# Entry Into Fiber and State Aid for the Deployment of High-Speed Internet: Evidence from France

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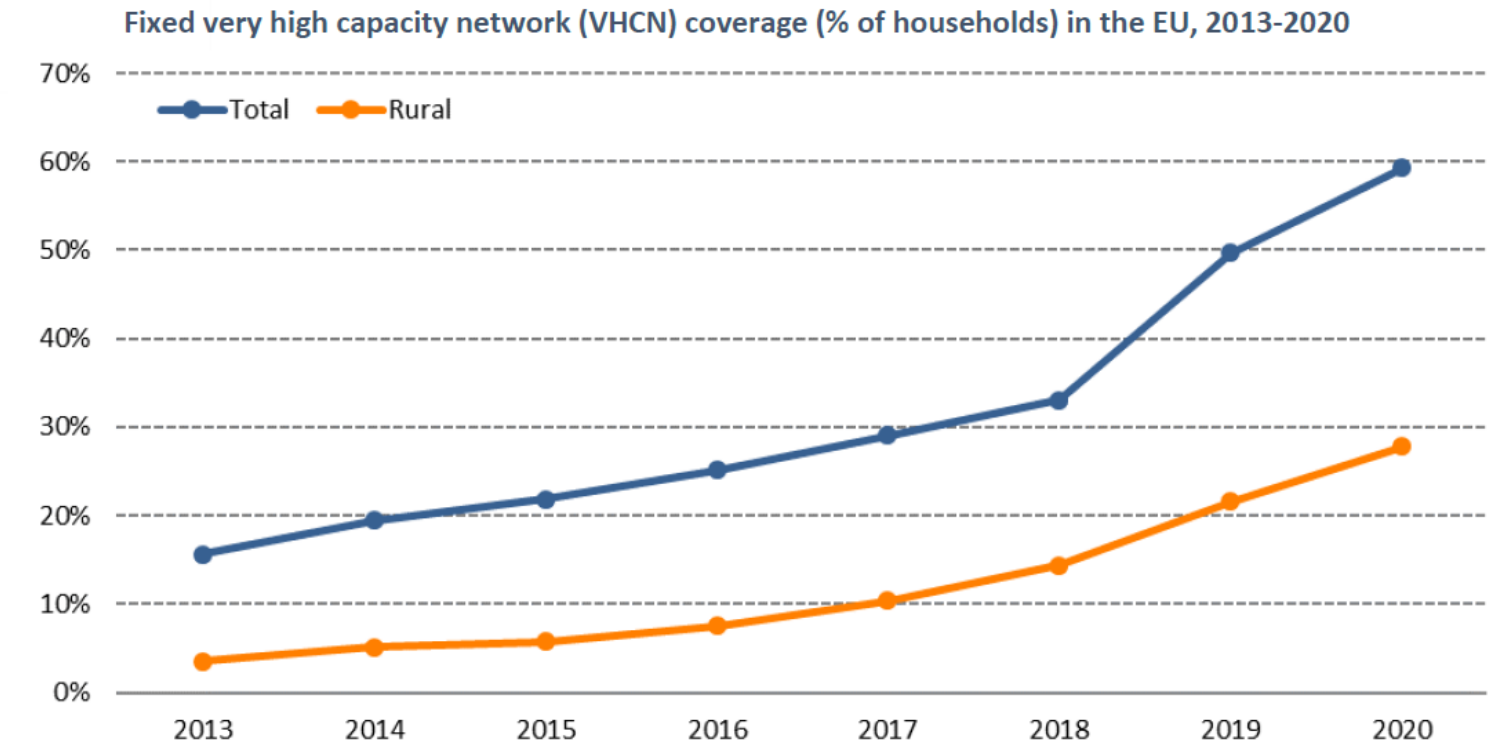
# The transition to ultrafast broadband (>300Mbps)

- Digital single EU market should foster economic development and reduce digital divide between geographic areas.

- EU sets objectives for deployment and coverage by so called very high capacity networks (VHCN):

  - By 2025 all EU households should have access to at least 100Mbps connection (Gigabit connectivity, 2016).

