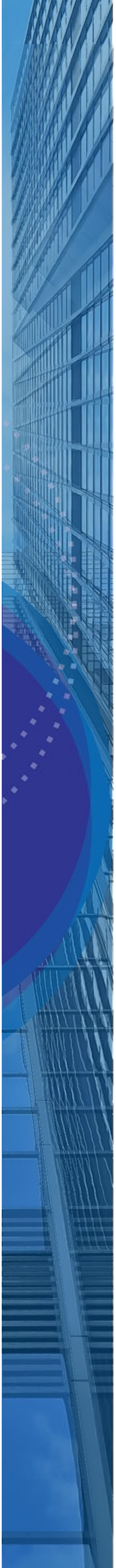

The Efficiency of State Aid for the Deployment of High-Speed Broadband: Evidence from the French Market

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The Efficiency of state aid for the Deployment of High-Speed Broadband: Evidence from the French Market*

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Abstract

In this paper, we develop a framework for assessing the efficiency of public subsidies in developing broadband fiber networks. We estimate a structural model of fiber entry using a rich dataset on fiber deployment for more than 34,000 municipalities in mainland France from 2014 to 2019. We then assess whether private investment would have occurred in subsidized municipalities in the absence of state aid for broadband deployment. We find that between 64% and 93% of the time, public subsidies were granted to municipalities where private entry would not have occurred. Overall, we estimate the cost of "inefficient" public subsidies to be between 243 and 902 million euros, with total subsidies amounting to 2,203 million euros by the end of 2019. Finally, we find that the plan helped to increase fiber coverage in subsidized municipalities in the early stages of fiber deployment.

Keywords: State Aid; Ex-Post Evaluation; Broadband; Entry; Coverage; Crowding Out.
JEL Classification: D22, L1, L4, L33, L96, H44.

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1 Introduction

Since the launch of the Digital Agenda for Europe in 2010,[1] the European Union (EU) has set targets for nationwide broadband coverage with next-generation access (NGA) networks providing ultra-fast access to the Internet. Such networks are considered strategic for consolidating the EU's digital single market, fostering economic and social development, and bridging the digital and economic divide in rural areas.[2] However, deploying broadband infrastructure involves high fixed costs that may not be recovered in areas with low or uncertain demand. As a result, some regions may remain unserved by private operators.

Member States of the European Union can provide public subsidies to support the deployment of broadband networks, subject to certain conditions. In particular, financial support must comply with EU state aid rules.[3] Public subsidies should not be a substitute for private investment. They should be targeted to areas where private operators have no incentive to deploy broadband infrastructure, thus, bringing significant social and economic benefits.

In this context, France proposed to the European Commission in 2013 the *Plan France Très Haut Débit* (hereafter the "French Broadband Plan"), a national high-speed broadband plan that aims to provide broadband connections of at least 30 Mbps for all by the end of 2022 and fiber connections for all by 2025, with a total budget of 3 billion euros.[4]

In this paper, we study the efficiency of state aid granted to local authorities through this plan. State aid is efficient when it is used in areas where private operators would not profitably invest. Otherwise, public subsidies may crowd out private investment and undermine the incentives for private operators to invest. We use a model of entry by a fiber operator to estimate whether private investment could have happened in a given area in the absence of state aid. This allows us to identify areas where state aid enabled fiber deployment and where private investment would have occurred without public support. We also examine the impact of state aid on fiber coverage while controlling for the endogeneity of fiber entry.

We use panel data over the period 2014-2019 with information on fiber deployment, the

[1] See 'A digital agenda for Europe,' COM(2010)245 final, Brussels, 19 May 2010.

[2] High-speed broadband infrastructure is expected to stimulate growth and job creation by increasing productivity and stimulating innovation in products and services. For empirical evidence on the positive impact of broadband infrastructure on growth and job creation, see, among others, Czernich, Falck, Kretschmer and Woessmann (2011) and Ahlfeldt, Koutroumpis and Valletti (2017).

[3] See: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2013:025:0001:0026:EN:PDF

[4] See: https://agence-cohesion-territoires.gouv.fr/france-tres-haut-debit-53; https://www.arcep.fr/demarches-et-services/collectivites/le-plan-france-tres-haut-debit-pfthd.html

number of infrastructure operators, state aid and socio-demographic characteristics of more than 34,000 municipalities in mainland France.[5] We adopt a two-step empirical approach. In the first step, we estimate a model of fiber entry by infrastructure operators in local municipalities and find that local market characteristics, such as market size and income, are important determinants of fiber entry. We also find evidence of a "replacement effect" from the legacy copper network in fiber entry decisions.[6] Prior investment in neighboring municipalities is also a very strong determinant of investment, suggesting that cost factors are more important than demand factors in driving deployment decisions. Finally, we find that entry becomes easier over time.

Based on the estimates from the entry model, we calculate entry thresholds, that is, the minimum market size required to support fiber entry in a given municipality at a given time. We use these entry thresholds to evaluate the efficiency of the French Broadband Plan. To do so, we consider a hypothetical policymaker who must decide whether to grant state aid for fiber deployment in a given municipality at a given time. We assume that the policymaker has access to the same type of entry model and information as we do. As such, the policymaker can compare the market size of the municipality with the entry threshold to determine whether there is a prospect of private entry. Using this approach, if a municipality that received state aid has a market size below the entry threshold, we consider the plan to have efficiently addressed the lack of private investment. Otherwise, we consider the plan to have crowded out potential private investment.

In its *State Aid Broadband Guidelines*, the European Commission considers that an area is eligible for state aid if there is no prospect of private investment within three years.[7] Therefore, we consider two extreme scenarios regarding the ability of the policymaker to anticipate the evolution of entry thresholds over time. In the first scenario, we assume that a "myopic" policymaker can estimate the current entry threshold but hold it constant over time. In the second scenario, we assume that a "forward-looking" policymaker can perfectly anticipate the evolution of entry thresholds in the next three years.

When considering a "myopic" policymaker, we find that the plan was highly efficient. In 93% of the cases, state aid benefited municipalities where private entry would not have occurred in the

[5] Our analysis does not include Corsica and overseas territories of France.

[6] Following Arrow (1962), an operator has less incentive to invest in a new technology if it is already earning revenues from an old technology.

[7] See "EU Guidelines for the application of state aid rules in relation to the rapid deployment of broadband networks," 2013/C 25/01), 26 January 2013, Article (75).

year in which the aid became effective. If we instead consider a "forward-looking" policymaker, the degree of efficiency of the state aid plan drops to 64%. In this instance, crowding out of private investment cannot be ruled out, which may result from high uncertainty about the costs or demand for high-speed broadband in the early stages of fiber deployment.

We use our estimates to calculate the costs of 'efficient' and 'inefficient' state aid in these two scenarios, based on the average cost of state aid per line in a municipality. According to our estimates, in 2019, in the scenario of a "myopic" policymaker, 'efficient' state aid amounted to 1,960 million euros, while 'inefficient' state aid amounted to 243 million euros (i.e., 11% of total expenditure). In the scenario of a "forward-looking" policymaker, 'inefficient' state aid amounted to 902 million euros (41% of total expenditure). These figures represent an upper bound because the total number of lines in municipalities is used in the calculation (which may be higher than the actual number of lines that received state aid).

Once fiber networks are deployed with the help of state aid, it is important to assess how coverage in these areas compares to municipalities with private investments, which we analyze in the second part of this paper. For this purpose, we use a two-stage Heckman selection model to account for the endogeneity of fiber entry. We find that the French Broadband Plan allowed for higher fiber coverage in aided municipalities compared to unaided municipalities, especially during the early stages of the period under analysis. This effect diminishes over time.

Thus, our results suggest that the French Broadband Plan was relatively successful in helping to achieve the objectives of ultra-fast broadband deployment set by the EU, enabling deployment in areas that would otherwise not have been covered by the private sector and stimulating overall coverage. Additionally, broadband deployment under the plan may have generated spillover effects and facilitated investment in neighboring areas, as suggested by our results. However, some crowding out of private investments is also observed.

The remainder of the paper is organized as follows. In Section 2, we review the relevant literature and discuss our contribution. In Section 3, we outline the objectives of the Digital Agenda for Europe, provide an overview of the EU state aid regime, and describe the main features of the French Broadband Plan. In Section 4, we present our datasets. In Section 5, we introduce the econometric framework, and the estimation results are discussed Section 6. Section 7 concludes.

2 Literature Review

This paper contributes to three strands of the empirical literature on (i) entry in telecommunications markets, (ii) investment in next-generation broadband networks, and (iii) the impact of state aid on broadband deployment.

First, the paper relates to the literature on entry into local telecommunications markets. Using a latent variable representation of market profitability, this literature examines the market characteristics that influence entry. In addition to the demand and cost shifters influencing entry (e.g., market size and population density), the literature highlights the role of differentiation (Greenstein and Mazzeo, 2006), sunk costs (Xiao and Orazem, 2011), managers' strategic ability (Goldfarb and Xiao, 2011), and entry threats (Wilson, Xiao and Orazem, 2021). These papers rely on data from the U.S., although two recent papers focus on European markets. In the first paper, Nardotto, Valletti, and Verboven (2015) use an entry model as a first stage to study the effect of entry of alternative operators on broadband penetration in the UK between 2005 and 2009. They find that entry did not foster broadband adoption, but did increase service quality to the benefit of consumers. In the second paper, Bourreau, Grzybowski and Hasbi (2019) use a similar approach to study the impact of competition in the legacy copper network on the deployment of high-speed broadband in France. They find that a higher number of local competitors in a municipality reduces the incentives to deploy and expand broadband coverage at speeds of 30Mbps or higher. Our first contribution to this literature is to consider fiber entry in local markets where legacy broadband (DSL) services are already available, thus accounting for the competition between "old" and "new" broadband technologies. Our second contribution is to use an entry model to assess the efficiency of the state aid granting process. Since the entry model can identify where a private operator would have found it profitable to enter, we can identify areas where public subsidies have effectively addressed the lack of private investment and those where they may have crowded them out.

Second, our paper contributes to the empirical literature on investment in next-generation access (NGA) fiber networks. This literature examines the impact of sectoral regulation on the deployment of fiber networks (see, e.g., Bacache, Bourreau and Gaudin (2014), Briglauer (2015), and Briglauer, Cambini and Grajek (2018)). In particular, Briglauer et al. (2018) use data on incumbent telecom operators and cable operators for 27 European member states from 2004 to 2014, and show that stricter access regulation hurts investment by incumbent telecom operators.

