, we crossed these data with a press release, published on its website, listing the municipality where households can subscribe to its FtTH offers as of October 2014.

Regarding Free’s data, they have been extracted on an unofficial website updated by Free’s users community. The data are consistent with information gathered on other websites, as well as with Free’s 2014 Annual Report. For each municipality, we know whether there are active fiber connections.

This database has been completed with 6 other sources. First, variables on the copper network have been taken from two databases coming from Orange’s Information System as of December 2014. They inform us on the Main Distribution Frame (MDF) type as well as on the existence of unbundling both at the MDF level and at the municipality level.
Second, data on cable FttLA deployment have been extracted from Numericable’s website. Two snapshots have been realized, one in June 2014 and the other in October 2014. For each municipality, we know whether Numericable has upgraded its cable network to provide very high broadband services.

Third, socio-demographic characteristics come from INSEE, the French National Institute for Statistics and Economics Studies. INSEE publishes data at the municipality level such as density of population, level of education, income, housing and economic data such as the unemployment rate or the cost of labour. Some municipality characteristics are also extracted from INSEE databases, such as the degree of urbanization of the municipality, the type of economic or political zones with the employments zones and the canton-ville zones. These information have all been collected by INSEE in 2011, but the level of education in 2010. Finally, other municipality characteristics have been extracted from DATAR such as the municipality topography and from SNCF website such as the municipality directly connected by train to Paris or to major European municipalities as of January 2015.

The different databases have been merged using the INSEE code which uniquely identifies a municipality. This code was nevertheless not included in the dataset coming from SFR, Numericable and SNCF. As a substitute, we use the name of the municipality as well as the department number in the merging process.

Following the merger process, we obtained information on more than 99.7% of the French metropolitan municipalities (excluding Corsica). 85 municipalities out of the 36,192 counted in 2014 are missing from the final dataset. This is explained by an evolution of the administrative scope of these municipalities between 2011 and 2014. The socio-demographic and municipality characteristics data are from 2011, whereas the data on FtTH and FttLA deployment and on the copper network date from 2014. In the meantime, some municipalities have been split into two different new municipalities and some others have been merged, resulting in a modification of the name and INSEE code of the municipalities. Thus, the final database is fairly representative of the French metropolitan municipalities.

5 Econometric Model

In this section we derive a model of entry of broadband services providers in France. As discussed in Section 3, there are four main market players: Orange, SFR, Free and Numericable, which differ with respect to their market positions. The small firms which provide broadband via LLU are ignored in this analysis. The previous fixed-line incumbent operator, Orange, deploys fiber alone or in co-investment with SFR or Free. SFR provides xDSL services via LLU and deploys fiber alone or in co-investment with Orange or Free. Similarly, Free provides xDSL services via LLU and deploys fiber network alone or in co-investment with Orange or SFR. Finally, Numericable owns cable network, which has been upgraded to provide broadband services and provides xDSL services via LLU. Moreover, in October 2014, Numericable acquired SFR and since then they can be considered as a single decision maker. We need to consider these differences between firms when modelling their decisions to enter local markets and provide broadband services.

The local market entry decisions by broadband operators differs from the standard problem of entry, for instance by supermarkets or cinemas, due to the following reasons. In general, each of the operators sets nationwide prices without geographic differentiation in dependence on the number and type of entry. Since each household in general gets only one broadband connection, the total demand in a local market is well defined by the household’s number.
Consumers can substitute between broadband access via xDSL or fiber, where fiber is of higher quality due to higher download and upload speeds.

The following cost factors can be distinguished with respect to broadband service provision. There are country-level fixed costs due to backbone infrastructure deployment and maintenance, administration, marketing, etc. and local market fixed costs because the operator needs first to connect the backbone infrastructure to the local market and then to deploy the network within the local market and establish connections to the households. These local fixed costs in general differ by consumers since they depend on the distance from the household to the backbone. After the infrastructure is deployed the marginal costs are relatively small and may include any rental expenditures and customer services. There are therefore economies of scale in that once a local area is connected to the backbone, the average costs of infrastructure declines with the number of connected consumers. There are similar local economies of scale for a connection between the backbone network and apartment block or a district with many houses. The presence of economies of scale when price is fixed on the country-level implies that only a certain number of entrants can be accommodated by a market of given size.

