Public policy confronted to technological changes

Maude Hasbi

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

TELECOM ParisTech

2017-ENST-0036

EDITE - ED 130

Doctorat ParisTech

T H È S E

pour obtenir le grade de docteur délivré par

TELECOM ParisTech

Spécialité « Economie »

présentée et soutenue publiquement par

Maude HASBI

le 17 juillet 2017

Les politiques publiques face aux changements technologiques

Directeur de thèse : **Marc BOURREAU**

Jury

Mme Christine ZULEHNER , Professeur, Goethe-Universität Frankfurt	Présidente
M. Eric BOHLIN, Professeur, Chalmers University of Technology	Rapporteur
M. Carlo CAMBINI, Professeur, Politecnico di Torino	Rapporteur
Mme Julienne LIANG , Responsable de recherche economique, Orange	Invité
M. Lukasz GRZYBOWKI, Maître de conférence, TELECOM ParisTech	Invité

T H È S E

TELECOM ParisTech
école de l'Institut Mines-Télécom - membre de ParisTech
46 rue Barrault 75013 Paris - (+33) 1 45 81 77 77 - www.telecom-paristech.fr

Telecom ParisTech

Public Policy Confronted to Technological Changes

Doctorate thesis,

Specialty: Economics

Defended by

Maude Hasbi

July 2017, 17th

Thesis Committee

Marc	Bourreau	Professor, Telecom ParisTech	Advisor
Christine	Zulehner	Professor, Goethe-Universität Frankfurt	Examiner
Erik	Bohlin	Professor, Chalmers University of Technology	Referee
Carlo	Cambini	Professor, Politecnico di Torino	Referee
Lukasz	Grzybowski	Associate Professor, Telecom ParisTech	Invited
Julienne	Liang	Economist, Orange Group	Invited

Acknowledgement

I would like to thank every person without whom this thesis would not have been possible. It is the completion of four years of research, of which three years as a CIFRE at the Regulatory Department of Orange.

I am particularly grateful to Marc Bourreau for having supervised this PhD thesis. I thank him for his availability and his wise advices. He has been able to guide me in my choices, taking into account both my double background in economics and law and my interests for questions of public policies and regional developments.

I also would like to thank Julienne Liang who has supervised this thesis with a kindly ear at Orange. Julienne gave me the opportunity to pursue my research in the most optimal and efficient conditions. Her practical advices have always been useful in my work.

I would like to thank Marc Lebourges, Director of the Europe Economy division at the Regulatory Department of Orange, for having accepted me in his team, first as a trainee and then as a PhD researcher. His implication in our researches is a real advantage and a chance for all Orange's PhD researchers.

I acknowledged my colleagues from Orange for their good mood and the delightful moments we had. A special thanks to Philippe Vidal for all the data extractions he made for me.

After my three years of research at Orange, I had the opportunity to finish my PhD thesis at Telecom ParisTech, where I had the immense chance to work with stimulating persons. I am indebted to Lukasz Grzybowski, Christine Zulehner and Frank Verboven for their advices. I also thank my colleagues, PhD student or outside the world of research for the good atmosphere and the cheerful moments we had.

I wish to express my deepest gratitude to Erik Bohlin for having trusted me and accepted me for two months at the economics department of Chalmers University of Technology at Göteborg. I benefited there from an exceptional work environment and fruitful and stimulating discussions.

I would also like to thank Christine Zulehner, Carlo Cambini, Erik Bohlin, Marc Bourreau, Lukasz Grzybowski and Julienne Liang, who made me the honor to be part of the Jury of this thesis.

Résumé

Les services de télécommunications sont souvent qualifiés d'essentiel pour un pays, contribuant à la croissance économique, à l'inclusion sociale et au développement. Ces trente dernières années, le secteur des communications électroniques en Europe a connu trois révolutions majeures. Une révolution réglementaire avec l'évolution d'un monopole public dominé par un opérateur historique vers l'ouverture du marché à la concurrence. Le processus a commencé à la fin des années 1980.

Cette révolution est partiellement la conséquence d'une révolution sous-jacente: une révolution technologique, avec le passage de l'analogique vers le numérique. Des cabines téléphoniques publiques vers les nouveaux smartphones, des modems vers le haut débit et plus récémment vers le très haut débit. Le secteur des télécommunications a fait l'objet de vagues successives de changements technologiques, façonnant la manière dont nous communiquons et dont nous travaillons.

Ces deux révolutions, réglementaire et technologique, sont intrinsèquement liées. Une régulation spécifique, sur-mesure, est définie pour les différents marchés et les différentes technologies en fonction de leurs caractèristiques inhérentes. La régulation va affecter l'état de la concurrence sur les marchés, ainsi que les incitations à investir des opérateurs. Inversement, la régulation va être elle-même impactée par l'évolution de la concurrence sur le marché. Grajek et al (2012) fournissent des preuves empiriques de cette interaction entre régulation et investissement.

La troisième révolution est quant à elle, une révolution des usages et des business models. On est passé de l'utilisateur du téléphone au consommateur de services de communications électroniques, connecté à Internet pour communiquer, échanger, vendre, acheter, se relaxer.... un éco-système numérique complexe a été crée. Les opérateurs de télécommunications traditionnels fournissent désormais des services multi-medias en concurrence avec les opérateurs "Over the Top" OTT. Les contenus numériques sont principalement financés par la publicité sur Internet.

Cette thèse aborde plusieurs sujets relatifs à l'impact de la régulation sectorielle sur la concurrence et l'investissement dans le secteur des communications électroniques. En particulier, cette thèse soulève des questions relative à la pertinence de la régulation, lorsque celle-ci est imposée à de technologies anciennes, notamment lorsque des technologies plus efficaces et plus modernes sont disponibles sur le marché à un prix abordable. Cette thèse permet également

d'analyser comment la régulation sectorielle affecte la concurrence entre technologies et indirectement l'investissement des opérateurs privés. Des analyses plus complètes sont proposées en ce qui concerne le marché du haut et du très haut débit. J'y estime dans quelle mesure l'impact de la concurrence (via le dégroupage de la boucle locale cuivre) vient affecter les incitations à investir des opérateurs dans les réseaux en fibre optique. Enfin, cette thèse permet d'évaluer l'impact des réseaux très haut débit sur la croissance économique au niveau local, en termes d'impact sur les créations d'entreprises et les créations d'entreprises unipersonnelles. Cette dernière étude a pour objectif de quantifier les bénéfices économiques provenant du déploiement de ces réseaux de nouvelle génération.

Dans une première section, nous aborderons les services de télécommunications en tant que élément du service universel. Dans une seconde section, nous nous intéresserons au marché du haut et très haut débit. Troisièmement, nous ferons un point sur les enjeux qui structurent le secteur des communications électroniquement actuellement, avant d'aborder les questions de recherche étudiées dans la thèse et les principaux résultats.

0.1 Les Services de Télécommunications Elément du Service Universel

A travers le service universel, les autorités publiques s'assurent que chacun ait accès aux services de communications de base, à une qualité et un prix raisonnable, alors même que ces services ne seraient pas fournis par les mécanismes de marché. Le service universel comprends l'émission et la réception d'appel nationaux et internationaux depuis une ligne fixe; l'émission gratuite des appels d'urgence à partir de tous téléphones, dont les cabines téléphoniques; la disponibilité d'un annuaire téléphonique pour tous les abonnés; l'accès à tous aux cabines téléphoniques publiques, notamment l'accès aux personnes présentant des besoins spécifiques ou aux ménages à faibles revenus; ainsi que la fourniture d'un nombre suffisant de cabines téléphoniques sur le domaine public.

Le service universel est considéré comme un instrument de politique publique permettant d'éviter l'exclusion sociale ou géographique. Sa protection vise notamment les ménages à faibles revenus et les personnes handicapées. C'est sur cette population spécifique que les conséquence d'une modification des éléments constitutifs du service universel importe le plus. Par ailleurs, tout comme le service postal, les réseaux de télécommunications sont un outil de développement régional et rural.

0.1.1 La Fourniture des Cabines Téléphoniques Publiques

Dans les économies industrialisées, les cabines téléphoniques peuvent être vues comme la première technologie qui a conduit au développement du secteur des télécommunications. A travers leur inclusion dans le service universel, tant au niveau européen que national, les cabines téléphoniques publiques ont joué un rôle dans l'inclusion social et ont, par ce fait, été un instrument de politique économique et sociale. Au niveau européen, les obligations de service universel sont définies de manière générale par la Commission Européenne. Des dispositions plus spécifiques ont été adoptées au niveau national, comme les obligations de couverture. Fondées sur l'existence de circonstances nationales particulières, 11 Etats Membres ont imposé des obligations de couverture entre 2005 et 2009. Par exemple, en Italie la loi impose de fournir une cabine téléphonique par tranche de 1000 habitants dans les zones avec moins de 10 000 habitants, 2 cabines dans les zones comptant entre 10 000 et 100 000 habitants et 3 cabines dans les zones comptant plus de 100 000 habitants.

Bien que les cabines téléphoniques ont été un outil permettant de fournir à chacun un accès aux services de communications de base, ces dernières années des changements technologiques majeurs se sont produits, provocant une baisse des prix des téléphones mobiles et des communications mobiles. Avec la démocratisation de l'Internet, des moyens de communications alternatifs se sont développés. En conséquence, les ménages européens ont fortement augmenté leur présence en ligne et modifié leur manière de communiquer.

0.1.2 Le Marché des Communications Electroniques en Europe

Le taux de pénétration élevé des téléphones mobiles a offert de nouvelles possibilités de communiquer en mobilité. Les consommateurs peuvent émettre et recevoir des appels avec un téléphone privé, alors même qu'ils ne se trouvent pas à leur domicile. D'après l'Union Internationale des Télécommunications le pourcentage d'abonnements mobiles a considérablement augmenté entre 2005 et 2009 dans l'Union Européenne. En moyenne, la proportion d'abonnement mobile est passée de 95,69% en 2005 à 119,20% en 2009. En 2012, 126,13% des Européens avaient un abonnement mobile. Entre 2005 et 2009, la première raison citée pour expliquer l'utilisation des cabines téléphoniques publiques était l'impossibilité d'utiliser son téléphone mobile, soit parce qu'il n'y avait pas réseau, soit parce qu'il n'y avait plus de batterie ou de crédit. En 2010, 45% des utilisations de cabines téléphoniques étaient dues à cette raison.

De plus, en 2014 plus de 40% des européens utilisaient l'Internet quotidiennement, 36% des ménages européens utilisaient les services de voix sur IP. En 2008, les services de voix sur IP étaient encore considérés comme émergent par la Commission Européenne, en particulier dans les nouveaux pays membres. Mais ces services se sont diffusés rapidement à travers l'Union Européenne et de nouvelles applications de communications se sont développées, telles que WhatsApp ou Messenger, qui permettent également d'émettre et recevoir des appels vidéos.

Par ailleurs, pour réduire l'hétérogénéité dans la valeur estimée par les ménages des différents services de communications, les opérateurs ont introduit des offres regroupant plusieurs services sur le marché. Ces paquets de services sont vendus avec un discount comparé à leur vente en tant que service individuel. En 2005, la Commission qualifiait ces services de développements récents. En 2009, 38% des ménages européens avait une de ces offres.

Tous ces changements technologiques ont amené à ouvrir le débat sur la nécessité de réévaluer le périmètre du service universel, afin de s'assurer que les services actuellement garantis devaient toujours l'être et d'étudier si d'autres services devaient y être inclus. Deux aspects principaux sont débattus: la pertinence de conserver la fourniture des cabines téléphoniques publiques dans le périmètre du service universel et la pertinence d'élargir ce périmètre aux services haut débit.

0.2 Le Marché du Haut et du Très Haut Débit

Ces dernières années, la Commission s'est fixé pour objectif d'apporter, d'ici 2013, un accès universel au haut débit pour tous les citoyens de l'Union Européenne. Pour ce faire la Commission Europénne s'est dotée d'une stratégie numérique pour l'Europe ("Digital Agenda for Europe"). La stratégie prévoit que d'ici à 2020, l'ensemble des citoyens de l'Union Européene ait accès au haut débit, avec des vitesses de connexion au moins égales à 30 Mbps. De plus, 50 % des ménages européens devraient avoir des abonnements à plus de 100 Mbps. Ces objectifs pourraient être atteins avec le déploiement des réseaux très haut débit.

En décembre 2014, le marché européen du haut débit été dominé par la technologie DSL avec 59% des parts de marché, câble (19%), FttH (6%), haut débit mobile (10%), autres technologies haut débit, tels que le satellite et le haut débit mobile (4%).

0.2.1 Le marché du DSL

En Europe, la première technologie d'accès à l'Internet est le DSL. La technologie DSL est associée au réseau cuivre, qui est détenu par l'opérateur historique et permet de fournir des services de voix et de services haut débit (xDSL) sur le marché de détail. Les opérateurs xDSL alternatifs peuvent également fournir des services haut débit à leurs abonnés en utilisant le réseau de l'opérateur historique. Dans l'Union Européen, l'accès de gros à la boucle locale cuivre de l'opérateur historique (dégroupage de la boucle locale ou LLU pour "Local Loop Unbundling") est régulé. Le dégroupage a joué un rôle fondamental dans la diffusion du haut débit en introduisant de la concurrence entre l'opérateur historique et les opérateurs alternatifs, qui ne possédaient pas leur propre réseau. D'après la théorie de l'échelle d'investissement, une première phase de concurrence par les services est un pré-requis à l'entrée des opérateurs alternatifs sur le marché. Cela leur permet d'engranger des informations sur le marché, de constituer leurs bases clients. Ensuite, dans une seconde phase de concurrence par les infrastructures, ils seront incités à déployer leur propre réseau.

La technologie DSL permet de fournir des connexion haut débit jusqu'à 12 Mbps pour l'ADSL et 24 Mbps pour l'ADSL2+. Cependant la vitesse de connexion sur le réseau cuivre dépend de la longueur de ligne. Le signal haut débit s'atténue avec la longueur de ligne.

0.2.2 Les Réseaux de Nouvelle Génération

Depuis les années 2010, les opérateurs DSL ont commencé à investir dans des réseaux en fibre optique (FttH), un réseau de nouvelle génération, qui permet de fournir des services très haut débit sur le marché de détail. Les réseaux en fibre optique FttH sont déployés jusque l'abonné et permettent le transfère de vidéo, de données, de voix et de services de vidéo-conférence. Les réseaux FttH peuvent permettre de fournir des services très haut débit jusqu'à 100 Mbps et plus.

Les câblo-opérateurs fournissent également des services haut débit sur le marché de détail en utilisant leur réseau en câble coaxial. Leur couverture territoriale diffère selon les pays d'Europe. Parallèlement au déploiement des réseaux fibre, les cablo-opérateurs ont modernisé leur réseau (DOCSIS 3.0) afin de fournir des services très haut débit à leurs abonnés. Cependant, contrairement aux réseaux fibre, la modernisation du réseau câble ne consiste pas à déployer un nouveau réseau, mais à déployer de la fibre en amont dans le réseau, jusqu'à un point appelé le dernier amplificateur (FttLA "Fiber to the Last Amplifier"). La partie terminale du réseau en câble coaxial demeure. Ces réseaux modernisés permettent de fournir des services très haut débit avec des vitesses de connexion d'au moins 30 Mbps et souvent de 100 Mbps ou plus.

De pus, afin d'accroître les débits délivrés par le réseau cuivre, une technologique plus efficace, le VDSL a été déployée. Il s'agit là aussi de déployer de la fibre optique plus en amont dans le réseau, jusqu'à un point appelé le sous répartiteur. Les DSLAMs des opérateurs (éléments actifs du réseau) seront ensuite migrés du répartiteur au sous répartiteur. La partie terminale en cuivre demeure. Le VDSL est une technologie moins chère à déployer, qui permet de fournir des débits jusque 50 Mbps (en fonction de la longueur de ligne).

Dans les zones de plus faible densité, où l'investissement privé est peu probable, les collectivités publiques ont commencé à investir dans des réseaux haut et très haut débit, tel que le réseau FttH. Elles ont également investi dans le VDSL afin d'accroître la vitesse de connexion sur le réseau cuivre. Les réseaux d'initiatives publiques sont déployés afin d'assurer la couverture complète du territoire et d'éviter une fracture numérique entre les territoires.

D'après le rapport "EU Single Market", en décembre 2014, 26% des connexions fixe avaient un débit de 30 Mbps et 9% un débit de plus de 100 Mbps. En un an, les abonnements au très haut débit avec des vitesses de connexion de plus de 30 Mbps ont augmenté de 24% et de 44% pour les connexions de plus de 100 Mbps.

0.2.3 La Transition du Cuivre vers la Fibre

Compte tenu du coût élevé du déploiement des réseaux fibre, il est probable que ceux-ci coexistent avec le réseau cuivre pendant quelques temps. Pour cette raison, les autorités publiques ont cherché les moyens d'assurer une transition rapide vers les réseaux très haut débit et de garantir la couverture complète de leur territoire. Les autorités publiques peuvent influencer le développement d'un secteur en définissant des politiques de régulation spécifiques ou en influençant le choix final des consommateurs pour une technologie. La Commission Européenne a adopté une approche fondée sur la neutralité technologique afin de définir ses objectifs pour sa stratégie Europe 2020 (et plus récemment 2025). Au cœur du débat se trouve l'impact du dégroupage de la boucle locale cuivre sur les incitations des opérateurs à investir dans les réseaux en fibre optique. Un rapport commandé par l'Association des opérateurs alternatifs

(WIK 2011) montre que la promotion du dégroupage via la fixation de prix d'accès bas inciterait les opérateur à investir dans la fibre. Alors qu'un rapport, cette fois commissionné par l'Association des opérateurs historiques (Plum 2011) conclut qu'une telle politique viendrait décourager l'investissement.

En ce qui concerne l'impact de la régulation sur les incitations à investir des opérateurs privés dans les réseaux de nouvelle génération, la littérature théorique est abondante. Certaines études s'intéressent à la relation entre la régulation de l'accès au réseau cuivre et la régulation de l'accès au réseau fibre et leurs impacts sur les déploiements fibre et la migration des consommateurs (voir par exemple Bourreau et al. (2012), Briglauer (2015), Brito (2012)). Bourreau et al. (2012) et (2014) ont analysé la migration du cuivre vers les réseaux de nouvelles générations. Ils ont identifié trois effets contradictoires venant influencer les incitations à investir des opérateurs: un effet de replacement, un effet de revenu sur le marché de gros et un effet de migration des consommateurs. De plus, ils démontrent l'existence d'économie d'échelle dans le déploiement des réseaux fibre et l'importance de la séquentialité des investissements. Le deuxième opérateur peut bénéficier des procédures effectuées par le premier opérateur.

Nitsche et al. (2011) ont analysé comment les différents régimes de régulation imposés aux réseaux de nouvelle génération pouvaient affecter les incitations à investir des opérateurs. La Commission Européenne a choisi de réguler les réseaux en fibre optique de la même manière que le réseau cuivre. D'après la Directive Cadre et la Directive Accès, des obligations asymétriques sont imposées à l'opérateur historique. Celui-ci doit fournir l'accès à son génie civil à des conditions transparentes, non discriminatoire et orientées vers les prix. Il doit également publier une offre de référence. L'accès aux infrastructures existantes est considéré comme un pré-requis indispensable pour assurer une concurrence dynamique dans le déploiement des réseaux fibre.