Similarly, Fabritz and Falck (2013) find that deregulation stimulated fiber deployment by incumbents in the UK during 2007-2013. Briglauer, Cambini, Gugler and Stocker (2023) study the impact of net neutrality regulations on fiber and cable infrastructure investment and subscriptions. Using data for 32 OECD countries for 2003-2019, they find that these regulations have reduced investment and subscriptions. This paper contributes to this literature by considering the role of state aid –another form of public intervention– and its impact on the deployment of NGA fiber networks.

Finally, our paper is related to the literature on the impact of state aid on broadband deployment. Briglauer, Dürr, Falck, and Hüschelrath (2019) evaluate the effect of a state aid program introduced by the German State of Bavaria in 2010 and 2011 on improving broadband availability in rural areas. Using a difference-in-differences (DiD) model, they show that subsidized municipalities have higher broadband coverage at higher speeds than non-subsidized (matched) municipalities. Similarly, Duso, Nardotto, and Seldeslachts (2021) study the impact of state aid broadband plans implemented in Germany between 2011 and 2013 on broadband coverage and competition. Using a DiD approach, they find that state aid has improved broadband coverage in the aided municipalities without distorting local competition. Briglauer and Grajek (2023) use cross-country data to study the effectiveness of state aid programs for the deployment of new fiber broadband networks. Using data from 32 OECD countries for 2002-2019, they find that the availability of a state aid program to support broadband deployment significantly increases broadband coverage. Finally, Wilson (2021) studies the impact of public investment in broadband infrastructure on private investment using U.S. data at the zip code level. He estimates a discrete choice model of demand for Internet access and a dynamic oligopoly model in which private and public firms make entry and investment decisions. He finds that public investment crowds out private investment to some extent. However, this effect is dominated by a dynamic preemption effect, as the threat of public provision of broadband induces private firms to invest preemptively.

We contribute to this literature in two ways. First, we use an entry model to evaluate the effectiveness of a state aid program. Our estimates of entry thresholds for each municipality allow us to determine whether a private operator would have entered a local market in the absence of state aid. In addition, since the entry thresholds vary over time, we can study how the efficiency of the program is affected by the degree of market foresight of policymakers. Second, we assess the impact of state aid on coverage using a control function approach to correct for potential sample selection bias.

3 State Aid for Broadband and the French Broadband Plan

In this section, we provide background information on state aid for broadband in the European Union. We then describe the French broadband state aid plan in more detail.

3.1 EU Digital Agenda and State Aid for Broadband

In May 2010, the European Union (EU) announced its Digital Agenda to boost Europe's economy and consolidate the EU Digital Single Market. At the time, Europe was lagging behind other regions in terms of fast and reliable digital networks.[8] Moreover, coverage with very high capacity fiber networks[9] capable of delivering ultrafast broadband was much lower in rural areas than in urban areas, revealing a persistent digital divide.[10]

Several factors may explain the slow transition from basic to ultra-fast broadband. First, on the supply side, deploying very high capacity networks requires large fixed and sunk costs. Operators may also face an opportunity cost in deploying next-generation networks due to their revenues from legacy broadband networks based on the digital subscriber line (DSL) technology (the so-called "replacement effect"). Finally, operators deploying fiber networks face competition from Internet service providers using other technologies (e.g., DSL and cable). On the demand side, switching costs may discourage basic broadband users from subscribing to new ultra-fast broadband offers. Moreover, their willingness to pay for higher speeds may be low, at least in the early stages of the diffusion of the new technology.

Most importantly, there may be a lack of private investment in the provision of ultra-fast broadband in rural and less densely populated areas due to high deployment costs and low uncertain demand. At the same time, covering these areas should be socially desirable due to the high economic and social benefits that are not internalized by market players.

[8] See: European Commission, "The EU explained: Digital Agenda for Europe," November 2014.

[9] Very high capacity networks (VHCN) correspond to "any network providing a fixed-line connection with fiber roll out at least up to the multi-dwelling building" or any network providing the same quality of service (BEREC, 2020). ultra-fast broadband, which enables connection speeds of 100 Mbps or more, requires VHCNs.

[10] In 2011, 10% of households in the EU were covered by very high capacity networks but only 2% in rural areas. See European Commission, "Digital Economy and Society Index (DESI)," 2020, p. 10-11.

As the demand for fast and reliable connectivity increases and the digital divide becomes more visible, the need for widespread deployment of very high capacity networks has become a key policy objective. The 2010 Digital Agenda for Europe set a target of providing at least 50% of European households with access to ultra-fast broadband by 2020. In 2016, the EU updated this target, with the objective that by 2025, all EU households should have access to ultra-fast broadband.[11]

To foster the deployment of very high capacity networks, the European Commission has issued recommendations on next-generation access networks and revised its state aid guidelines for broadband deployments. State aid is an important policy tool for deploying networks in rural and low-density areas, where it is not financially viable for private operators to do so on their own.[12]

State aid control is intended to ensure that the positive effects of the aid outweigh possible distortions of competition. For broadband specifically, state aid should not be granted in areas where market operators have already invested or would normally choose to invest. Otherwise, they would crowd out private investment and distort competition.

3.2 The French Broadband Plan

In 2013, the French government launched the *Plan France Très Haut Débit* (hereafter, the "French Broadband Plan"). This plan supports the design and funding of broadband infrastructure in France, mainly based on fiber-to-the-home (FTTH) networks.

Under this program, the French territory is divided into private and public initiative zones. Private initiative zones are areas where fiber deployment is not eligible for public funding. These zones include very densely populated areas, where fiber deployment is expected to be driven by infrastructure-based competition, and some less densely populated areas, where major telecommunications operators have expressed their intention to deploy very high capacity networks without public funding. In total, private initiative zones represent 20.7 million households .[13]

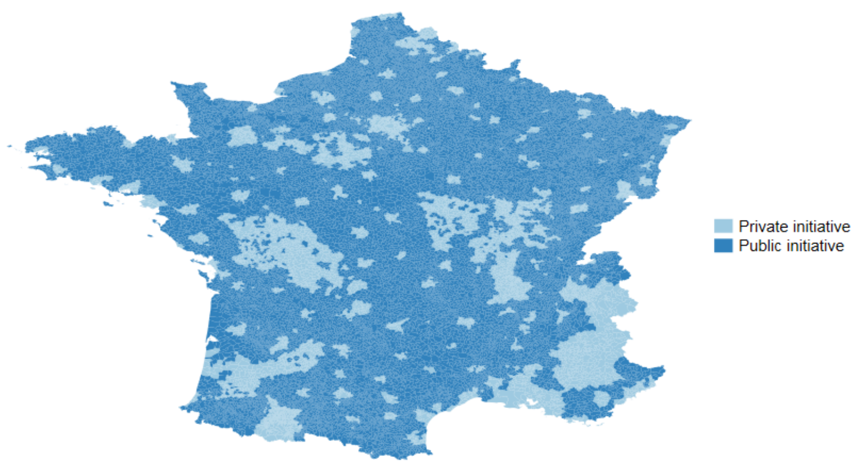
[11] See: European Commission, "Connectivity for a Competitive Digital Single Market - Towards a European Gigabit Society," COM(2016) 587 final.

[12] Article 107(1) of the Treaty on the Functioning of the European Union (TFEU) defines state aid as "any State resources granted by a Member State which distorts or threatens to distort competition by favoring certain undertakings or the production of certain goods."

[13] Very dense areas were defined by ARCEP in 2009 as a list of 148 municipalities. In 2013, ARCEP revised the list and reduced the number of municipalities to 106 due to the lack of deployment or infrastructure-based competition in some municipalities.

Public initiative zones are areas (typically rural) where no private investment is planned for the deployment of fiber networks, at least in the near future. With the support of the State and the EU, local authorities can cover these areas by forming partnerships with private operators. Access to the subsidized network must be open and non-discriminatory, with oversight by the French regulator, ARCEP. Public initiative zones cover 16.5 million households.

Figure 1: Public and private initiative zones for fiber coverage in France as of the 4th quarter of 2020.



Source: own elaboration based on data from AVICCA.
Note: 27,566 municipalities are categorized as public initiative zones and 6,792 as private initiative zones. 85 municipalities are mixed initiative zones (they have both private and public initiative networks). They are depicted here as part of the private initiative zone.

Figure 1 shows the distribution of private and public initiative zones in the fourth quarter of 2020. Public authorities estimated that a total investment of 21 billion euros over 10 years, from both public and private sources, would be necessary to achieve the objectives set by the French Broadband Plan.[14] Within this total investment, the program consolidates a State budget of about 3 billion euros to support the deployment of public initiative networks (*"Réseaux d'initiative publique"* or "RIP" by its French acronym).

[14]See: France Stratégie (2020), "Déploiement du très haut débit et Plan France très haut débit. Evaluation socioéconomique", Technical report.

Eligibility for State funding is subject to examination by the ANCT (*"Agence Nationale de la Cohésion des Territoires"*, formerly *"Agence du Numérique"*).[15] Only municipalities located in public initiative zones are eligible. State subsidies are paid in several installments, spread over several years, at the rate of network construction and upon proof that the network has been built following current regulations and technical specifications. Projects are designed at the departmental or regional level, and applications are under the responsibility of the local authorities.[16]

In 2016, the European Commission approved the French Broadband Plan. As of January 2021, 82 projects were eligible for state aid (74 in mainland France). Table A.1 in the Appendix shows the list of projects with the departments or regions concerned.

4 Data

We combine data from multiple sources. First, we use data on fiber-to-the-home infrastructure provided by ARCEP. Second, we build a database on state aid at the municipality level using information from the ANCT. Third, we collect information on the socio-economic and geographic characteristics of municipalities from INSEE (French National Institute for Statistics and Economic Studies). Fourth, we use information from AVICCA, which is the French association of local authorities involved in electronic communications and audiovisual, to identify the type of zone of each municipality (public, private, or mixed). Fifth, we use information on the quality of the French legacy copper network provided by the incumbent operator Orange.