We consider operator’s decision to deploy technology \( k \in \{d,c,f\} \), where \( d \) denotes xDSL deployment via LLU, \( c \) denotes fiber deployment in co-investment and \( f \) denotes fiber deployment alone. Both SFR and Free have these three investment options. Orange provides xDSL services directly on the whole country territory. In fact, we only observe deployment of fiber in markets in which xDSL is already deployed, except Numericable which instead of deploying fiber, upgrades its cable network in areas in which it also deploys xDSL via LLU or not. Hence, the profit function of operator \( j \) from deployment of technology \( k \) in local area \( m \) can be written as:

\[
\Pi_{jm}^{jk} = n_{jm}^{jk} (N_m, 1^{-j}) [r_m^{jk} (p_m^{jk} - c_m^{jk}) - f_m^{jk}] - F_m^{jk}
\]

where \( n_{jm}^{jk} (N_m, 1^{-j}) \) is the number of subscribers of provider \( j \) and technology \( k \), which is a function of the local market size \( N_m \) and entry decisions by the main competitors denoted by vector \( 1^{-j} \). This vector denotes entry via LLU only or both via LLU and fiber, since there is no entry by fiber only. The price is set on the country level but consumers in particular markets may choose different tariffs, which is denoted by market-specific average consumer price \( p_{jk,m} \). The average marginal cost of providing broadband by technology \( k \) is denoted by \( c_{jk,m} \), which we assume to be zero, and \( f_{jk,m} \) is the average fixed cost of installation at the household’s premises. There is also a fixed cost \( F_{jk,m} \) due to the connection of the local market to the backbone infrastructure. We assume that the stream of revenues from the local market depends on the ‘quality’ of consumers in this market, i.e., how long they are expected to stay with the provider and technology as denoted by the number of months \( T_{jk,m} \). Hence, after some manipulation the profit function has three components:

\[
\Pi_{jm}^{jk} = n_{jm}^{jk} (N_m, 1^{-j}) r_m^{jk} p_m^{jk} - n_{jm}^{jk} (N_m, 1^{-j}) f_m^{jk} - F_m^{jk}
\]

As mentioned above, we observe fiber entry only in markets in which there is already deployed xDSL via LLU, in which case the number of subscribers to fiber is also influenced by competition with own xDSL services. Only Numericable provides broadband services via cable network in some areas in which it does not offer xDSL services via LLU. Moreover, the
French regulator promotes fiber deployment in co-investment. In such case, the individual-specific and local fixed costs will be shared between operators.

There are the following differences in profit functions for xDSL and fiber. First, the prices for xDSL are in general lower than for fiber due to a difference in quality. Second, there may be a difference in the number of months consumers stay with the provider. Third, the individual-specific fixed and local fixed costs should be lower for xDSL than for fiber. Finally, the number of subscribers is differently affected by entry of other xDSL and fiber providers.

The operator decides to deploy broadband technology $k$ in local market $m$ if the expected profit $\Pi^{jk, m}$ is greater than for any other deployment option and greater than zero, which is equivalent to no deployment. After adding to the profit function defined by equation (2) the error term $\varepsilon^{jkm}$, which is assumed to be type I extreme value distributed, the probability of entry by operator $j$ with technology $k$ in market $m$ can be written as:

$$P_{jkm} = \frac{\exp(\pi_{m}^{jk})}{1 + \sum_{j'k} \exp(\pi_{m}^{j'k})}$$  \hspace{1cm} (3)

Since there are differences in modes of entry by operators, the choice probabilities must have suitably modified summations in the numerator. Defining $y_{jkm} = 1$ if operator $j$ deploys technology $k$ in market $m$, and $y_{jkm} = 0$ otherwise, the log likelihood function can be written as:

$$\mathcal{L}(\theta) = \sum_{m=1}^{M} y_{jkm} \log P_{jkm}$$  \hspace{1cm} (4)

where $\theta$ is the parameters vector of variables which influence profit function. The maximum likelihood estimator is the value of the parameter vector $\theta$ that maximizes (4). For each operator we estimate a separate model.

As shown in equation (2), there are three components of profit function which affect entry: revenues, sum of individual-specific fixed costs and local market fixed costs. Empirically, we can model the problem of entry in dependence on market-specific demand and supply factors which influence these three components. The revenues $n_{m}^{jk} (N_{m}, 1^{-j}) T_{m}^{jk} P_{m}^{jk}$ are influenced by the potential number of subscribers to fiber and variables which approximate the quality of subscribers, such as the level of income, unemployment rate, share of population in different age groups. These variables may affect both the length of time individuals stay with the operator, the type of contract they choose and the price they pay. The number of fiber subscribers depends on the market structure, i.e., the number and type of broadband services offered by other market players which decide to enter the market, and on the quality of xDSL services which depends on the type of MDF equipment in the local area. These variables may influence revenues linearly or in interaction with competitors’ entry dummy variables. The sum of individual fixed costs $n_{m}^{jk} (N_{m}, 1^{-j}) f_{m}^{jk}$ depends on the number of subscribers and the average cost of individual installations, which may be influenced by factors such as the density of population, the geographic area, the number of consumers living in flats and houses, whether the local market is urbanized, mountainous, etc. These factors also may influence local fixed costs, $F_{jk, m}$.