De plus, les opérateurs ayant un pouvoir de marché significatif doivent fournir l'accès à leur réseau à tout autre opérateur à un prix régulé. Ces obligations inclues les éléments passifs du réseau, telle que la boucle locale cuivre (pour le dégroupage) et l'accès à des éléments actifs du réseau fibre (pour le bitstream).

Le génie civil représente le poste de coûts le plus important dans le déploiement de réseaux. En outre, en dehors des zones très dense, la Commission Européenne encourage le co-investissement afin d'accroître la couverture du territoire en regroupant les ressources et en réduisant les coûts.

0.2.4 Les Spécificités du Secteur du Haut et Très Haut Débit en France

En France, cinq opérateurs principaux se font concurrence sur le marché de détail du haut débit: Orange, SFR, Free, Bouygues Telecom et Numéricable. Orange est l'opérateur historique. Il détient l'infrastructure cuivre, qu'il utilise pour fournir des services de communications électroniques (voix et Internet DSL) à ses abonnés. SFR, Bouygues Telecom et Free sont des opérateurs alternatifs DSL, qui ne possèdent pas leur propre réseau. En conséquence, ils fournissent des services de communications électroniques à leurs abonnés en utilisant le réseau cuivre d'Orange via le dégroupage de la boucle locale.

Depuis 2010, les opérateurs DSL ont commencé à investir dans les réseaux en fibre optique (FttH). Orange et SFR sont les plus actifs dans les déploiements. Free déploie son réseau en fibre principalement dans les zones très dense. Toutefois, il investit peu et se concentre sur la montée en débit sur le réseau cuivre (VDSL). Les opérateurs DSL ont signé des accords de co-investissement afin de mutualiser les coûts de déploiements dans les zones moins denses.

Numéricable est le câblo-opérateur. Il fournit des services de communications électroniques (voix et Internet) à ses abonnés en utilisant son réseau en câble coaxial. Sa couverture est plutôt limitée, puisque son réseau ne couvre que 30% de la population, principalement dans les zones denses. Depuis 2007, Numéricable modernise son réseau en remplaçant une partie de ses câbles coaxiaux par des câbles en fibre optique. La partie terminale de son réseau demeure en câble coaxial. En avril 2014, Numéricable a acheté SFR.

En 2014, le marché français des communication électroniques était dominé par la technologie DSL: 88% des abonnements internet étaient souscris via cette technologie. Câble (6%), FttH (3,6%), les abonnements aux technologies alternatives, telles que le WiFi, le satellite et l'Internet mobile ne représentaient que 1,8%.

0.3 Les Enjeux Actuels

Cette sous-section présente les enjeux structurant du secteur des communications électroniques relativement à l'impact de la ré gulation et de la concurrence entre technologies.

0.3.1 La Régulation des Anciennes Technologies

Le cadre réglementaire a été défini afin d'assurer la transition d'un structure monopolistique vers une structure concurrentielle, dans un secteur caractérisé par, d'une part des coûts fixes élevés, pour la plupart irrécupérables, et d'autre part, des économies d'échelle.

Après la libéralisation du secteur des télécommunications, la fourniture de cabines téléphoniques a été inclue dans les éléments constitutifs du service universel. Le service universel a été conçu comme un outil réglementaire permettant d'assurer que chacun ait accès aux services de communications de base à une qualité et un prix raisonnable, alors même que ces services ne seraient pas fournis par le marché.

Bien que les cabines téléphoniques ont été un moyen d'assurer l'accès aux services de télécommunications à chacun, des changements technologiques importants se sont produits ces dernières années provocant une baisse des prix des téléphones mobiles, ainsi que du prix des communications mobiles. Avec la démocratisation de l'Internet, des services alternatifs de communications se sont développés. Les ménages européens ont fortement accru leur présence en ligne et modifier leurs habitudes de communication, ce qui a provoqué une baisse drastique de l'utilisation des cabines téléphoniques.

En conséquence, on peut s'interroger sur la pertinence de la régulation lorsque celle-ci s'applique à une technologie ancienne. Une des principales questions est de se demander comment la régulation devrait évoluer: devrait-elle être modifiée ou supprimée lorsque la technologie devient obsolète?

0.3.2 Impact de la Régulation sur la Concurrence et l'Investissement

L'objectif de la régulation est de promouvoir la concurrence en assurant l'interconnexion entre l'opérateur historique et les opérateurs alternatifs. L'une des régulations fondamentales fut la réglementation de l'accès à la boucle locale cuivre de l'opérateur historique, afin de permettre aux opérateurs alternatifs de fournir des services de téléphonie fixe et haut débit sur le marché de détail.

La théorie de "l'échelle d'investissement" (the "ladder of investment" LoI) (Cave 2006) suggère que la régulation de l'accès à la boucle locale de l'opérateur historique, permettant de créer de la concurrence par les services, n'est pas seulement pro-concurrentielle (réduction des barrière à l'entrée), mais aussi un instrument indirect permettant de favoriser la concurrence par les infrastructures. En conséquent, la concurrence par les service et la concurrence par les infrastructures ne sont plus des substituts, mais deviennent complémentaires. Avec l'ouverture à la concurrence, une multitude d'opérateurs alternatifs sont entrés sur le marché à travers le dégroupage de la boucle locale.

Bien que la régulation de la boucle locale, dans le court-terme, joue un rôle central dans la promotion de la concurrence, elle peut également impacter les stratégies d'investissement des opérateurs, spécifiquement en ce qui concerne l'investissement dans les nouvelles technologies d'accès ("New Generation Access (NGA) network"). L'une des questions fondamentales est donc d'analyser comment la régulation affecte la concurrence entre les technologies et indirectement les incitations à investir des opérateurs.

Il y a un vaste champ d'études théoriques sur la relation entre régulation de l'accès et investissement. Toutefois, le sens du lien entre les deux reste ambigu. Nitsche et al. (2011) soulignent les bénéfices provenant des différents régimes de régulation de l'accès comparés à une situation avec absence de régulation. Alors que Briglauer et al. (2011) mettent en lumière l'existence d'un impact négatif de la régulation de l'accès sur le déploiement des réseaux et plaident pour un retrait de la régulation ("regulatory holiday"). Pour une revue complète de la littérature, se référer à Cambini et al. (2009).

Il n'y a que très peu d'études empiriques qui estiment l'impact de la régulation de l'accès sur la concurrence et l'investissement. Bacache et al. (2010) et Garrone (2011) ne trouvent pas de preuves empiriques venant supporter la théorie de l'échelle d'investissement. De plus, la plupart des études reposent sur des données agrégées, rares sont les études utilisant des données micro-économiques. Voir par exemple Dauvin et al. (2014) au NUTS niveau 1 pour l'Union Européene ou Nardotto (2015) pour le Royaume Uni.

De surcroît, compte tenu du coût de déploiement élevé des réseaux très haut débit de nouvelle génération, en particulier des réseaux en fibre optique, il est très probable que ces réseaux coexistent quelque temps avec le réseau cuivre de l'opérateur historique. Seuls quelques articles de recherche analysent la relation entre régulation de l'accès et investissement dans les réseaux très haut débit. Voir par exemple Bourreau et al. (2012) et (2014) pour la littérature théorique et Bacache et al. (2014), ainsi que Briglauer et al. (2015) pour des évidences empiriques.

0.3.3 Impact des Réseaux Très Haut Débit sur la Croissance Economique Locale

Les réseaux très haut débit sont considérés comme étant une réponse aux limitations des réseaux haut débit d'ancienne génération. Ils sont relativement exempts de problèmes d'atténuation de signal et peuvent potentiellement fournir des débits illimités. Les autorités publiques ont adopté des plans haut débit nationaux très ambitieux pour s'assurer que les bénéfices de ces réseaux de télécommunications de nouvelle génération se diffusent dans leur pays.

Cependant, compte tenu des coûts élevés d'investissement pour déployer ces réseaux haut et très haut débit, il est pertinent, d'un point de vue de politique publique, de quantifier les bénéfices apportés par ces réseaux.

Une des première tentative de quantification de l'impact du haut débit sur la croissance économique provient de Koutrumpnis et al. (2009) pour 22 pays de l'OCDE pour la période 2002-2007. Ils trouvent un impact positif de l'adoption du haut débit sur la croissance du produit intérieur brut (PIB), lorsqu'une masse critique est atteinte. Gruber et al. (2014) pour l'Union Européenne et Kolko (2012) au niveau local pour les Etats-Unis, trouvent également une relation positive entre la diffusion du haut débit et la croissance économique locale.

Considérant l'impact des réseaux haut débit sur le surplus du consommateur, les études sont mitigées. Certaines études mettent en lumière la présence d'un impact positive de la disponibilité du haut débit sur le surplus du consommateurs (voir par exemple Crandall et al. (2011), Dutz et al. (2009)) ou une relation positive entre haut débit et emploi (Crandall et al. (2007), Gillett et al. (2006)). Alors que d'autres études ne trouvent aucun lien entre la disponibilité du haut débit et la réduction du taux de chômage (Kolko (2012), Jayakar et al. (2013) and Czernich (2014)).

0.4 Questions de Recherche et Principaux Résultats

Dans cette sous-section, je présente brièvement les questions de recherche et les principaux résultats.

0.4.1 Obligations de Service Universel et Utilisation des Cabines Téléphoniques Publiques: Est-ce que la Régulation est Toujours Nécessaire à l'Ere des Téléphones Mobiles?

Dans le second chapitre de thèse, j'analyse si les obligations de services universels attachées à la fourniture des cabines téléphoniques publiques sont toujours pertinentes dans un contexte de changements technologiques. Par exemple, les téléphones mobiles sont de plus en plus utilisés, des moyens de communications alternatifs ont émergé avec la voix sur IP, comme Skype ou plus récemment des applications tels que WhatsApp ou Messenger. J'analyse l'effet des obligations de services universels sur l'utilisation des cabines téléphoniques en Europe, entre 2005 et 2009, avec une attention particulière pour les utilisateurs vulnérables, tels que les ménages à faibles revenus. La seconde question de cette étude consiste à étudier ce qui se passerait si les cabines téléphoniques publiques étaient exclues du service universel.

Afin d'estimer l'effet des obligation de service universel sur l'utilisation des cabines téléphoniques, le modèle linéaire suivant est défini:

$$\begin{aligned} Payphone\_use_{it} = \beta_0 + \beta_1 reg_{it} + \beta_2 altertech_{it} + \beta_3 prices_{it} + \beta_4 job_{it} \\ + \beta_5 area_{it} + \beta_6 year + \beta_7 \phi_{it} + \beta_8 \rho_{it} + \epsilon_{it}. \end{aligned} \tag{1}$$

avec i le ménage et t une période (en année). Le ménage i choisi le nombre d'appels qu'il va émettre depuis une cabine téléphonique au temps t ($Payphone\_use_{it}$). Par hypothèse son choix est indirectement influencé par le régime de régulation en place, (reg_{it}), les différentes alternatives qu'il possède pour communiquer, fixe, mobile ou les deux ($altertech_{it}$), et de leur coût d'utilisation, $prices_{it}$. De plus, le choix du ménage est supposé être influencé par sa classe socio-professionnelle d'appartenance, job_{it}, et l'aire géographique dans laquelle il vit, $area_{it}$. Deux matrices de variables de contrôle sont ajoutées: ϕ_{it} contrôle pour les différences en termes de caractéristiques locales, de démographie, et ρ_{it} de différences entre pays. Finalement, $year$ capture une potentielle saisonnalité ϵ_{it} représente le terme d'erreur, clustered au niveau des pays.

Le modèle est estimé sur une base de données de 27 pays européen entre 2005 et 2009.

Afin d'estimer ce qu'il se passerait si l'obligation de service universelle relative à la fourniture des cabines téléphoniques était retirée, je défini un modèle contre factuel. En fixant la présence d'obligation de service universel à 0 dans les pays imposant de telles obligation, le modèle prédit le nombre moyen d'utilisation des cabines téléphoniques par an, si aucune régulation n'était imposée. En comparant cette prédiction avec le nombre observé moyen d'utilisation des cabines téléphoniques pour cette même population, on obtient l'effet moyen attendu de la régulation.

($Payphone\_use_{1it}$) représente le nombre potentiel d'appels émis depuis une cabine téléphonique par le ménage i au temps t si le ménage habite dans une zone géographique où une régulation est imposée, et ($Payphone\_use_{0it}$) représente le nombre potentiel d'appels émis depuis une cabine téléphonique, s'il n'y avait pas de régulation. Pour chauqe ménage, l'équation s'écrit:

$$Payphone\_use_{it} = Payphone\_use_{0it} + uso_{it}(Payphone\_use_{1it} - Payphone\_use_{0it}). \quad (2)$$

avec $Payphone\_use_{1it}$ les ménages habitant dans un pays qui impose une obligation de service universel, et $Payphone\_use_{0it}$ les autres ménages.

Avec $E[Payphone\_use_{1it} - Payphone\_use_{0it}]$ représente l'effet moyen attendu de la régulation, et $E[Payphone\_use_{1it} - Payphone\_use_{0it}|uso_{it} = 1]$ l'effet moyen attendu de la régulation pour les ménages habitant dans un pays qui impose une obligation de service universel. Cette expression peut s'écrire:

$$\begin{aligned} E[Payphone\_use_{1it} - Payphone\_use_{0it}|uso_{it} = 1] &= E[Payphone\_use_{1it}|uso_{it} = 1] \\ &\quad - E[Payphone\_use_{0it}|uso_{it} = 1]. \end{aligned} \quad (3)$$

Le premier terme représente le nombre moyen d'appels émis par an depuis une cabine téléphonique pour les ménages habitant dans un pays qui impose une obligation de service universel, ce qui est observable. Le deuxième terme représente le nombre moyen d'appels émis par an depuis une cabine téléphonique pour les ménages habitant dans un pays qui impose une obligation de service universel, si aucune régulation n'était imposée, ce qui n'est pas observable.

Je trouve que l'imposition d'une obligation de service universel générale pour la fourniture des cabines téléphoniques publiques n'a pas d'effet significatif sur l'utilisation de ces dernière. En revanche, si cette obligation est couplée à une obligation de couverture, i.e., lorsqu'un nombre minimal de cabines téléphoniques est défini en fonction de la densité de population, alors l'impact devient positif. De plus, le modèle contre factuel prédit que si la fourniture des cabines téléphoniques publiques étaient retirée des obligations de service universel, en moyenne dans l'Union Européenne entre 2005 et 2009, l'utilisation des cabines téléphoniques aurait diminué de 15%.

0.4.2 Dégroupage de l'Opérateur Historique et Entrée Dans la Fibre Optique: Etude Empirique pour la France

Dans le troisième chapitre, co-écrit avec Marc Bourreau et Lukasz Grzybowski, j'analyse quels sont les déterminants de l'entrée sur le marché de la fibre optique. Plus particulièrement, j'estime dans quelle mesure la concurrence via le dégroupage de la boucle locale cuivre affecte l'entrée et le déploiement de réseaux en fibre optique. Pour ce faire, il faut déterminer quels sont les facteur qui expliquent combien d'opérateurs peuvent entrer sur un marché, le marché fibre. La décision d'entrer sur le marché est modélisée en considérant que la demande sur le marché est stochastique.A la fin de chaque période, les opérateurs décident s'ils continuent d'opérer sur le marché à la période suivante, s'ils décident d'entrer sur un nouveau marché ou s'ils décident de sortir du marché (lorsqu'ils sont déjà présent sur le marché). Les opérateurs formulent des hypothèses sur la demande, les coûts et la concurrence avec les autres opérateurs sur le marché.

Le nombre d'entrant sur le marché fibre dans la commune i au temps t est donc $N_{it} = n \in \{0, 1, 2, 3\}$.

$$\pi_{it}^{n} = \alpha_t ln S_{it} + X_{it}\beta_t - \mu^n I(N_{it} = n) + \epsilon_{it} \equiv \bar{\pi}_{it}^{n} + \epsilon_{it}, \tag{4}$$

où S_{it} est la taille potentielle du marché, approximée par le nombre de ménage dans la commune, X_{it} est un vecteur d'autres caractéristiques des communes, qui potentiellement peuvent être des déterminants du profit (revenu, densité de population, la proportions d'appartements dans le nombre total d'habitations). μ^n représente l'effet négatif sur les profits de l'entrée de l'opérateur n^{th}, et ϵ_{it} et le terme d'erreur.

Le modèle est estimé sur une base de données comprenant toutes les communes française sur la période 2010-2014.

Il y a trois cas possible où l'on peut observer au temps t dans la commune (marché) i, $N_{it} = n$ opérateurs actifs.

Dans le premier cas, il y avait moins de n opérateurs à la période $t-1$ et un ou plusieurs opérateurs sont entrés sur le marché au temps t, donc on a $N_{it} > N_{it-1}$. Dans ce cas pour le n^{th} opérateur marginal, le profit attendu de l'entrée sur le marché doit être supérieur au coût irrécuparable d'entrée. Mais pour l'opérateur marginal $(n+1)^{th}$, le profit d'entrée estimée est inférieur au coût irrécupérable d'entrée, l'expression s'écrit:

$$\textbf{Case 1, net entry: } N_{it} > N_{it-1} \text{ if } \pi_{it}^{n} \geq SC \text{ and } \pi_{it}^{n+1} < SC. \tag{5}$$

Dans le second cas, aucun opérateur rentre sur, ou sort du marché au temps t, ce qui signifie qu'il y avait n opérateur à la période $t-1$ et $N_{it} = N_{it-1}$. Dans ce cas, l'opérateur marginal n^{th} a décidé de rester sur le marché, parce son profit estimée en restant sur le marché est supérieur à 0. Mais pour l'opérateur marginal $(n+1)^{th}$, le profit d'entrée estimée est inférieur au coût irrécupérable d'entrée, il n'y a donc pas d'entrée sur le marché, l'expression s'écrit:

$$\textbf{Case 2, inaction: } N_{it} = N_{it-1} \text{ if } \pi_{it}^{n} \geq 0 \text{ and } \pi_{it}^{n+1} < SC. \tag{6}$$

Enfin, dans le troisième cas, il y avait n opérateurs au temps $t-1$ et un ou plusieurs opérateurs sont sortis du marché au temps t, ce qui donne $N_{it} < N_{it-1}$. Dans ce cas, le marché n'est plus profitable pour que plus de n opérateurs continuent à opérer sur le marché. L'opérateur marginal $(n+1)^{th}$ estime qu'il n'est plus profitable de continuer d'opérer sur le marché et décide de sortir. Une fois que cet opérateur est sorti du marché, l'opérateur marginal n^{th} estime que ses profits sont positifs s'il reste sur le marché, l'expression s'écrit:

$$\textbf{Case 3, net exit: } N_{it} < N_{it-1} \text{ if } \pi_{it}^{n} \geq 0 \text{ and } \pi_{it}^{n+1} < 0. \tag{7}$$

Par ailleurs, les estimations sont utilisées dans le but de calculer les seuils de marché permettant à un opérateur supplémentaire d'entrer sur le marché. Pour chaque marché i au temps t je calcule les seuils d'entrée pour $n = 1, 2, 3$ opérateurs fibre en calculant la taille de marché critique qui égalise le profit à 0:

$$S_{it}^{n} = \exp((-X_{it}\beta_t + \mu^n I(N_{it} = n))/\alpha_t). \tag{8}$$

Les seuils sont spécifiques à chaque marché et montrent une grande variation en fonction des variables venant impacter les profits.