Data on fiber-to-the-home infrastructure. We obtained data from ARCEP on the geographic location, deployment status, and identity of the fiber infrastructure operator for more than 16 million buildings in France as of June 2020.[17] We aggregate this data at the municipality level using the geographic location of each building. The data includes information on the

[15] State aid concerns only certain parts of the network, namely passive network elements, civil engineering works, reception equipment for satellite technologies and terrestrial wireless networks, and exceptionally and to limited extent studies directly related to the project.

[16] Local authorities are French administrative structures, distinct from the State administration, which are responsible for the interests of the population of a given territory (municipalities, departments, regions, etc.). Local authorities can join forces to exercise their powers by creating public cooperation bodies.

[17] The fiber infrastructure operator deploys the fiber network in a given area and offers services to residential and business customers. The operator can also lease access to its network to other "commercial" operators who in turn offer services to consumers.

availability date of each building's mutualization point (MP). The MP is the interface between the core fiber network of the operator and the fiber optic lines that connect consumers' premises. We use the MP availability date as the fiber entry date, as it indicates that the most expensive part of the fiber network has been deployed.[18]

Thus, for each quarter between 2014 and 2019, we observe the number of fiber operators and the number of FTTH lines deployed in each municipality in mainland France. To estimate the fiber coverage rate in each municipality, we use publicly available data from ARCEP on the total number of dwellings (hereafter "lines") in each municipality in 2020.[19] We define the fiber coverage rate as the ratio between the number of fiber lines deployed and the total number of lines (dwellings) in the municipality.

Figure 2 shows the evolution of FTTH deployment in France in public, private, and mixed-initiative zones. By the end of 2019, more than 60% of French households were covered by fiber (i.e., the mutualization point of the building was available). However, while coverage is above 80% in private and mixed-initiative zones, it is less than 30% in public initiative zones.

Panels (a) and (b) of Figure 3 show the geographic location of fiber deployments in the first period (2014Q1) and the last period (2019Q4) covered by our data. The first deployments occur in the main urban areas and then tend to expand around the initially covered municipalities in a cluster. To account for any geographic dependence in fiber deployments and potential spillover effects, for each municipality, we calculate the average fiber coverage in neighboring municipalities in the previous quarter.[20]

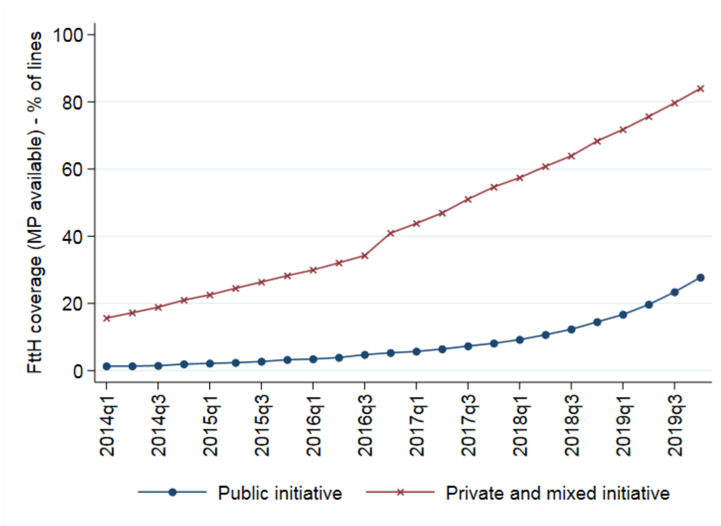
Table 1 shows the number of municipalities with different numbers of infrastructure operators for the period 2014-2019. Only a few municipalities have two or more infrastructure operators. Moreover, Table A.3 in the appendix shows that there is a large number of entries and no exits by fiber infrastructure operators in mainland France during this period.

[18]For some buildings, the MP availability date is missing. In this case, we replace the missing information with the availability date of the first optical access point (*Point de branchement optique* in French) deployed in the building.

[19]ARCEP's data was retrieved on 20 May 2021 from the following website: https://www.data.gouv.fr/en/datasets/ma-connexion-internet/. We compare this information with the number of lines provided by AVICCA. For a few municipalities, the total number of lines according to ARCEP is different from the one provided by AVICCA. We keep the source that gives the number of lines closer to the number of households in the municipality reported by INSEE. In a few cases, the number of installed lines is higher than the total number of lines in the municipality, in which case we set the former equal to the latter.

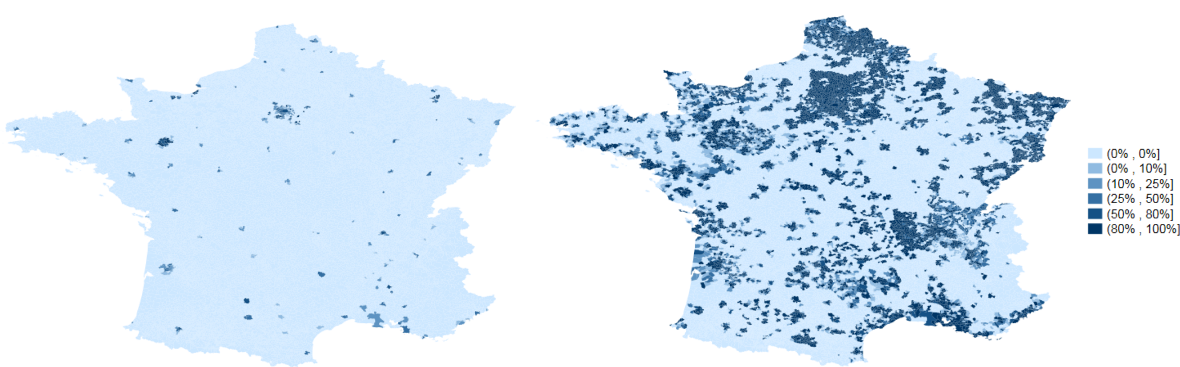
[20]Neighboring municipalities are those that share a border with a given municipality. The list of neighboring municipalities as of January 2021 in mainland France was retrieved on 22 June 2021 from the following website: www.data.gouv.fr/en/datasets/liste-des-adjacences-des-communes-françaises.

Figure 2: Evolution of fiber deployment in France.



Source: ARCEP.

Figure 3: Fiber coverage in mainland France municipalities (rate of connectable lines - 2014Q1 and 2019Q4).



(a) 2014Q1

(b) 2019Q4

Data on state aid. We received two datasets from the ANCT on state aid in the context of the French Broadband Plan. The first dataset contains information on the decisions taken

Table 1: Number of municipalities with the presence of infrastructure operators and municipalities with state aid.

	Number of operators						State aid
Year	0	1	2	3	4	5	
2014	33,827	495	73	37	10	1	23
2015	33,404	905	77	41	15	1	191
2016	32,271	1,983	112	60	16	1	560
2017	30,838	3,301	191	89	22	2	1,451
2018	27,905	6,054	326	132	24	2	3,564
2019	22,840	10,875	522	169	34	3	6,771

by the Prime Minister on projects presented by local authorities requesting state aid.[21] For each project, we have information on (i) the departments involved; (ii) the type of decision (preliminary agreement, final decision, other); (iii) the date of the decision; (iv) the reference number of the decision; (v) the amount of aid granted; and (vi) a dummy variable indicating whether the decision was valid as of January 2021. We take into account only projects for which a final decision has been made since it is only in this case that public funds can be released. Second, for each project, we obtained a "proxy" file used by the ANCT to calculate the amount of the aid. Each proxy file contains an approximation of the number of eligible lines in each municipality covered by the project.

We combine these two datasets to construct a database that identifies the municipalities in mainland France that receive state aid. Municipalities receive state aid as a reimbursement when they provide evidence of network construction. For our analysis, we make the simplifying assumption that state aid is effective when the first FTTH line is deployed in the municipality.[22]

As of January 2021, there are 74 projects in mainland France with a valid state aid decision (either preliminary or final). They represent a total amount of state aid of 2.82 billion euros. We focus on the state aid projects that have been confirmed by the Prime Minister through a final decision, representing an aid amount of 2.58 billion euros.[23]

Table 1 shows the cumulative number of municipalities benefiting from state aid in mainland

[21]Projects are conceived at the departmental or regional level.

[22]On average, we observe the first deployment in an aided municipality four quarters (one year) after the date of the Prime Minister's decision to grant aid.

[23]Preliminary decisions can be subject to changes throughout the scrutiny process by the ANCT and may not give way to disbursements.

France during the period 2014-2019. By the end of 2019, 6,771 municipalities had received state aid.[24] Figure 5 in the appendix shows the geographic location of aided municipalities.

Data on socio-demographic characteristics of municipalities. We obtained socio-demographic information at the municipality level from the French National Institute for Statistics and Economic Studies (INSEE). In particular, we have municipal-level data on the population size (defined as the number of households). This information is published with a two-year lag and is only available until 2017. Since firms do not have access to more recent statistics, we consider that they make their entry decisions based on demographic information with a two-year lag. In addition, we have information on the median household income per municipality for the years 2014-2017.[25]

Data on zone types. We obtained data from AVICCA on the type of zone of each municipality in mainland France.[26] This information allows us to identify whether a municipality belongs to a public, private, or mixed-initiative zone in the context of fiber deployment. At the end of 2020, 80% of the municipalities in mainland France (40% of the population) were located in public initiative zones.

Data on the quality of the copper network. We obtained information on the quality of the legacy copper network in each municipality from the French incumbent operator Orange. We use this information to proxy for the opportunity cost that incumbent operators may face in deploying next-generation networks due to their revenues from the legacy copper network (the "replacement effect"). In general, broadband signals suffer attenuation as they travel along a copper line from an exchange point to a customer's premises. This is called copper loss, and it translates into a reduction in speed for DSL access. The further a customer is from the exchange, the more copper loss they may experience. We consider that the revenues from legacy DSL networks are lower when copper loss is higher, due to a lower quality of broadband

[24] In 2019, out of the 27,153 municipalities located in public initiative zones, 17,326 were covered by a project for which a final decision had been made. However, only for about a quarter of them (6,771), fiber deployment had begun.

[25] This information comes from the *Dispositif Fichier localisé social et fiscal (Filosofi)* and is missing for municipalities with less than 30 households. We replace missing values by the median household income in the department.

[26] The information corresponds to the fourth quarter of 2020 and was collected from the following website: www.avicca.org/content/open-data-avicca.

experience. The quality of copper networks generally remains unchanged over time because it is controlled by the incumbent operator, Orange, which, due to the availability of fiber technology, does not invest in improving copper networks.

