Valuing the Virtual: The Impact of Fiber to the Home (FTTH) on Property Prices in France

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PRELIMINARY DRAFT

Abstract

This paper examines the value that households place on broadband internet access, explicitly focusing on the impact of eligibility for Fiber to the Home (FTTH) technology on property prices. Using a Spatial Discontinuity Design based on the border of fiber eligibility zones which have significantly expanded under France's Plan *Très Haut-Débit*, I find that FTTH eligibility is a significant determinant of property prices, with an average increase of 1.4 percent (2.2 percent for houses). I also consider heterogeneities in FTTH valuation based on socioeconomic characteristics, local factors and income levels. These findings highlight the growing importance of fast and reliable Internet access for households and have important implications for policymakers and Internet service providers.

JEL Classification: L96 ; R31 ; R38

Keywords: Telecommunication ; Broadband Internet ; FTTH ; Impact Evaluation ; Regression Discontinuity Design ; Hedonic Price ; House market

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Introduction

The *France Très-Haut Débit* (THD) Plan was unveiled by the French government on February 20, 2013[1]. The strategy to achieve the objective of covering the entire territory with very high-speed Internet[2] is largely based on the deployment of Fiber To The Home (FTTH) technology[3].

The installation of broadband telecom infrastructure, similar to major public amenities such as high-speed train networks and highways, can have positive effects on economic wealth and activity (Czernich et al. 2011; Kolko 2012; Briglauer and Gugler 2019). These infrastructure investments can lead to agglomeration effects that benefit economic actors (Clercq, D'Haese, and Buysse 2023), while their impact on economic inequality remains less clear (Forman, Goldfarb, and Greenstein 2012; Houngbonon and Liang 2021). Beyond the performance of copper networks that provide broadband Internet access, the deployment of fiber optic networks offers enhanced performance and ensures high-quality data transmission. Such advancements make it especially important to consider FTTH (Fiber To The Home) technology.

Indeed, FTTH is presented as a technology which is aimed at meeting both present and future demands for high-quality internet connectivity (Prat 2008). By providing ultra-high-speed access, FTTH technology contributes to the emergence of new content (streaming, online gaming, etc.), the reinforcement of certain practices (increased use of telecommuting, video conferencing, online commerce, cloud-based services, etc.), and the development of new tools (virtual and augmented reality, Internet of Things (IoT) connectivity, multi-device connectivity, etc.). As the rollout of ultra-high-speed Internet infrastructure progresses and while previous research has highlighted the significance of broadband access for households (Ahlfeldt, Koutroumpis, and Valletti 2017; Liu, Prince, and Wallsten 2018), the value of FTTH access and the potential benefits of assured network quality enabled by this telecom technology remain uncertain and require further investigation. Furthermore, understanding the degree of variation in how these infrastructures are valued is a key concern.

[1]The Very High-Speed Internet Plan is part of a European strategy -the Digital Agenda- which aims to provide all European citizens with access to a 30 Mb/s network.

[2]ARCEP (the French telecom regulator) defines several levels of quality of bandwidth: High speed: from 512 Kb/s to 29.99 Mb/s; Very High Speed: 30 Mb/s and beyond.

[3]The FTTH implies a connection by an optical fiber line from end to end to the user's home. It is the fixed technology that brings the best performance in terms of downstream and upstream speeds.

To address this research question, this study focuses on the case of France, which has made significant investments in FTTH network deployment. In an effort to bridge Europe's broadband penetration gap and accelerate the adoption of new-generation telecom technologies, the *Plan Très Haut-Débit* primarily relies on the deployment of optical fiber, which offers superior performance compared to xDSL technologies (with maximum speeds of up to 10Gbps and low latency). The objective is to generalize FTTH access throughout the country by 2025.

One method to estimate the value households place on infrastructure is through analyzing the housing market. In this research, we utilize a hedonic pricing model to estimate household valuations for enhanced broadband Internet access. Hedonic pricing models provide a means to determine the willingness to pay (WTP) for non-market goods, such as connectivity. This approach has been effectively employed in various scenarios, including estimating the perceived negative externalities of wind turbines on housing prices (Gibbons 2015; Dröes and Koster 2016; Jensen et al. 2018), as well as evaluating the effects of nuclear plants through hedonic pricing models (Ando, Dahlberg, and Engström 2017; Tanaka and Zabel 2018).

To deduce this households' willingness to pay for access to very high-speed Internet, I rely on an evaluation of the impact of the deployment of optical fiber networks in France within the context of the *France Très-Haut Débit* plan on the sale price of properties. Fiber optics is often considered as a sustainable improvement, this can lead to an increase in the value of the properties that benefit from it. This improvement may vary according to the basic copper network characteristics of the connected building, but also to the location characteristics of the sold property. ARCEP has made tools available on its website[4], in order to monitor the deployment of the FTTH network in France and to inform consumers about the technologies and speeds available at their addresses. Based on this French Open Access data, I was able to build a new database combining information on property transactions and information on the internet network and in particular FTTH eligibility for the whole of France since 2019. Using data on fiber eligibility at the level of each building collected by ARCEP, it is possible to reconstruct eligibility zones with the finest precision possible in Q2-2020[5]. In addition, a government database is available to collect all real estate transactions

[4]In the form of interactive maps at the following web address: https://maconnexioninternet.arcep.fr/.

[5]This quarter has been chosen in particular, because it's the start of a major update of fiber-eligible addresses as part of the "Ma connexion internet" tool. In this way, a reliable estimate can be made of the number of locations connected and to be connected. In addition, the data is dated 6 months after release, at the time of the study, which is

that have taken place, this information is associated with additional information on the property (selling price, characteristics on the type and size of the property ...).

To accurately estimate the valuation of FTTH by households, it is crucial to address several challenges in identifying the impact of fiber eligibility on housing prices. One key challenge is disentangling the effect of FTTH eligibility from other positive locational characteristics, such as accessibility to transportation, proximity to schools, or nearby parks. Additionally, the availability of FTTH is endogenous, meaning it is influenced by factors that also determine the demand for FTTH and are likely to be correlated with property prices, such as income levels and education levels.

To overcome these challenges, I leverage the progressive roll-out of FTTH and the construction of eligibility zones to determine the FTTH eligibility status of each property. The gradual deployment of FTTH infrastructure leads to variations in internet speed over time within a very small geographical area. Exploiting this discrete change in the eligibility boundary, I employ a Spatial Discontinuity Design as an identification strategy. This approach allows me to compare the house prices of two neighboring properties that are similar in terms of observable characteristics but differ in their FTTH eligibility status. By isolating the impact of FTTH eligibility in this manner, we can accurately evaluate its effect on property prices.

The results from our analysis reveal positive and significant price effects of FTTH eligibility across various models. On average, properties eligible for FTTH experience a remarkable 1.4% increase in price (2.2% for houses), highlighting the tangible benefits households perceive from upgraded broadband infrastructure. A “donut” Regression Discontinuity approach is employed to address concerns about non-random sorting around the eligibility threshold. To validate the causal impact of fiber eligibility and underscore the role of progressive deployment, I conduct a sensitivity analysis and a placebo test. The sensitivity analysis demonstrates the consistent positive coefficient associated with fiber eligibility across varying analysis windows, with the effect stabilizing at a range of 70 meters. Furthermore, the placebo test reveals no significant effect as the cut-off is shifted away from the actual eligibility boundary. These results further corroborate the causal relationship between FTTH eligibility and property prices.

why I have selected all the year 2019. https://www.arcep.fr/actualites/actualites-et-communiques/detail/n/marche-du-haut-et-du-tres-haut-debit-fixe-6.html, accessed April 2023

The study goes beyond property price analysis to explore heterogeneity in FTTH valuation. Subgroup regressions unveil variations in the magnitude and significance of the effect based on the rural or urban context of the commune where the property is located. The most substantial increase in FTTH valuation is observed in the most rural communes and medium-sized to large towns. In contrast, no significant effect is detected in the largest cities, where advanced FTTH deployment and other competing factors may diminish the impact. Additionally, the analysis reveals that the greatest increase in FTTH valuation occurs in the poorest deciles of towns, indicating the potential transformative power of fiber infrastructure in economically disadvantaged areas. These findings highlight the positive impact of FTTH eligibility on property prices, underscoring the significant value households attribute to enhanced broadband connectivity. It also reveals the importance of considering heterogeneities in FTTH valuation based on socioeconomic characteristics, local factors, income levels... These insights are valuable for policymakers and stakeholders involved in expanding FTTH coverage, particularly in rural and economically disadvantaged regions.