Je trouve un effet positif de la concurrence via le dégroupage de la boucle locale cuivre sur l'entrée des opérateurs sur le marché de la fibre optique. Je montre également que la probabilité d'entrée des opérateurs fibre sur le marché est plus élevée lorsqu'ils font face à la concurrence du câble. Les opérateurs fibre peuvent essayer de conserver des parts de marché similaires sur les segments du haut et du très haut débit. De plus, je trouve que les déploiements de la technologie VDSL sur le réseau cuivre a un impact négatif sur l'entrée dans le marché de la fibre optique. La technologie VDSL permet de fournir des débits plus élevés sur le réseaux cuivre. Les opérateurs pourraient substituer les investissements dans la fibre par des investissements dans le VDSL.

Au fil des années les seuils de marché nécessaires pour qu'un opérateur supplémentaire entre sur le marché diminuent. Ce qui signifie que des communes situées en zones moins denses deviennent profitables au cours du temps. Cependant, de nombreuses communes situées en zone rurale restent non profitable pour l'investissement privé, ce qui pourrait amener le débat sur la nécessite de déployer des réseaux publics.

0.4.3 Impact des Réseaux Très Haut Débit sur la Croissance Economique Locale: Etude Empirique

Dans le quatrième chapitre de thèse, j'analyse l'impact de la présence des réseaux très haut débit sur la croissance économique locale. J'adopte une approche basée sur la neutralité technologique pour estimer si les communes dans lesquelles un réseau très haut débit fibre, (Fibre to the Home ou FttH), câble (DOCSIS 3.0 ou FttLA) sont plus attrayantes pour les nouvelles entreprises. De plus, j'analyse si les réseaux de nouvelle génération ont un impact sur les créations d'entreprises unipersonnelles.

Pour ce faire, j'analyse quels sont les facteurs qui entrent dans la décision des firmes de s'installer dans une localité. Dans leur prise de décision, les firmes tiennent compte de la taille potentielle du marché, ainsi que de la qualité de la demande, en termes de pouvoir d'achat. De plus, je m'attends à ce que les firmes prennent en compte le niveau d'éducation et la composition de la population, en termes de qualification approximée par l'appartenance aux différentes classes socio-professionnelles. En outre, j'utilise des variables retardées de deux ans afin de contrôler pour la présence d'un potentiel problème de causalité inverse.

J'utilise un modèle avec effets fixes pour éliminer de potentiels problèmes d'endogénéité provenant des regresseurs ne variant pas dans le temps ou ne variant pas d'une municipalité à l'autre. Le nombre d'entreprises s'installant dans chaque municipalité est modélisé comme une fonction des caractéristiques géographiques locales avec des effets fixes.

$$Y_{it+1} = \alpha + \delta \; superfastbb_{it} + \beta \; X_{it-2} + \gamma \; Z_{it-2} + \; year + \; \eta_i + \; \epsilon_{it}. \tag{9}$$

Avec :

$$Y_{it+1} = 0, 1, 2, ... \tag{10}$$

Y_{it+1} est le nombre de nouvelles entreprises créées dans la commune i au temps $t+1$. La variable d'intérêt est une variable binaire $superfastbb_{it}$, qui indique la présence d'un réseau très haut débit dans la commune i au temps t.

X_{it-2} est une matrice de caractéristiques locales attachées à la commune i au temps $t-2$ et Z_{it-2} est une matrice des caractéristiques du marché du travail dans la commune i au temps $t-2$. η_i est un effet fixe pour les variables ne variant pas dans le temps, et qui peuvent avoir un effet sur l'attractivité des communes et donc biaiser les résultats. Par exemple, la présence de subvention ou d'un système de taxation plus avantageux, un coût du capital plus faible. $year$ est une variable binaire pour chaque années capturant les effets fixes temps. Finalement, ϵ_{it} est le terme d'erreur i.i.d. clustered au niveau de la commune, qui permet de capturer les facteurs non observés.

Le modèle est estimé sur une base de donnée excluant Paris, Lyon et Marseille, qui sont des agglomérations attractives pour les entreprises en général. De plus, la base de données comprends toutes les communes françaises de plus de 2 000 habitants. Ainsi, la base de données inclut près de 5 000 communes sur 6 ans (2010-2015). J'utilise une log-transformation pour une meilleure interprétation des résultats.

$$\begin{aligned} ln\_new\_establishment_{it+1} = \; & \alpha + \; \delta \; superfastbb_{it} + \; \beta_1 \; ln\_establishment_{it-2} \\ & + \beta_2 \; ln\_households_{it-2} + \; \beta_3 \; density_{it-2} + \; \beta_4 \; income_{it-2} + \; \gamma_1 \; unempl_{it-2} \\ & + \gamma_2 \; perc\_uni\_diploma_{it-2} + \; \gamma 3 \; socio\_professional\_groups_{it-2} + \; year + \; \eta_i + \; \epsilon_{it}, \end{aligned} \tag{11}$$

avec $ln\_new\_establishment_{it+1}$ le nombre de nouvelles entreprises créées dans la commune i au temps $t+1$ et $establishment_{it-2}$ le nombre d'entreprises opérant dans la commune i

au temps $t - 2$. Le nombre d'entreprises dans une localité est fortement correlé au nombre d'entreprises opérant dans cette localité les années précédentes. Je contrôle pour les différences de caractéristiques entre entreprises en divisant les entreprises dans les trois principaux secteurs marchands: la construction, l'industrie et le tertiaire. Le secteur tertiaire est lui même divisé en trois sous-secteurs: le sous-secteur du commerce, transport et des services; la fourniture de services aux entreprises; la fourniture de services aux ménages.

J'ajoute le nombre de ménage (en log) dans la commune i au temps $t - 2$, qui est un proxy pour la taille de marché, et la densité de population dans la commune i au temps $t - 2$. De plus, j'ajoute le revenu fiscal moyen et le taux de chômage dans la commune i au temps $t - 2$. Les deux variables sont des approximations de la qualité de la demande, en termes de pouvoir d'achat.

J'ajoute également la proportion d'habitants avec un diplôme de l'enseignement supérieur dans la commune i au temps $t - 2$, ainsi que le nombre d'habitants appartenant aux différentes classes socio-professionnelles dans la commune i au temps $t - 2$, qui est un proxy pour le niveau de qualification de la population.

Je met en lumière l'existence des bénéfices des réseaux très haut débit sur la croissance au niveau local. Les communes sur lesquelles un tel réseau a été déployé, apparaissent plus attractive pour la création d'établissement du secteur tertiaire. Cependant, je ne trouve aucun lien significatif qui viendrait confirmer la présence d'un lien positif entre la présence des réseaux très haut débit et les créations d'entreprises dans les autres secteurs marchands. Toutefois, je montre qu'il existe un impact positif de ces réseaux sur la création d'entreprises unipersonnelles.

Abstract

This thesis approaches several issues related to the impact of sector-specific regulation on competition and investments in the electronic communication sector. More specifically, it raises the question of the relevance of regulation when applied to an old technology, when enhanced and affordable alternative technologies are available. It also analyzes how regulation affects competition between technologies and indirectly operators' investments. Further analyses are provided for the fixed broadband market, with an assessment of the effect of competition via local loop unbundling on operators' incentives to invest into fiber networks. Finally, this thesis evaluates the impact of very high-speed broadband networks on local economic growth, in terms of establishment creation and sole proprietorship creation. It attempts to quantify the economic benefits stemming from the roll-out of next generation access networks.

Contents

I General Introduction **1**

1 Regulation of Old Technologies **3**

2 Impact of Regulation on Competition and Investment **3**

3 Impact of Very High Speed Broadband Networks on Local Economic Growth **4**

4 Research Questions and Results **5**

4.1 Universal Service Obligations and Public Payphone Use: Is Regulation Still Necessary in the Era of Mobile Telephony? 5

4.2 Unbundling the Incumbent and Entry into Fiber: Evidence from France 6

4.3 Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence 6

5 Thesis Plan **7**

II Universal Service and Public Payphone Provision **11**

1 Introduction **13**

2 The Effect of Universal Service Obligations on Public Payphone Use **16**

3 Econometric Model **18**

4 The Data **21**

5 Estimation Results **25**

5.1 Impact of Universal Service Obligations on Public Payphone Use 25

5.2 Impact of Universal Service Obligations on Vulnerable End Users and on Regional and Rural Development 28

5.3 Counterfactual Analysis 31

6 Conclusion **35**

III Entry into the Fiber Market **47**

1 Introduction **49**

2 Literature Review **52**

3 Broadband Market in France **55**

4 The Data **57**

5 Econometric Models **59**

5.1 LLU Entry 60

5.2 Fiber Entry 62

6 Estimation Results **64**

7 Conclusion **72**

IV Very High-Speed Broadband Networks and Local Economic Growth **85**

1 Introduction **87**

2 Literature Review **89**

3 The Data **91**

3.1 Dependent Variables 91

3.2 Very high-speed Broadband Networks 92

3.3 Explanatory Variables and Controls 92

4 Econometric Strategy **93**

4.1 Empirical Approach 93
4.2 Potential Endogeneity 95
4.3 Empirical Models 97

5 Estimation Results **99**
5.1 Robustness Checks 102
5.2 Matching Estimator 103
5.3 Panel Data Model with Fixed Effects and Difference-in-Differences for Deployments in 2013 106

6 Conclusion **112**

V General Conclusion **121**

1 Review of the Main Results **122**
1.1 Universal Service Obligation and Public Payphone Use 122
1.2 Local Loop Unbundling and Entry into Fiber 123
1.3 Impact of Very High-Speed Broadband on Local Economic Growth 124

2 Future Projects **125**

List of Figures

1 Percentage of municipalities in which deployment of broadband technology was reported per year 80
2 Potential population covered by a broadband technology per year (in millions) . 81
3 Number of municipality in which a fiber network has been deployed per year depending on the number of LLU operators 82
4 Parallel lines assumption: number of new establishments 108
5 Parallel lines assumption: number of new establishments from the commerce, service and transportation sector 109
6 Parallel lines assumption: number of new sole proprietorships 109

List of Tables

1 Impact of universal service on the use of public payphones by European households between 2005 and 2009 . . . 26

2 Impact of universal service on the use of public payphones by low-income households and households living in rural areas in the European Union between 2005 and 2009 . . . 29

3 Average change in the use of public payphones per year in the European Union . 31

4 Average change in the use of public payphones between 2005 and 2009 by socio-professional groups . . . 32

5 Average change in the use of public payphones between 2005 and 2009 by area of living . . . 33

6 Average change in the use of public payphones use per country between 2005 and 2009 . . . 33

7 Variables description . . . 41

8 Summary statistics . . . 42

9 Average change in the yearly number of payphone calls between 2005 and 2009 by socio-professional groups . . . 43

10 Average change in the yearly number of payphone calls between 2005 and 2009 by area of living . . . 43

11 Average change in yearly number of payphone calls between 2005 and 2009 by socio-professional groups . . . 44

12 Average change in the yearly number of payphone calls between 2005 and 2009 by area of living . . . 44

13 Average change in the yearly number of payphone calls between 2005 and 2009 by socio-professional groups . . . 45

14 Average change in the yearly number of payphone calls between 2005 and 2009 by area of living . . . 45

15 Average change in the yearly number of payphone calls between 2005 and 2009 by socio-professional groups 46
16 Average change in the yearly number of payphone calls between 2005 and 2009 by area of living 46
17 LLU entry in municipalities 66
18 FttH entry in municipalities 68
19 LLU entry thresholds 71
20 Fiber entry thresholds 72
21 Variable description (municipality-level data) 79
22 Summary statistics (all years) 79
23 Summary statistics by the number of fiber entrants in municipality (average values) 81
24 Summary statistics by the number of LLU entrants in municipality (average values) 81
25 Deployment of fiber in municipalities by Orange, SFR and Free 82
26 Deployment of xDSL via LLU in municipalities by SFR, Free and Numericable . 82
27 The number of observations (municipalities in years 2010-2014) with the presence of Orange, SFR and Free by the number of entries 83
28 LLU entries and exits between periods 83
29 Fiber entries and exits between periods 83
30 Panel data estimation with fixed effects: establishment creation and new sole proprietorships 100
31 Covariate for Balance Test 104
32 Average treatment effect on the treated: establishment creation, new establishments in the industry and construction sectors 105
33 Average treatment effect on the treated: establishment creation in the tertiary sector and new sole proprietorships 105
34 Model 2 - Panel data estimation with fixed effects: establishment creation and new sole proprietorships, deployments in 2013 110
35 Difference-in-Difference: establishments creation, deployments in 2013 111
36 Summary of effects 112

37 Data sources 119
38 Summary Statistics 120
39 Evolution of company creations in France 120

Part I

General Introduction

Introduction

Telecommunications services are commonly viewed as essential for a country, participating to economic growth, social inclusion and development. Over the last 30 years, the European electronic communications sector has been through three major revolutions. A regulatory revolution with the evolution of a public monopolistic sector dominated by a historical incumbent operator toward the opening up of the market to competition. The process started in the late 1980's.

This revolution has been partly the consequence of an underlying technological revolution with the switch from analog to digital communications. From public payphones to the newest smartphone, from narrowband to broadband and recently very high-speed broadband, the telecommunications sector has been subject to many waves of technological changes, shaping the way we communicate and do business.

Both the regulation and the technological revolutions are intrinsically linked. Tailored regulations are applied to the different markets and technologies depending on their inherent characteristics. The regulation impacts the state of competition in the markets as well as operators' incentives to invest. In return, the regulation is impacted by the operators' investments and the development of competition in the market. Grajek et al. (2012) provide an empirical evidence of this interplay between regulation and investments.

Finally, the third revolution is the one of the uses and business models. From the telephone user to the consumer of electronic communications services getting online to communicate, exchange, sell, shop, relax,... a complex digital eco-system has been created. Traditional telecommunication operators are now providing media services in competition with Over-The-Top players (OTT). Digital content is mostly funded through online advertising.

The remainder of this chapter is organized as follows. In Section 1, I question the relevance of regulation when applied to old technologies. In Section 2, I present the relationship between regulation, competition and investments in the electronic communications market. Section 3 provides an overview of the potential impact of next generation access networks on local economic growth. Finally, the last Section briefly reviews the research questions and main results of the thesis.

1 Regulation of Old Technologies

The regulatory framework has been designed to ensure the transition from a monopolistic to a competitive environment in a sector characterized by high fixed costs, mostly sunk and displaying economies of scale and scope.

After the liberalization of the telecommunications sector, public payphone provision has been included in the scope of universal service. Universal service is a regulatory tool designed to ensure that everyone has access to basic communication services at a reasonable quality and an affordable price, even if the market would not provide it.

Although public payphones have been a mean to provide communication access to everyone, in the recent years major technological changes have occurred leading to a price decrease in mobile phones and mobile calls. With the democratization of the Internet, alternative means of making or receiving calls have emerged. European households have drastically increased their online presence and modified the way they communicate resulting in a sharp decline in payphone use.

As a result the relevance of regulation is called into question when this one applies to an old technology. One of the main question is how regulation should evolved: should it be modified or suppressed when the technology become obsolete?

2 Impact of Regulation on Competition and Investment

The objective of regulation was to spur competition by ensuring efficient interconnection between the incumbent and alternative operators. One of the key policy was the regulation of access to the incumbent's copper local loop to enable alternative operators to provide fixed telephone and broadband services on the retail markets.

The "ladder of investment" (LoI) theory (Cave (2006)) suggests that regulating access to the incumbent's local loop infrastructure, to create service-based competition, is not only pro-competitive by itself as it reduces barriers to entry, but is also an indirect instrument to promote facility-based competition. Thus, service-based competition and facility-based competition are no longer substitutes, but instead become complements. With the opening up to competition, a multitude of alternative operators have entered the market via local loop unbundling.

Though access regulation plays a central role in promoting competition in the short-term, it may also impact operators' incentives to invest, especially as regards investments in next generation access networks. One of the main question is, therefore, how the regulation impacts competition between technologies and indirectly operators' incentive to invest.

There is a broad range of theoretical literature on the relationship between access regulation and investments. However, the sense of this link still remains unclear. Nitsche et al. (2011) show the benefits from different regime of access regulation on investments compare to the absence of regulation (regulatory holiday). On the contrary, Briglauer et al. (2011) find a negative impact of access regulation on networks deployment and call for a regulatory holiday. For a comprehensive literature review, see Cambini et al. (2009).

There are only few empirical papers which estimate the impact of access regulation on competition and investments. Bacache et al. (2010) and Garrone (2011) do not find any evidence supporting the LoI theory. In addition, most of the studies rely on aggregated data, few make use of micro-level data. See among others Dauvin et al. (2014) at the NUTS 1 level for the EU or Nardotto et al. (2015) for the UK.

Besides, considering the high deployment costs of next generation access networks, notably fiber infrastructures, they are likely to coexist with the legacy copper networks for some time. Yet, the literature on the relationship between access regulation and investments in high speed broadband networks is rather scarce. See for example Bourreau et al. (2012) and (2014) for a theoretical literature and Bacache et al. (2014) and Briglauer et al. (2015) for empirical evidences.

3 Impact of Very High Speed Broadband Networks on Local Economic Growth

Very high-speed broadband networks are seen as a response to the limitations of old generation access networks. They do not suffer from the signal attenuation experienced by copper lines and could potentially provide unlimited speed. Policy makers have adopted ambitious broadband plan to bring the benefits of these electronic communication technologies to their country. However, considering the high investment cost of deploying broadband and very high-speed broadband networks, it would be highly relevant, from a policy perspective, to quantify the benefits of their roll-out for the local economy.

One of the first attempt to measure broadband's impact on economic growth comes from Koutrumpis et al. (2009) for 22 OECD countries for the period 2002-2007. They find a strong positive impact of broadband adoption on national GDP, as a critical mass been reached. Gruber et al. (2014) for the EU and Kolko (2012) at the local level for the US, also find a positive relationship between broadband expansion and local economic growth.

As regards the impact of very high-speed broadband networks on consumers surplus, the evidences are mitigated. Some studies find a positive impact of broadband availability on consumers surplus (see for examples Crandall et al. (2001), Dutz et al. (2009)) or a positive association between broadband availability and employment for the US (Crandall et al. (2007), Gillett et al. (2006)). But other studies find no evidence that broadband availability reduces the unemployment rate (see, for example, sKolko (2012), Jayakar et al. (2013) and Czernich (2014)).

4 Research Questions and Results

In this section, I briefly review the research questions and main results of the thesis.

4.1 Universal Service Obligations and Public Payphone Use: Is Regulation Still Necessary in the Era of Mobile Telephony?

In the second chapter, I analyze whether universal service obligations are still relevant for the provision of public payphones in a context of technological changes. For example, mobile telephony has become widely used, alternative means of telephony have emerged with VoIP services, such as Skype or more recently mobile applications such as WhatsApp or Messenger. I investigate the effect of universal service obligations on public payphone use in Europe, between 2005 and 2009, with a particular focus on vulnerable end-users, among them low-income households.

The second question addressed in the paper is what would happen if public payphones were removed from the scope of universal service.