In our data, municipalities are assigned to the following categories based on the average quality of copper lines measured in decibels (dB): 20dB and below (outstanding); 20-30dB (excellent); 30-40dB (very good); 40-50dB (good); 50-60dB (poor and may experience connectivity problems); and 60dB or above (bad, will experience connectivity problems).

We merged the different datasets using the unique INSEE code for each municipality. After merging, we have information on 34,443 municipalities in mainland France for the years 2014-2019, at a quarterly pace, resulting in a total of 826,632 observations.[27] Table 2 reports summary statistics for the variables used in the analysis.

Table 2: Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Number of infrastructure operators	826,632	0.11	0.36	0	5
Number of households (thousands)	826,632	0.76	3.37	1	100
Fiber coverage (%)	826,632	0.07	0.23	0	1
State aid (dummy)	826,632	0.04	0.21	0	1
Income (euros)	826,632	20,327	3,419	9,958	48,310
Public initiative zone (dummy)	826,632	0.80	0.40	0	1
Private and mixed-initiative zone (dummy)	826,632	0.20	0.40	0	1
Copper line quality - outstanding	826,632	0.18	0.39	0	1
Copper line quality - excellent (dummy)	826,632	0.16	0.37	0	1
Copper line quality - very good (dummy)	826,632	0.14	0.35	0	1
Copper line quality - good (dummy)	826,632	0.18	0.39	0	1
Copper line quality - poor (dummy)	826,632	0.16	0.37	0	1
Copper line quality - bad (dummy)	826,632	0.17	0.37	0	1

Note: The maximum values of number of households were truncated to 100,000 due to a few extreme cases. There are 34,443 municipalities and 24 quarters in our database.

5 Empirical Analysis

State aid is allowed in the EU if it alleviates a market failure or addresses another objective of common interest. Moreover, state aid should be well-targeted with limited distortion of compe-

[27] In 2020, there were 34,479 municipalities in mainland France. Due to administrative changes in the years 2014-2019 (some municipalities split, and others merged) and a lack of information for some small municipalities in the different data sources, we removed 36 small municipalities from the data.

tition. In our context, state aid serves the common interest and does not distort competition if, without public funding, private operators would not have found it profitable to build a fiber network. If this is the case, we consider that state aid has been efficiently provided.[28] Conversely, if a private operator could have invested without public support, the aid is inefficient because it has crowded out private investment.

To determine whether there was a prospect of private investment at the time the public funding was provided, we start by building a model of fiber entry in the next subsection. In this model, a network operator decides to enter a given area with fiber if and only if its expected net profit from entry is positive. Then, we use the estimates from on the entry model to calculate entry thresholds, i.e., the minimum number of households required for private entry to occur. If the number of households in a municipality that received state aid is below the threshold, we conclude that state aid was efficient. Otherwise, if it is above the threshold, we conclude that state aid was inefficient.

Finally, we present a reduced-form model of fiber coverage in which we account for the endogeneity of fiber entry through a control function approach. We use this model to compare fiber coverage in municipalities with and without state aid.

5.1 Model of Fiber Entry

We build a model of fiber entry by infrastructure operators. We assume that at the end of each period, operators decide whether to enter into "new" local markets and deploy fiber in the next period. They form expectations about market demand, costs, and competition from other operators. These expectations are fulfilled in equilibrium, and the marginal operator enters the market. We make inferences about the profit determinants assuming a free entry equilibrium, where operators enter a local market if, and only if, it is profitable for them to do so, i.e., expected gross profits exceed entry costs. As noted earlier, we do not observe exits in our data, and thus entry is a final decision.[29]

The number of fiber entrants in municipality i at time t is denoted as $N_{it} = n \in \{0, 1, 2, 3, 4, 5\}$.

[28]Note that it must also be the case that the social benefit of covering the area exceeds the cost of deployment. In our analysis, we always assume this to be true.

[29]Some of the fixed costs of entry into local markets may be sunk. The presence of sunk costs implies that less demand is needed for an incumbent to continue operations than to support a new entrant. Sunk costs cannot be identified in our setup, because we observe at most one entry and no exit at all. Therefore, we estimate the entry model without sunk costs.

The discounted future stream of profits of an operator facing n competitors in market i at time t can be written as:

$$\bar{\pi}_{it}^{n} = \alpha S_{it} + \sum_{b_k \in B} \alpha_{b_k} S_{it} \times \mathbb{1}\{S_{it} \in b_k\} + X_{it}\beta - \mu^{n} + \epsilon_{it} \equiv \pi_{it}^{n} + \epsilon_{it}, \tag{1}$$

where S_{it} is the market size approximated by the number of households. To account for non-linear market size effects due to economies of scale in fiber deployment, we introduce differential effects by market size intervals that we call "bands". To do this, we define the vector $B = \{b_1, b_2, b_3, b_4, b_5\}$ as a set of five household size bands, with $b_1 = [0, 2,000)$, $b_2 = [2,000, 5,000)$, $b_3 = [5,000, 10,000)$, $b_4 = [10,000, 20,000)$, and $b_5 = [20,000, \infty)$. Next, we denote by X_{it} the vector of other characteristics of municipalities that are potential demand or supply determinants of profits (including income, the type of zone, the quality of the legacy copper network, and the fiber coverage in neighboring municipalities). We also include a set of year-dummy variables and department-dummy variables to account for the fact that firms' profits may differ across geographic locations due to other specific factors. Some of these variables impact the demand for fiber Internet and, consequently, revenues, while others influence deployment costs, or both demand and costs. Additionally, the year and department dummy variables may affect both demand and costs.[30] Finally, μ^n represents the negative effect on profits from the n^{th} firm, and ϵ_{it} is the error term, which has a standard normal distribution. The profits, π_{it}^{n}, are unobserved and represent a latent variable.

This reduced-form profit specification is similar to the models estimated by Xiao and Orazem (2011), Nardotto et al. (2015), and Bourreau et al. (2019), and does not distinguish between marginal and fixed costs, as in Bresnahan and Reiss (1991). Our model does not account for heterogeneity between firms, which may exist due to differences in size, geographic presence, and cost structure.

Since there is only a small number of markets with two or more infrastructure operators, as shown in Table 1, we truncate the number of entrants to one, which simplifies our entry model. In equilibrium, in market i and at time t, there is entry of at least one fiber network ($N_{it} = 1+$)

[30] In 2021, there were 94 departments in mainland France, excluding Corsica.

when the condition $\bar{\pi}^1_{it} > 0$ is satisfied, which yields, using the profit specification (1):

$$\alpha S_{it} + \sum_{b_k \in B} \alpha_{b_k} S_{it} \times \mathbb{1}\{S_{it} \in b_k\} + X_{it}\beta - \mu^1 + \epsilon_{it} > 0.$$

The probability of observing $N_{it} = 1+$ entrants in market i at time t is thus given by:

$$Pr(N_{it} = 1+) = \Phi(\alpha S_{it} + \sum_{b_k \in B} \alpha_{b_k} S_{it} \times \mathbb{1}\{S_{it} \in b_k\} + X_{it}\beta - \mu^1), \tag{2}$$

where $\Phi(.)$ denotes the cumulative normal distribution function. The parameter vector $\theta = (\alpha, \alpha_{b_2}, \ldots, \alpha_{b_5}, \beta, \mu^1)$ is estimated by maximizing the following log-likelihood function:

$$\hat{\theta} = \arg\max \sum_{i=1}^{M} \sum_{t=1}^{T} [y_{it} \ln(Pr(N_{it} = 1 + |\theta)) + (1 - y_{it}) \ln(Pr(N_{it} = 0|\theta))], \tag{3}$$

where y_{it} takes the value of 1 when $N_{it} = 1+$, and 0 otherwise. The model estimated is a simple probit model, or an ordered probit model in the case where the entry of one and two or more fiber infrastructure operators is considered.

5.2 Entry Thresholds and State Aid Granting Decision

Using the estimates $\hat{\theta}$ from the entry model described above, we define the entry threshold $\hat{S}_{it}$ as the number of households in municipality i at time t necessary to allow the entry of $N_{it} = 1+$ fiber networks. It is calculated as follows:

$$\hat{S}_{it} = \frac{\hat{\mu}^1 - X_{it}\hat{\beta}}{\alpha + \sum_{b_k \in B} \alpha_{b_k} \mathbb{1}\{S_{it} \in b_k\}}. \tag{4}$$

We use these entry thresholds to assess the efficiency of the French Broadband Plan. We consider the policymaker's decision as follows. At a given time t, the policymaker must decide whether to grant public funding for the deployment of a high-speed network in a municipality i. According to the European Broadband State Aid Guidelines, the policymaker should only grant public funding if no private operator is likely to invest in the municipality within the next three years.[31] The policymaker must therefore assess the likelihood of a private operator entering the

[31] The European Commission considers an area eligible for state aid if there is currently no NGA network in the area, and it is unlikely that an NGA network can be built within three years. See "EU Guidelines for the

market with fiber. We assume that the policymaker can develop an entry model, as we did, using the same data we collected.

According to our entry model, a private operator can enter the market if the size of the municipality is larger than the entry threshold. If we follow the European state aid guidelines for broadband, the policymaker must then compare the size of the municipality under consideration with the estimated entry thresholds in the next three years. However, this would require a "forward-looking" policymaker with a strong ability to anticipate future technological developments. An alternative assumption is to assume a "myopic" policymaker who anticipates technological developments poorly and considers the current entry threshold at time t to be valid for the next three years.[32]

The first hypothesis of a "forward-looking" policymaker leads to an overestimation of the 'inefficiency' of state aid. Conversely, the second hypothesis of a "myopic" policymaker leads to an underestimation. The degree of rationality that can reasonably be expected from a policymaker probably lies between these two extremes. These two extreme scenarios provide us with a lower and an upper bound for the 'inefficiency' of state aid.

5.3 Fiber Coverage

Once fiber networks are deployed with the help of state aid, it is important to assess how coverage in these areas compares to municipalities with private investments. For this purpose, we use a two-stage Heckman selection model to account for the endogeneity of fiber entry. In particular, we estimate a reduced-form equation for the share of households in a given municipality with access to ultra-fast broadband over fiber

$$y_{it} = \rho SA_{it} + \gamma Z_{it} + u_{it}, \tag{5}$$

where y_{it} denotes the share of households in municipality i and period t with fiber coverage (i.e., the mutualization point is available in the household's building); SA_{it} is an indicator variable for state aid in municipality i and period t; and Z_{it} is a set of control variables that may determine coverage, including demand and cost shifters.

application of state aid rules in relation to the rapid deployment of broadband networks," 2013/C 25/01), 26 January 2013.