The remainder of this paper is organized as follows. Section 2 describes the data used in this study. Section 3 introduces the identification strategy. Section 4 presents the results. Section 5 concludes.

The french broadband infrastructure

Context

There are two main fixed-line broadband technologies that coexist in France today: xDSL, in particular ADSL (Asymmetric Digital Subscriber Line), and FTTH (Fiber to the Home). Primarily, there is a physical difference between these two technologies: one relies on the copper network deployed for fixed-line telephony, while FTTH uses end-to-end optical fiber between the optical connection node and the subscriber. This physical difference implies significant differences in characteristics and quality. The most important is the potential bandwidth that each of these technologies can deliver: ADSL bandwidths can range from 1 to 15 megabits per second, while FTTH bandwidths can vary from a minimum of 100 Mbps to 8 Gbps. FTTH can be seen as an improved version of ADSL, offering very high-speed access (when ADSL offers high-speed) and low signal attenuation, for a more stable connection. Fiber optics is therefore the medium that offers the best performance and scalability (**SOURCE**).

Because of its physical characteristics, based on the fixed telephone network, the ADSL network covers 99% of the country (30 million copper lines), so in the 2000s, most French households benefited from ADSL. But with the massive rollout of fiber optics as shown in Figure 1, by 2022 most Internet subscriptions will no longer be ADSL, but FTTH networks. In total, by the end of the 1st quarter of 2020, 25.2 million premises were eligible for very-high-speed services, all technologies combined, including 18.6 million outside very dense areas.

Driven by major public policies, two opposing trends are underway. On the one hand, the massive rollout of FTTH through the French ultra-high-speed broadband plan, and on the other, the decommissioning of copper and the dismantling of the copper network from 2023 by the incumbent operator, Orange[6]. In February 2013, the Government defined the "France Très Haut Débit" plan, which succeeds the national very high-speed broadband program launched in 2010. Among the 20 billion euros proposed by the State to develop access to very high-speed broadband for all, 3 billion euros in subsidies have been provided to support local authority projects led by Public Initiative Networks, with the aim of covering 100% of the population with broadband Internet (**avec encore une part importante d'autres technologies Internet**) by 2022. The goal was to achieve fiber connectivity for 80% of premises by 2022, and then to generalize FTTH access throughout the country by 2025. Notably, the number of premises eligible for fiber increased from 2.3 million in the fourth quarter of 2012 to 10.3 million in the fourth quarter of 2017. In 2020, a record year, 5.8 million premises became eligible for fiber connectivity[7]. As a result, fiber optic networks are gradually being rolled out across the country to form the reference network.

ARCEP plays a major role in the roll-out of fiber in France, and has defined 3 types of zone to divide the role between private operators and local authorities[8]: very dense zones, where private operators roll out their own network; relatively less dense zones, where operators show interest or join forces to roll out fiber; and lastly, less dense and less "profitable" zones, where the network is rolled out by local authorities, mobilizing public funding. Within this Plan Très haut débit, opera-

[6] https://www.arcep.fr/actualites/actualites-et-communiques/detail/n/fermeture-du-cuivre-290722.html, accessed June 2023

[7] https://www.amenagement-numerique.gouv.fr/fr/actualite/raccordements-ftth-etape-determinante-deploiements, accessed February 2023

[8] https://www.arcep.fr/nos-sujets/la-couverture-internet-fixe-a-haut-et-tres-haut-debit.html, accessed June 2023

tors have committed to respecting FTTH network deployment objectives, and the Government has entrusted the French regulatory authority for electronic communications, posts, and press distribution (ARCEP) with the task of monitoring compliance with these commitments and sanctioning any failures to do so[9]. This has led to the creation of tools such as "My Internet Connection" to regularly monitor premises that are not yet eligible for fiber.

The transition from copper to FTTH for high bandwidth and low latency has also been reflected in household preferences, with ultra-high-speed broadband enabling several additional uses[10], highlighting a significant trend in household preferences regarding broadband services. Some studies (Grzybowski and Liang 2015; Grzybowski, Hasbi, and Liang 2018) have concluded that consumer valuation of FTTH broadband experienced a consistent increase over time, while the attractiveness of ADSL relative to FTTH decreased significantly, both in relative terms and absolute terms. These results indicate a clear shift in consumer priorities, with an increasing emphasis on the speed of connection provided by FTTH. Households are placing greater importance on the ability of their internet connection to deliver high-speed performance, and FTTH is meeting these evolving expectations more effectively than ADSL.

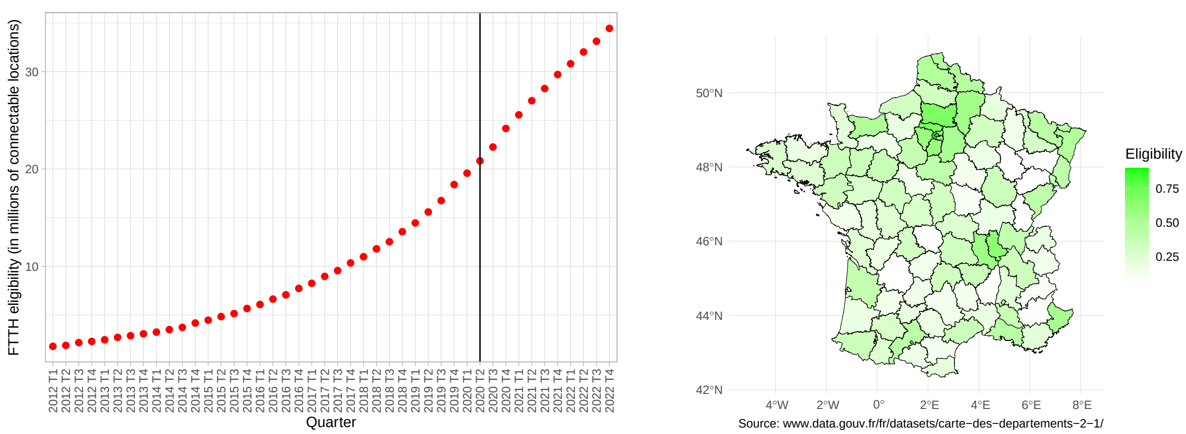


Figure 1

[9]In accordance with Article L.33-13 of the French Post and Electronic Communications Code.

[10]Ultra-fast download and upload speeds, seamless streaming and online gaming, multiple device connectivity, cloud-based services and storage, video conferencing and telecommuting, virtual and augmented reality (VR/AR), Internet of Things (IoT) connectivity

Data

To address the research question, a method was developed to integrate a comprehensive set of quarterly databases covering the period from Q2-2018 to Q4-2021 at the address level for the entire French metropolitan territory. This analysis encompasses 90 departments[11]. Figure 2 illustrates the included departments and the corresponding FTTH eligibility areas. The method involved merging two main datasets: one providing information on the broadband internet network at each address, and the other compiling all property transactions that occurred in France over the past 5 years. Since there was no common joining key available, the developed method played a crucial role in facilitating the merging process.