# Deployment of Very High Capacity Networks (VHCN): Where are we at the EU level?




*Source: IHS Markit, Omdia, Point Topic and VVA, Broadband coverage in Europe studies.*

*Source: European Commission*
*Digital Economy and Society Index (DESI) 2021*

# Barriers to transition and market failure

**Demand-side barriers**

- Switching costs between technologies (from DSL to Fibre)
- Low willingness-to-pay for higher speed of >100Mbps?

**Supply-side barriers**

- Large fixed and sunk costs to invest in next-generation networks
- Replacement effect
- Competition from other broadband providers: mobile, cable

Market failure for the provision of ultrafast broadband in certain areas:

- Policy tools to provide incentives for deploying ultra-fast broadband infrastructure: co-investment, State aid
- In France, 80% of municipalities (42% of population) are categorized as 'public initiative zones' which qualify for State aid

# The French broadband scheme: Plan France Très Haut Débit

Nationwide program to support local authorities in the design and deployment of public initiative networks (in 'public initiative zones'):

- $\approx$ 3 billion euros in state aid
- $>$30 Mbit/s coverage for all in 2022
- Fiber to the Home (FTTH) coverage for all in 2025

# Research Questions

- How does state aid impact fiber entry?
  - Whether state aid leads to entry in municipalities where otherwise it would have not occurred (fixes market failure).
  - Whether state aid leads to potential crowding out of private investments through earlier entry.

- How does state aid impact fiber deployment?
  - Does coverage go slower or faster in aided municipalities compared to similar non-aided municipalities?

# Literature

1. Entry into telecoms markets:
   - Xiao & Orazem (2011), Nardotto et al. (2015), Bourreau et al. (2019)
2. Investments in next-generation broadband networks:
   - Effect of access regulation on the migration from copper to fiber networks (Country level: Bacache et al., 2014; Briglauer, 2015; Briglauer et al., 2018. Local level: Minamihashi, 2012; Fabritz and Falck, 2013, Calzada et al., 2018 )
3. Impact of state aid on the deployment of broadband networks:
   - Matteucci (2019), Briglauer et al. (2019), Duso et al. (2021)

Our paper: entry into fiber (infrastructure operators) and State aid for fiber deployment

# Data overview

Panel data on 34,443 municipalities in Mainland France for the years 2014–2019 (quarterly)

FTTH infrastructure (ARCEP):

- Number of FTTH lines deployed in each municipality
- Number of infrastructure operators

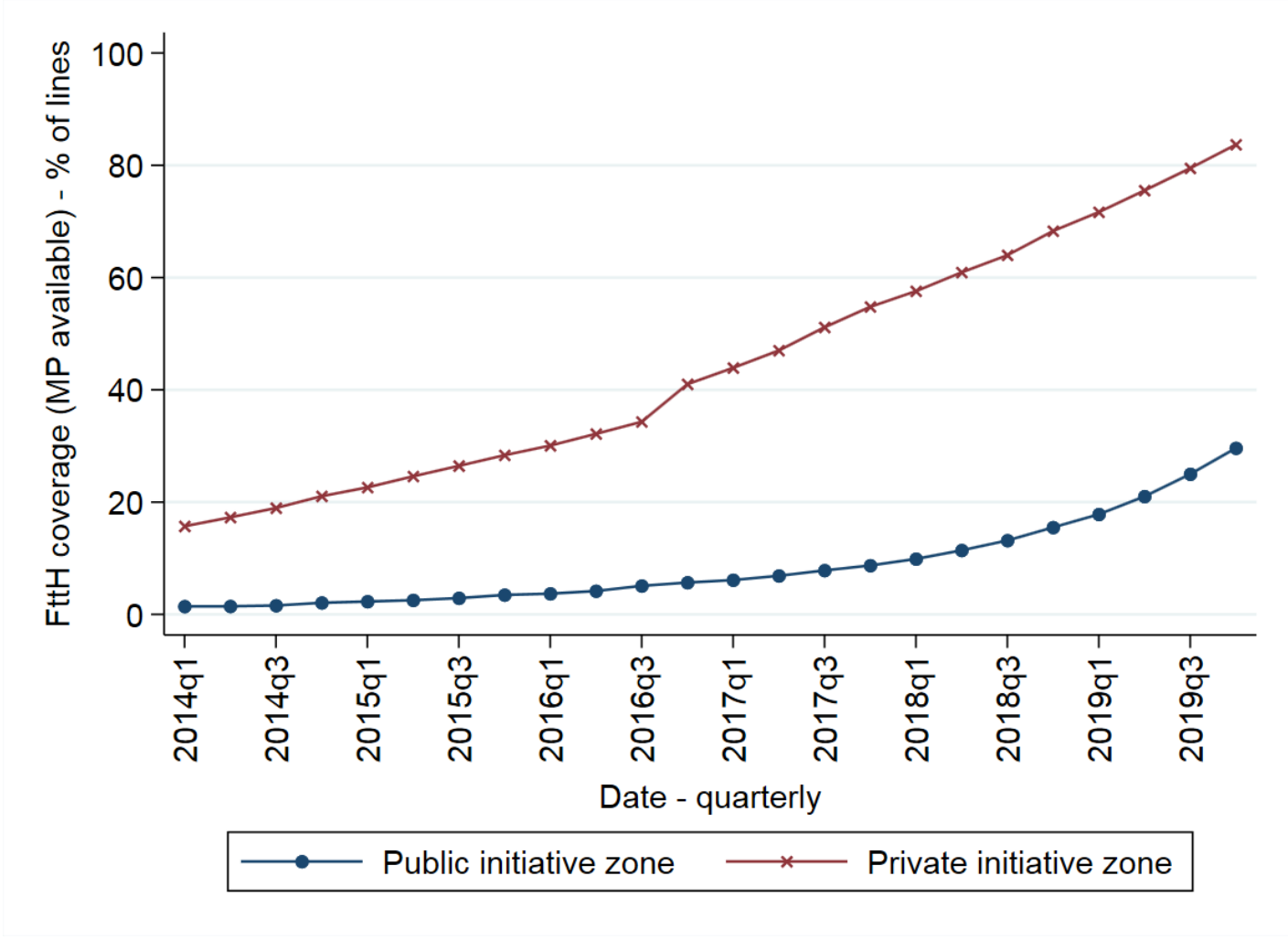
State aid (ANCT):