[32]Cooper and Kovacic (2012) discuss the possible behavioral biases of regulators and in particular myopia, which can "lead the regulator to favor policies that focus excessively on short-run considerations."

When estimating equation (5), we need to correct for a potential sample selection bias. Indeed, fiber coverage y_{it} is only observed when there is at least one infrastructure operator in the municipality ($N_{it} = 1+$ in our entry model). To take this into account, we follow Heckman (1979) and estimate the model in two stages using a control function approach. Specifically, in the first stage, we estimate the entry model discussed in the previous section (Model I). Then, the hazard function (inverse Mills ratio) denoted by $\lambda(S_{it}, X_{it}; \theta)$ is defined using the entry model estimates as follows:

$$\lambda(S_{it}, X_{it}; \hat{\theta}) \equiv E(\epsilon_{it} | \hat{\pi}^n_{it} > -\epsilon_{it}) = \frac{\phi(\hat{\pi}^n_{it})}{\Phi(\hat{\pi}^n_{it})}. \tag{6}$$

Assuming that the error terms of the two models of fiber entry and fiber coverage, ϵ_{it} and u_{it}, are multivariate normally distributed, one can show that:

$$\begin{aligned} E(y_{it} | X_{it}, S_{it}, Z_{it}) &= \rho SA_{it} + \gamma Z_{it} + E(u_{it} | N_{it} > 0), \\ &= \rho SA_{it} + \gamma Z_{it} + \sigma_{u\epsilon} \lambda(S_{it}, X_{it}; \theta), \end{aligned} \tag{7}$$

where $\theta = (\alpha, \alpha_{b_2}, \ldots, \alpha_{b_5}, \beta, \mu^1)$ is the parameter vector from the entry model, and $\sigma_{u\epsilon}$ is the covariance between u_{it} and ϵ_{it}. In the second stage, we estimate the following modified coverage equation for the sample of municipalities with positive coverage:

$$y_{it} = \rho SA_{it} + \gamma Z_{it} + \sigma_{u\epsilon} \lambda(S_{it}, X_{it}; \hat{\theta}) + \varepsilon_{it}. \tag{8}$$

In this equation, we exploit the fact that the error term u_{it} can be decomposed into the sum of two terms and written as $u_{it} = \sigma_{u\epsilon} \lambda(S_{it}, X_{it}; \hat{\theta}) + \varepsilon_{it}$, where by construction ε_{it} is mean zero conditional on S_{it}, X_{it} and Z_{it}.

The municipality characteristics included in the estimation of equation (8) are the same as in the model of fiber entry, except for market size and the dummy variable identifying municipalities with no fiber coverage in neighboring municipalities in the previous period. These are our exclusion restrictions, which are required in the Heckman selection model.

In particular, we need at least one variable that determines the entry of fiber operators but is not correlated with the error term in the fiber coverage equation. Market size makes markets more attractive for fiber deployment, but it should not affect the share of the population covered by fiber. In other words, the share of the population covered by fiber should be comparable in smaller and larger municipalities, conditional on the presence of infrastructure fiber operators in those municipalities. Moreover, fiber deployment in neighboring municipalities influences entry, as the roll-out of a fiber backbone facilitates entry into adjacent municipalities. However, it should not directly impact the level of coverage in the municipality. We consider that only the level of coverage in neighboring municipalities in the previous period can influence the current level of coverage in a given municipality. This is because the coverage level reflects how far the overall roll-out work has progressed in a given area.

Although we do not expect the market size to have a direct impact on fiber coverage, it may be correlated with omitted municipality-specific characteristics. To mitigate this problem, we use in the estimation a set of municipality characteristics and department dummy variables, as well as year dummy variables. For comparison, we first estimate equation (8) using ordinary least squares (OLS) without a correction term and then use the Heckman two-stage procedure described above.

6 Estimation Results

Our estimation is done in the following steps. First, we estimate the fiber entry model using the maximum likelihood estimator in equation (3).The model estimated is a simple probit model. Second, we use the estimates from the entry model to compute entry thresholds, as described in equation (4). We use them to assess the efficiency of the French Broadband Plan. Third, we use the estimates from the entry model to compute the correction term (6). Fourth, we use ordinary least squares to estimate the coverage equation (8). This equation includes the number of fiber entrants and the correction term from the entry model (6). We also include local market characteristics, as well as time and department dummy variables in the estimation as discussed above.

6.1 Fiber Entry

Table 3 shows the estimation results of our model of fiber entry using panel data for 34,406 municipalities over the period 2014-2019.[33] In practice, there are few municipalities with two

[33]Fiber entry occurred before the start of the period in all municipalities in the departments of Hauts-de-Seine and Paris. Since our model includes department dummies, they must be excluded from the analysis, reducing the

or more infrastructure operators (e.g., only 2.1% of municipalities are in this case in the fourth quarter of 2019). Since there is little variation in the number of infrastructure operators, we focus on the presence of at least one infrastructure operator in the municipality. Therefore, our dependent variable is either 0 if there is no infrastructure operator in the municipality or 1 if there is one or more infrastructure operators. As a robustness check, we also estimated the model for the entry of only one operator and two or more operators. Our results concerning the determinants of entry, as well as model predictions, remain almost unchanged. The only difference is that we can estimate entry thresholds for one and for two or more fiber operators.

Some municipalities with at least one infrastructure operator received state aid, but there are no aided municipalities with no infrastructure deployed. Therefore, state aid perfectly predicts entry.[34] Therefore, to identify the effect of state aid, we estimate three different entry models using alternative assumptions about the municipalities benefiting from state aid. Model I is estimated using a restricted sample of 27,601 out of 34,406 municipalities that never received state aid during the period of analysis, some of which are located in public initiative zones. This approach assumes that state aid is randomly allocated within the public initiative zone. Therefore, the likelihood of entry in aided municipalities should be the same as in unaided municipalities with similar characteristics. Model II is estimated by setting the number of infrastructure operators to zero whenever a municipality receives state aid. It assumes that entry would not have occurred in aided municipalities in the absence of state aid. Finally, Model III is estimated using the full sample of municipalities. As state aid is not included as a control variable in this model, it assumes that entry would have occurred in aided municipalities, regardless of the presence of state aid.

The results of the three models are qualitatively similar. We find that the market size (measured as the number of households in the municipality) significantly and positively affects fiber entry. The effect is non-linear and decreases with market size, as suggested by the coefficients of the interactions between market size and market size bands. We also find that a higher income level has a positive and statistically significant effect on fiber entry, suggesting a higher demand for broadband in wealthier municipalities.

In the estimation, we also include two variables to test the intuition of a geographic dependence in fiber entry suggested by the graphical analysis of deployments (see Section 4). First, we

initial sample of 34,443 municipalities to 34,406 municipalities.

[34]We consider a municipality to have received state aid when the first fiber lines are deployed.

Table 3: Fiber entry in municipalities - presence of at least 1 infrastructure operator.

Dep. Var: Number of operators (0,1+)	(I)	(II)	(III)
Nb Households	0.510***	0.427***	0.522***
	(0.0682)	(0.0518)	(0.0576)
Nb Households interactions (ref: <2,000)			
Nb Households * [2,000 ; 5,000)	-0.153***	-0.123***	-0.180***
	(0.0439)	(0.0339)	(0.0372)
Nb Households * [5,000 , 10,000)	-0.268***	-0.216***	-0.280***
	(0.0584)	(0.0442)	(0.0485)
Nb Households * [10,000 ; 20,000)	-0.339***	-0.273***	-0.349***
	(0.0636)	(0.0483)	(0.0539)
Nb Households * (>20,000]	-0.418***	-0.345***	-0.431***
	(0.0650)	(0.0498)	(0.0552)
Log(Income)	0.631***	0.517***	0.405***
	(0.175)	(0.137)	(0.144)
No coverage in neighbor dummy t-1	-0.871***	-0.990***	-0.822***
	(0.0414)	(0.0500)	(0.0376)
Level of coverage in neigbor t-1	3.254***	1.791***	3.262***
	(0.216)	(0.207)	(0.111)
Year dummies (ref 2014)			
2015	0.208***	0.254***	0.241***
	(0.0528)	(0.0479)	(0.0495)
2016	0.514***	0.576***	0.542***
	(0.0692)	(0.0736)	(0.0622)
2017	0.686***	0.706***	0.728***
	(0.0937)	(0.0912)	(0.0706)
2018	0.829***	0.856***	0.967***
	(0.121)	(0.138)	(0.0790)
2019	1.018***	0.827***	1.183***
	(0.172)	(0.156)	(0.0918)
Type of initiative zone (ref: public)			
Private and mixed initiative	0.942***	1.033***	0.202**
	(0.139)	(0.109)	(0.0971)
Copper loss (ref: <=20dB)			
20dB-30dB excellent	0.0873*	0.0613	0.0952***
	(0.0477)	(0.0374)	(0.0356)
30dB-40dB very good	0.203***	0.138***	0.170***
	(0.0544)	(0.0431)	(0.0432)
40dB-50dB good	0.278***	0.226***	0.267***
	(0.0624)	(0.0442)	(0.0430)
50dB-60dB poor	0.340***	0.254***	0.337***
	(0.0529)	(0.0424)	(0.0421)
>=60dB bad	0.272***	0.213***	0.340***
	(0.0671)	(0.0594)	(0.0487)
μ_1	9.467***	8.322***	5.993***
	(1.815)	(1.441)	(1.473)
Department fixed effects	Yes	Yes	Yes
Observations	663,240	825,744	825,744
LL	-50,279	-73,411	-102,617

Note: Robust standard errors in parentheses (clustered at the department level). Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively use a dummy variable that identifies municipalities with no fiber coverage in neighboring municipalities in the previous period. Its coefficient is negative and statistically significant, indicating that the absence of fiber coverage in neighboring municipalities reduces the likelihood of entry. Second, we use a continuous variable on the average fiber coverage in neighboring municipalities in the previous period. It is positive and statistically significant implying that higher coverage in neighboring municipalities increases the likelihood of entry. We interpret this result as confirming a geographic dependence in fiber deployment. In practice, infrastructure operators need to deploy a fiber backbone, which is the nerve center of their network. When a sufficiently high share of municipalities in a given area is covered, the backbone has been deployed, making it less costly to cover additional adjacent municipalities.