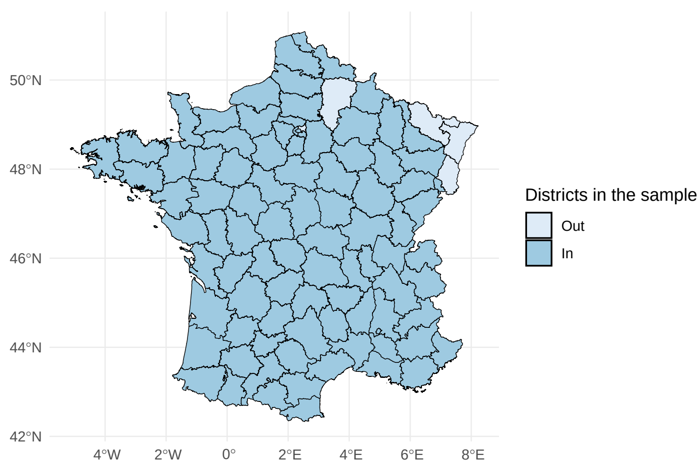
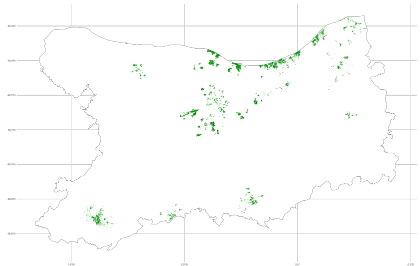


Figure 2: Districts in the sample

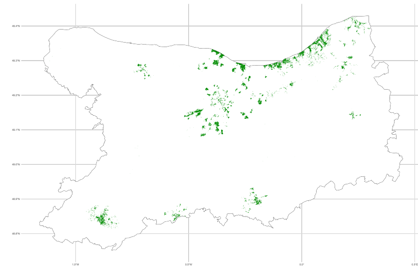
I specifically rely on the data files data sourced from the French telecom authority allowing the construction of FTTH deployment maps with precision at the building level for every quarter since the second quarter of 2018 as shown in Figure 3. These data were obtained from the "My Internet Connection" tool[12], which includes two sub-databases: one listing all addresses (the building database), and the other associating building identifiers with network characteristics such as internet speeds, fiber eligibility, and operators offering these technologies.

To achieve the first research objective of merging fiber eligibility data with geospatial data sources, several steps were undertaken, as depicted in Figure 4. By utilizing the fiber eligibility files, the

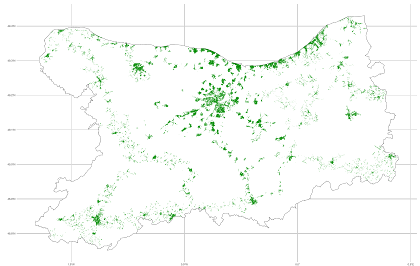
[11]Excluding certain departments due to their exclusion from the DVF database or flaws in the ARCEP database
[12]https://maconnexioninternet.arcep.fr/, accessed January 2023



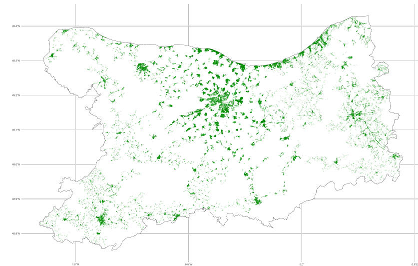
(1) Q2-2018



(2) Q2-2019



(3) Q2-2020



(4) Q2-2021

Figure 3: Evolution of FTTH eligibility zones in the Calvados district (14) between Q2-2018 and Q2-2021.

FTTH deployment history at the building level was reconstructed, using geospatial objects[13], and constructing Voronoi polygons limited by a 30m radius around each GPS point. The Voronoi diagrams allowed the division of space into cells based on the proximity to each seed point, enabling the determination of the FTTH eligibility area for each quarter. These polygons were then aggregated to obtain the complete map of FTTH eligibility zones in 2020Q2.

The second dataset used was the “Demande de Valeurs Foncières” (Land Value Request) database, which is published and produced by the French General Directorate of Public Finance. This database provides information on property transactions that occurred in metropolitan France over the last five years, including transaction prices and property characteristics. The eligibility status of an address in a given quarter was determined based on whether the very high-speed internet connection capacities had been effectively deployed or if an agreement had been signed[14] by projecting coordinates of the transactions from the “Demande de Valeurs Foncières” database that occured in 2019 onto the FTTH eligibility area in Q2-2020. This comprehensive merging method resulted in a unique dataset that indicates the fiber eligibility status of each property at the time of the transaction and the distance to the nearest eligibility boundary.

To incorporate additional situational feature variables that impact property prices, the “OpenStreetMap” databases at the department level were utilized. These databases contain various geographical information, such as data on roads, footpaths, cafés, railway stations, and points of interest. Three map files were utilized: “points.shp” for calculating the distance to the nearest school, “buildings.shp” for deducing the proximity to a railway station, and “natural.shp” for calculating the distance to the nearest park. Furthermore, information at the commune level was added for heterogeneity analyses, based on indicators provided by INSEE for the year 2016[15]. Two variables were used: average income at the commune level and the degree of urbanity. Basic descriptive statistics of the variables used in the analysis by treatment group are provided in Table 6 in the Appendix.

[13]For all the map processing functions, we use the package sf and the package “qgisprocess” which allows the use of the commands of the software QGIS (Open Source geographic information system) with the interface R.

[14]The other properties including the buildings “connectable on demand”, “in the process of being connected” or “targeted for future deployments” are considered as non-eligible.

[15]https://www.data.gouv.fr/fr/datasets/data-insee-sur-les-communes/, accessed May 2023

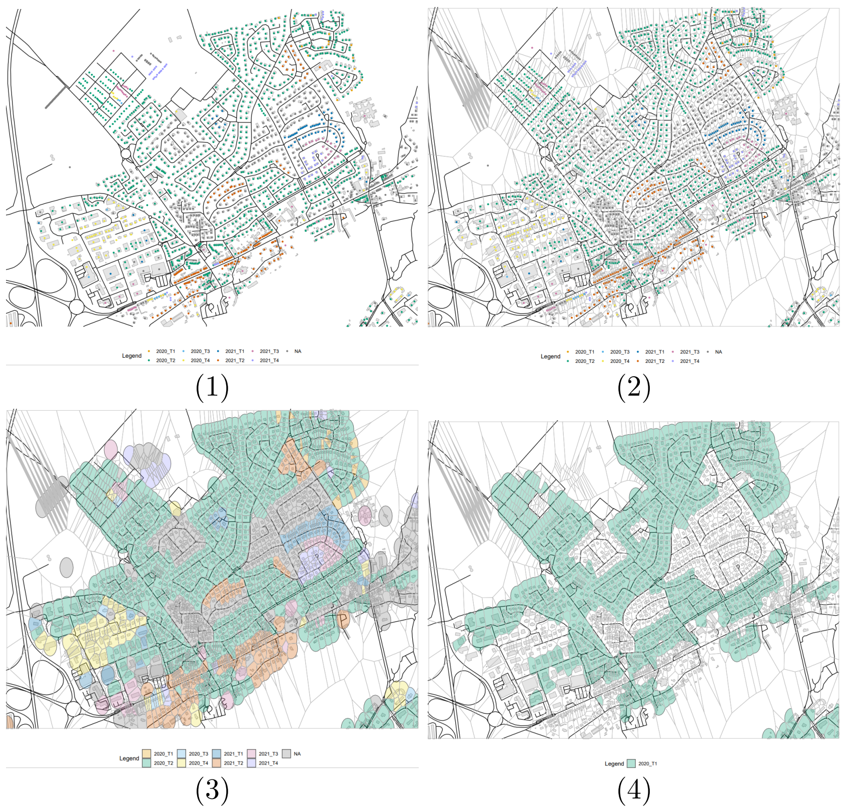


Figure 4: Method for constructing FTTH eligibility boundaries.