- Date and amount of aid granted by the State for a specific project (department or supra-department level)
- Number of lines concerned by aid (municipality level)

Market characteristics:

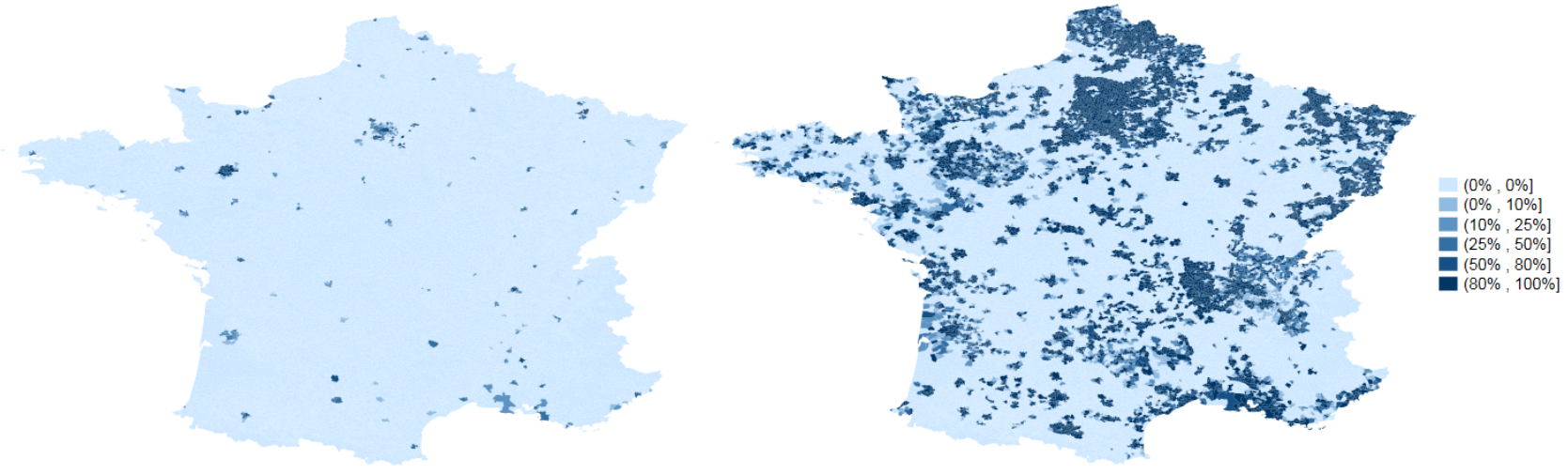
- Population, population density, median fiscal income (Insee)
- Type of initiative zone – public, private or mixed (Avicca)
- Quality of the legacy copper network (Orange)