We expect that densely populated municipalities will attract operators’ investments into fiber with a higher threshold as the degree of investment increases. Similarly, the number of
flats in a municipality is expected to have a positive impact on fiber deployment, whereas the opposite is expected as regards the number of houses. This is because the deployment cost is higher for houses than for blocks with many flats. Moreover, we expect that operators take account of topographic factors. The cost of fiber roll-out increases in mountainous area, which is expected to hinder firms’ incentive to invest. Moreover, the entry cost may depend on the timing of entry since the first competitor to deploy may face additional costs related to administrative procedures.

When deciding whether to invest into a new fiber network, all firms face a replacement effect, which should be higher for Orange since it owns the copper network. Therefore we expect that in municipalities where copper lines have been upgraded to VDSL2 or where a high broadband MDF has been built, the firms’ incentive to invest into fiber network will be lessened. Though, demographic parameters may counteract by making the market profitable. Besides, we expect that the cable network upgrade operated by Numericable impacts positively on the DSL operators’ investment decision. Operators may also have a common interest in co-investing in less densely populated municipalities to avoid that, as a first mover, Numericable takes all the market.

6 Estimation Results
Table 2 shows the entry decisions made by each market player and the number of local markets for which we observe such entries. The decisions of firms are interdependent and should be analyzed jointly, which involves solving a discrete game. In this preliminary version of the paper we ignore the interdependence which may bias the estimates of variables representing entry of competitors. The entry decision of each firm is estimated separately in dependence on its market position.

Orange owns the copper network and decides whether to invest in fiber in co-investment with SFR or Free or alone. Table 2 shows estimation results for multinomial logit of entry decisions into local markets relative to the outside option which is no entry. The local market population size does not seem to have an impact on entry decision but both the number of houses and flats have a positive impact on both co-investment and entry alone. The number of houses is more important for co-investment and the number of flats for investment alone. These variables approximate the potential revenue from the market but are also related to the cost of deployment. The potential revenue from the market is also influenced by the ‘quality’ of the market which is related to income. The unemployment rate has a negative impact on both modes of entry. Both modes of entry are less likely in mountainous areas and in Ile-de-France. Ile de France is made of rural areas at 63%. More than half of Ile de France’s territory is agricultural.

The upgrade of MDFs to VDSL technology has a negative impact on fiber investment alone, even though this decision may be endogenous. Also, the entry of competitors via LLU may be endogenous. Orange is more likely to enter alone in areas in which also SFR enters alone. The decision to co-invest obviously cannot be modelled. Free’s entry into fiber does not affect the entry decision of Orange, whereas Numericable’s decision to upgrade cable has a positive impact on Orange’s fiber investment decision, especially as regards co-investment. The impact of entries via LLU is also positive. The number of LLU operators in a local market impacts positively Orange’s fiber investment decision.

Table 2 shows also the determinants of SFR’s entry decisions which consist of four options: no investment; investment in LLU only; co-investment into fiber and ULL; own
investment into fiber and ULL. SFR has long been Orange’s primary challenger on the DSL market via LLU offers. The local market population size has a positive impact on SFR all modes of entry, but is more important for co-investment and especially investment alone. The number of houses has a negative impact on SFR’s entry especially for LLU and LLU and fiber alone. On the contrary the number of flats positively influences all modes of entry, but is only significant regarding LLU. The unemployment rate has a negative impact on all modes of entry notably as regards fiber investment. The density of population impacts positively investment. All modes of entry are less likely in mountainous areas and for fiber investment in Île de France.

The upgrade of MDFs to VDSL technology has a negative, though insignificant, impact on all SFR’s modes of entry. On the contrary, Free’s LLU entry influences positively SFR’s entry, especially via LLU. The impact of SFR LLU entry by SFR itself has no impact on its investment into fiber alone. However, it has a positive impact on its co-investment decision. Whereas Numericable’s cable upgrade has a positive impact on SFR’s co-investment, it has a negative impact on SFR’s investment alone.