Methodology

Spatial Discontinuity Design

Measuring the effect of fiber eligibility on housing prices presents several challenges. The objective of our methodology is to isolate the impact of fiber eligibility from other factors that affect property prices and may be unobserved but correlated with FTTH eligibility. Additionally, endogeneity may arise due to the interplay between FTTH eligibility and factors influencing broadband demand, potentially leading to correlations with property prices.

To address these challenges, the methodology employs a spatial discontinuity design based on fiber eligibility zones to evaluate the effect of FTTH eligibility on property prices. The FTTH connection represents a discrete change that allows properties to access higher-quality internet connectivity. Since the assignment rule is deterministic, this spatial discontinuity design adopts a sharp approach where the treatment probability (optic fiber eligibility of the property) changes from 0 to 1 at the eligibility cutoff.

The spatial discontinuity design combines elements of both quasi-experimental and randomized experimental methods. In the spatial discontinuity framework, treatment assignment is non-random but determined by a covariate's value on either side of a threshold—the eligibility boundary in this case. Additionally, this spatial discontinuity approach mimics the essence of a randomized experiment at a localized level (Bertanha and Imbens 2020; Chaplin et al. 2018). The discontinuity regression aims to compare housing prices on opposite sides of the eligibility boundary, leveraging the naturally occurring variation near the boundary. The running variable is the distance from the FTTH deployment boundary at the time of the study. By focusing on observations in close proximity to the FTTH deployment boundary, a non-parametric estimation approach is employed, using a naive and arbitrary distance (e.g., 79 meters for the baseline estimates) to select relevant observations.

Since the eligibility zone expands over time, the variation in potential internet speeds generated by fiber eligibility on both sides of the eligibility boundary, during the deployment period, can be considered exogenous and treated as if it were randomly assigned.

The FTTH connection is established at the individual house level, introducing a characteristic that affects the property. Building on the assumption made by (Ahlfeldt, Koutroumpis, and Valletti 2017), the hypothesis is that the change in housing prices reflects the value associated with access to faster internet technology, specifically FTTH. An hedonic price model (Rosen 1974) is employed, which assumes that the price of a property is determined by its specific characteristics (e.g., size, garden) and its location-related attributes (e.g., distance to the nearest train station, school…). The hedonic price regression allows for the separation of various determinants of house prices, facilitating the measurement of the impact of FTTH eligibility on property prices.

The empirical specifications employed in this study aim to model the (log) price of properties sold at full postcode i and time t, associated with boundary j, using the following equation:

$$Y_{ijt} = \alpha + \beta FTTH_{ij} + \delta X_i + \gamma_t + \mu_i + \eta_j + \epsilon_{ijt} \quad (1)$$

Here, Y_{ijt} represents the log price of the property at postcode i and time t associated with boundary j. The variable $FTTH_{ij}$ is a binary indicator that signifies whether the property sold in postcode i associated with boundary j falls within the FTTH "eligible" zone (at the time of the study). The vector X_i consists of observed property and location characteristics (such as the number of rooms, building area, lot size, distance from the nearest school, distance from the nearest train station, and distance from the nearest park). The term γ_t represents time fixed-effects (quarterly), while μ_i accounts for unobserved time-invariant effects at the postcode level. The variable η_j captures the effect of proximity to the nearest boundary j of FTTH deployment at the time of the study. Lastly, ϵ_{ijt} denotes the error term.

To summarize, this specification encompasses the logarithm of property price as a function of FTTH eligibility, along with a range of partially observed and unobserved internal property characteristics. Employing a non-parametric approach, the analysis focuses on properties located within a close proximity to the deployment boundary, explicitly leveraging the spatial discontinuities in FTTH eligibility and their impact on bandwidth speed. By employing this methodology, I aim to attribute differences in price changes across a common boundary to the fiber eligibility status of the properties.

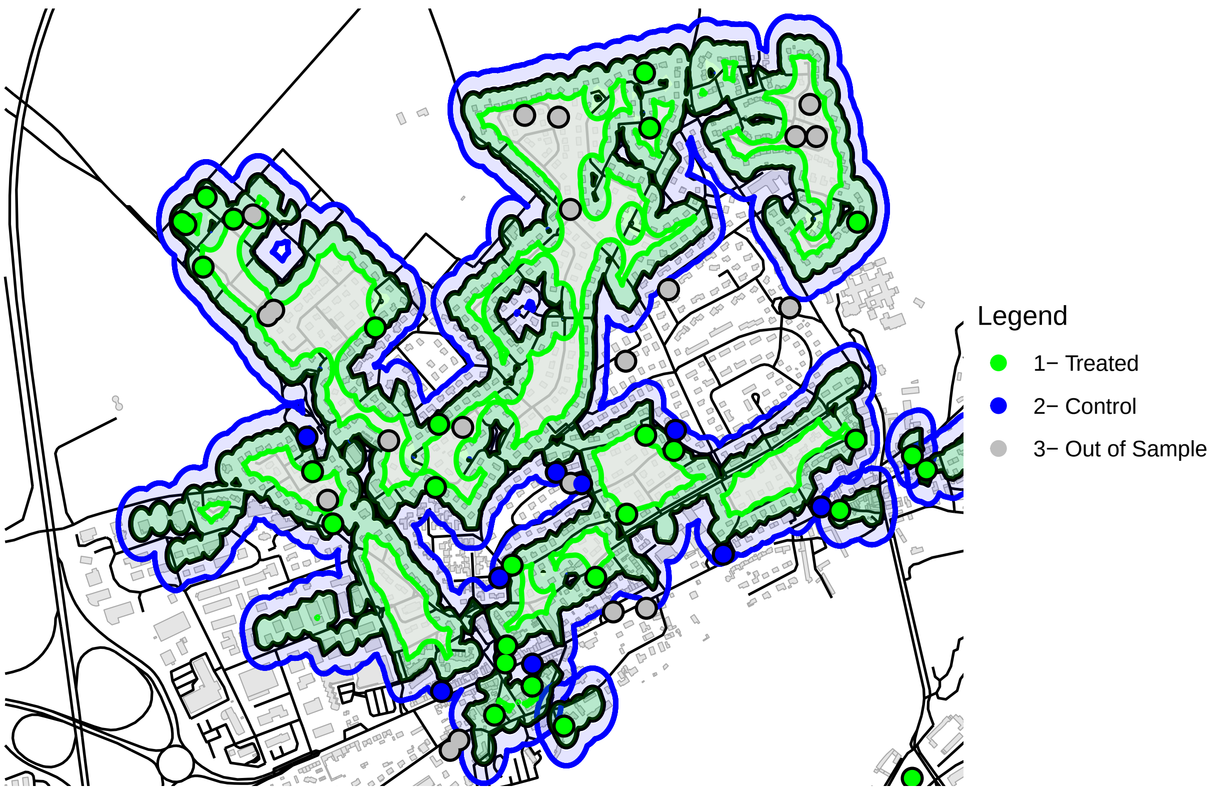


Figure 5: Map illustrating the methodology - Focus on eligibility zone in Bretteville-sur-Odon (14760).

Figure 5 provides a visual representation of the methodology employed and the sample selection process. The green areas indicate the fiber-eligible zones during Q2-2020, while the black line represents the deployment frontier or the cut-off point. To determine whether an observation is treated, we consider real estate sales of houses or apartments from Q1-2019 to Q4-2019 that fall within these green zones. The control group consists of sales outside these green zones. Therefore, the selection of observations for the non-parametric regression estimation is based on their distance to the deployment frontier (black line). On the treated side (highlighted green zone), only observations within 35 meters from the boundary are selected for the main regression. Similarly, on the control side, only observations within 35 meters are retained (represented by the blue area). Observations that are not selected appear in grey. The "boundary" fixed effect is determined by the closest zone boundary to each observation.