# Deployment of fiber in France



# Deployment of fiber in France

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




**(a)** 2014Q1

**(b)** 2019Q4

# Summary statistics

**Table:** Number of municipalities with presence of infrastructure operators.

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

**Table:** Cumulative number of municipalities with State aid.

| Year | Total |
|---|---|
| 2014 | 23 |
| 2015 | 191 |
| 2016 | 560 |
| 2017 | 1,451 |
| 2018 | 3,564 |
| 2019 | 6,771 |

# Econometric models

1. Structural model of fiber entry
   - Study the determinants of entry into fiber
   - Compute entry thresholds: minimum market size required to support fiber entry in a given municipality at a particular point in time
   - Evaluate of Plan's efficiency
     - Market size $<$ entry threshold: private entry would not have occurred (state aid fixed a market failure)
     - Market size $>=$ entry threshold: private entry would have occurred (possible crowding out)

2. Two-stage Heckman selection model of fiber coverage in which we account for the endogeneity of fiber entry (correction term).

# Entry into fiber

# Model of entry: profit function

We follow Xiao & Orazem (2011), Nardotto et al. (2015), Bourreau et al. (2019).

Discounted value of future profits in market $i$, with $n$ competitors:

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

- $S_i$ is the potential market size (households)
- $b_k$ are market size intervals (non-linear market size effects)
- $X_i$ is a vector of other profit determinants (e.g., income, deployment spillovers)
- $\mu_n$ is a fixed effect, representing the negative profit impact from the $n^{th}$ firm
- $\epsilon_i$ is an i.i.d. normally distributed error term

Using data from a cross-section of independent markets allows estimating the parameters using Maximum Likelihood Estimation (MLE). This is a simple 'Ordered Probit Model' if $\epsilon$ is N(0,1).

# Model of entry: three specifications

- State aid perfectly predicts entry – there are no aided municipalities without infrastructure deployed (we assume that State aid is when the first fiber lines are deployed).

- We estimate three different entry models:
  - Model I: restricted sample of 27,601 out of 34,406 municipalities that never received State aid during our period – assumes that the likelihood of entry in aided municipalities should be the same as in unaided municipalities with similar characteristics.
  - Model II: sets the number of infrastructure operators to zero whenever a municipality receives State aid – assumes that entry would not have occurred in aided municipalities in the absence of State aid.
  - Model III: full sample of municipalities – assumes that entry would have occurred in aided municipalities regardless of the presence of State aid.

# Results - Entry model (1/2)

**Table:** Fiber entry - presence of at least 1 infrastructure operator

| *Dep. Var: Number of operators (0,1+)* | (I) | (II) | (III) |
|---|---|---|---|
| Nb Households | 0.511*** | 0.427*** | 0.523*** |
| | (0.0684) | (0.0517) | (0.0577) |
| *Ref: Nb Households interactions (< 2,000)* | | | |
| Nb Households * [2,000 ; 5,000) | -0.155*** | -0.124*** | -0.183*** |
| | (0.0439) | (0.0337) | (0.0371) |
| Nb Households * [5,000 , 10,000) | -0.268*** | -0.215*** | -0.281*** |
| | (0.0589) | (0.0443) | (0.0488) |
| Nb Households * [10,000 ; 20,000) | -0.340*** | -0.272*** | -0.349*** |
| | (0.0638) | (0.0483) | (0.0540) |
| Nb Households * (> 20,000] | -0.419*** | -0.345*** | -0.432*** |
| | (0.0651) | (0.0497) | (0.0553) |
| Log(Income) | 0.638*** | 0.520*** | 0.408*** |
| | (0.177) | (0.138) | (0.144) |
| No coverage in neighbor dummy t-1 | -0.870*** | -0.989*** | -0.821*** |
| | (0.0414) | (0.0498) | (0.0377) |
| Level of coverage in neigbor t-1 | 3.260*** | 1.790*** | 3.263*** |
| | (0.216) | (0.207) | (0.111) |
| *Type of initiative zone (ref: public)* | | | |
| Private initiative | 0.921*** | 1.020*** | 0.184* |
| | (0.138) | (0.109) | (0.0968) |
| Mixed initiative | 1.676*** | 1.574*** | 0.956*** |
| | (0.466) | (0.356) | (0.367) |
| *[Continues...]* | | | |
| $\mu_1$ | 9.533*** | 8.349*** | 6.032*** |
| | (1.830) | (1.448) | (1.474) |
| Department fixed effects | Yes | Yes | Yes |
| Observations | 662,424 | 825,744 | 825,744 |
| LL | -49921 | -73325 | -102454 |