I find that a general universal service obligation on the provision of public payphone do not have a significant impact on public payphone use. However, when this obligation is coupled with a coverage obligation, i.e., when a minimum number of payphones, depending on the density of population is determined, this impact becomes positive. In addition, the counterfactual model predicts that if public payphones had been removed from the scope of universal service, on average in the European Union between 2005 and 2009, public payphone use would have declined by 15 percent.

4.2 Unbundling the Incumbent and Entry into Fiber: Evidence from France

In the third chapter, co-authored with M. Bourreau and L. Grzybowski, I analyze what are the determinants of entry into the fiber market. More specifically, I estimate how LLU-based competition influences entry and the deployment of fiber infrastructures.

I find a positive impact from LLU competition on entry by fiber operators. I also show that fiber operators are more likely to enter the markets in areas in which they face competition from upgraded cable. Fiber operators may try to keep similar market shares on the broadband and very high-speed broadband segments. In addition, I find that the deployment of the VDSL technology, which provides higher Internet speed on the copper network, slows down fiber deployment. Firms may substitute investment in fiber network by upgrading lines on the copper network.

4.3 Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence

In the fourth chapter, I analyze whether the presence of a very high-speed broadband network has an impact on economic growth at the local level. I adopt a technology neutral approach to investigate whether municipalities in which a very high-speed broadband network has been deployed, either fiber (Fiber to the Home, FttL) or upgraded cable (Fiber the the Last Amplifier, FttLA or DOCSIS 3.0), are more likely to attract new firms. In addition, I assess whether these next generation access networks have an impact on the creation of sole proprietorships.

I find positive evidence of the benefits of very high-speed broadband networks for economic growth at the local level. Municipalities, in which such networks have been deployed, appear more attractive for establishments belonging to the commerce, service and transportation sector. However, I do not find any significant evidence to support that very high-speed broadband networks have an impact on the creation of establishments from any other non-farm market sector. However, I also provide evidence of the positive impact of the local presence of these networks for the creation of sole proprietorships.

5 Thesis Plan

The reminder of this thesis is as follows. The second chapter addresses issues related to the scope of Universal Service. The third chapter consists in assessing what are the determinants of entry into fiber and especially how competition via local loop unbundling and via upgraded cable affects operators' incentives to invest into fiber. It also investigates what are the determinants of entry into local loop unbundling. The third chapter addresses the question of whether next generation access networks have an impact on local economic growth. The last chapter concludes this thesis. I provide a clear summary of the research questions and analyses addressed in this thesis, and formulate some directions for future research.

References

Ahlfeldt, G., Koutroumpis, P. and T. Valletti (2017). "Speed 2.0 – Evaluating access to universal digital highways," *Journal of the European Economic Association*, 15(3), 586–625.

Bacache, M., Bourreau, M. and G. Gaudin (2014). "Dynamic Entry and Investment in New Infrastructures: Empirical Evidence from the Fixed Broadband Industry," *Review of Industrial Organization*, 44(2), 179–209.

Bourreau, M., Cambini, C. and P. Dogan (2012), "Access pricing, competition, and incentives to migrate from "old" to "new" technology," *International Journal of Industrial Organization*, 30(6), 713–723.

Bourreau, M., Cambini, C. and P. Dogan (2014), "Access regulation and the transition from copper to fiber networks in telecoms," *Journal of Regulatory Economics*, 45(3), 233–258.

Briglauer, W., Ecker G. and K. Gugler (2013),"The impact of infrastructure and service-based competition on the deployment of next generation access networks: Recent evidence from the European member states," *Information Economics and Policy*, 25(3), 142–153.

Briglauer, W. (2015). "How EU sectorspecific regulations and competition affect migration from old to new communications infrastructure: recent evidence from EU27 member states, " *Journal of Regulatory Economics*, 48(2), 194-217.

Brito, D., Pereira, P. and J. Vareda (2012). "Incentives to invest and to give access to non-regulated new technologies," *Information Economics and Policy*, 24(3-4), 197–211.

Cave, M. (2006) "Encouraging infrastructure competition via the ladder of investment", *Telecommunications Policy*, 30, 223–237.

Crandall, R. W., Litan, R. E. and W. Lehr (2007). "The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of U.S. Data" *Issues in Economic Policy*, The Brooklin Institution, Number 6.

Grajek, M. and L.H. Röller (2012). "Regulation and Investment in Network Industries: Evidence from European Telecoms," *The Journal of Law and Economics*, 55(1), 189–216.

Czernich, N. (2014). "Does Broadband Internet Reduce the Unemployment Rate? Evidence for Germany," *Information Economics and Policy*, 29, 32–45.

Dauvin, M. and L. Grzybowski (2014). "Estimating broadband diffusion in the EU using NUTS 1 regional data," *Telecommunications Policy*, 38(1), 96–104.

Distaso, W., Lupi, P. and F.M. Manenti (2006). "Platform Competition and Broadband Uptake: Theory and Empirical Evidence from the European Union," *Information Economics and Policy*, 18, 87–106.

Dutz, M. Orszag, J. and Robert, W. (2009). "The Substantial Consumer Benefit of Broadband Connectivity for us Households," Compass Lexecon *Internet Innovation Alliance*

Gillet, S.E., Lehr, W.H., Osario, C.A. and M.A. Sirbu (2006). "Measuring the Economic Impact of Broadband Deployment. Final Report," National Technical Assistance, Training, Research and Evaluation Project No. 99-07-13829.

Gruber, H., Hätönen, J. and P. Koutroumpis (2014). "Broadband Access in the EU: An Assessment of Future Economic Benefits," *Telecommunications Policy*, 38, 1046–1058.

Jayakar, K. and E.A. Park (2013). "Broadband Availability and Employment: An Analysis of County-Level Data from the National Broadband Map," *Journal of Information Policy*, 3, 183-200.

Kolko, J. (2012). "Broadband and Local Growth," *Journal of Urban Economics*, 71, 100–113.

Koutroumpis P. (2009). "The Economic Impact of Broadband on Growth: A Simultaneous Approach," *Telecommunications Policy*, 33, 471–485.

Nitsche, R. and L. Wiethaus (2011). "Access regulation and investment in next generation networks – A ranking of regulatory regimes," *International Journal of Industrial Organization*, 29(2), 263–272.

Part II
Universal Service and Public Payphone Provision

Universal Service Obligations and Public Payphone Use: Is Regulation Still Necessary in the Era of Mobile Telephony?[1]

Abstract

This paper analyses empirically whether universal service obligations for public payphone provision are still relevant in the European electronic communications market. It relies on micro-level data on 106,989 households from 27 EU countries, from 2005 to 2009, to estimate the impact of universal service obligations on public payphone use. A counterfactual scenario predicts the average use of public payphones if no universal service obligations were imposed in the EU countries. The estimation results show that universal service obligations do not have any significant impact on public payphone use. Only coverage obligations, i.e., when the law imposes a minimum number of payphones depending on the density of population, have a positive, though low, impact on payphone use. The counterfactual model predicts that if universal service obligations had been absent, between 2005 and 2009 public payphone use would have been 15 percent lower.

Keywords: Universal service obligations; Public payphones.

JEL Classification: L51, L96.

[1]Published in *Telecommunications Policy*, vol.39, pp. 421-435, 2015.

1 Introduction

Technological developments are generally considered to be welfare-enhancing, notably by replacing old technologies with more elaborated services that lead to price decreases. However, since the massive adoption of a new technology often leads to a sharp decline in the use of the old one, it can also have negative consequences for a fraction of the society, which relies on the old technology. This issue is of prime importance in the communications sector, where regulators have to trade-off between economic efficiency and social equity. A vast literature has studied the competition between an old and a new technology in industries subject to sector-specific regulation (see, among others, Avenali, Matteucci and Reverberi, 2010; Bourreau, Cambini and Dogan 2012a and 2012b; Valletti, Hoernig and Barros, 2012; and Briglauer, Ecker and Gugler, 2013). Though abundant, this literature has neglected the existence of universal service obligations for the provision of the services that rely on the old technology. Should an old technology be kept afloat artificially by regulation for the sake of universal service when a more efficient technology has appeared?

The paper analyses empirically whether universal service obligations are still relevant for the provision of public payphones, an old technology threatened by the development of mobile telephony. It investigates the effect of universal service obligations on public payphone use, with a particular focus on vulnerable end users, among them low-income households. The second question addressed in the paper is what would happen if public payphones were removed from the scope of universal service. Both questions are crucial for policy makers and regulators.

Universal service is one of the keystones of the liberalisation of the telecommunications sector. It aims to guarantee that affordable access to a minimum set of communication services of specified quality subsists after the end of the public monopoly. Universal service is designed to avoid social exclusion, ensuring that everyone, and specifically those that an unregulated market would not serve for economic efficiency reasons, has access to a basic set of communication services. Universal service also includes free access to emergency services (yet, this specific issue is not addressed).

In 2009, the European Commission stated that services such as the provision of a connection to a telephone network and public payphones are considered by EU law to be a safety net for achieving social inclusion.[1] Nonetheless, the inclusion of public payphones in the scope of universal service is not solely founded on social grounds but also on economic grounds. Due to the existence of network externalities, it may be founded from a social welfare point of view to support the expansion of the network. Besides, as the postal network, the telecommunications network is a means to promote regional and rural development.

However, over the last decades, technological, economic and social developments have occurred, altering the way end-users communicate. Mobile phones have been massively adopted, whereas public payphone use has declined in both urban and rural areas. As a result, the upholding of public payphone provision in the scope of universal service is being hotly debated in the European Union.

In 2013, ten EU countries did not enforce any universal service obligations for public payphone provision, considering that due to the widespread use and coverage of mobile telephony services, mobile phones represented a substitute for payphones.[2] Others, such as France, suggested its progressive withdrawal.[3] The paper contributes to the debate by providing empirical evidence on the impact of universal service obligations on public payphone use in the EU. Despite its obvious policy relevance, few studies have addressed the question of the sustainability of universal service obligations, when old technologies subject to regulatory obligations face fierce competition from more advanced technologies. In particular, no such study has specifically focused on their relevance when applied to public payphone provision.

So far, the debates in the literature have essentially focused on the need to modify the scope of universal service to take account of technological changes (see, for example, Nucciarelli, Sadowski and Ruhle, 2014). Other authors have assessed whether the economic and social grounds justifying the enforcement of a universal service policy remain valid. For example,

[1] European Commission (2009) Press Release IP/09/164 Telecoms: Portugal referred to the European Court of Justice over selection of companies providing universal service.

[2] These 10 countries are: Belgium, Denmark, Estonia, Finland, Luxembourg, The Netherlands, Latvia, Romania, Sweden, and Slovakia.

[3] ARCEP Opinion 2013-0519 on a project of decree related to telephone price reduction for some category of people in the frame of universal service (April 16, 2013).

Garcia-Murillo and Kuerbis (2005) and Alleman, Rappoport and Banerjee (2010) argue that maintaining universal service obligations for public payphone provision in mature telecommunications markets could generate major distortions of economic efficiency. In the postal sector, Gautier and Poudou (2013) show that owing to the massive adoption of new communication technologies, end users willingness to pay for legacy services (i.e., postal services) has declined. Stern (2003) demonstrates, for the US market, that the switch from payphones to a mobile phone by an individual creates a negative externality to all payphone users. Simpson (2004) underlines the importance to consider the need to create progressive, socially responsible, universal service reflective of the requirements of 21st century users.

Another stream of the literature has explored the social process underlying technological transitions. Rihll, Wang and Tucker (2011) indicate that the non-use of a more advanced technology does not necessarily imply the existence of inequality. On the contrary, a new technology can be rejected by a part of the population not under affordability considerations, but as a choice of non-use. Nevertheless, in sectors where universal service concerns prevail, the inefficiency and inadequacy of the old technology turns out to be an insufficient reason, for policy makers, to remove the universal service obligations attached to its provision. They consider that the cost of the new technology might hinder the switch from end users (see Adda and Ottaviani, 2005, for a thorough analysis). Despite the existence of a large body of policy-oriented studies, there is no quantitative analysis in the literature of the impact of regulation on payphones use. The objective and contribution of the present paper is to provide such a study.

The impact of universal service on public payphone use is estimated, after controlling for individual and cross-country differences, using micro-level pooled cross-sectional data on 106,989 households from 27 EU countries, from 2005 to 2009. The first main finding is that universal service obligations do not have a significant impact on public payphone use. The second main finding is that if universal service obligations had been absent, the use of payphones would have decreased on average, in the European Union between 2005 and 2009, by 15 percent.

The remainder of this article is structured as follows. Section 2 provides a brief theoretical discussion on the effects of universal service obligations on public payphone use. Section 3 introduces the econometric model, and Section 4 the data. Section 5 presents the estimation results. Finally, Section 6 concludes.

2 The Effect of Universal Service Obligations on Public Payphone Use

In the European Union, public payphone regulation is provided for by the 2002 Universal Service Directive. Under Article 6 (1), the undertakings are required to provide a sufficient number of payphones in public areas, in all parts of the territory, including areas where the market might not deliver these services, to meet the reasonable needs of end users. They also have to comply with several obligations related to prices and quality of service. In addition, calls to emergency services remain free of charge at payphones similarly to landlines and mobile phones. More specific provisions, such as the minimum number of payphones to provide, depending on the population density, can additionally be imposed at the national level. Such coverage obligations have been defined in ten out of the twenty-one EU Member States.[4]

However, with the ubiquity of the GSM (2G) network and the near ubiquity of the UMTS (3G) network, along with the development of competition in the telecommunication market, the costs of both fixed and mobile phones have fallen significantly. Low-cost offers, such as prepaid mobile tariffs, along with social tariffs based on income criteria have appeared. The acquisition of a telephony access has become more and more affordable. In addition, with the increasing penetration rate of broadband, new ways of communications have emerged. National or international voice calls can now be made over the internet (VoIP) at an affordable price or even at no cost.

As a result, the question arises as to whether market failures in the provision of communication services still prevail in the European electronic communications market. Some European

[4]These 10 countries are: Belgium (removed in 2013), Czech Republic, France, Greece, Italy, Malta, The Netherland (removed in 2008), Poland (removed in 2010), Portugal, and Spain.

countries have examined how necessary public payphone services are perceived by the households. For example, in 2013, based on article 6 (2) of the Universal Service Directive, the Belgian regulator decided to remove public payphones from the scope of universal service, considering that the mobile phone constituted a comparable and affordable service, available in all parts of the territory.

Universal service obligations do not affect directly the demand for public payphones, but the supply-side (i.e., the provision of public payphones). As undertakings are compelled to provide a sufficient number of public payphones, the demand is indirectly impacted. Therefore, the question as to whether universal service obligations have an impact on public payphone use is addressed by analysing how the demand evolves depending on the existence of universal service obligations.

To the extent that universal service obligations are binding for the firms, the supply of payphones, and hence their use, is expected to be more important with universal service obligations than without. However, this would not mean that universal service obligations are still necessary. Therefore, though a positive impact can be expected, it is also expected to be rather low. The average data show that public payphones are used predominantly by mobile phone owners when they cannot use their mobile phone, either because it is out of range, out of credit or out of battery. Yet, public payphone use is expected to be independent of mobile phone ownership. In addition, as public payphones are expected to be used principally by low-income households or households living in rural areas, a higher (more positive) impact of universal service obligations on these household categories is also expected.

3 Econometric Model

To test the effect of universal service obligations on public payphone use, the following linear model has been defined:

$$\begin{aligned} Payphone\_use_{it} = \beta_0 + \beta_1 reg_{it} + \beta_2 altertech_{it} + \beta_3 prices_{it} + \beta_4 job_{it} \\ + \beta_5 area_{it} + \beta_6 year + \beta_7 \phi_{it} + \beta_8 \rho_{it} + \epsilon_{it}. \end{aligned} \tag{1}$$

where i is a household and t a time period. Household i chooses the number of calls to make from a public payphone in year t ($Payphone\_use_{it}$). Their choice is assumed to depend indirectly on the regulatory policy, (reg_{it}), on the alternative communication technologies owned, either fixed or mobile ($altertech_{it}$), and on the costs of using them, $prices_{it}$. Besides, the households choice is expected to be influenced by the socio-professional group, job_{it}, and the area of living, $area_{it}$. Two sets of control variables are added to the model: ϕ_{it} controls for differences in demographic characteristics, and ρ_{it} for cross-country differences. Finally, year captures a potential time trend and ϵ_{it} represents the error term.

Then, to estimate whether the effect of universal service obligations varies depending on the alternative communication technologies owned, the socio-professional category of the household and its geographic area, the following variant model has been defined:

$$\begin{aligned} Payphone\_use_{it} = \beta_0 + \beta_1 reg_{it} + \beta_2 altertech_{it} + \beta_3 altertech_{it} * reg_{it} \\ + \beta_4 prices_{it} + \beta_5 jobs_{it} + \beta_6 job_{it} * reg_{it} + \beta_7 area_{it} \\ + \beta_8 area_{it} + * reg_{it} + \beta_9 year + \beta_{10} \phi_{it} + \beta_{11} \rho_{it} + \epsilon_{it} \end{aligned} \tag{2}$$

As the effect of universal service obligations (reg_{it}) is expected to depend on the value of other independent variables, three sets of interaction variables are added to Model (2). The regulation variable is interacted with the 4 different alternative communication technologies($altertech_{it} * reg_{it}$), the 8 different job categories ($job_{it} * reg_{it}$), and the 3 types of areas in which the household is settled ($area_{it} * reg_{it}$).[5]

The relationship between, on the one hand, public payphone use and on the other hand, the alternative technology, the job and the area of living is conditional to the presence or absence of universal service obligations. The coefficients of the interaction terms (β_3;β_6; β_8) represent the difference in the effect of the alternative technology owned, the job held and the area of living, respectively, between households living in countries where public payphone provision is regulated ($reg_{it} = 1$) and households living in countries where no regulation is imposed ($reg_{it} = 0$).

Finally, a counterfactual model predicts what would happen, in terms of public payphone use, if universal service obligations were absent. By setting universal service obligations to zero in countries where such obligations were imposed, the model predicts the average public payphone use in these countries if no regulation had been imposed. By comparing this prediction with the observed average public payphone use in the same population, the expected average regulation effect is obtained.

Let ($Payphone\_use_{1it}$) denote the potential public payphone use by household i at time t if the household lives in a country where a regulatory policy is imposed, and ($Payphone\_use_{0it}$) denote the potential public payphone use absent any universal service obligations. For each household, the equation writes:

$$Payphone\_use_{it} = Payphone\_use_{0it} + uso_{it}(Payphone\_use_{1it} - Payphone\_use_{0it}). \quad (3)$$

where $Payphone\_use_{1it}$ stands for the households living in countries imposing universal service obligations and $Payphone\_use_{0it}$ stands for the other households.