The coefficients of year dummies are positive, statistically significant, and increasing over time. This suggests that entry becomes easier over time, which may be due to technological progress and decreasing deployment costs. Demand for fiber may also grow as the need for higher speeds and connection reliability increases. Unsurprisingly, entry is more likely in private (and mixed) initiative zones than in public ones.[35] Furthermore, municipalities with a lower quality of the legacy copper network experience more entry than municipalities with outstanding quality. This reflects the opportunity cost operators may face in deploying next-generation networks due to their revenues from the legacy copper network (the "replacement effect"). Finally, we include in the estimation a set of department dummy variables that are highly significant. They control for other factors that determine the attractiveness of municipalities belonging to the same department and do not vary over time. Moreover, as discussed above, the state aid subsidies are also designed at the departmental level.

In other specifications of our model that are not reported due to space constraints, we included the population density in the municipality, which should impact the cost of fiber deployment. However, this variable turns out to be insignificant when added to the current set of determinants of entry. We have also included a richer set of control variables for the heterogeneity of municipalities, where department dummy variables interact with a dummy variable denoting urban municipalities, but model predictions do not improve. We have also estimated alternative model specifications including demand and cost factors such as surface area, employment rate, number of jobs, age categories, and active population by socio-professional categories as explanatory

[35]We use a single dummy variable for private and mixed-initiative zones because there are only 85 municipalities classified as mixed.

variables. None of these have a significant effect on fiber entry. In particular, they lose their significance when we use the coverage in neighboring municipalities as a control variable in our model.

In summary, our estimation results confirm the role that market size and other local market characteristics play in determining fiber entry. In particular, our results suggest that fiber entry is driven more by cost factors than demand factors, as deployment in neighboring areas appears to play an important role in entry decisions.

The three models we estimate may have different biases. In Model I, we consider that state aid is granted randomly which may not be the case. For example, political factors or differences in the involvement of local representatives may influence the location and timing of state aid. In Model II, some aided municipalities may have experienced fiber entry without state aid. Finally, Model III assumes that fiber entry would have occurred in aided municipalities regardless of whether state aid was received, which is not realistic.

Although state aid may not be assigned randomly within the public initiative zone, our preferred model is Model I. This is because it provides the best entry predictions among our three models (see Table A.2 for a comparison of prediction rates across models and years). Moreover, Models II and III make extreme assumptions about entry for municipalities receiving state aid. Model I makes correct predictions in 97% of cases., but its prediction accuracy declines over time, particularly for the last two years (2018-2019) and for the cases of effective entry. This suggests that other factors, which are not included in our model may explain why entry accelerates at the end of the period. For instance, a sharp increase in demand for ultra-fast broadband in recent years may have stimulated operators' deployment efforts. Non-economic reasons, such as the 'political will' of local authorities, may also play a role.[36] With these caveats in mind, we use the estimates from Model I to calculate entry thresholds for each municipality, which we use to assess the efficiency of the French Broadband Plan.

Our data comprises a panel of more than 34,000 municipalities over the period 2014-2019. Since we cannot account for this number of fixed effects, the observations for the same municipality are treated as a cross-section in the estimation, where the increasing likelihood of entry over

[36]For example, in 2021, the Brittany local authority responsible for FTTH deployment signed an agreement with the consortium in charge of deploying the fiber network in the region's public initiative zones. The aim was to accelerate deployment following complaints from residents and mayors about delays in access to ultra-fast broadband. See https://www.lesechos.fr/pme-regions/bretagne/les-retards-du-reseau-tres-haut-debit-breton-exaspere-entreprises-et-elus-1353384.

time is accounted for by the year dummies. The estimated coefficients are averages over the entire period and the error terms are clustered by departments, as the error terms for municipalities belonging to the same department may be correlated.

6.2 Entry Thresholds and Efficiency of the French Broadband Plan

Based on the estimates from Model I in the previous section, we compute the entry threshold for each municipality and period in our data. The column (2) in Table 4 reports the average entry thresholds for all municipalities in a given year, while the column (4) reports the average entry thresholds only for municipalities where entry occurred in a given year. For comparison, columns (3) and (5) show the average size in terms of the number of households in all municipalities and in municipalities where entry took place in a given year, respectively. The entry threshold is interpreted as the necessary minimum number of households required for fiber entry to be profitable. The entry threshold varies depending on the characteristics of the municipality. For example, the deployment of fiber in neighboring municipalities and a higher level of income lower the entry threshold for a given municipality. The entry threshold declines over time for all municipalities, as shown in Table 4. The average number of households required to sustain fiber entry was initially 7,945 in 2014 but fell to 3,371 in 2019. Where entry has already occurred, the average entry threshold declined from 9,087 in 2014 to 1,521 in 2019. For these municipalities, the average entry thresholds are lower compared to entry thresholds in all municipalities, except in 2014. There were 579 municipalities with fiber in 2014 including those with state aid. In 2015, there were 423 municipalities with new entries compared to 5,065 in 2019, also including state aid.

We also consider that these decreasing entry thresholds may be due to declining investment costs, increasing demand, or a combination of both. In particular, the decline in investment costs may be due to technological improvements or learning by doing in building fiber networks.[37] Xiao and Orazem (2011) and Nardotto et al. (2015) also report decreasing entry thresholds for network deployment over time.

To assess the efficiency of the French Broadband Plan, we compare the entry threshold pre-

[37]Estimated entry thresholds are negative for a few municipalities. In particular, this is true for small municipalities with high fiber coverage in neighboring municipalities. We believe this is consistent with lower investment costs in areas where the fiber backbone is already deployed. In these cases, we consider that entry would occur almost independently of market characteristics and set the entry threshold at one household.

Table 4: Average entry thresholds and market size.

	All municipalities		Municipalities with entry		
	(2)	(3)	(4)	(5)	(6)
Year	Entry thresholds	Market size	Entry thresholds	Market size	Entries
2014	7,945	718	9,087	11,674	579
2015	7,400	718	5,799	1,650	423
2016	6,549	718	5,156	2,802	1,133
2017	5,759	749	3,593	1,770	1,433
2018	4,831	749	2,505	693	2,933
2019	3,371	749	1,521	595	5,065

Notes: Entry thresholds and market size are in terms of number of households.

dicted by Model I with the market size of each municipality. As discussed in the previous section, municipalities should receive state aid only if their market size is below the entry threshold, meaning that entry would not be profitable for a private operator. If this is indeed the case, we consider that the French Broadband Plan has allocated state aid efficiently. Otherwise, the plan may have introduced a market distortion by crowding out private investment.

Table 5 shows (i) the number of municipalities benefiting from state aid for the first time in each year; (ii) among them, those with entry thresholds higher than market size; and (iii) the proportion of aided municipalities for which we consider the French Broadband Plan as efficient, resulting from the ratio between (ii) and (i). Table 6 shows the cumulative figures over time.

Our conservative assumption of a "myopic" policymaker is that he can evaluate the current entry threshold but cannot foresee future technological developments. As such, he holds this threshold constant for the next three years. This scenario corresponds to columns (ii) and (iii) in Tables 5 and 6. Under this assumption, our results suggest that the French Broadband Plan was quite efficient. Overall, in 93% of the cases, the market size of the municipalities receiving state aid was below the entry threshold predicted by our model in the year when state aid was granted. In other words, private operators were not expected to enter these markets in the year in question.

By contrast, a "forward-looking" policymaker would anticipate that entry thresholds will decrease over time. Therefore, he would assess the desirability of state aid by comparing the market size with the entry threshold in three years. The results for this scenario are shown in columns (iv) and (v) of Tables 5 and 6. Under this assumption, the efficiency of the state aid plan is lower. For 64% of the municipalities that received state aid between 2014 and 2019, our model does not predict unaided entry by a private operator within a three-year window. However, for the remaining 36% of the municipalities, we predict the entry of a private operator within three years. Therefore, public funding in these municipalities appears to have crowded out private investment while accelerating fiber deployment relative to what the private sector would have achieved. Note that in this scenario, the figures for the years 2017-2019 overstate the efficiency of state aid, as we do not have predictions on the evolution of entry thresholds for the entire three-year period following the entry with state aid.

Table 5: Number and proportion of municipalities where state aid was efficient in a given year for a "myopic" and "forward-looking" policymaker.

Year	(i) State aid	(ii) Entry threshold higher than market size: myopic	(iii) State aid efficiency	(iv) Entry threshold higher than market size: forward-looking	(v) State aid efficiency
2014	23	23	100%	19	83%
2015	168	168	100%	148	88%
2016	369	365	99%	221	60%
2017	891	888	100%	543	61%
2018	2,113	1,918	91%	1,099	52%
2019	3,207	2,939	92%	2,310	72%
Total	6,771	6,296	93%	4,339	64%

Table 6: Cumulative number and proportion of municipalities where state aid was efficient in a given year for a "myopic" and "forward-looking" policymaker.

Year	(i) State aid	(ii) Entry threshold higher than market size: myopic	(iii) State aid efficiency	(iv) Entry threshold higher than market size: forward-looking	(v) State aid efficiency
2014	23	23	100%	19	83%
2015	191	191	100%	167	87%
2016	560	556	99%	388	69%
2017	1,451	1,444	99%	931	64%
2018	3,564	3,362	94%	2,030	57%
2019	6,771	6,301	93%	4,340	64%

Thus, by extending fiber coverage to areas that private operators would otherwise not have covered, the French Broadband Plan successfully addressed the gap in broadband availability.

However, it has led to some degree of crowding out, which we estimate to be between 7% and 36%, depending on the degree of rationality one can expect from the policymaker. When considering these results, it is important to note that crowding out cannot be entirely avoided due to uncertainties about the demand for ultra-fast broadband and investment costs, particularly in the early stages of fiber deployment.

Our entry model is estimated using data for 2014-2019, and we evaluate the efficiency of state aid in the same period. However, when deciding whether to grant state aid at some date t, the policymaker only has information up to that point. Therefore, as a robustness check, we estimate our entry model using data only for 2014-2016, as shown in Table A.4 in the Appendix. We then use the estimates to predict entry thresholds in the out-of-sample years 2017-2019 and assess the efficiency of state aid in this period. This approach brings us closer to an *ex-ante* evaluation of the state aid decision process. The results we obtain for a "myopic" policymaker are shown in the Appendix in Table A.5. We applied the coefficient of the dummy variable for the year 2016 to the years 2017-2019, which can be interpreted as the same level of costs in these four years. The efficiency of state aid is worse than reported in Tables 5 and 6.