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

# Results - Entry model (2/2)

**Table:** Fiber entry - presence of at least 1 infrastructure operator

| *Dep. Var: Number of operators (0,1+)* | (I) | (II) | (III) |
|---|---|---|---|
| *[Continuation...]* | | | |
| *Year dummies (ref 2014)* | | | |
| 2015 | 0.210*** | 0.255*** | 0.242*** |
| | (0.0532) | (0.0481) | (0.0497) |
| 2016 | 0.518*** | 0.579*** | 0.545*** |
| | (0.0700) | (0.0741) | (0.0628) |
| 2017 | 0.691*** | 0.711*** | 0.732*** |
| | (0.0939) | (0.0913) | (0.0709) |
| 2018 | 0.835*** | 0.860*** | 0.972*** |
| | (0.120) | (0.138) | (0.0788) |
| 2019 | 1.020*** | 0.832*** | 1.189*** |
| | (0.172) | (0.155) | (0.0913) |
| *Copper loss (ref: <=20dB)* | | | |
| 20dB-30dB excellent | 0.0904* | 0.0631* | 0.0975*** |
| | (0.0473) | (0.0371) | (0.0355) |
| 30dB-40dB very good | 0.201*** | 0.136*** | 0.169*** |
| | (0.0547) | (0.0431) | (0.0433) |
| 40dB-50dB good | 0.278*** | 0.224*** | 0.265*** |
| | (0.0628) | (0.0442) | (0.0432) |
| 50dB-60dB poor | 0.343*** | 0.253*** | 0.336*** |
| | (0.0535) | (0.0427) | (0.0422) |
| >=60dB bad | 0.272*** | 0.213*** | 0.339*** |
| | (0.0676) | (0.0593) | (0.0486) |
| $\mu_1$ | 9.533*** | 8.349*** | 6.032*** |
| | (1.830) | (1.448) | (1.474) |
| Department fixed effects | Yes | Yes | Yes |
| Observations | 662,424 | 825,744 | 825,744 |
| LL | -49921 | -73325 | -102454 |

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

# Results - Entry thresholds

**Table:** Average entry thresholds and market size

| | All municipalities | | Municipalities with entry | |
|---|---|---|---|---|
| Year | Entry thresholds | Market size | Entry thresholds | Market size |
| 2014 | 7,970 | 718 | 9,919 | 7,566 |
| 2015 | 7,436 | 718 | 6,889 | 2,179 |
| 2016 | 6,647 | 718 | 6,555 | 3,034 |
| 2017 | 5,950 | 749 | 5,248 | 2,286 |
| 2018 | 5,191 | 749 | 4,550 | 846 |
| 2019 | 4,074 | 749 | 3,535 | 714 |

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

# Results – Efficiency analysis

**Table:** Cumulative number and proportion of municipalities where State aid was necessary (myopic case)

| Year | (i) State aid | (ii) Entry threshold higher than market size | (iii) State aid efficiency |
|---|---|---|---|
| 2014 | 23 | 23 | 100% |
| 2015 | 191 | 191 | 100% |
| 2016 | 560 | 556 | 99% |
| 2017 | 1,451 | 1,443 | 99% |
| 2018 | 3,564 | 3,361 | 94% |
| 2019 | 6,771 | 6,296 | 93% |

**Table:** Cumulative number and proportion of municipalities where State aid was necessary (3 years)

| Year | (i) State aid | (iv) Entry threshold higher than market size | (v) State aid efficiency |
|---|---|---|---|
| 2014 | 23 | 18 | 78% |
| 2015 | 191 | 167 | 87% |
| 2016 | 560 | 387 | 69% |
| 2017 | 1,451 | 931 | 64% |
| 2018 | 3,564 | 2,030 | 57% |
| 2019 | 6,771 | 4,339 | 64% |

- When spillovers from coverage in neighboring municipalities are ignored, all State aid is efficient in both cases.