Because, the Regression Discontinuity Design (RDD) aims to compare means as the estimates approach the treatment threshold on either side, it is important that the estimates are not sensitive to observations precisely at the threshold (Almond et al. 2011). To address the potential concern of non-random sorting around the threshold, I employ a Donut Regression Discontinuity estimation (Barreca et al. 2011). This involves removing observations in the immediate proximity of the FTTH boundary, acknowledging the possibility that properties at the frontier may differ systematically from surrounding observations. Hence, all observations ranging from 0 to 7 meters, both above and below the threshold, were excluded from the analysis.

Moreover, this RDD "donut" method tackles a second concern related to the method for determining treatment based on maps. It is likely that the eligibility of a dwelling at the border is not entirely accurate. In other words, there is a possibility that properties sold, whose geographical projection comes from the DVF database, and are close to the fiber deployment boundary may not be assigned to the correct group (treatment or control). To mitigate this, I ensure that there are no treated properties in the control group and vice versa.

Validity of the Regression Discontinuity Identifying Assumptions

Before conducting a discontinuity regression, several assumptions need to be considered to ensure the validity of the analysis. First, it is assumed that observations can only transition from the control group to the treatment group and not vice versa. This means that once a house becomes eligible for optic fiber, it remains in the treatment group and cannot change its eligibility status.

Secondly, all relevant variables, except the treatment variable, should exhibit smooth variation at the eligibility frontier. This implies that the potential outcomes of variables other than the treatment between the treatment and control groups must be continuous at the discontinuity threshold. This assumption is crucial to ensure that observations just outside the eligibility zone serve as appropriate counterfactuals for observations just inside the zone.

Table 1: Table of Comparison of Prices and Other Characteristics of the Properties In the Eligible and Non-eligible zones

	Whole sample			Within 35m of boundary		
	Non-Eligible	Eligible	SE	Non-Eligible	Eligible	SE
	(1)	(2)	(3)	(4)	(5)	(6)
Log(price)	11.822	12.055	(0.085)***	11.897	12.099	(0.079)**
House	0.663	0.427	(0.053)***	0.341	0.323	(0.038)
Number of rooms	3.570	3.435	(0.099)	3.136	3.248	(0.08)
Number of m2	83.775	76.725	(2.331)***	70.407	72.313	(1.567)
Distance Train	10.641	4.406	(0.788)***	4.517	3.303	(0.328)***
Distance School	2.849	1.272	(0.201)***	1.114	0.899	(0.076)***
Distance Park	2.888	0.927	(0.224)***	0.659	0.524	(0.043)***

Note: For the three first columns, all properties are considered. For the three last columns, only properties between 7 meters and 35 meters are selected.

The validity of the design is assessed in Table 1, which examines dwelling properties and situational characteristics on each side of the FTTH eligibility boundary. The table also investigates how the log of the selling price varies across the boundary. Columns (1) and (4) present the mean values for properties sold within FTTH eligibility boundary areas, considering the whole sample and a bandwidth of 35m, respectively[16]. Columns (2) and (5) provide the mean values for properties in non-eligible areas within the same setup. Columns (3) and (6) display the clustered standard error of the difference in means between FTTH eligible and non-eligible properties.

The results reveal that the differences in the log of the selling price remain statistically significant when a bandwidth is assigned. However, it is important to note that most differences in the own

[16] To ensure accurate eligibility classification, properties sold within a distance of 7 meters from the boundary were excluded from the analysis.

characteristics of properties become relatively small and statistically insignificant as the bandwidth decreases. The only variables that consistently maintain significant differences across the boundary are the locational variables (distance from the school, train station and park), likely due to their proximity to the city center. All these variables are taken into account in the estimated hedonic price model.

Furthermore, according to this RDD assumption, the variables describing the number of rooms, the building and land area of the dwelling in square meters show no significant jumps at the frontier, as depicted in Figure 7. This suggests that these covariates exhibit a continuity at the threshold, further supporting the presence of a discontinuity only in the treatment variable (fiber eligibility) and the primary outcome (the log of the sale price). The RDD assumption assumes that variables other than the treatment and main outcome remain continuous at the threshold, and the observed continuity of these covariates reinforces this assumption. But, even though the jump is "small" (a few metres), we can see a small discontinuity in the situational variables, showing that the areas connected to fiber as a priority are those closest to city centers.

Results

Graphical Analysis

To initiate the analysis, a graphical examination is conducted to explore the relationship between property prices and FTTH eligibility. RD plots are utilized as a visual tool to assess the potential impact of FTTH eligibility on property prices. In Figure 6, a discontinuity regression graph is presented, where the x-axis represents the distance from the boundary. Positive values indicate the treated side, while negative values indicate the control side. The boundary is depicted by the vertical bar at 0. On the y-axis, the logarithm of the property price is displayed. The red trend lines represent the predicted values derived from a linear regression of the outcome variable on the distance to the boundary. The RD plot clearly demonstrates a distinct jump in the mean price of properties located within a narrow window around the eligibility threshold in the eligibility zone. This observation suggests a notable impact of FTTH eligibility on property prices.

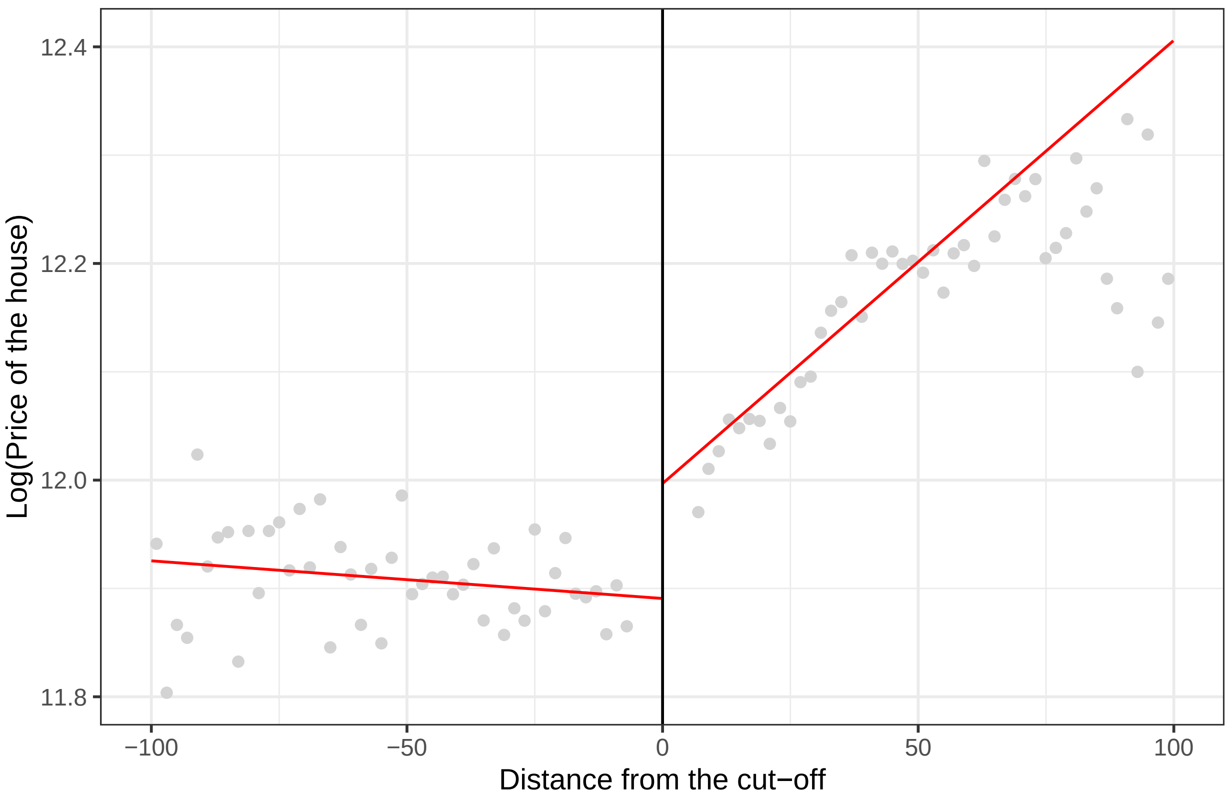


Figure 6: This figure illustrates the spatial discontinuities in property prices based on FTTH eligibility. Negative distances indicate locations within the boundary segment that are not eligible for Fiber to the Home (FTTH) technology. The dots represent the mean transaction prices within 5-meter distance bins.