We then use our estimates to calculate the costs of 'efficient' and 'inefficient' state aid in the two scenarios of a "myopic" and "forward-looking" policymaker. For these calculations, we use the maximum amount of aid per line a municipality can claim, and the number of lines in each municipality reported by ARCEP and AVICCA.[38] The cost per line is the same for all municipalities in the same department but differs from department to department. Table 7 shows the estimated cumulative costs over time for municipalities that received state aid. Note that the number of lines deployed that received public subsidies is lower than the total number of lines used in the calculation. Therefore, our calculations represent an upper bound on the cost of state aid. According to our estimates, in 2019, in the scenario of a "myopic" policymaker, 'efficient' state aid corresponds to 1,964 million euros and 'inefficient' state aid to 239 million euros (i.e., 11% of total expenditure). In the scenario of a "forward-looking" policymaker, 'inefficient' state aid corresponds to an expenditure of 905 million euros (41% of total expenditure). Note that municipalities with 'inefficient' state aid tend to be larger on average than those with 'efficient' state aid. This explains why the degree of inefficiency is higher for expenditures than for the number of municipalities.

[38] Source: "Investissements d'Avenir - Développement de l'Economie Numérique. France Très Haut Débit, Réseaux d'initiative publique," March 2017, p. 42 and 43.

Table 7: Cumulative cost of state aid for full coverage (million euros)

	Myopic				Forward-looking			
	Efficient		Inefficient		Efficient		Inefficient	
	Cost	Lines	Cost	Lines	Cost	Lines	Cost	Lines
2014	23	46			18	36	5	10
2015	94	210			68	153	26	57
2016	264	602	33	65	107	240	190	426
2017	604	1,420	36	73	293	679	347	815
2018	1,075	2,684	102	302	575	1,389	602	1,597
2019	1,964	4,917	239	636	1,298	3,202	905	2,351

Note: The number of lines (in tsd) corresponds to total number of lines in municipalities reported by ARCEP and AVICCA.

6.3 Fiber Coverage

Table 8 reports the estimation results for our coverage model. We estimate four regressions. We first consider a specification in which the effect of state aid is constant over time (columns (1) and (2)). Then, to capture potential differences in trends between aided and unaided municipalities, we consider a specification where the effect of state aid interacts with year dummies (columns (3) and (4)). For each specification, we estimate two regressions, using OLS, and the correction term for the presence of fiber infrastructure operators (column denoted as Heckman).

In columns (1) and (2) of Table 8, the presence of state aid has a significant and positive impact on fiber coverage. Its average magnitude over the period 2014-2019 in the OLS estimation (column (1)) is 6.1%. When the correction term from the fiber entry model is included in the estimation (column (2)), the magnitude of the impact of state aid increases slightly to 6.4%. The significant estimate of the Mills ratio indicates that the OLS estimates suffer from a sample selection bias.

In columns (3) and (4) of Table 8, we see that the positive impact of state aid on fiber coverage is large at the beginning of the period but declines over time. The coefficient of the Mills ratio is again positive and statistically significant, suggesting that the OLS estimates suffer from a sample selection bias. Based on the estimates from column (4) in Table 8, Figure 4 shows the evolution of the impact of state aid on fiber coverage over time. The additional coverage in aided municipalities was 47% in 2014, 29% in 2015, 21% in 2016, 15% in 2017, and 8% in 2018.[39]

[39] The impact of state aid on coverage in the years 2015-2019 is calculated by adding each interaction coefficient

There is no evidence that state aid allowed for significantly higher coverage in 2019.

We include in the models several control variables to account for the heterogeneity of local markets, which we expect to impact fiber deployment significantly. The effects are qualitatively similar across specifications, except for differences in the significance level of certain variables. In specification (4), a higher level of fiber coverage in neighboring municipalities in the previous period is associated with a higher fiber coverage in the municipality. This confirms the existence of geographic dependence in fiber deployment. The coefficient of income is negative and statistically significant at the 90% level. This suggests that income effects are dominated by cost effects. Fiber coverage is higher in private and mixed-initiative zones than in public initiative zones. Moreover, coverage expands as the quality of the legacy copper network decreases. This result reinforces the evidence of a replacement effect that we also find when we estimate the entry model. The coefficients of yearly dummies are positive, statistically significant, and increasing over time. This is intuitive as deployment is an incremental process. Finally, we include department dummy variables in the estimation to control for differences in the attractiveness of the municipalities that belong to them. Most of them are highly significant.

Our results suggest that the presence of state aid in municipalities has allowed for higher fiber coverage, especially at the beginning of the period. Over time, the gap with unaided municipalities appears to be closing. This may reflect a reduction in uncertainty about demand or costs for private operators deploying fiber infrastructure in unaided municipalities.

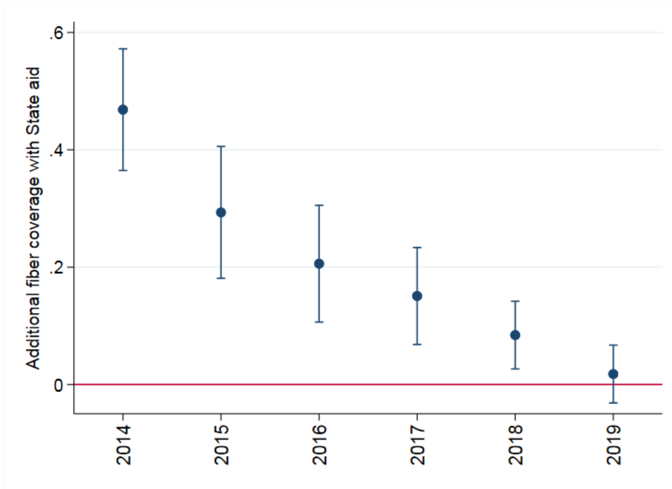
7 Conclusion

In this paper, we develop a framework for assessing the efficiency of public subsidies in developing broadband fiber networks. In particular, we use a rich dataset on fiber deployment, state aid, and local market characteristics in France to analyze the efficiency of state aid granted through the French Broadband Plan (*Plan France Très Haut Débit*). First, we study the determinants of entry into fiber and evaluate the plan's efficiency. Second, we assess the impact of state aid on fiber coverage, controlling for the endogeneity of fiber entry.

State aid is an important policy tool for deploying broadband networks in rural and low-density areas, where private operators may not have an incentive to invest. However, state aid is subject to control, as it may distort competition or crowd out private investment. In particular,

to the coefficient of the state aid dummy.

Figure 4: Evolution of the impact of state aid on fiber coverage.



Note: Estimates from column (4) in Table 8, where the dependent variable is the fiber coverage rate at the municipality level. Each point represents the additional coverage rate in aided municipalities. For example, in 2015, aided municipalities had 29% additional coverage relative to unaided municipalities. The vertical lines represent the 95% confidence intervals.

it is important to ensure that state aid is granted in areas where market operators would not choose to invest.

Our results suggest that the French Broadband Plan was in general successful in covering areas that would not have been covered otherwise. However, this comes at the cost of some level of crowding out. Depending on how well the policymaker can anticipate the prospects of entry in the near future, we find that in around 64% to 93% of the cases, state aid benefited municipalities where private entry would not have occurred. Crowding out may result from the uncertainty about costs or demand levels, or from the process itself, with local authorities' impatience to obtain coverage.

When evaluating the plan's efficiency, we also examined the determinants of fiber entry. We find that local market characteristics, such as market size and income, are important determinants. Interestingly, we also find evidence of a strong geographic dependence on fiber entry and a replacement effect from the legacy copper network in fiber entry decisions. We also find that fiber entry becomes easier over time.

We use our estimates to calculate an upper bound on the cost of 'efficient' and 'inefficient' state aid, based on the average cost of state aid per line and the total number of lines in a municipality. According to our estimates, in 2019, in the case of a "myopic" policymaker who is unable to foresee the decrease of entry thresholds, 'inefficient' state aid amounts to 243 million euros or 11% of total expenditure. In the case of a "forward-looking" policymaker who can anticipate the evolution of entry thresholds within three years, 'inefficient' state aid amounts to an expenditure of 902 million euros or 41% of total expenditure.

We also examine the impact of state aid on fiber coverage, controlling for the endogeneity of fiber entry. Our analysis suggests that the French Broadband Plan allowed for higher fiber coverage rates in aided municipalities, especially at the beginning of the period of analysis. This effect diminishes over time so that by the end of the observation period, there is no difference between aided and unaided municipalities. Our interpretation is that due to strong uncertainty about demand and costs, private operators gradually rolled out their networks in local areas, leading to a gap in coverage between aided and unaided municipalities. This gap narrowed and eventually disappeared as these uncertainties were resolved over time.

Due to data limitations and our focus on infrastructure operators, we are unable to study the impact of state aid on competition between Internet service providers or the impact of fiber competition on deployment. The analysis of entry into the downstream market for the provision of fiber services to residential and/or business customers is an interesting avenue for future research. Moreover, we assume that there is no favoritism or capture in the granting of public subsidies in local markets. For example, there may be political factors (e.g., differences in the involvement of voters or local representatives across markets, and political orientation at the regional, departmental, and local levels) that influence the location and timing of state aid. These questions could be the subject of further research on state aid.

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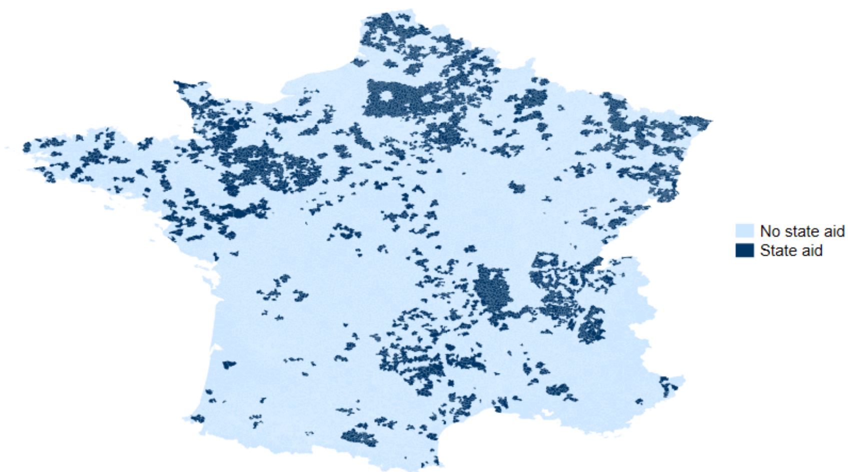
Appendices

Appendix A1 Additional Figures and Tables

Figure 5: Municipalities benefiting from state aid as of 2019Q4.