Let $E[Payphone\_use_{1it} - Payphone\_use_{0it}]$ denote the expected average regulation effect, and $E[Payphone\_use_{1it} - Payphone\_use_{0it}|uso_{it} = 1]$ the expected average regulation effect for the households living in a country imposing universal service obligations. This expression can

[5] There are 4 types of alternative communication technologies (Mobile phone only; Fixed telephone only; Bundle of fixed and mobile phones; Internet connection), 8 job categories (Self-employed; Managers; Employees (Clerical Worker); Manual Workers; House persons, i.e. such as housewives; Unemployed; Retired; Students) and 3 types of area (Rural areas or villages; Small and Middle Towns; Large Towns).

be rewritten:

$$E[Payphone\_use_{1it} - Payphone\_use_{0it}|uso_{it} = 1] = E[Payphone\_use_{1it}|uso_{it} = 1] - E[Payphone\_use_{0it}|uso_{it} = 1]. \quad (4)$$

The first term represents the average number of public payphone calls per year in the population living in countries imposing a regulation, which is observable. The second term is the average number of public payphone calls per year in the population living in countries imposing a regulation if no regulation were imposed, which is unobserved.

The models are estimated with ordinary least squares (OLS). Another option would have been to use a discrete choice model. The models are also estimated with an ordered logit using a categorical dependent variable on the frequency of use. The estimation results are similar to those obtained with OLS. However, the five modalities of the dependent variable are unbalanced, as the fifth modality representing the proportion of households, which never uses a public payphone, concentrates 87 percent of the households. The remaining 13 percent are shared between the four first modalities. As a result, the models have been estimated with a simple logit model. A dummy variable has been created. It takes the value 1 if household i has used a payphone during year t and 0 otherwise. The same qualitative results have been obtained.[6]

In all specifications, cluster (at country level) standard errors that are robust to heteroskedasticity are reported.

[6] All these estimations results are available upon request from the author.

4 The Data

The main data on public payphone use have been extracted from 4 annual E-communication household surveys published by the European Commission from 2005 to 2009.[7] These surveys have been conducted in 27 European countries and constitute micro-level pooled cross-sectional data on 106,989 households overall over the four years. For each country, there are approximately 1,000 observations per year (around 500 for small countries). The data provide information on public payphone use by indicating how often households use them. The data also include information on the telecommunication equipment available in the household, such as the different telephony accesses or the existence of an internet connection, as well as information on individuals characteristics, such as age, gender, area of living and job.

This database has been completed with four other sources. First, the variables on the state of regulation in European countries have been constructed from regulatory policy documents published by NRAs and BEREC. When the information was not available or only in the national language, it has been obtained by contacting the NRA or in some cases the national operator in charge of providing universal service.

Second, data on the prices of mobile and fixed telecommunication services have been extracted from the Telecoms Price Developments Reports. These reports are produced on an annual basis for the European Commission Directorate General for Information Society by Teligen. They give the price of different composite baskets of telecommunications services, either fixed or mobile, in the Member States from 1998 to 2010.[8] Third, data related to EU countries such as the density of population, the unemployment rate and the gross domestic product (GDP) per capita come from Eurostat. This third set of data is measured at the NUTS 2 level, which is

[7] Special Eurobarometer 249/ Wave 64.4 - E-communication household survey published in July 2006 (fieldwork December 2005 January 2006). Special Eurobarometer 274/ Wave 66.3 - E-communication household survey published in April 2007 (fieldwork November December 2006). Special Eurobarometer 293/ Wave 68.2 - E-communication household survey published in June 2008 (fieldwork November December 2007). Special Eurobarometer 335/ Wave 72.5 - E-communication household survey published in October 2010 (fieldwork November December 2009).

[8] A detailed definition of these composite baskets of fixed-line or mobile services is given on the Teligen Report. It is publicly available on the European Commission website. See $http : //ec.europa.eu/digital - agenda/sites/digital - agenda/files/voice_tariff_1998_2010.pdf$

the basic regional level for the application of regional policies. Finally, data on mobile phones and fixed phones subscriptions have been collected from the ITU databases for the EU Member States for the years 2000 to 2012.

Table A and Table B in Appendix A present the list of the variables used in the estimation and some summary statistics. Following the European Commission methodology, in order to take account of the differences that could remain between East and West Germany, these regions have been separated in the analysis. The same is true for Great Britain and Northern Ireland. The following paragraphs describe the variables used in the empirical analysis.

Dependent variable

The dependent variable, $Payphone\_use_{it}$, is a continuous variable representing the average number of public payphone calls made by household i in year t. This variable has been constructed from a categorical variable measuring the frequency of use. The frequency of use has five categories: once a week or more often; about once a month; less often than once a month; when away from home or travelling; never. The dependent variable has been built by computing for each category the number of payphone calls depending on the number of days, weeks and months in a year. Different values have been tested for each category, however it did not change the sign or the significance of the coefficients in the regression. The following values have been chosen: Once a week or more often: 60 calls per year (approximately every 6 days); About once a month: 17 calls per year (app. every 3 weeks); Less than once a month: 4.5 calls per year (app. every 2 to 5 months or every 2.7 months); When away from home or travelling: 2 calls per year (app. every 6 months); Never: 0 call per year.

Explanatory variable

The regulatory variables, reg_{it}, consist of two dummies. The first one, uso_{it}, takes the value 1 if universal service obligations for public payphone provision have been imposed in households i country in year t, and 0 otherwise. The second one, cov_{it}, takes the value 1 if universal services obligations imposed a minimum number of payphones to provide, depending on the density of population, in households i country in year t, i.e., coverage obligations and 0 otherwise.

As the alternative communication technologies can be seen as a substitute for public payphones, their impact on public payphone use has been estimated. Three dummy variables measure the availability of a telephony access in the household: mo_{it} takes the value 1 if household i owns a mobile phone but no fixed telephone in year t (mobile only), and 0 otherwise;fo_{it} takes the value 1 if household i owns a fixed telephone but no mobile phone in year t (fixed only), and 0 otherwise. Finally, fm_{it} takes the value 1 if household i owns both a mobile phone and a fixed telephone in year t (fixed and mobile), and 0 otherwise.

A dummy variable, $internet_{it}$, takes the value 1 if household i has an Internet connection at home in year t, and 0 otherwise. Nowadays, the Internet represents a gateway providing a wide range of communication services. Voice calls can be achieved through VoIP services, such as Skype, and it is also possible to communicate via e-mail or via more elaborated communication services offered by social networks. The vector of alternative communication technologies is then:

$$altertech_{it} = mo_{it}, fo_{it}, fm_{it}, internet_{it}. \tag{5}$$

The variables on the alternative telephony technologies prices are defined as follows. The variable $fixed\_rental_{it}$ represents the monthly PSTN rental charge (VAT included) in euro for household i in year t. A variable on the average price of a basket of fixed-telephone calls in euro, $fixed\_price_{it}$, has been added, as well as a variable on the average price of a basket of mobile calls in euro, $mobile\_price_{it}$. Obviously, these prices vary across countries, but not across households within a given country. The vector of prices is then:

$$prices_{it} = fixed\_rental_{it}, fixed\_price_{it}, mobile\_price_{it}. \tag{6}$$

Universal service is considered as a safety net for vulnerable end users (notably low-income households) and as a means to promote rural development, by ensuring that households located in remote areas have access to communication services. Therefore, the impact of the socio professional group and of the type of area of living have been estimated. The job_{it} variable has 8 modalities, while the $area_{it}$ variable has 3 modalities: rural area or village, small or middle-sized town, and large town. There is no quantitative criterion to define the type of area. This is a qualitative variable based on the respondent perception.

Control variable

The group of socio-demographic variables, ϕ_{it}, includes a continuous variable as well as a dummy variable indicating the age_{it} and the gender, $woman_{it}$, of household is respondent in year t. The vector of socio-demographic characteristics is then:

$$\phi_{it} = age_{it}, woman_{it}. \tag{7}$$

The second group of variables, ρ_{it}, controls for cross-country differences by including country characteristics, measured at the NUTS 2 level, namely, the density of population, $dens_{it}$, which may affect network costs, the unemployment rate, $unempl_{it}$, and the gross domestic product per capita (gdp_{it}), which may affect the demand for communications services. Variables on the national level of mobile and fixed telephones subscription per 100 inhabitants, $mobile\_sub_{it}$ and $fixed\_sub_{it}$, are also included. To take account of differences between Eastern and Western countries, a dummy variable, EU15, identifies the first 15 countries in the EU. These control variables are commonly used in the academic literature dealing with the use of information technologies.[9] The vector of country characteristics is then:

$$\rho_{it} = dens_{it}, unempl_{it}, gdp_{it}, mobile\_sub_{it}, fixed\_sub_{it}, EU15_{it}. \tag{8}$$

Finally, four dummy variables have been created for the years 2005, 2006, 2007 and 2009 to

[9] See for example Grzybowski and Verboven (2014) Substitution between fixed line and mobile access: the role of complementarities or Bart and Heimeshoff (2014) Does the growth of mobile markets cause the demise of fixed networks? Evidence from European Union.

take into account a potential time trend in the use of public payphones.

5 Estimation Results

The first sub-section presents the empirical results for the baseline model (Model (1)), which estimates the impact of regulation on public payphone use. The second sub-section presents the empirical results for Model (2), which estimates whether imposing universal service obligations enhances the use of public payphones by vulnerable end users and contributes to regional and rural development.

5.1 Impact of Universal Service Obligations on Public Payphone Use

The following table presents the estimation results for Model (1), which estimates the general impact of universal service obligations (1a) and the specific impact of coverage obligations (1b).

Table 1: Impact of universal service on the use of public payphones by European households between 2005 and 2009

	(1a)		(1b)	
uso	0.274	(0.21)		
cov			0.606**	(0.23)
mo	-4.801***	(0.63)	-5.274***	(0.85)
fo	-5.125***	(0.79)	-5.696***	(1.07)
fm	-5.556***	(0.80)	-6.128***	(1.07)
internet	-0.863***	(0.14)	-0.808***	(0.14)
mobile_price	0.062***	(0.02)	0.066***	(0.02)
fixed_price	-0.027**	(0.01)	-0.041***	(0.01)
fixed_rental	0.004	(0.03)	0.012	(0.02)
Self-employed	0.176	(0.14)	0.228*	(0.13)
Manager (ref)	0.000	(.)	0.000	(.)
Employees	-0.018	(0.08)	-0.012	(0.09)
Manual Worker	0.366**	(0.15)	0.497***	(0.14)
House Person	0.206	(0.18)	0.170	(0.19)
Unemployed	0.909***	(0.26)	1.045***	(0.30)
Retired	0.002	(0.13)	0.101	(0.12)
Student	0.165	(0.20)	0.229	(0.21)
Rural Area	-0.977***	(0.15)	-0.901***	(0.15)
Small/Middle Town	-0.650***	(0.13)	-0.559***	(0.12)
Large Town (ref)	0.000	(.)	0.000	(.)
2006	-0.149	(0.11)	-0.139	(0.10)
2007	0.121	(0.16)	0.151	(0.15)
2009	-0.105	(0.23)	-0.041	(0.21)
Age	-0.029***	(0.01)	-0.027***	(0.01)
Women	-0.203***	(0.07)	-0.213**	(0.08)
EU15	1.073***	(0.37)	0.760**	(0.29)
gdp	0.004	(0.02)	0.014	(0.01)
dens	0.443***	(0.13)	0.380***	(0.10)
unempl	10.642**	(4.65)	11.905***	(4.22)
mobile_sub	-0.008	(0.01)	-0.004	(0.01)
fixed_sub	-0.006	(0.01)	-0.000	(0.01)
Constant	8.269***	(1.20)	8.081***	(1.30)
Observations	102162		90217	
R	0.05		0.05	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The estimation results show that the coefficient of universal service obligations is positive, but not statistically significant. Therefore, it cannot be concluded that universal service obligations have an impact on public payphone use. By contrast, column (1b) shows that coverage obligations have a positive and significant impact on payphone use. On average between 2005 and 2009, households living in countries imposing coverage obligations have made 0.606 public payphone calls more per year than households living in the other countries.

The coefficient of each alternative technology is negative and significant, as expected. The highest substitution effect comes from the bundle of fixed and mobile phones, meaning that households subscribing to both services are less inclined to use payphones. Households having a mobile phone only use public payphones slightly more than those having a fixed telephone only. To understand this result, which may sound rather surprising, note that the main reason explaining public payphone use is the impossibility to use ones mobile phone.[10]

Similarly, households having an internet connection at home are less likely to use public payphones. This can result from the existence of two substitution effects. The first substitution effect appears due to a lower marginal cost of an IP call compared to a public payphone call. The second substitution effect operates when a member of a household is away from home and wants to call at his place. He can then decide to call through the IP network if he has internet at home. Hence, with the emergence of cheap or even free VoIP services, such as Skype, some households have started to substitute public payphones with the Internet.

Not surprisingly, public payphone use slightly increases with the price of mobile calls. On average, a one-euro increase in the price of mobile calls raises the number of payphone calls by 0.062 per year. Yet, the price of fixed calls has an unexpected negative impact. This could be explained by the similar pricing scheme applied to call origination departing from the fixed telephone network and from public payphones: higher prices for fixed telephony may also imply higher prices for payphone calls, leading to a lower use of payphones.

Some socioeconomic variables are significant in explaining the heterogeneity across households and countries in the use of payphones. Western European households tend to use public

[10] See the E-communication household survey published by the Commission (footnote 8).

payphones more intensively than their Eastern neighbours. Public payphones use also decreases with the age of the household, but increases with the unemployment rate and to a lesser extent with the density of population. This latter result is confirmed by the relatively lower use of public payphones by households living in less urbanised areas compared to those living in large towns. GDP per capita, which is a proxy for income, is not significant. The income effect seems to be better captured at the household level. Public payphone users are slightly more prevalent among low-income households, such as manual workers and particularly unemployed.

5.2 Impact of Universal Service Obligations on Vulnerable End Users and on Regional and Rural Development

Model (2) estimates whether the impact of universal service is different depending on the alternative communication technologies owned, the socio-professional group of the household and its area of living. The estimation results are provided in column (2a) when universal service obligations are imposed and in column (2b) when specific coverage obligations have been defined.

Table 2: Impact of universal service on the use of public payphones by low-income households and households living in rural areas in the European Union between 2005 and 2009

	(2a)		(2b)	
uso	1.186	(1.09)		
cov			3.277	(2.16)
mo	-4.993***	(0.23)	-4.657***	(0.89)
fo	-4.658***	(0.36)	-4.583***	(0.98)
fm	-5.030***	(0.32)	-4.960***	(0.98)
internet	-0.797***	(0.27)	-0.728***	(0.18)
uso/ cov # mo	0.247	(0.73)	-1.483	(1.74)
uso/ cov # fo	-0.513	(0.99)	-2.560	(2.21)
uso/ cov # fm	-0.634	(0.96)	-2.807	(2.23)
uso/ cov # internet	-0.056	(0.29)	-0.095	(0.25)
mobile_price	0.064***	(0.02)	0.071***	(0.02)
fixed_price	-0.030**	(0.01)	-0.045***	(0.01)
fixed_rental	0.002	(0.02)	-0.005	(0.02)
Self-employed	0.381**	(0.18)	0.295**	(0.12)
Manager (ref)	0.000	(.)	0.000	(.)
Employees	-0.034	(0.10)	-0.003	(0.07)
Manual Worker	0.208	(0.13)	0.287**	(0.10)
House Person	0.451***	(0.16)	0.422*	(0.24)
Unemployed	0.461*	(0.26)	1.021**	(0.44)
Retired	0.228	(0.29)	0.257*	(0.15)
Student	-0.261	(0.24)	-0.170	(0.16)
Rural Area	-0.514	(0.33)	-0.771***	(0.17)
Small/Middle Town	-0.120	(0.07)	-0.416***	(0.10)
Large Town (ref)	0.000	(.)	0.000	(.)
uso/ cov # Self-employed	-0.250	(0.25)	-0.089	(0.27)
uso/ cov # Manager (ref)	0.000	(.)	0.000	(.)
uso/ cov # Employees	0.009	(0.13)	0.024	(0.17)
uso/ cov # Manual Worker	0.179	(0.23)	0.573	(0.34)
uso/ cov # House Person	-0.279	(0.24)	-0.365	(0.25)
uso/ cov # Unemployed	0.492	(0.39)	0.109	(0.65)
uso/ cov # Retired	-0.302	(0.34)	-0.396*	(0.23)
uso/ cov # Student	0.541	(0.33)	1.084**	(0.43)
uso/ cov # Rural Area	-0.584	(0.37)	-0.351	(0.28)
uso/ cov # Small/Middle Town	-0.661***	(0.18)	-0.427	(0.27)
uso/ cov # Large Town (ref)	0.000	(.)	0.000	(.)
2006	-0.131	(0.11)	-0.106	(0.10)
2007	0.152	(0.17)	0.180	(0.14)
2009	-0.068	(0.24)	0.020	(0.20)
Age	-0.029***	(0.00)	-0.027***	(0.01)
Women	-0.202***	(0.07)	-0.223***	(0.07)
EU15	1.189***	(0.36)	0.896***	(0.30)
gdp	0.002	(0.02)	0.015	(0.01)
dens	0.442***	(0.13)	0.367***	(0.09)
unempl	10.364**	(4.53)	11.561***	(4.11)
mobile_sub	-0.010	(0.01)	-0.008	(0.01)
fixed_sub	-0.009	(0.01)	-0.006	(0.01)
Constant	7.928***	(1.29)	7.818***	(1.37)
Observations	102162		90217	
R2	0.05		0.06	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The estimation results show that the effect of universal service obligations on public payphone use is not significant per se. Nonetheless, by introducing interaction terms the slope of universal service obligations is allowed to differ depending on the alternative communication technologies owned, the socio-professional group and the area of living.

None of the coefficients of the interaction terms between the alternative communication technologies and universal service obligations is significant (columns (2a) and (2b)). This means that imposing universal service obligations for public payphone provision, either in general terms or through the definition of coverage obligations, does not affect the substitution from the alternative communication technologies. In other words, in the era of mobile telephony, universal service obligations have no effect on public payphone use.

Similarly, the interaction terms between the socio-professional groups and universal service obligations are not significant (column 2a). As a result, the use of public payphones by low-income households in countries where universal service obligations are imposed is not different from the use by low-income households in countries where no regulation is applied.

Nevertheless, two interaction terms with coverage obligations are significant (column (2b)): for retired and students. In countries imposing coverage obligations, the retired are less likely to use public payphones than the other socio-professional groups compared to the other countries. On the contrary, in these countries, students tend to use them relatively more. On average, in countries with coverage obligations, the retired make 0.139 payphone calls (0.257-0.396) less per year than the managers, whereas in the other countries, the retired make 0.257 payphone calls more per year than the managers. Similarly, in countries where coverage obligations are imposed, students make 0.914 payphone calls (-0.170+1.084) more per year than the managers, whereas in the other countries, they make 0.170 payphone calls less per year than the managers. As a result, the imposition of coverage obligations only has a positive effect, in terms of public payphone use, on students and a negative effect on the retired relatively to their use by the managers.

Finally, the interaction terms between small and middle towns and universal service obligations is significant, but only in the first regression (Column (2a)). In countries imposing universal service obligations, regardless of the existence of coverage obligations, households living in small and middle towns use public payphones less than households living in large towns, compared to the countries where no regulation is imposed. No significant difference is observed in public payphone use between households living in rural areas in countries imposing universal service obligations and in countries where no regulation is imposed.