The Impact of FTTH eligibility on Property Prices

We can empirically address the hypothesis that households place a positive value on access to optic fiber, expecting an impact of optic fiber eligibility on property prices. Table 2 presents the results of estimating the model described by equation (1), considering all properties in columns (1) and (2) and house sales only in columns (3) and (4). The average effect of optic fiber eligibility is estimated for the entire sample in columns (1) and (3), while columns (2) and (4), use a non-parametric estimation with a bandwidth of 35 meters, including controls in each specification. Controls include property characteristics (a dummy variable indicating whether the property is a house or not; the number of rooms; the building_area in square meters and the size of the garden for houses regressions), and location factors (the distance to the nearest train station; the distance to the nearest school and the distance to the nearest park).

Table 2: Pricing results

	Log(price)			
	All Sales		House Sales Only	
	(1)	(2)	(3)	(4)
FTTH	0.018***	0.012***	0.041***	0.022***
	(0.004)	(0.004)	(0.003)	(0.005)
Num.Obs.	737024	234810	373428	71881
R2	0.629	0.674	0.642	0.771
FE: postalcode	X	X	X	X
FE: quarter	X	X	X	X
FE: Boundary		X		X

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Across all models, positive and significant price effects of FTTH eligibility are found. The initial findings suggest that, on average, the price of FTTH "eligible" properties is 1.4% and 2.2% higher, confirming the results of Ahlfeldt, Koutroumpis, and Valletti (2017) who compared ADSL and ADSL+ connections. This implies a 1.4% increase in property prices, which amounts to €3,431 for a property valued at €245,086, the average selling price within the sample (which includes only sold properties between Q1-2019 and Q4-2019).

Table 3: Pricing results

	Log(price)			
	(1)	(2)	(3)	(4)
FTTH	0.018***	0.014***	0.040***	0.023***
	(0.004)	(0.004)	(0.003)	(0.005)
bad_ADSL	0.019***	0.005	0.007	-0.017
	(0.005)	(0.015)	(0.006)	(0.016)
FTTH × bad_ADSL	-0.003	0.000	0.013**	0.029*
	(0.007)	(0.014)	(0.006)	(0.015)
Num.Obs.	733101	232930	372770	71516
R2	0.629	0.675	0.642	0.772
RMSE	0.49	0.47	0.47	0.33
FE: postalcode	X	X	X	X
FE: quarter	X	X	X	X
FE: Boundary		X		X

* p < 0.1, ** p < 0.05, *** p < 0.01

Robusteness

I conduct some further checks to reassure that broadband speed does, indeed, cause an increase in property prices. To validate the positive and significant effect of FTTH eligibility on housing prices, a sensitivity analysis was conducted. Figure 8 illustrates the variation of the coefficient associated with fiber eligibility on real estate transaction prices, by adjusting the analysis window from 35m to 200m in one-meter increments. This involves selecting only observations within a buffer zone on both sides of the eligibility boundary. Remarkably, the coefficient remains consistently positive and significant, stabilizing at a range of 75m.

To further examine the causal impact of fiber eligibility and demonstrate that the observed effect is likely due to the progressive deployment of fiber, a placebo test was conducted. Figure 9 demonstrates the results obtained by shifting the cut-off on both sides of the border and performing the same estimation procedure, but this time assigning either a false treatment or a false control group. It can be observed that as we move away from the actual cut-off, no significant effect is observed.

While our results are robust to various tests and suggest a causal relationship between fiber eligibility and property prices, it is important to avoid generalizing these findings beyond the determined buffer zone.

Heterogeneity analysis

The valuation of FTTH (Fiber-to-the-Home) by households can vary depending on the socioeconomic characteristics of the cities or areas in which they are located. However, local characteristics also play a significant role in shaping FTTH valuation. To examine the heterogeneous effects, subgroup regressions were conducted, revealing variations in both effect size and significance level depending on the context.

Table 4: Pricing results by Urban-Rural Subsamples

	Log(price)					
	(1)	(2)	(3)	(4)	(5)	(6)
FTTH	0.037*	0.017	0.033***	-0.001	0.017***	0.027
	(0.021)	(0.013)	(0.011)	(0.007)	(0.006)	(0.017)
Num.Obs.	4776	10259	24717	46222	118591	30245
R2	0.684	0.670	0.678	0.707	0.699	0.375
FE: Boundary	X	X	X	X	X	X
FE: postalcode	X	X	X	X	X	X
FE: quarter	X	X	X	X	X	X

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In order to analyze the impact of FTTH eligibility across different areas, the sample was divided into six sub-groups based on the degree of rurality or urbanity of the commune where the property was sold. In Table 4, regression models were estimated for each sub-group: (1) rural communes, (2) communes with less than 10000 inhabitants, (3) communes with less than 50000 inhabitants, (4) communes with less than 200000 inhabitants, (5) communes with more than 200000 inhabitants, and (6) the three largest cities in France (Paris, Lyon, and Marseille). The results indicate that the effect of fiber eligibility is significant and positive in two main categories of communes: the most rural communes and medium-sized to large towns. The coefficient magnitude is highest for the most rural communes, suggesting that once eligible for FTTH, the value of dwellings in these areas increases significantly. It is likely that in less densely populated areas, the costs of FTTH roll-out are higher, making eligible properties in rural communes more valuable. Conversely, in the biggest cities, no significant effect is detected for two reasons. Firstly, the deployment of FTTH may be highly advanced, questioning the quality of the control group as a counterfactual. Secondly, in these tightly competitive markets, other factors may take precedence over FTTH connection, and households may find their existing ADSL connection sufficient (explaining a smaller R2). Among the urban communes (small to large), the coefficient is most significant for the group of large cities, indicating that access to fiber is an important issue for urban households. The finding that households in the most rural communes place a high value on fiber highlights the importance of public authorities in deploying FTTH infrastructure in these areas (Clercq, D'Haese, and Buysse 2023).

Table 5: Pricing results by Revenue Deciles

	Log(price)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FTTH	0.031**	0.000	0.027**	0.025*	0.016	0.022*	0.027	0.001	-0.004	-0.013
	(0.013)	(0.011)	(0.013)	(0.015)	(0.014)	(0.011)	(0.019)	(0.009)	(0.011)	(0.010)
Num.Obs.	15398	20226	20440	18908	13366	24958	24433	18899	20499	27438
R2	0.613	0.705	0.703	0.700	0.757	0.695	0.686	0.683	0.723	0.713
FE: Boundary	X	X	X	X	X	X	X	X	X	X
FE: postalcode	X	X	X	X	X	X	X	X	X	X
FE: quarter	X	X	X	X	X	X	X	X	X	X

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Furthermore, the analysis in Table 5 reveals that the greatest increase in FTTH valuation is observed not in the richest decile of towns but in the poorest decile. In poorer cities or areas, access to reliable and high-speed internet infrastructure, such as FTTH, may be relatively limited compared to wealthier cities. As a result, the presence of FTTH can be perceived as a valuable asset, providing faster and more stable internet connectivity. In areas where reliable internet access is scarce, the demand for FTTH is likely to be higher, leading to a higher valuation by households. Additionally, the perceived value of FTTH in terms of its potential impact on economic opportunities may be higher in poorer cities, as the presence of FTTH infrastructure can act as a catalyst for economic development, attracting businesses, facilitating remote work, improving access to online education and training, and enhancing overall economic prospects.