With respect to Free’s entry strategy, as shown in Table 2, only 3 alternatives are observed since we do not have information on its co-investments: no investment, investment in LLU only, investment into fiber (either in co-investment or by itself) and LLU. The local market population size influences positively Free’s investment, especially regarding fiber. Similarly to SFR, the number of houses has a negative impact especially as regards fiber entry. Unlike SFR, the number of flats has a negative impact on all modes of entry. The unemployment rate also has a negative impact on Free’s investment, especially regarding fiber deployment. On the contrary, the density of population has a positive impact. As for the other operators, all modes of entry are less likely in mountainous areas. Yet, Free’s entry is more likely in Île de France. Regarding fiber, this result may be explained by the low level of investment achieved by Free.

The upgrade of MDFs to VDSL technology has no significant impact on Free’s entry into fiber. However, Free’s LLU is positively influenced by SFR’s LLU. Besides, Free LLU has a negative impact on its own fiber investment. Free’s fiber entry is positively influenced by other operators LLU and especially by Orange’s fiber deployment. However, this result may reflect co-investment between the two operators, that we could not modelled. On the contrary, Numericable’s cable network upgrade has a negative but insignificant impact on Free’s LLU investment, but none on its fiber investment.

The same models have been estimated without the French main agglomerations; i.e. Paris, Lyon, Marseilles representing 135 municipalities, to assess whether the entry decision of firms were different. The estimation results are similar in terms of sign and significance, hence we focus our discussion on the full sample of municipalities.

7 Conclusion

In this paper, we estimate models of entry into local markets by broadband services providers in France using cross-section data of 36,107 municipalities in Metropolitan France in September 2014. There are four main market players: Orange, SFR, Free and Numericable, which differ with respect to market position and entry strategies. The previous fixed-line incumbent operator, Orange, deploys fiber alone or in co-investment with SFR or Free. SFR provides xDSL services via LLU and deploys fiber alone or in co-investment with Orange or
Free. Similarly, Free provides xDSL services via LLU and deploys fiber network alone or in co-investment with Orange or SFR. Finally, Numericable owns the cable network, which has been upgraded to provide broadband services, and provides xDSL services via LLU. The entry decisions of these firms are interdependent and should be analyzed jointly. However, in this preliminary version of the paper we ignore the interdependence, which may bias the estimates of variables representing competitors’ entry. The entry decision of each firm is estimated separately in dependence on its market position.

We find that there is some interdependence between LLU and fiber deployment. In municipalities where DSL lines have been upgraded to VDSL2, Orange has less incentive to invest into fiber in co-investment. But the impact on fiber deployment by the other two fiber operators is insignificant. The impact of LLU on fiber deployment by the different operators is also mixed. Fiber deployments by Orange either as co-investment or investment alone are positively influenced by the number of LLU operators. As regards SFR, it is more likely to deploy fiber as co-investment in areas in which there is LLU entry by Free and in fiber alone in areas in which Orange deploys fiber alone. SFR is also more likely to co-invest into fiber in municipalities in which there is Numericable’s FttLA. However, Numericable’s FttLA deployment reduces SFR’s probability to deploy fiber alone. However, we find that SFR faces a replacement effect as its LLU deployments have a negative impact on its fiber investment.

Finally, Free is also more likely to deploy fiber alone in areas in which there is LLU entry by SFR and in areas where Orange deploys fiber but Numericable’s FttLA deployment has no effect. Overall, we can conclude that DSL technology has an impact on fiber deployment, as operators face a replacement effect whenever they decide to enter the fiber market. This replacement effect appears in areas where MDFs have been upgraded to VDSL2 technology providing better bandwidth. Considering the positive impact of the number of LLU operators on Orange’s entry into fiber, we can conclude that not only a wholesale revenue effect is at play, but also a retail revenue effect. Orange’s marker shares may lower with the number of LLU operators. In investing in a more efficient technology in areas where there is more LLU operators, Orange may win back market shares on the retail market. In addition, we show that a competition effect exists between FttLA and FttH, as operators are more likely to co-invest in areas where Numericable has upgraded its network.

We also find that market characteristics significantly impact the mode of entry. The density of population has a positive impact on fiber investment. It appears that the population density threshold to reach for SFR and Free to invest into fiber is higher than for Orange. Though the population variable coefficients are positive for all estimations, it is significant only for SFR and Free. A higher population is needed for investment alone, than for co-investment or for ULL. We also find that whereas the number of houses has a positive impact on Orange’s strategy, its impact becomes negative for the alternative DSL operators. This may be explained by the higher cost required to connect houses to the network. On the contrary, the coefficients of the flat variables are positive in all estimations Orange and SFR, but significant only for Orange estimation and for SFR LLU strategy. The negative sign of the flat variable for Free may be explained by the low number of fiber deployment realized by the operator. The deployments have occurred in large cities with a high density of population mostly located in Ile de France.