5.3 Counterfactual Analysis

The central question in this paper is whether universal service obligations for public payphone provision are still relevant today. To discuss this question, a counterfactual, where public payphones would be removed from the scope of universal service, has been set up. The analysis is conducted following a two-step method. First, the predicted average number of public payphone calls per year is calculated by running the baseline model (Model (1)). Then, the counterfactual scenario is built by setting uso to zero and by recomputing this predicted average number of calls. This simple exercise enables to estimate the effect of universal service obligations on public payphone use. The results of the counterfactual analysis show that, on average between 2005 and 2009, European households have made 1.45 public payphones calls per year. If in all European Member States the universal service obligations had not been in place, public payphones would have been used 1.23 times per year, which corresponds to a 15 percent decrease.[11]

Table 3: Average change in the use of public payphones per year in the European Union

	Observed	Predicted	If no USO	
2005	1.76	1.77	1.54	-12.77%
2006	1.49	1.47	1.24	-15.36%
2007	1.52	1.50	1.28	-14.32%
2009	1.07	1.08	0.86	-19.99%
Total	1.46	1.45	1.23	-15.17%
Observations	102162			

[11] The results of counterfactual analysis are qualitatively robust to the definition of the dependent variable. For the different value tested to construct the dependent variable as a continuous variable (see Section 3), a variation of approximately 15 percent is found, even if the coefficients vary.

Absent universal service obligations public payphone use decreases over the years. Whereas in 2005 the number of calls made from public payphones would have decreased by roughly 13 percent, it would have dropped by 20 percent in 2009. This might be explained by the substitution effect from the alternative communication technologies, only households that really needed public payphones would have kept using them. The counterfactual model predicts that on average, absent regulation, the highest decrease in public payphone use would have been observed among the managers, the employees (clerical workers), the self-employed, as well as the retired. (See Table 4). These socio-professional groups are those using the least public payphones. This might also suggest an indirect effect of the age, as observed in Model (1). On the contrary, the demand for public payphones by low-income households is less elastic to a change in regulatory policy, maybe because they rely more on this old technology compared to the other socio-professional groups. For example, absent regulation, public payphone use would have declined by 21 percent for the managers, and by only 8 percent for the unemployed.

Table 4: Average change in the use of public payphones between 2005 and 2009 by socio-professional groups

	Observed	Predicted	If no USO	
Self-employed	1.33	1.33	1.11	-16.61%
Managers	0.99	0.97	0.77	-20.72%
Employees	1.22	1.26	0.98	-18.12%
Manual workers	1.97	1.86	1.72	-11.75%
House persons	1.75	1.76	1.52	-13.69%
Unemployed	2.94	2.87	2.64	-8.24%
Retired	1.04	1.04	0.83	-20.56%
Students	1.92	1.92	1.70	-11.48%
Total	1.46	1.45	1.23	-15.17%

The results also indicate that if universal service obligations had been removed, the highest consequences would have been encountered in less urbanised areas. On average, between 2005 and 2009, the number of public payphone calls would have declined by 19 percent in rural areas or villages, where they are the least used, compared to only 11 percent in large towns. (See Table 5).

Table 5: Average change in the use of public payphones between 2005 and 2009 by area of living

	estimated	predicted	If no USO	
Rural area or village	1.17	1.17	0.95	-18.75%
Small/middle town	1.33	1.30	1.08	-16.70%
Large town	2.02	2.02	1.80	-11.14%
Total	1.46	1.45	1.23	-15.17%

The predictions show that if public payphones had been excluded from the scope of universal service, the highest decline in terms of use would have been encountered in countries where they are the least used, such as Cyprus, Slovenia and Czech Republic. By contrast, the lowest decrease would have been observed in countries where public payphones are the most used, such as Spain and Greece. (See Table 6).

Table 6: Average change in the use of public payphones use per country between 2005 and 2009

Country	Observed	Predicted	If no USO	
CY	0.14	0.29	0.02	-93.31%
SI	0.29	0.36	0.08	-76.61%
CZ	1.18	0.59	0.32	-46.31%
EE	0.62	0.69	0.41	-39.85%
MT	1.01	1.02	0.74	-26.99%
PL	1.06	1.03	0.75	-26.72%
LV	1.45	1.17	0.89	-23.51%
AT	1.80	1.52	1.25	-18.02%
DE-W	1.63	1.61	1.34	-16.99%
BE	1.74	1.90	1.63	-14.43%
FR	1.62	2.01	1.73	-13.65%
BG	2.71	2.04	1.76	-13.45%
IT	2.05	2.04	1.77	-13.43%
PT	2.34	2.40	2.12	-11.44%
GR	3.75	2.71	2.44	-10.10%
ES	4.25	3.19	2.91	-8.60%

Countries in bold and italic imposed coverage obligations

The results are illustrated by conducting the same counterfactual analysis on 4 specific countries: Spain, where coverage obligations are imposed, and where public payphone use is the highest of the European Union;[12] Italy, where coverage obligations are imposed;[13] West Germany, where public payphones are moderately used and where no coverage obligations are imposed;[14] Poland, where public payphone use is low and where coverage obligations are imposed.[15] The results of this counterfactual analysis are shown in Appendix B.

The predictions confirm the results obtained at the European level. Regardless of the existence of coverage obligations, absent universal service obligations, the highest decrease in public payphone use would have been observed among the managers, the employees, the self-employed and the retired. Low-income households are less elastic to a change in payphone regulation than the other groups. The difference between the socio-professional groups (in terms of use) is more pronounced in countries where public payphones are the least used. Besides, the predictions show that, absent regulation, public payphone use would have decreased more in less urbanised areas. Nevertheless, it indicates that the differences of impact between areas would have been larger in countries where public payphones had been the least used. As a result, public payphone use in rural areas would have declined more in Poland and in West Germany, than in Italy and especially in Spain.

[12] In Spain, the 2005 Royal Decree 424/2005 imposed, between 2005 and 2011, to provide: one public payphone when it is justified by the low penetration of fixed telephone, the lack of mobile access or by the existence of high distances to similar facilities in municipalities with less than 500 inhabitants; and at least one public payphone for municipalities with more than 1,000 inhabitants and one more for every 1,500 additional inhabitants. In 2011, the coverage obligations have been lightened: the Royal Decree 726/2011 imposed to provide: one public payphone in municipalities with less than 1,000 inhabitants when it is justified for the reasons enumerated above; and at least one public payphone for municipalities with more than 1,000 inhabitants and one more for every 3,000 additional inhabitants.

[13] In Italy, the Telecommunication law imposed to provide one public payphone per 1,000 inhabitants in the areas counting less than 10,000 inhabitants, two per 1,000 inhabitants in areas counting between 10,000 and 100,000 inhabitants and three per 1,000 inhabitants in areas counting more than 100,000. In 2010, the NRA authorised a phase out of public payphones covered by universal service.

[14] The 78 of the German telecommunication law provides for a general obligation to provide public payphones on the German territory to meet the needs of end users.

[15] In Poland, between 2006 and 2011, the article 88 of the telecommunication law imposed to provide one public payphones per 1950 inhabitants. In 2012, the provision of public payphones has been withdrawn from the scope of universal service.

6 Conclusion

The paper analyses whether the imposition of universal service obligations for public payphone provision is still relevant in todays electronic communication market. Using micro-level pooled cross-sectional data on 106,989 households from 27 EU countries, from 2005 to 2009, three model specifications are estimated. The first one estimates the impact of regulation on public payphone use. The second specification introduces interaction terms to assess the effect of regulation on public payphone use by vulnerable end users. Finally, the third specification sets up a counterfactual scenario to predict what would have happened if no universal service obligation had been imposed.

The first specification shows that imposing universal service obligations for public payphone provision has no significant impact on their use. Only coverage obligations have a positive and significant, but low, impact on public payphone use, i.e., when the law imposes a minimum number of payphones depending on the density of population. It also reveals a high substitution effect from alternative technologies. Households having a bundle of mobile and fixed phones are the least likely to use public payphones. Besides, fixed telephone owners are less inclined to use public payphones than mobile phone owners. Finally, the model highlights that the development of VoIP services contributes to lower the use of public payphones, though to a lesser extent than the other alternative technologies.

The second specification shows that universal service has a higher impact on public payphone use by students relatively to the managers (i.e., the reference group), only when the law imposes coverage obligations. On the contrary, imposing coverage obligations has a negative effect, in terms of payphone use, on the retired relatively to the managers compared to the other countries where no coverage obligations are imposed. However, imposing universal service obligations does not enhance the use of public payphones by the other socio-professional groups or by households living in rural areas. Besides, public payphone use by households having an alternative communication technology, such as a mobile phone and/or a fixed phone, is similar in countries where universal service obligations are imposed and in the others. This means that in the era of mobile telephony, universal service obligations have no effect on public payphone use.

The third specification predicts that if public payphones had been removed from the scope of universal service, on average in the European Union between 2005 and 2009, public payphone use would have declined by 15 percent. The counterfactual model also predicts that the demand for public payphones would have been more elastic to a change in regulatory policy in countries where they were the least used. Overall, such policy change would have had a higher negative effect on the managers, the employees and the retired, as well as on households living in rural areas. Low-income households and households living in large towns are predicted to be less elastic to a policy change.

A limitation of this paper, though, is that the dataset covers the period 2005 to 2009 only, and therefore, does not include data on more recent years. Yet, based on the results for 2005-2009 and on the evolution of the electronic communications market between 2009 and 2015, it is possible to conjecture what could happen, in terms of public payphone use, if universal service obligations were removed in the EU in 2015.

The question is whether public payphone use would decline more or less than 15 percent following a change in regulation. Two opposing effects are potentially at play: a substitution effect and a composition effect. First, one can conjecture that the substitution between payphones and mobile phones is stronger in 2015 than it was in 2009: since 2009, the prices of mobile telephony services have continued to fall; besides, low-cost offers have emerged, among them prepaid mobile tariffs and fixed and mobile social tariffs based on income criteria. If this is correct, would public payphones be removed from universal service, the percentage of decline in their use could be higher in 2015 than it was in 2005-2009. The second potential effect is a composition effect. Due to the substitution between payphones and mobile phones, the composition of the user base of payphones has probably changed. One can therefore conjecture that in 2015, compared to 2009, a higher share of public payphones users is made of low-income individuals, i.e., those that are less elastic to a change in payphone regulation. Would public payphones be removed from universal service, this composition effect would reduce the percentage of decline in payphone use.

If the substitution has a higher impact on the percentage of public payphone use than the composition effect, in 2015, the decline in public payphone use following a change in regulatory policy could be higher than 15 percent. However, even in this case, it would apply to a smaller number of payphones users. As a result, this discussion suggests that removing payphones from the scope of universal service would still have a relatively low welfare cost (in terms of reduced usage) in 2015.

References

Adda, J. and Ottaviani, M. (2005). "The transition to digital television," *Economic Policy*, 20(41), 160–209.

Alleman, J., Rappoport, P. and Banerjee, A. (2010). "Universal service: A new definition? ," *Telecommunications Policy*, 34(1-2), 86–91.

Avenali, A., Matteucci, G. and Reverberi, P. (2010). "Dynamic access pricing and investment in alternative infrastructures," *International Journal of Industrial Organization*, 28(2), 167–175.

Bart, A. K. and Heineshoff, U. (2014). "Does the growth of mobile markets cause the demise of fixed networks? Evidence from the European Union," *Telecommunications Policy*, 38(11), 945–960.

BIPT Council Decision of 6 May 2013 on the Abolition of Universal Service Obligations Regarding the Provision of Public Pay Phones and Other Access Points to Public Telephony Services. Retrieve from:

BEREC (2010). Report on Universal Service Reflections for the Future. Retrieve from:

Bourreau, M., Cambini, C. and Doan, P. (2012). "Access Regulation, Competition, and Broadband Penetration: An International Study," *Telecommunication Policy*, 34, 661–671.

Bourreau, M., Cambini, C. and Doan, S. (2012a). "Access pricing, competition, and incentives to migrate from "old" to "new" technology," *International Journal of Industrial Organization*, 30(6), 713–723.

Bourreau, M., Cambini, C. and P. Dogan (2014). "Access regulation and the transition from copper to fiber networks in telecoms," *Journal of Regulatory Economics*, 45(3),233–258.

Bourreau, M., Cambini, C. and P. Hoernig, S. (2012b). "Ex ante regulation and co-investment in the transition to next generation access," *Telecommunications Policy*, 36(5), 399–406.

Briglauer, W., Ecker, G. and Gugler, K. (2013). "The impact of infrastructure and service-based competition on the deployment of next generation access networks: Recent evidence from the European Member States," *Information Economics and Policy*, 25(3), 142–153.

Cremer, H., Gasmi, F., Grimaud, A. and Laffont, J.J. (2002). "Universal service: An economic perspective," *Annals of Public and Cooperative Economics*, 72(1), 5–43.

Downes, T. and Greenstein, S. (2007). "Understanding why universal service obligation may be unnecessary: The private development of local internet access markets," *Journal of Urban Economics*, 62(1), 2–26.

Garcia-Murillo, M. and Kuerbis, B. (2005). "The effect of institutional constraints on the success of universal service policies: A comparison between Latin America and the World," *Telecommunications Policy*, 29(9-10), 779–796.

Gautier, A. and Poudou, J.C. (2013). "Reforming the postal universal Service," *CORE Discussion Paper 2013024*,

Grzybowski, L. and Verboven, F. (2014). "Substitution between fixed-line and mobile access: The role of complementarities," *KU Leuven Discussion Paper Series DPS14.12*, Retrieved from:

Dauvin, M. and L. Grzybowski (2014). "Estimating broadband diffusion in the EU using NUTS 1 regional data," *Telecommunications Policy*, 38(1), 96–104.

Jaag, C. (2011). "The future of the USO Economic rationale for universal services and implications for a future-oriented USO," Working Paper. Retrieved from:

OECD (1995). Committee on Information Computer Communications Policy: Universal Service Obligations in a Competitive Telecommunications Environment. Retrieved from:

OECD (2012). Working Party on Communication Infrastructures and Services Policy: Universal Service Policies in the Context of National Broadband Plans. Retrieve from:

Ofcom (2005). Review of the Universal Service Obligation. Retrieved from:

Nucciarelli, A., Sadowski, B. and Ruhle, E. (2014). "Should next generation access networks falls within the scope of universal service? A European Union perspective," *Government Information Quaterly*, 31(1), 90-99.

Rihll, E., Wang, V. and Tucker, J. (2011). "On phatic technologies for creating and maintaining human relationships," *Technology in Society*, 33(1-2), 44–51.

Sey, A. (2008). "Where did all payphones go? Intermediaries, innovation and insecurity in the mobile phone industries," Conference paper. Retrieved from:

Simpson, S. (2004). "Universal service issues in converging communications environments: The case of the UK," *Telecommunications Policy*, 28(3-4), 233–248.

Stern, A. (2003). "Demise of the pay phone industry. Assessing the Welfare Implications," *Senior Economics Thesis, Haverford College*,Retrieved from:

Valletti, T., Hoernig, S. and Barros, P. (2002). "Universal service and entry: The role of uniform pricing and coverage constraints," *Journal of Regulatory Economics*, 21(2), 169-190.

Appendix A: Data set

Table 7: Variables description

Variable Name	**Description**	**Source**
Payphones_use	Household annual number of public payphone use	Eurobarometer Surveys
Payphone_fi	Household frequency use of public payphone	Eurobarometer Surveys
mo	Household having a mobile phone only	Eurobarometer Surveys
fo	Household having a fixed phone only	Eurobarometer Surveys
fm	Household having a fixed and a mobile phones	Eurobarometer Surveys
internet	Household having an internet connection at home	Eurobarometer Surveys
Rural	Household living in rural area or villages	Eurobarometer Surveys
Middle towns	Household living in small or middle sized towns	Eurobarometer Surveys
Large towns	Household living in large towns	Eurobarometer Surveys
age	Age of the households respondent	Eurobarometer Surveys
woman	Gender of the households respondent	Eurobarometer Surveys
Self-employed	Households respondent being self-employed	Eurobarometer Surveys
Manager	Households respondent being a manager	Eurobarometer Surveys
Employee	Households respondent being an employee	Eurobarometer Surveys
Manual worker	Households respondent being a manual worker	Eurobarometer Surveys
House person	Households respondent being a house person	Eurobarometer Surveys
Unemployed	Households respondent being unemployed	Eurobarometer Surveys
Retired	Households respondent being retired	Eurobarometer Surveys
Student	Households respondent being a student	Eurobarometer Surveys
mobile_cost	Average price of a basket of mobile calls	Teligen Report
fixed_cost	Average price of a basket of fixed calls	Teligen Report
fixed_rental	Monthly PSTN rental charge for residential customers (incl. VAT)	Teligen Report
gdp	Gross domestic product per capita	Eurostat
dens	Regional density of population	Eurostat
unempl	Regional unemployment rate	Eurostat
mobile_sub	Mobile-cellular telephone subscriptions per 100 inhabitants	ITU
fixed_sub	Fixed telephone subscriptions per 100 inhabitants	ITU
uso	Existence of universal service obligations	Policy Documents
cov	Existence of coverage obligations	Policy Documents

Table 8: Summary statistics

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Payphone_use	105254	0.13	0.34	0	1
Frequence of payphone use	106381	4.763	0.73	1	5
mo	106989	0.26	0.44	0	1
fo	106989	0.15	0.35	0	1
fm	106989	0.55	0.50	0	1
Internet	105780	0.48	0.50	0	1
Rural areas	106733	0.36	0.49	0	1
Middle towns	106733	0.36	0.48	0	1
Large towns	106733	0.27	0.45	0	1
Age	106989	48.04	18.27	15	98
Woman	106989	0.56	0.50	0	1
Self-employed	106989	0.07	0.25	0	1
Manager	106989	0.10	0.30	0	1
Employee	106989	0.11	0.31	0	1
Manual worker	106989	0.20	0.40	0	1
House person	106989	0.09	0.28	0	1
Unemployed					
Retired	106989	0.29	0.45	0	1
Student	106989	0.08	0.27	0	1
Mobile_cost	106834	12.38	5.18	4.12	29.66
Fixed_cost	106834	36.84	7.19	18.02	57.42
Fixed_rental	106834	13.38	4.68	3.99	25.46
gdp	106834	21.86	13.69	2.7	80.8
Dens	106834	0.26	0.64	0.0059	6.90
unempl	106834	0.08	0.04	0.019	0.29
Mobile_sub	103737	109.14	18.05	61.34	153.13
Fixed_sub	103737	41.50	12.84	19.34	66.38
uso	106989	0.76	0.43	0	1
cov	94852	0.43	0.50	0	1

Appendix B: Counterfactual Analysis

Average change in the yearly number of public payphone calls between 2005 and 2009 at the national level:

In Spain:

Table 9: Average change in the yearly number of payphone calls between 2005 and 2009 by socio-professional groups

	estimated	predicted	If no USO	Variation
Self-employed	2.38	2.84	2.57	-9.65%
Managers	2.31	2.80	2.53	-9.79%
Employees	3.08	2.94	2.67	-9.32%
Manual workers	6.74	3.63	3.36	-7.54%
House persons	3.34	3.04	2.77	-9.01%
Unemployed	8.97	4.27	3.99	-6.43%
Retired	2.79	2.81	2.53	-9.77%
Students	5.95	3.71	3.44	-7.39%
Total	4.25	3.19	2.91	-8.60%

Table 10: Average change in the yearly number of payphone calls between 2005 and 2009 by area of living

	estimated	predicted	If no USO	Variation
Rural area or village	3.96	2.96	2.69	-9.25%
Small/middle town	4.47	3.06	2.78	-8.97%
Large town	4.46	3.77	3.50	-7.27%
Total	4.25	3.19	2.91	-8.60%