In conclusion, the valuation of FTTH by households exhibits variations based on the socioeconomic characteristics of the cities or areas, local factors and income levels. Understanding these heterogeneities is crucial for policymakers and stakeholders involved in the deployment of FTTH infrastructure, as it helps identify areas with higher demand and underscores the importance of public support for expanding FTTH coverage, particularly in rural and economically disadvantaged regions.

Conclusion and Policy Implications

We can draw several conclusions regarding the impact of FTTH eligibility on property prices and its heterogeneity across different contexts. Fiber eligibility appears to be an important determinant of property prices. Thus it appears that fiber eligibility has a significant and positive effect on the transaction price of a house. On average, FTTH "eligible" properties were found to have higher prices, indicating that households place a strong value on access to optic fiber. The analysis of effect heterogeneity is also essential. The impact appears to be relatively stronger in the most rural communes and medium-sized to large towns, where the increase in property value upon FTTH eligibility is more pronounced.

These findings have policy implications. Policymakers should focus on expanding FTTH coverage in rural and poor regions, as these areas exhibit higher demand and potential economic benefits from improved internet connectivity. Public support and investment are crucial to ensure equal access to FTTH infrastructure and bridge the digital divide. Policymakers should also consider the local context and tailor their strategies accordingly. The impact of FTTH may vary depending on the degree of rurality or urbanity, income levels, and the stage of FTTH deployment. Understanding these heterogeneities is essential for effective decision-making and resource allocation for future investment and growth potential. By understanding these dynamics and considering the policy implications, policymakers can make informed decisions to promote the deployment of FTTH infrastructure, foster economic growth, and enhance the overall well-being of communities.

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Appendix

Table 6: Descriptive Statistics

	0	1	Overall
	(N=365469)	(N=371580)	(N=737049)
Log(Price)			
Mean (SD)	11.8 (0.794)	12.0 (0.792)	11.9 (0.801)
Median [Min, Max]	11.9 [0.693, 19.8]	12.0 [0.693, 17.8]	12.0 [0.693, 19.8]
House			
Mean (SD)	0.655 (0.475)	0.420 (0.494)	0.537 (0.499)
Median [Min, Max]	1.00 [0, 1.00]	0 [0, 1.00]	1.00 [0, 1.00]
Number of rooms			
Mean (SD)	3.55 (1.52)	3.41 (1.48)	3.48 (1.50)
Median [Min, Max]	4.00 [1.00, 67.0]	3.00 [1.00, 56.0]	3.00 [1.00, 67.0]
Building area			
Mean (SD)	83.3 (42.1)	76.2 (37.8)	79.7 (40.1)
Median [Min, Max]	79.0 [9.00, 800]	72.0 [9.00, 820]	75.0 [9.00, 820]
Distance from train station			
Mean (SD)	10.5 (11.0)	4.38 (6.65)	7.43 (9.56)
Median [Min, Max]	7.07 [0, 90.8]	1.87 [0.00713, 76.4]	3.09 [0, 90.8]
Distance from school			
Mean (SD)	2.82 (3.35)	1.26 (1.91)	2.03 (2.83)
Median [Min, Max]	1.37 [0.00152, 33.7]	0.566 [0.000334, 32.0]	0.781 [0.000334, 33.7]
Distance from Park			
Mean (SD)	2.85 (3.76)	0.910 (1.78)	1.87 (3.09)
Median [Min, Max]	0.987 [0, 37.8]	0.323 [0, 26.0]	0.485 [0, 37.8]
Quarter			
2019/01	79058 (21.6%)	81216 (21.9%)	160274 (21.7%)
2019/02	86876 (23.8%)	90449 (24.3%)	177325 (24.1%)
2019/03	102107 (27.9%)	105754 (28.5%)	207861 (28.2%)
2019/04	97428 (26.7%)	94161 (25.3%)	191589 (26.0%)
2020/01	0 (0%)	0 (0%)	0 (0%)

Note:

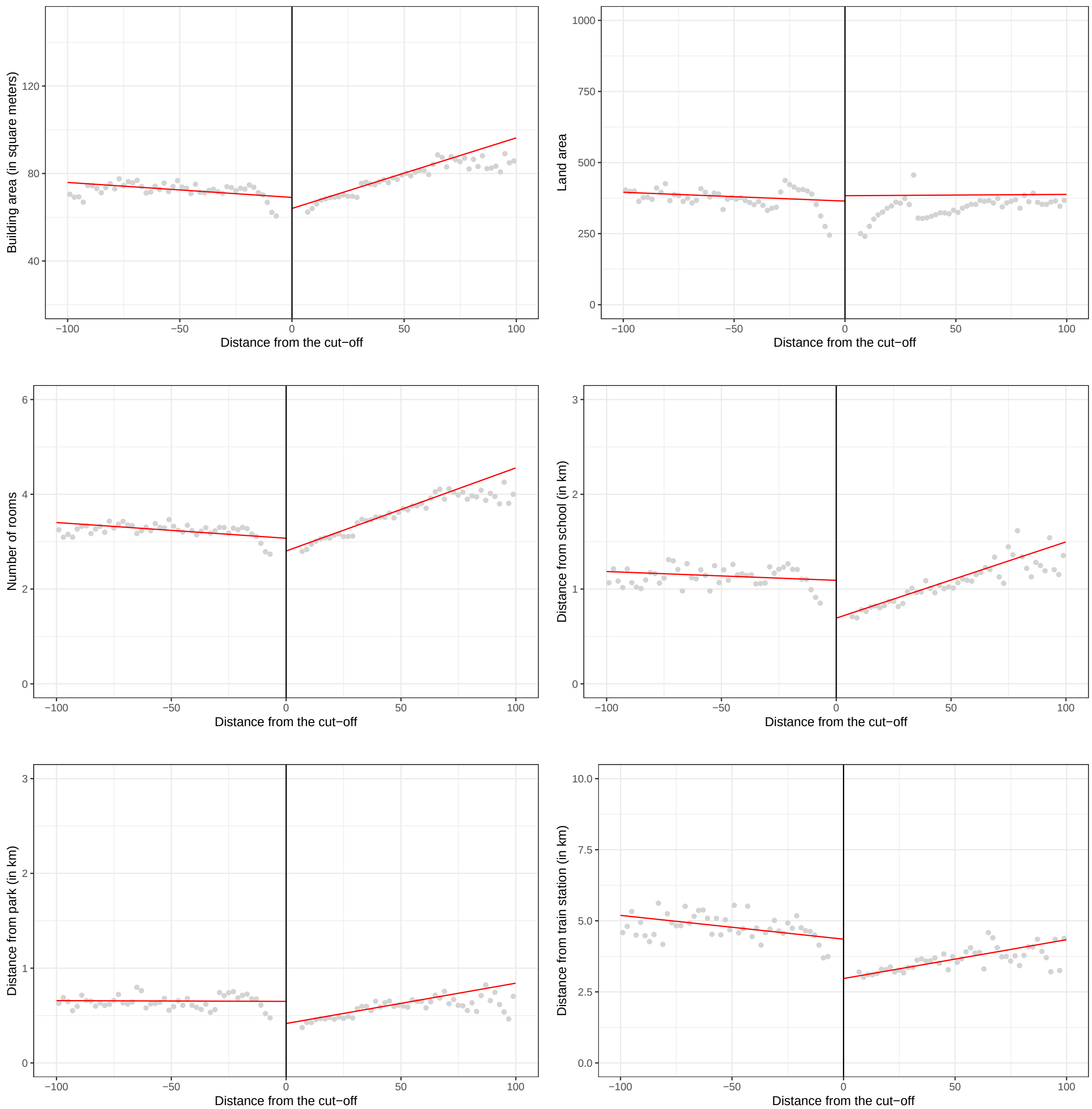

Figure 7: This figure illustrates the spatial discontinuities in property covariates (building and land area, number of rooms and distance from the nearest school) based on FTTH eligibility. Negative distances indicate locations within the boundary segment that are not eligible for Fiber to the Home (FTTH) technology. The dots represent the mean transaction prices within 5-meter distance bins.