# Results - Efficiency analysis - costs

What is the the cost of 'efficient' and 'inefficient' State aid?

*Cost of State aid : (Total lines x Plan's coverage) x Maximum amount of aid per line*

**Table:** Cumulative cost of State aid for full coverage (million Euros)

| | Myopic | | | | 3 years | | | |
|---|---|---|---|---|---|---|---|---|
| | Efficient | | Inefficient | | Efficient | | Inefficient | |
| | Cost | Lines | Cost | Lines | Cost | Lines | Cost | Lines |
| 2014 | 23 | 46 | | | 17 | 34 | 6 | 12 |
| 2015 | 94 | 210 | | | 68 | 153 | 26 | 57 |
| 2016 | 264 | 602 | 33 | 65 | 106 | 239 | 191 | 427 |
| 2017 | 603 | 1,420 | 36 | 74 | 298 | 691 | 342 | 803 |
| 2018 | 1,074 | 2,681 | 103 | 305 | 579 | 1,398 | 598 | 1,588 |
| 2019 | 1,960 | 4,907 | 243 | 645 | 1,301 | 3,207 | 902 | 2,346 |

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

# Deployment of fiber

# Model of fiber deployment

Two-stage Heckman selection model:

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

Where

- $y_{it}$ denotes the share of lines in municipality $i$ and quarter-year $t$ with Mutualization Point (MP) available
- $SA_{it}$ is an indicator variable of state aid in municipality $i$ and quarter-year $t$
- $Z_{it}$ is a set of control variables that may determine coverage
- $\lambda(S_{it}, X_{it}; \theta)$ is the Heckman correction term estimated using the entry model
- $\varepsilon_{it}$ is assumed normally distributed

# Results - Deployment model (1/3)

**Table:** Fiber coverage in municipalities (1/2)

| *Dep. Var: Fiber coverage rate* | (1) OLS | (2) Heckman | (3) OLS | (4) Heckman |
|---|---|---|---|---|
| State aid (dummy) | 0.061** | 0.064** | 0.518*** | 0.468*** |
| | (0.030) | (0.030) | (0.043) | (0.053) |
| State aid (dummy) * 2015 | | | -0.196*** | -0.175*** |
| | | | (0.034) | (0.033) |
| State aid (dummy) * 2016 | | | -0.299*** | -0.262*** |
| | | | (0.042) | (0.046) |
| State aid (dummy) * 2017 | | | -0.359*** | -0.318*** |
| | | | (0.041) | (0.049) |
| State aid (dummy) * 2018 | | | -0.434*** | -0.384*** |
| | | | (0.037) | (0.046) |
| State aid (dummy) * 2019 | | | -0.506*** | -0.451*** |
| | | | (0.035) | (0.048) |
| Level of coverage in neigbor t-1 | 0.378*** | 0.489*** | 0.381*** | 0.451*** |
| | (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 initiative | 0.063** | 0.108*** | 0.065** | 0.093*** |
| | (0.030) | (0.033) | (0.031) | (0.032) |
| Mixed initiative | 0.073 | 0.135** | 0.076 | 0.115* |
| | (0.058) | (0.058) | (0.059) | (0.059) |
| *[Continues...]* | | | | |
| Department dummies | Yes | Yes | Yes | Yes |
| Year dummies | Yes | Yes | Yes | Yes |
| Constant | 0.758** | 0.603 | 0.769** | 0.670* |
| | (0.364) | (0.385) | (0.364) | (0.382) |
| Observations | 81,616 | 81,616 | 81,616 | 81,616 |
| Adjusted R-squared | 0.289 | 0.291 | 0.296 | 0.297 |