In Italy:

Table 11: Average change in yearly number of payphone calls between 2005 and 2009 by socio-professional groups

	estimated	predicted	If no USO	Variation
Self-employed	1.31	1.88	1.61	-14.55%
Managers	1.99	1.65	1.38	-16.57%
Employees	1.74	1.90	1.63	-14.39%
Manual workers	3.90	2.58	2.30	-10.64%
House persons	1.55	2.00	1.73	-13.68%
Unemployed	3.05	3.60	3.33	-7.62%
Retired	1.71	1.54	1.26	-17.82%
Students	2.47	2.41	2.13	-11.39%
Total	2.05	2.04	1.77	-13.43%

Table 12: Average change in the yearly number of payphone calls between 2005 and 2009 by area of living

	estimated	predicted	If no USO	Variation
Rural area or village	2.84	1.60	1.32	-17.15%
Small/middle town	1.90	2.01	1.73	-13.65%
Large town	1.92	2.46	2.18	-11.15%
Total	2.05	2.04	1.77	-13.43%

In West Germany:

Table 13: Average change in the yearly number of payphone calls between 2005 and 2009 by socio-professional groups

	estimated	predicted	If no USO	Variation
Self-employed	1.96	1.46	1.19	-18.74%
Managers	0.96	1.22	0.94	-22.51%
Employees	1.12	1.43	1.15	-19.19%
Manual workers	1.78	2.15	1.87	-12.76%
House persons	2.79	1.59	1.31	-17.26%
Unemployed	5.42	3.12	2.84	-8.80%
Retired	0.91	1.29	1.01	-21.32%
Students	2.21	2.35	2.08	-11.66%
Total	1.63	1.61	1.34	-16.99%

Table 14: Average change in the yearly number of payphone calls between 2005 and 2009 by area of living

	estimated	predicted	If no USO	Variation
Rural area or village	1.13	0.97	0.69	-28.34%
Small/middle town	1.59	1.53	1.25	-17.98%
Large town	2.33	2.67	2.40	-10.26%
Total	1.62	1.61	1.34	-16.99%

In Poland:

Table 15: Average change in the yearly number of payphone calls between 2005 and 2009 by socio-professional groups

	estimated	predicted	If no USO	Variation
Self-employed	0.87	0.75	0.47	-36.62%
Managers	1.06	0.52	0.24	-53.15%
Employees	1.34	0.65	0.38	-41.93%
Manual workers	1.13	1.22	0.95	-22.39%
House persons	1.26	1.14	0.86	-24.08%
Unemployed	1.54	2.41	2.13	-11.39%
Retired	0.77	0.78	0.51	-34.93%
Students	1.37	1.37	1.09	-20.04%
Total	1.06	1.03	0.75	-26.72%

Table 16: Average change in the yearly number of payphone calls between 2005 and 2009 by area of living

	estimated	predicted	If no USO	Variation
Rural area or village	0.97	1.00	0.73	-27.40%
Small/middle town	1.00	0.90	0.62	-30.53%
Large town	1.27	1.25	0.98	-21.85%
Total	1.06	1.03	0.75	-26.72%

Part III
Entry into the Fiber Market

Unbundling the Incumbent and Entry into Fiber: Evidence from France*

Abstract

We use panel data on 36,066 municipalities in metropolitan France over the period 2010-2014 to estimate two models of entry into local markets by: (i) alternative operators using wholesale access on the legacy copper network via local loop unbundling (LLU), and (ii) the incumbent and two alternative operators using fiber technology. We find that local market presence of LLU operators has a positive impact on entry by fiber operators. First, we observe in the data that in the case of two fiber entrants, the deployment of FttH is always preceded by entry via LLU. Moreover, the estimation results suggest that the decision to deploy fibre by the incumbent and competitors is positively influenced by the presence of other LLU operators. High speed fiber broadband allows firms to differentiate their offering from DSL-based services. Moreover, the presence of upgraded cable network stimulates fiber deployment. Firms using DSL technology deploy FttH to avoid being preempted by cable operator. We also find that the deployment of VDSL technology, which allows higher Internet speed on the copper network, slows down fiber deployment. Firms may choose to upgrade copper lines on the legacy network instead of investing in fiber networks. We use the estimates to calculate entry thresholds into local markets, which are substantially lower for broadband provision via LLU than via fiber and decrease over time. Fiber deployment becomes cheaper over time but remains unprofitable for the vast majority of municipalities in France.

Keywords: Fiber Broadband; Local Loop Unbundling; Market Entry.

JEL Classification: K23, L13, L51, L96.

*Co-authored with Marc Bourreau and Lukasz Grzybowski (Telecom ParisTech)

1 Introduction

Universal access to superfast broadband is on top of the public policy agenda in the European Union. The roll-out of fiber-optic networks, delivering superfast broadband access to the Internet, is expected to improve productivity and stimulate growth and job creations (see Rller and Waverman, 2000; Czernich et al. 2011; Ahfeldt et al. 2015). In the US, the National Broadband Plan aims at providing 100 Mbit/s connections to 100 million households by 2020.[16] In Europe, the Commission has set as a target that half of European households should have the ability to access the Internet at speeds of 100 Mbit/s or more by 2020.[17] In September 2016, the Commission further announced that by 2025 all European households should have access to connections with speed of at least 100 MB/s.[18] The roll-out costs of next generation access networks are, however, significant. For example, the European Commission has estimated that it would cost between 181 and 268 billion euros to achieve its 2020 objectives.[19] Private operators deploying fiber also face competition from the previous broadband technology, which has been promoted in Europe through specific regulations.

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

The contribution of this paper is to analyze how broadband provision on the incumbent's legacy copper network via local loop unbundling (LLU) influences entry and deployment of fiber infrastructures. To the best of our knowledge, this is the first paper which at a granular

[16] "Connecting America: The National Broadband Plan, Federal Communications Commission," March 2010
[17] "A Digital Agenda for Europe," European Commission, COM(2010) 245.
[18] Source: "State of the Union 2016: Towards a Better Europe - A Europe that Protects, Empowers and Defends".
[19] See COM(2010) 472 final.

local level analyzes the deployment of fiber infrastructures and the impact of legacy broadband networks on the deployment of next generation access infrastructures. Our results shed light on the ongoing debate on the impact of LLU and the optimal policies to achieve universal access to high speed broadband.

The introduction of LLU has generated heated policy debates. While LLU can facilitate entry of alternative operators and allow new entrants to acquire market experience progressively, some (in particular incumbent) operators have argued that it may undermine investment incentives for both incumbent and entrant operators.

Recently, the regulatory debate has centered on the impact of LLU on firms' incentives to roll-out next generation access networks. Due to their high deployment costs, fiber-optic access infrastructures are likely to coexist with the legacy copper networks for some time. A Report commissioned by the European Competitive Telecommunication Association (WIK 2011) argued that promoting LLU via low access prices would foster investments in fiber, while another Report written for the European Telecommunications Network Operators (Plum 2011) concluded that it would rather discourage fiber deployment.

Governments and regulators face a complex trade-off between promoting competition on the legacy copper network via LLU and providing industry players with the proper incentives to roll-out fiber networks. However, even though this question is critical for both policymakers and academics, so far there exists only limited and mostly aggregated empirical evidence on the impact of regulation of legacy networks on the roll-out of fiber networks.

In this paper, we analyze the impact of LLU on fiber investments using panel data on more than 30,000 municipalities in metropolitan France. The French market is interesting for our analysis for the following reasons. First, the regulation of wholesale broadband access via LLU in France has promoted entry and competition since the early 2000's. Second, in the past few years fiber broadband has been deployed not only by the former telecommunications incumbent Orange, but also by its two main rivals, SFR and Free. Third, there is a single cable network operator, Numericable, which has been upgrading its network to a hybrid fiber-coaxial architecture allowing for Internet speeds comparable to fiber. Fourth, since 2013 Orange and other DSL operators have been upgrading copper network towards VDSL technology, which can provide Internet speed of up to 50 Mbp/s to some consumers.[20]

We use panel data on 36,066 municipalities in metropolitan France over the period 2010-2014 to estimate two models of entry into local markets by: (i) operators seeking wholesale access to the copper legacy telecommunications network via local loop unbundling (LLU), and (ii) the incumbent and two other operators using fiber technology. In the model of fiber entry, we allow the entry decision to depend on the local market presence of competing LLU operators. We also consider the impact of local market presence of upgraded cable modem and upgraded DSL lines to VDSL. When estimating the models, we take into account the role of local market characteristics such as market size, population density and income.

We find that the local market presence of LLU operators has a positive impact on entry by fiber operators. In the data we observe that the fiber entrants SFR and Free always enter via LLU first. However, based on the estimation results, the decision to deploy fiber by the incumbent Orange and the two competitors is also positively influenced by the presence of other LLU operators. High speed fiber broadband allows firms to differentiate their offer from DSL-based services. Moreover, the presence of upgraded cable stimulates fiber deployment. Firms using DSL technology deploy fiber to avoid being preempted by cable operator Numericable. This result suggests that firms recognize that consumers increasingly care about connection speed. Moreover, being first in the market matters for building consumer base and recouping investment costs. In addition, we find that the deployment of VDSL technology, which provides higher Internet speed on the copper network, slows down fiber deployment. Thus, firms may choose to upgrade copper lines on the legacy network instead of investing in fiber networks.

Our results have important policy implications since they show that the competition with LLU operators does not impede fiber entry. We find that the main variable that influences fiber deployment is market size. The market size required for the first operator and additional

[20] The highest speed of DSL connection is 8 MB/s. ADSL2+ and VDSL provide higher speed in the range between 8 MB/s and 50MB/s for premises close to the exchange. Thus, these advanced technologies are not available to all consumers.

operators to enter is decreasing over time, which implies that it becomes easier to enter less densely populated municipalities. Entry thresholds for LLU operators are much smaller than for fiber operators, which reflects the scale of investment required to enter the market. Since LLU operators to a large extent rely on the incumbent's infrastructure, the scale of initial investment is much smaller. Our results also indicate that fiber provision will remain unprofitable in the vast majority of smaller municipalities in France. There is therefore a critical role for public policy to provide incentives to telecommunications firms to deploy fiber and enter less densely populated municipalities by means of co-investment agreements.

The remainder of the paper is organized as follows. In Section 2, we review the relevant literature on regulation and investment in the telecommunications industry. Section 3 introduces the broadband industry in France. Section 3 presents the data. Section 4 introduces the econometric framework. Section 5 presents the estimation results. Finally, Section 6 concludes.

2 Literature Review

The link between access regulation and investment incentives has long been recognized in the theoretical literature (see for example, Valletti 2003; Hori and Mizuno 2006; Klumpp and Su 2010).[21] A few recent studies look more specifically at the effect of access regulation on investment incentives when the new infrastructure co-exists with the legacy infrastructure (Inderst and Peitz 2012; Bourreau, Cambini and Doğan 2012 and 2014). They show that access regulation of the legacy network (via LLU, for example) has ambiguous effects on the incentives to roll-out new infrastructure.

The empirical literature on investments in fiber networks is rather scant. Most studies have analyzed the effects of regulation and competition between technologies on adoption of the DSL broadband technology using aggregate country-level data.[22] Only few studies rely on

[21]See also Guthrie (2006) and Cambini and Jiang (2009) for comprehensive surveys of the literature. The relation between access and investment has generated heated policy debates, and a large number of policy papers have addressed this question; see, among others, Crandall, Ingraham and Sidak (2004), Hausman and Sidak (2005) and Hazlett and Bazelon (2005).

[22]See, among others, Distaso, Lupi and Manenti (2006), Denni and Gruber (2007), Lee and Brown (2008), Bouckaert, Dijk and Verboven (2010), Lee et al. (2011), Gruber and Koutroumpis (2013).

more fine-grained data. In particular, Dauvin and Grzybowski (2014) use NUTS 1 level data for the EU countries, while Nardotto, Valletti and Verboven (2015) use micro-data at the local level for the UK. In general, competition is found to have a significant and positive impact on broadband diffusion but with some differences with respect to the role of inter- and intra-platform competition.[23] Only very few papers analyze investments in high speed broadband networks. Bacache, Bourreau and Gaudin (2014) analyze the migration from LLU to fiber in 15 European Member States over the period 2002-2010, while Briglauer (2015) studies the determinants of fiber investments for the 27 EU Members over the period 2004-2013.[24] However, these two studies use aggregate country-level data.

There are only two recent papers which use local market data. In a recent paper, Minamihashi (2012) uses municipality-level data for Japan in years 2005-2009 and finds that LLU regulation imposed on the Japanese incumbent operator has prevented entrants from deploying new broadband infrastructures. According to his counter-factual exercise, LLU regulation leads to 24% decrease in the roll-out of new infrastructures. However, the incumbent's NGA investments were not hindered by the LLU regulation. In another paper, Fabritz and Falck (2013) use data on local exchange areas in the UK for the years 2007-2013 to analyze how the introduction of geographically differentiated regulation of wholesale broadband access has influenced investment in NGA networks by the incumbent. They find that deregulation has had a positive effect on the roll-out of fiber.

There is also a growing body of literature on the so-called "ladder of investment" (LoI) which refers to a regulatory approach aiming to reconcile service-based competition (or intra-platform competition) and facility-based competition (or inter-platform competition). The LoI approach suggests that regulating access to the incumbent firm's local loop infrastructure, in order to create service-based competition, is not only pro-competitive by reducing barriers to entry but it is also an indirect device to promote facility-based competition. In this manner, service-based

[23] Inter-platform competition: when entrants build their own infrastructure; intra-platform competition: when entrants lease access to incumbents' facilities.

[24] See also Grajek and Röller (2012), who study the impact of pro-entry regulation on incumbents' and entrants' aggregate investments.

and facility-based competition are no longer substitutes, but become complements.

A number of empirical studies put the LoI approach to the test. Using data on US States, Hazlett and Bazelon (2005) find a negative effect of unbundled access on the development of facility-based competition. Hausman and Sidak (2005) focus on five countries, the US, the UK, New Zealand, Canada, and Germany, and find that mandatory unbundling failed to spur infrastructure investments by incumbents or entrants. Using data from the European broadband market, Crandall and Sidak (2007) conclude that there is weak or no evidence of a ladder of investment. Grajek and Röller (2009) use data from 20 EU Member States over a 10 year period and find that promoting market entry by means of regulated access undermines incentives to invest in facility-based competition. In another paper, Waverman et al. (2007) use data from 27 European countries and find that the intensity of access regulation measured by LLU prices has a negative impact on investment in alternative and new access infrastructure. Using data from 15 European Member States, Bachache et al. (2010) find no LoI effect between LLU and new infrastructure connections but a LoI effect between bitstream access and LLU connections. It thus appears that entrants climb the ladder of investment to LLU level but do not reach the next level to build their own infrastructure.[25]

The literature on entry is mature and excellently reviewed by Berry and Reiss (2007). There are only few studies which analyze entry into telecommunications markets, which is due to a lack of appropriate local-level data. Most of the studies focus on entry into local telecommunications markets in the US prior to the FCC decision in 2004 to reverse its open access policy (see Greenstein and Mazzeo 2006; Economides, Seim and Viard 2008; Xiao and Orazem 2009 and 2011; Goldfarb and Xiao 2011), at a time when broadband was still in its infancy. In a more recent study, Molnar and Savage (2015) analyze the impact of entry using data on about 5,500 households in the US to analyze the relationship between broadband Internet market structure and product quality. Finally, Nardotto et al. (2015) study the deployment of broadband technology in the last decade in the UK. However, they do not observe entry in high-speed broadband

[25] Another growing body of literature analyzes competition between broadband technologies from a consumer perspective. See for instance Cardona, Schwarz, Yurtoglu and Zulehner (2009) and Grzybowski, Nitsche, Verboven and Wiethaus (2014).

(fiber) in their period of analysis.

3 Broadband Market in France

Broadband connections provide consumers with high-speed access to the Internet.[26] In France, four main wireline technologies are used to deliver broadband: DSL, cable modem, VDSL, and optical fiber. In 2014, DSL represented 88% of all broadband connections, cable modem 6.6% and optical fiber 3.6%.[27] According to our data, in 2014 the copper network has been upgraded to VDSL in 22% of the municipalities.[28]

Digital subscriber line (DSL) is a family of technologies used to transmit data over the traditional copper telephone wires, which connect customer premises to the main distribution frames (MDFs) of the historical operator (France Telecom/Orange in France). To provide DSL services to consumers, an operator builds a backhaul network down to the MDFs, and then installs DSL equipments in the MDFs to deliver high-speed Internet over copper lines. The asymmetric version of the DSL technology ('ADSL') was first introduced in France in 1999 by Orange. To allow entry and competition in the broadband market, the French regulator ARCEP quickly mandated Orange to provide access to its MDFs and copper lines to competitors, a policy known as 'Local Loop Unbundling' or LLU.[29]

This regulation led to a wave of entry of operators in local municipalities via LLU. Table 26 shows the number of municipalities with at least one LLU entrant in 2014. Free and SFR are the most active LLU operators, and therefore the main competitors for Orange, with a presence in 19,488 and 14,141 municipalities, respectively, as of 2014. There is also a competitive fringe

[26] The European Commission defines broadband as Internet connections with speed of at least 144 kbps.

[27] Other broadband technologies such as WiFi or satellite represented only 1.8% of broadband connections in 2014. Source: ARCEP observatory - High and very-high speed Internet - Retail market.

[28] In 22% of municipalities, at least one line has been upgraded to VDSL in 2014.

[29] Discussions between Orange and the regulator about LLU started in December 1999. In April 2000, the French government was preparing a law mandating LLU, when the European Commission published its 2000 Regulation on unbundled access to the local loop.

of smaller LLU operators.[30]

Cable modem is a technology allowing to provide broadband over the coaxial cables originally developed to carry television signals. There is only one cable operator in France, Numericable, which covers about 30% of the population, mostly in urban areas. In 2007, Numericable started to upgrade its cable network using the DOCSIS 3.0 standard, a hybrid fiber-coax technology which can deliver speeds that far exceed DSL speeds. In October 2014, Numericable acquired SFR, the third largest DSL player.

Very-high-bit-rate digital subscriber line (VDSL) is a specific DSL technology providing faster transmission speeds than standard DSL for very short copper lines.[31] The deployment of VDSL has been authorized by the French telecommunications regulator ARCEP in October 2013.[32] VDSL is deployed by the main DSL operators, Orange, Free and SFR.

Optical fiber is a technology that converts electrical signals carrying data into light, and transmits it over fibers. It can provide speeds that exceed by far the speeds achievable with the DSL or cable modem technologies. In France, from 2010 onwards, the main DSL operators – Orange, SFR and Free – have started to roll out fiber-to-the-home (FTTH) networks up to consumers' premises.

To sum up, standard broadband (with speeds below 30 Mbps) is provided mainly with the DSL technology by the incumbent Orange and LLU entrants (SFR, Free and a competitive fringe). To deliver fast broadband (with speeds above 30 Mbps), the main DSL operators (Orange, SFR and Free) deploy fiber and/or VDSL in local municipalities, and the cable operator Numericable upgrades its network.