Source: ANCT.

Table 8: Fiber coverage in municipalities.

Dep. Var: Fiber coverage rate	(1) OLS	(2) Heckman	(3) OLS	(4) Heckman
State aid (dummy)	0.062**	0.064**	0.518***	0.467***
	(0.030)	(0.030)	(0.043)	(0.053)
State aid (dummy) * 2015			-0.196***	-0.174***
			(0.034)	(0.033)
State aid (dummy) * 2016			-0.299***	-0.261***
			(0.042)	(0.046)
State aid (dummy) * 2017			-0.359***	-0.316***
			(0.041)	(0.048)
State aid (dummy) * 2018			-0.434***	-0.382***
			(0.037)	(0.045)
State aid (dummy) * 2019			-0.506***	-0.449***
			(0.035)	(0.047)
Level of coverage in neigbor t-1	0.379***	0.491***	0.382***	0.453***
	(0.039)	(0.034)	(0.037)	(0.038)
Log(Income)	-0.070*	-0.066*	-0.075**	-0.072*
	(0.036)	(0.037)	(0.036)	(0.037)
Type of initiative zone (ref: public)				
Private and mixed initiative	0.063**	0.110***	0.066**	0.095***
	(0.029)	(0.032)	(0.030)	(0.032)
Copper loss (ref: <=20dB)				
20dB-30dB excellent	0.019	0.030*	0.022	0.028*
	(0.015)	(0.015)	(0.015)	(0.015)
30dB-40dB very good	0.065***	0.073***	0.067***	0.071***
	(0.018)	(0.018)	(0.018)	(0.018)
40dB-50dB good	0.111***	0.117***	0.112***	0.116***
	(0.023)	(0.023)	(0.023)	(0.023)
50dB-60dB poor	0.147***	0.153***	0.147***	0.151***
	(0.026)	(0.026)	(0.026)	(0.026)
>=60dB bad	0.155***	0.156***	0.155***	0.156***
	(0.030)	(0.030)	(0.030)	(0.030)
Year dummies (ref 2014)				
y2015	0.053***	0.047***	0.031**	0.030***
	(0.016)	(0.013)	(0.012)	(0.012)
y2016	0.090***	0.085***	0.064***	0.064***
	(0.024)	(0.022)	(0.021)	(0.020)
y2017	0.112***	0.111***	0.093***	0.095***
	(0.027)	(0.024)	(0.026)	(0.025)
y2018	0.164***	0.163***	0.166***	0.165***
	(0.029)	(0.026)	(0.031)	(0.029)
y2019	0.195***	0.197***	0.234***	0.232***
	(0.030)	(0.028)	(0.032)	(0.030)
Correction term entry (Mills ratio)		0.051***		0.033**
		(0.016)		(0.016)
Constant	0.758**	0.603	0.769**	0.668*
	(0.364)	(0.385)	(0.364)	(0.382)
Department dummies	Yes	Yes	Yes	Yes
Observations	81,629	81,629	81,629	81,629
Adjusted R-squared	0.289	0.292	0.297	0.298

Note: Robust standard errors in parentheses (clustered at the department level). Symbols *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table A.1: List of projects eligible to state aid in the framework of the French Broadband Program as of January 2021.

Project code	Departments/region	Project code	Departments/region
CD01	Ain	CD40	Landes
CD02	Aisne	LIMO	Limousin
PACA	Alpes-de-Haute-Provence & Hautes-Alpes	CD42	Loire
CD06	Alpes-Maritimes	CD44	Loire-Atlantique
ALSA	Alsace	CD45	Loiret
ARDR	Ardèche & Drôme	CD41	Loir-et-Cher
CD09	Ariège	CD46	Lot
CD10	Aube	CD47	Lot-et-Garonne
CD11	Aude	CD48	Lozère
AUVE	Auvergne	CD49	Maine-et-Loire
CD12	Aveyron	CD50	Manche
CD13	Bouches-du-Rhône	C972	Martinique
BRET	Bretagne	CD53	Mayenne
CD14	Calvados	C976	Mayotte
CD16	Charente	CD57	Moselle
CD17	Charente-Maritime	CD58	Nièvre
CD18	Cher	NPDC	Nord-Pas-de-Calais
CORS	Corse	CD60	Oise
CD21	Côte-d'or	CD61	Orne
CD79	Deux-Sèvres	CD64	Pyrénées-Atlantiques
CD24	Dordogne	CD66	Pyrénées-Orientales
CD25	Doubs	C974	Réunion
CD91	Essonne	C977	Saint-Barthélémy
CD27	Eure	C975	Saint-Pierre-et-Miquelon
CD28	Eure-et-Loir	CD71	Saône-et-Loire
CD30	Gard	CD72	Sarthe
CD32	Gers	CD73	Savoie
CD33	Gironde	CD77	Seine-et-Marne
GDES	Grand Est	CD76	Seine-Maritime
C971	Guadeloupe	CD80	Somme
C973	Guyane	CD81	Tarn
CD31	Haute-Garonne	CD82	Tarn-et-Garonne
CD52	Haute-Marne	CD94	Val-de-Marne
CD70	Haute-Saône	CD95	Val-d'oise
CD74	Haute-Savoie	CD83	Var
CD65	Hautes-Pyrénées	CD84	Vaucluse
CD34	Hérault	CD85	Vendée
CD36	Indre	CD86	Vienne
CD37	Indre-et-Loire	CD88	Vosges
CD38	Isère	CD89	Yonne
CD39	Jura	CD78	Yvelines

Table A.2: Comparison of correct prediction rates across models.

Year	Model I	Model II	Model III
2014	98.8%	98.7%	98.8%
2015	98.3%	98.2%	98.4%
2016	97.0%	96.7%	97.0%
2017	96.8%	96.2%	96.4%
2018	95.5%	95.1%	94.2%
2019	92.7%	91.6%	89.8%
All	97.0%	96.6%	96.4%

Note: Prediction rates are calculated as the ratio between the number of correct predictions (for entry and no entry) and the total number of observations. This ratio is calculated only for the 27,601 municipalities which do not benefit from state aid in the period 2014-2019.

Table A.3: Fiber entry and exit in years 2014-2019.

	Number of infrastructure operators (Nb fiber$_t$)					
Nb fiber$_{t-1}$	0	1	2	3	4	5
0	744,115	10,901	259	40	0	0
1	0	64,875	289	50	1	0
2	0	0	3,839	72	2	0
3	0	0	0	1,712	24	0
4	0	0	0	0	417	2
5	0	0	0	0	0	34

Note: 826,632 observations for 34,443 municipalities for the period 2014-2019. We observe entry, but no exit.

Table A.4: Fiber entry in municipalities - presence of at least 1 infrastructure operator: Estimation for years 2014-2016.

Dep. Var: Number of operators (0,1+)	(I)	(II)	(III)
Nb Households	0.379***	0.462***	0.462***
	(0.111)	(0.0822)	(0.0822)
Nb Households interactions (ref: <2,000)			
Nb Households * [2,000 ; 5,000)	-0.0739	-0.136**	-0.136**
	(0.0814)	(0.0603)	(0.0603)
Nb Households * [5,000 , 10,000)	-0.173*	-0.240***	-0.240***
	(0.1000)	(0.0741)	(0.0741)
Nb Households * [10,000 ; 20,000)	-0.214**	-0.292***	-0.292***
	(0.105)	(0.0784)	(0.0784)
Nb Households * (>20,000]	-0.291***	-0.372***	-0.372***
	(0.106)	(0.0796)	(0.0796)
Log(Income)	0.582**	0.574***	0.574***
	(0.239)	(0.183)	(0.183)
No coverage in neighbor dummy t-1	-1.085***	-1.028***	-1.028***
	(0.0799)	(0.0697)	(0.0697)
Level of coverage in neigbor t-1	3.804***	3.796***	3.796***
	(0.279)	(0.315)	(0.315)
Year dummies (ref 2014)			
2015	0.145***	0.183***	0.183***
	(0.0507)	(0.0499)	(0.0499)
2016	0.383***	0.443***	0.443***
	(0.0561)	(0.0610)	(0.0610)
Type of initiative zone (ref: public)			
Private initiative	0.285*	0.0670	0.0670
	(0.167)	(0.102)	(0.102)
Copper loss (ref: <=20dB)			
20dB-30dB excellent	0.0242	0.0354	0.0354
	(0.0730)	(0.0661)	(0.0661)
30dB-40dB very good	0.137	0.159**	0.159**
	(0.0948)	(0.0798)	(0.0798)
40dB-50dB good	0.226**	0.242***	0.242***
	(0.0928)	(0.0837)	(0.0837)
50dB-60dB poor	0.281***	0.252***	0.252***
	(0.0956)	(0.0782)	(0.0782)
>=60dB bad	0.137	0.197**	0.197**
	(0.120)	(0.0950)	(0.0950)
μ_1	8.274***	7.300***	7.300***
	(2.474)	(1.895)	(1.895)
Department fixed effects	Yes	Yes	Yes
Observations	331,620	412,872	412,872
LL	-12,695	-19,510	-19,510

Note: Robust standard errors in parentheses (clustered at the department level). Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively

Table A.5: Number and proportion of municipalities where state aid was efficient in a given year for a "myopic" policymaker: Estimation for years 2014-2016.

				Cumulated	
Year	(i) State aid	(ii) Entry threshold higher than market size	(iii) State aid efficiency	(iv) Entry threshold higher than market size	(v) State aid efficiency
2014	23	23	100%	23	100%
2015	168	165	98%	188	98%
2016	369	354	96%	542	97%
2017	891	863	97%	1,405	97%
2018	2,113	1,772	84%	3,177	89%
2019	3,027	2,809	88%	5,986	88%
Total	6,771	5,986	88%		