Our results provide important conclusions for policy makers and the rationale for public initiative. Private operators decisions of entry into fiber are based on the potential revenue expected from a local market and its ‘quality’ in terms of expected demand as well as on the cost of deployment. The thresholds to be reached, for example, in terms of population density,
number of flats or unemployment rate are much higher than for LLU, especially with respect to investment alone. Therefore, to ensure an optimal FttH coverage of France by private operators, policy makers should promote co-investment and insure that the investment profitability is not reduced by wholesale access regulation. Private operators will be more prone to invest into fiber in less densely populated area if they set commercially the wholesale access price and anticipate higher wholesale revenue. This finding confirms ARCEP policy, unlike the European Commission recommendation to regulate NGA infrastructure access. In other areas, where market characteristics show that the local market is not economically profitable, there is a rationale for public investment.
Bibliography


## Appendix

**Table 1: Overview of ARCEP FttH Network Regulation**

<table>
<thead>
<tr>
<th>High-density areas</th>
<th>Inside low-density pockets</th>
<th>Lower density areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outside low density pockets</strong></td>
<td>Concentration point of 300 single fibre lines, regardless of the size of the building</td>
<td>Concentration point of 1,000 single fibre lines, regardless of the size of the building</td>
</tr>
<tr>
<td>For buildings with at least 12 residential or business units or accessible through a visible sewer network: multi-fibre concentration point at the building entry point</td>
<td>3.2 million premises</td>
<td>0.8 million premises</td>
</tr>
<tr>
<td>* For other buildings (i.e. fewer than 12 units and not accessible via visible sewer): - general rule: concentration point of 100 single fibre lines (cabinet) - special cases (isolated buildings): multi-fibre concentration point (manhole, facade, terminal)</td>
<td>1.5 million premises</td>
<td></td>
</tr>
<tr>
<td>* Aim of the present recommendation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ARCEP’s website, La Fiber.

**Table 2: Entry decisions by Orange, SFR and Free**

<table>
<thead>
<tr>
<th></th>
<th>Orange</th>
<th>SFR</th>
<th>Free</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fiber co-invest</td>
<td>Fiber alone</td>
<td>LLU</td>
</tr>
<tr>
<td>Population</td>
<td>-0.015 (0.024)</td>
<td>-0.013 (0.028)</td>
<td>0.308*** (0.055)</td>
</tr>
<tr>
<td>Density</td>
<td>0.000*** (0.000)</td>
<td>0.001*** (0.000)</td>
<td>0.004*** (0.000)</td>
</tr>
<tr>
<td>House</td>
<td>0.477*** (0.070)</td>
<td>0.277*** (0.086)</td>
<td>-0.739*** (0.110)</td>
</tr>
<tr>
<td>Flats</td>
<td>0.126*** (0.043)</td>
<td>0.146*** (0.049)</td>
<td>0.332*** (0.082)</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>-0.910*** (0.026)</td>
<td>-0.828*** (0.031)</td>
<td>-0.148*** (0.002)</td>
</tr>
<tr>
<td>Mountains</td>
<td>-1.075** (0.420)</td>
<td>-1.112* (0.467)</td>
<td>-0.645*** (0.039)</td>
</tr>
<tr>
<td>Ile de France</td>
<td>-1.103*** (0.335)</td>
<td>-0.441 (0.272)</td>
<td>0.303*** (0.146)</td>
</tr>
<tr>
<td>NRA VDSL lines</td>
<td>-0.000* (0.000)</td>
<td>-0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td></td>
<td>LLU Free</td>
<td>LLU SFR+Neuf</td>
<td>Number of LLU operators</td>
</tr>
<tr>
<td>----------------------</td>
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</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td><strong>p</strong> <em>&lt; 0.01,</em>* p &lt; 0.05,** p &lt; 0.001</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>-1025</td>
<td>-14362</td>
<td>-12753</td>
</tr>
<tr>
<td>R²</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(I) Entry decision by Orange: (i) fiber co-investment, (ii) fiber investment alone; (II) Entry decision by SFR: (i) LLU only; (ii) LLU and fiber co-investment, (iii) LLU and fiber investment alone; (I) Entry decision by Free: (i) LLU, (ii) LLU and fiber co-investment, (iii) LLU and fiber investment alone, *** *p<0.01,** *p<0.05,* *p<0.1