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

# Results - Deployment model (2/3)

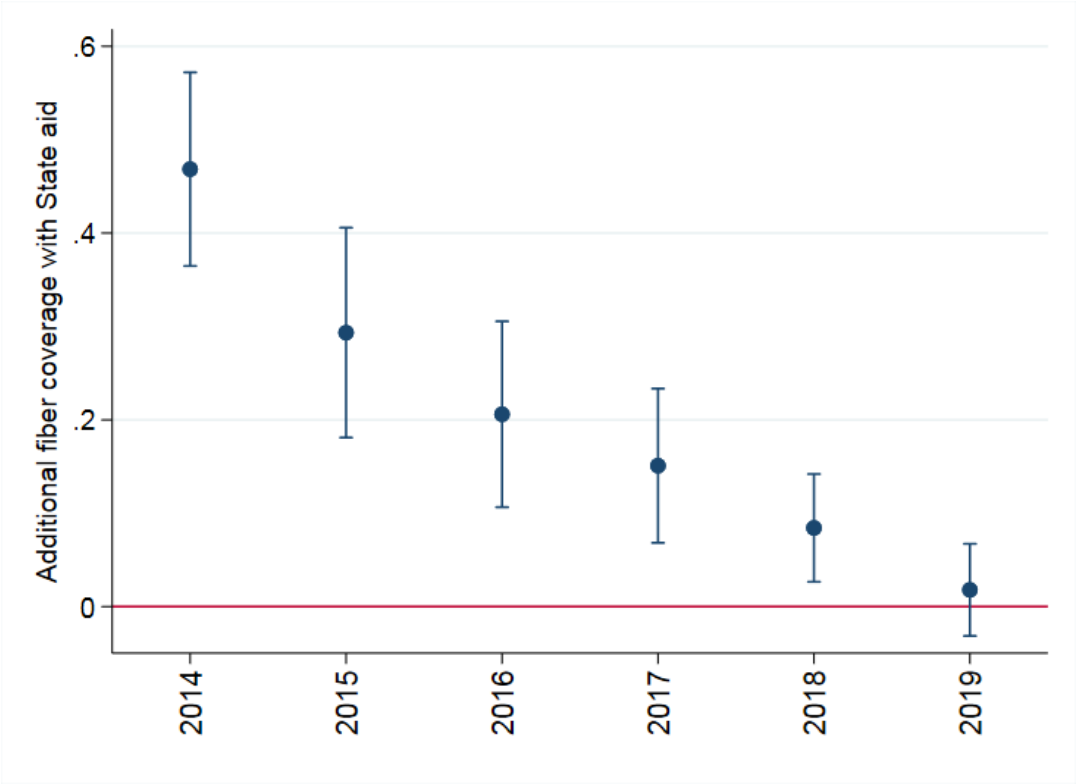
**Table:** Fiber coverage in municipalities (2/2)

| *Dep. Var: Fiber coverage rate* | (1) OLS | (2) Heckman | (3) OLS | (4) Heckman |
|---|---|---|---|---|
| *[Continuation]]* | | | | |
| *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*** | 0.072*** | 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 | 0.154*** | 0.156*** | 0.155*** | 0.156*** |
| | (0.030) | (0.030) | (0.030) | (0.030) |
| *Year dummies (ref 2014)* | | | | |
| y2015 | 0.052*** | 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*** | 0.112*** | 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) |
| Mills ratio | | 0.050*** | | 0.032** |
| | | (0.017) | | (0.016) |
| Department dummies | Yes | Yes | Yes | Yes |
| Constant | 0.758** | 0.603 | 0.769** | 0.670* |
| | (0.364) | (0.385) | (0.364) | (0.382) |
| Observations | 81,616 | 81,616 | 81,616 | 81,616 |
| Adjusted R-squared | 0.289 | 0.291 | 0.296 | 0.297 |

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

# Results - Deployment model (3/3)

**Figure:** Evolution of the impact of State aid on fiber coverage.




*Note:* Estimates from column (4) in the previous slide 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 additional 29% coverage with respect to non-aided municipalities. The vertical lines represent the confidence intervals at 95%.

# Conclusions

- We evaluate the efficiency of State aid granted through the French Broadband Plan.
- The entry of fibre networks is determined by demand and cost factors, where entry thresholds decrease over time.
- Strong geographic dependence in fiber entry and a replacement effect from the legacy copper network in fiber entry decisions.
- The State aid was in general successful in covering areas that would not have been covered otherwise (around 64% to 93% of municipalities).
- Enabled earlier entry in some municipalities (at the cost of some crowding out).
- Has allowed higher FTTH coverage rates in aided municipalities (in particular at the beginning of the period).