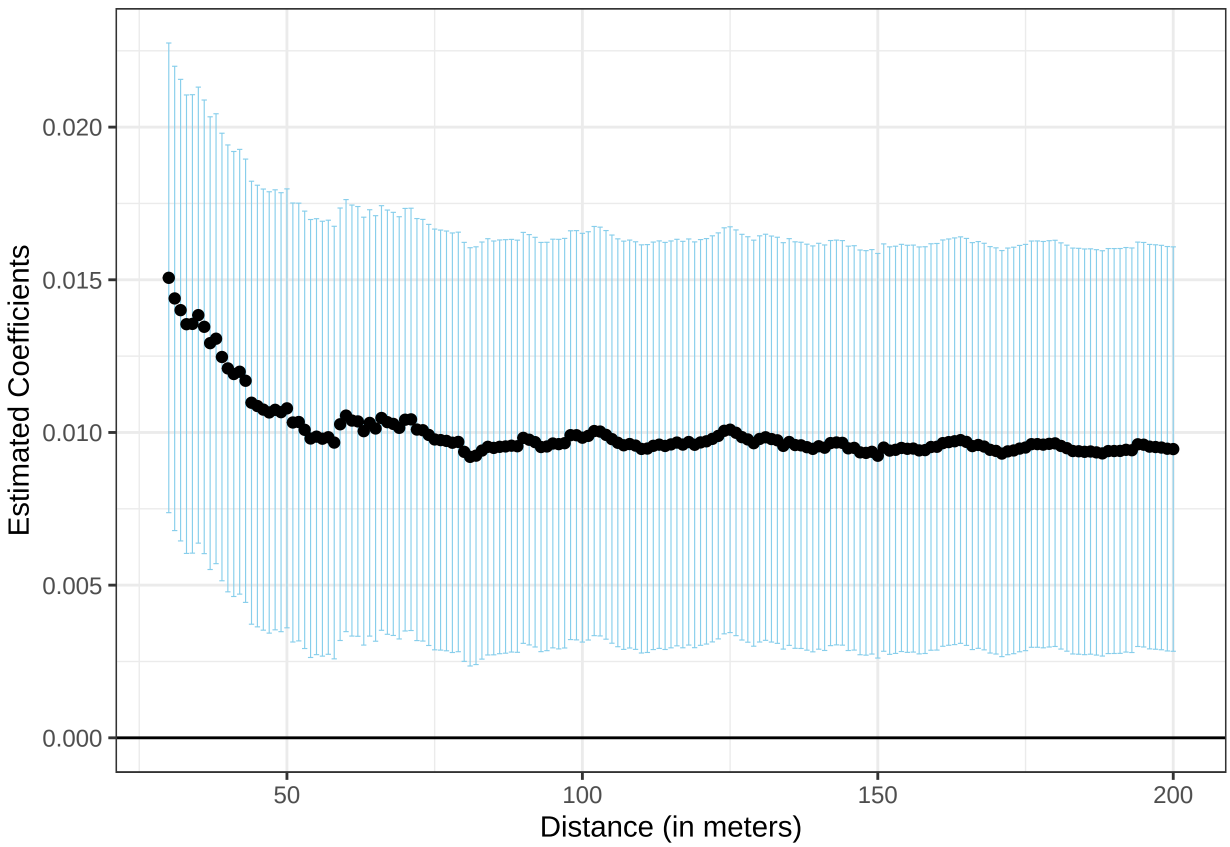

Figure 8: Sensitivity test

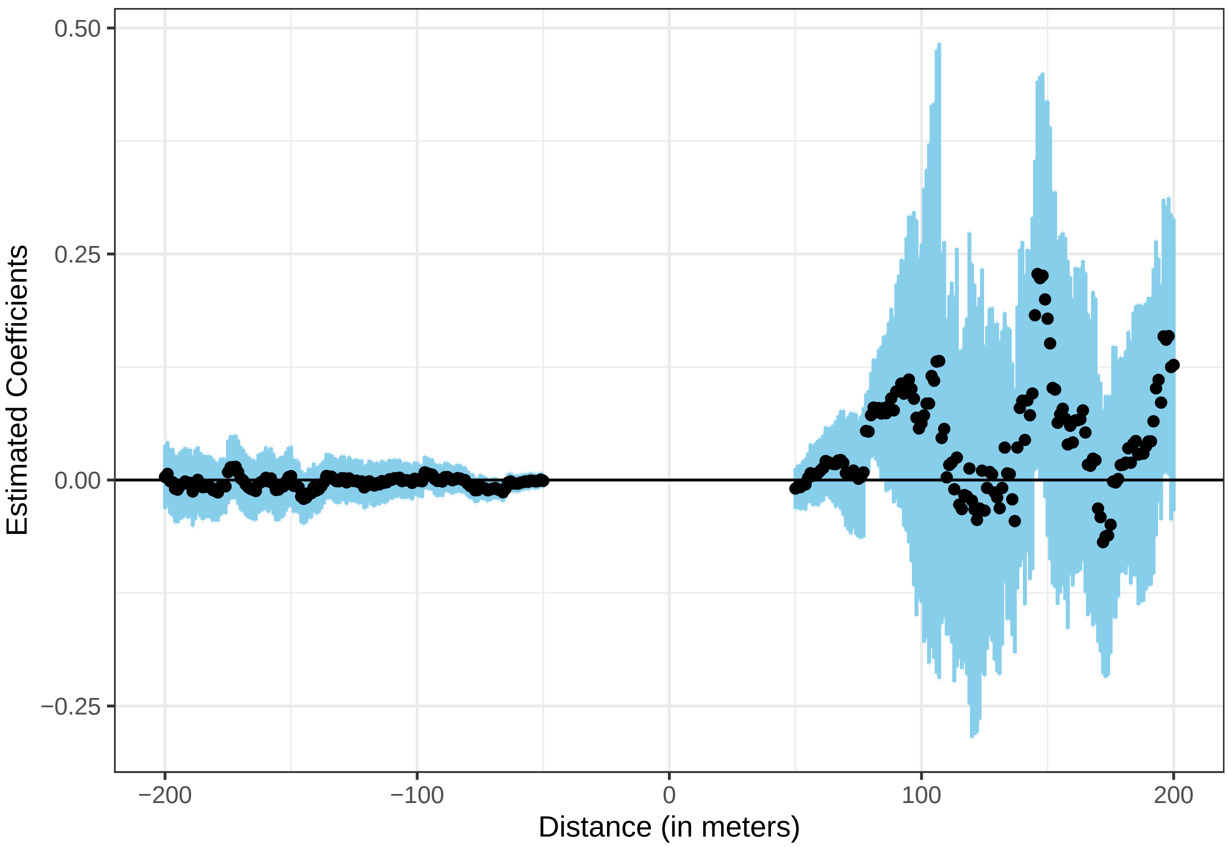

Figure 9: Placebo test