[30] The two next largest LLU operators are Axione (2,236 municipalities covered with LLU) and Bouygues Telecom (2,070 municipalities covered with LLU). The other LLU operators have mainly a regional presence and include Teloise, Moselle Telecom, Manche Telecom, Iris 64, Alsace Connexia, Medialys, Ovh, Armor Connectique, Herault Telecom, Ariege Telecom, Haut Rhin Telecom, Colt, Rennes Metropole Telecom, Alliance Connectic and a number of other very small operators.

[31] In France, operators deploy the second generation of VDSL, VDSL2. For VDSL2, the maximum speed is achieved for lines of 300 meters maximum. The connection speed decreases sharply for longer copper lines.

[32] In 2013, the authorization to implement VDSL concerned only the lines in direct distribution, i.e, those lines which were directly connected to a MDF. Since October 2014, ARCEP generalized the use of VDSL to all eligible lines, i.e., all lines connected to a street cabinet.

4 The Data

We use two data sets, which are available at the municipality level: one data set on broadband infrastructure deployments, and one data set with demographic information at the local level. The first data set was collected from different proprietary and public sources, and contains information on the broadband technologies available in each municipality. For each municipality in metropolitan France (excluding Corsica) and each year in the period 2010-2014, we observe which high-speed broadband technologies are available among fiber, broadband cable and VDSL. We also observe the number and identity of LLU operators in each municipality. There are between 1 and 7 LLU operators in municipalities in which the local loop has been unbundled. The share of municipalities with LLU increased from one third in 2010 to two third in 2014.

The data on fiber deployments by Orange was obtained directly from Orange. There are three possible states of fiber deployment by Orange at a given concentration point[33] in a municipality: 'deployed', 'in deployment' and 'planned'. We consider that fiber is available in a municipality if there is at least one concentration point with status 'deployed'.

The information on fiber deployment by the other firms, SFR and Free, was obtained from their websites. SFR publishes a map of France listing the municipalities in which it has deployed or will deploy fiber. For each municipality, we observe whether and when SFR is planning to deploy its network alone or in co-investment with another operator, except for the year 2014 for which no timeline of deployment was available. The information on fiber deployments by SFR in 2014 was collected using press releases published on its website, which lists municipalities where households can subscribe to fiber. The data on fiber deployment by Free was collected from two unofficial websites run by Free users.[34] The data collected from these websites are consistent with the information available on other websites and with Free's annual reports. For each municipality in metropolitan France, we know whether Free has active fiber connections.

The data on availability of broadband cable was collected from the website of the cable

[33] In France, the concentration point is a small street cabinet aggregating a dozen of copper lines. It's connected to the customers' premises on one side and to the street cabinet on the other side. There can be more than one concentration point in a given municipality.

[34] See `http://francois04.free.fr/` and `http://serge.31.free.fr/`.

operator, Numericable, for the years 2010 to 2014.[35] For each municipality, we know whether Numericable has upgraded its cable network to provide high-speed broadband. In October 2014, Numericable acquired SFR. However, the merger between the two operators does not affect our analysis, as the data for the year 2014 have been collected before its clearance by the Competition Authority.

Finally, we obtained data from Orange on the deployment of VDSL for the years 2010 to 2014. We observe for each municipality the number of lines upgraded to VDSL. From the same data set, we also know for each municipality the number and the identity of firms using LLU.

Figure 1 shows for each year the share of municipalities covered by the different high speed broadband technologies: fiber, upgraded cable, VDSL and LLU (i.e., DSL). Figure 2 shows for each year the potential population covered by the different broadband technologies. Finally, Figure 3 shows for each year the number of municipalities covered by fiber depending on the number of LLU operators.

Our second data set contains demographic information at the municipality level, and was obtained from the French National Institute for Statistics and Economic Studies (INSEE). We have municipality-level data on population size (defined as the number of households), population density (defined as the number of households divided by the surface of the municipality), and the number of flats and houses. This information is published with a delay and available only until 2012. 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. Finally, we have information on the average fiscal income per municipality in years 2010-2014, which was retrieved from the website of the General Direction of Public Finance (DGFIP). Table 21 describes the variables used in the analysis.

The different data sets were merged using the unique municipality INSEE code. However, since the INSEE code is not available for the municipality-level data set collected from the websites of SFR, Free and Numericable, we assigned to each municipality an INSEE code based on its name and department. After merging the data sets we have information on 36,066

[35]We collected historical information using the wayback machine. See: `archive.org/web/`.

municipalities (which represents 99.7% of municipalities in France), for the years 2010-2014.[36] Table 22 shows summary statistics for the data used in the analysis. Tables 23 and 24 show summary statistics depending respectively on the number of fiber operators and the number of LLU operators.

5 Econometric Models

In this section, we introduce the models of LLU and fiber entry that we estimate. As discussed in Section 3, an entrant who wants to provide DSL broadband services via LLU has to build its own backhaul network down to the incumbent's MDF, and then it has to locate its broadband equipments in the MDF, to which its broadband consumers are connected. Entry via fiber requires deploying fiber optic cables from the backbone network to every single house, which represents a much larger capital investment.[37]

In the previous literature on entry into broadband markets, both Xiao and Orazem (2011) for the US and Nardotto et al. (2015) for the UK consider that investments made by LLU operators are sunk. The identification of sunk costs is based on a comparison of entry thresholds for markets which experienced entry with thresholds for markets without entry. The sunk costs of entry imply that it takes less demand for an incumbent to continue operations than to support a new entrant. Table 28 shows that there is a large number of LLU entries and exits in the time period considered. By contrast, Table 29 shows a relatively small number of fiber entries and no exit at all. These differences lead us to take a different approach to model LLU and fiber entry. We first present below our model of LLU entry, and then our models of fiber entry.

[36] 112 municipalities out of the 36,192 counted in 2014 are missing in our final data set due to administrative changes during the period 2010-2014. Some municipalities have been split into two different ones, while others merged resulting in changes in names and INSEE codes.

[37] In general, the infrastructure fixed costs can be divided into country-level and local market-level costs. Country-level costs are related to the deployment and maintenance of the backbone network, administration, marketing, etc. Local market costs are related to network deployment and administration within the municipality. These costs depend on factors such as the size of geographic area to be covered, number of premises and spatial distribution of population. After the infrastructure is deployed, the marginal costs are relatively small and include factors such as modem rental expenditures and customer service. There are therefore economies of scale which imply that only a certain number of entrants can profitably operate in a municipality with certain socio-economic characteristics.

5.1 LLU Entry

We model the decisions of firms to enter via LLU assuming that the market demand is stochastic. At the end of each time period, firms decide whether to enter in the next period into 'new' local markets (where entry has not already taken place), and whether to continue operations in the 'old' local markets (where entry already occurred). Firms form expectations about market demand, cost levels and competition with other firms. These expectations are assumed to be fulfilled in equilibrium.

The number of LLU entrants in municipality i at time t is then $N_{it} = n \in \{0, 1, 2, 3, 4, 5+\}$, where 5+ refers to a situation with at least five entrants.[38] Following Xiao and Orazem (2011) and Nardotto et al. (2015), in presence of $n-1$ competitors, the discounted future profits of the n^{th} entrant firm in market i at time t can be written as:

$$\pi_{it}^{n} = \alpha_t lnS_{it} + X_{it}\beta_t - \mu^n I(N_{it} = n) + \epsilon_{it} \equiv \bar{\pi}_{it}^{n} + \epsilon_{it}, \quad (9)$$

where S_{it} is the potential market size approximated by the number of households, X_{it} is a vector of other characteristics of municipalities, which are potential determinants of profits, including income, population density, and the share of flats in the total number of premises. Finally, μ^n represents the negative effect on profits from the presence of the n^{th} firm, and ϵ_{it} is the error term.

Since LLU has been regulated in France since 2000 and LLU entry in general took place before fiber entry and before the cable network's upgrade to high speed broadband, we consider that LLU entry is not influenced by the availability of these two competing technologies.

The reduced-form profit specification (9) does not allow us to distinguish how the number of competitors affects the variable profits and the fixed costs, as in Bresnahan and Reiss (1991). The model also does not allow for simultaneous entry and exit. Instead, it focuses on the expected profitability from operating in the next period of the marginal firm which enters or

[38]Since there is only a small number of markets with more than five entrants, we truncate the number of entrants to five.

exits the market. The profits π_{it}^n include the non-sunk part of fixed costs. Firms may also have to incur a sunk cost SC to enter a local market, which cannot be recouped when they exit. We assume that all entrants have the same entry costs regardless of the order of entry. Since profits are not observed, π_{it}^n is a latent variable. We draw inferences on the profit determinants assuming a free entry equilibrium, where firms enter a local market if, and only if, it is profitable for them to do so.

There are three different cases in which we may observe that at time t in market i there are $N_{it} = n$ active firms.

In the first case, there were fewer than n firms in period $t-1$ and one or more firms have entered in period t, so that $N_{it} > N_{it-1}$. In this case, for the n^{th} marginal firm, the expected discounted benefits from entering must exceed the sunk cost of entry. But for the $(n+1)^{th}$ marginal firm, the benefits from entering must be lower than the sunk cost, which can be expressed as follows:

$$\textbf{Case 1, net entry: } N_{it} > N_{it-1} \text{ if } \pi_{it}^n \geq SC \text{ and } \pi_{it}^{n+1} < SC. \tag{10}$$

In the second case, no firm has entered or exited the market in period t, which means that there were n firms in period $t-1$ and $N_{it} = N_{it-1}$. In this case, the n^{th} marginal firm decides to stay in the market because its expected discounted benefits from continuation exceed 0. But for the $(n+1)^{th}$ marginal firm, the benefit from entering must not exceed the sunk cost of entry, which we can express as follows:

$$\textbf{Case 2, inaction: } N_{it} = N_{it-1} \text{ if } \pi_{it}^n \geq 0 \text{ and } \pi_{it}^{n+1} < SC. \tag{11}$$

Finally, in the third case, there were more than n firms in period $t-1$ and one or more firms have exited the market in period t, which implies that $N_{it} < N_{it-1}$. In this case, the market becomes unprofitable when more than n firms stay in operation. The $(n+1)^{th}$ marginal firm expects that it would be unprofitable to remain in the market, and decides to exit the market.

Once this firm has exited the market, the n^{th} marginal firm expects positive profits, which can be expressed as:

$$\textbf{Case 3, net exit: } N_{it} < N_{it-1} \text{ if } \pi_{it}^{n} \geq 0 \text{ and } \pi_{it}^{n+1} < 0. \tag{12}$$

Using the profit specification (9), the above inequalities can be combined to derive the following probability of observing $N_{it} = n$ entrants in market i at time t:

$$Pr(N_{it} = n) = \Phi(\overline{\pi}_{it}^{n} - SC \cdot I_{it}^{+}) - \Phi(\overline{\pi}_{it}^{n+1} - SC \cdot (I_{it}^{+} + I_{it}^{0})), \tag{13}$$

where $\Phi(.)$ denotes the cumulative normal distribution function, and $I_{it}^{+} \equiv I(N_{it} > N_{it-1})$ and $I_{it}^{0} \equiv I(N_{it} = N_{it-1})$ are indicator variables which show whether the number of firms increased (subscript +) or remained constant (subscript 0). The parameter vector $\theta = (\alpha_t, \beta_t, \mu^n)$ is estimated by maximizing the following log-likelihood function:

$$LL(\theta) = \sum_{i=1}^{M} \sum_{t=1}^{T} \sum_{n=1}^{N} y_{it} \ln(Pr(N_{it} = n|\theta)), \tag{14}$$

where y_{it} takes value of 1 if $N_{it} = n$, and 0 otherwise.

5.2 Fiber Entry

We use the same approach to model fiber entry. The discounted value of future profits for a fiber entrant can be written in an analogous way to (9), but with $n \in \{0, 1, 2, 3\}$. We use the same set of socio-economic characteristics as determinants of profits of fiber entrants.

Since fiber entry takes place in a much smaller number of local markets than LLU and we do not observe any exit, we are not able to identify sunk costs in this case. Without sunk costs, which implies that $SC = 0$, the model for fiber entry is static and reduces to a standard ordered logit or probit model. Another difference to the model of LLU entry is that the future profits of a potential fiber entrant are affected by the competition with other broadband technologies, which are already available in the local markets. We account for this competition as follows.

First, we create a variable which represents the number of LLU entrants in the local market, excluding the fiber operators SFR and Free. In the data, we observe that SFR and Free deploy fiber only in markets where they also have LLU operations. In general, firms which have invested into LLU in an area have lower incremental costs of investing into fiber. Therefore, the data would tell us that there is a positive effect of entry via LLU on fiber deployment by the same firm. To circumvent this problem, we analyze whether the number of other LLU operators has a positive or a negative impact on fiber entry. The impact of this variable on the profits of fiber entrants is ex ante ambiguous. The incumbent Orange may have lower incentives to deploy fiber in areas in which it already provides LLU access to competitors and receives wholesale revenues (wholesale revenue effect). At the same time, SFR and Free may have lower incentives to invest in areas in which there are many LLU competitors (business migration effect). On the other hand, all three firms may have higher incentives to invest in fiber in such areas to escape fierce competition by differentiating their offer and providing consumers with services of higher quality. In the analysis of fiber entry, we consider that the number of LLU entrants is exogenous because entry via LLU by SFR, Free and other firms took place before the deployment of fiber. Endogeneity of this variable would imply that entry via LLU is affected by potential future entry via fiber, which we do not consider as viable. We discuss this issue further in the next section.

Second, the incentives to deploy fiber may be influenced by the availability of the VDSL technology in the local market. We can expect that the availability of VDSL reduces the future profits of a potential fiber entrant, which makes fiber entry less likely. We have information on the share of VDSL lines in all copper lines in each municipality and year. Importantly, the deployment of VDSL started only in 2013. We create a dummy variable which takes value one for the municipalities with a nonzero share of VDSL, and zero otherwise. We also treat this variable as exogenous, i.e., as independent on the deployment of fiber, even though firms may decide to upgrade copper lines to VDSL instead of investing in fiber.

Finally, the availability of broadband Internet via cable in the municipality can influence the decision to enter with fiber. On the one hand, upgraded cable may discourage fiber entry since consumers have more choice and current cable subscribers may be reluctant to switch to fiber technology which does not offer higher connection speed. On the other hand, firms may deploy fiber to secure migration of their own consumers from DSL to fiber, who otherwise could be lost to cable. In most municipalities, broadband cable was deployed before fiber deployment took place. In the analysis, cable coverage is considered to be independent from the entry decisions by fiber operators. But we also allow this variable to be endogenous, as discussed in the next section.

Since, as shown in Table 27, Orange is the market leader with a presence in almost all municipalities in which fiber is deployed, we estimate a model in which the zero/one entry decision by Orange is regressed on the same set of explanatory variables. We use this model to test the robustness of our model of fiber entry. We study how the deployment of fiber by Orange in a local area is affected by: (i) the number of LLU entrants (excluding SFR and Free); (ii) the availability of VDSL; and (iii) the availability of broadband cable.

Our modeling approach has a number of limitations, which are due to the particularities of the broadband market and to data constraints. In particular, since LLU access regulation is in place on the whole country, the identification of its impact on fiber deployment is based on the differences in the number of LLU competitors in local markets. Therefore, in this paper we evaluate the impact of competition from LLU entrants on fiber deployment, rather than the impact of LLU regulation *per se.*

6 Estimation Results

Table 17 shows the estimation results for the model of LLU entry. Model I is estimated without sunk costs (ordered logit model) and Model II allows for non-zero sunk costs. Based on the value of the log-likelihood function, the preferred model is Model II. The variables which significantly affect LLU entry are market size and density of population. The interaction terms of the density of population with time dummies are significant, but do not suggest a particular increasing or decreasing trend. At the same time, the coefficients of time dummies increase over time. The share of flats in the total number of residencies is significant and negative. Finally, a higher level of income has a positive impact on LLU entry.

Table 17: LLU entry in municipalities

Variables	Model I	Model II
Loghh	0.334***	0.279***
	(0.008)	(0.011)
Logdensity	0.945***	0.694***
	(0.012)	(0.017)
Logdensity_2012	0.015	0.028
	(0.014)	(0.020)
Logdensity_2012	0.041***	0.117***
	(0.013)	(0.019)
Logdensity_2012	0.013	0.018
	(0.013)	(0.020)
Logincome	2.202***	1.565***
	(0.026)	(0.037)
Share flat	-0.099*	-0.450***
	(0.051)	(0.074)
Year 2012	0.287***	0.244***
	(0.052)	(0.078)
Year 2013	0.875***	1.207***
	(0.052)	(0.075)
Year 2014	1.094***	0.804***
	(0.051)	(0.081)
Cut_1	2.795***	-2.727***
	(0.099)	(0.141)
Cut_2	3.998***	-1.686***
	(0.099)	(0.141)
Cut_3	7.274***	1.425***
	(0.101)	(0.144)
Cut_4	9.574***	2.839***
	(0.105)	(0.147)
Cut_5	13.710***	5.607***
	(0.171)	(0.202)
Sunk cost		5.853***
		(0.031)
Observations	144,424	144,424
LL	-133,928	-67,589

Model I: entry by LLU operators without sunk costs. Model II: entry by LLU operators with sunk costs.

Table 18 shows the estimation results for the models of fiber entry. Model I is ordered logit model estimated without sunk costs. As discussed in the previous section, we were not able to estimate a model with sunk costs due to convergence issues, which may be caused by the particularities of our fiber entry data. Model II is an alternative specification of Model I, in which the cable network operator, Numericable, is considered to be one of the fiber entrants. In this way, we allow cable coverage to be determined endogenously together with the number of fiber entrants.[39] Finally, Model III is a logit model of fiber entry by Orange, as discussed in the previous section. The estimation results for all three models lead to similar conclusions.

[39]We also estimated an alternative specification of Model II, in which we take account of the merger between Numericable and SFR for the year 2014. We consider that for this year one of the firms exited the market in locations in which both of them had operations. We find similar estimation results.

Table 18: FttH entry in municipalities

Variable	Model I	Model II	Model III
Loghh	1.178***	0.631***	1.356***
	(0.050)	(0.030)	(0.065)
Logdensity	1.814***	0.936***	1.405***
	(0.164)	(0.066)	(0.203)
Logdensity_2011	-0.193	0.181**	-0.316
	(0.202)	(0.086)	(0.247)
Logdensity_2012	-0.683***	-0.123*	-0.744***
	(0.181)	(0.073)	(0.224)
Logdensity_2013	-1.062***	-0.292***	-0.989***
	(0.172)	(0.067)	(0.216)
Logdensity_2014	-1.138***	-0.380***	-0.931***
	(0.169)	(0.066)	(0.213)
Logincome	1.351***	1.848***	1.446***
	(0.121)	(0.076)	(0.163)
Share flat	1.908***	2.338***	2.053***
	(0.227)	(0.134)	(0.294)
ULL entrants	0.577***	0.541***	0.973***
	(0.059)	(0.034)	(0.070)
VDSL	-0.419***	-0.692***	-0.390***
	(0.104)	(0.060)	(0.123)
Cable	0.432***		0.474***
	(0.082)		(0.101)
Year 2011	1.035***	0.356***	1.271***
	(0.213)	(0.106)	(0.246)
Year 2012	1.864***	0.928***	2.260***
	(0.195)	(0.099)	(0.230)
Year 2013	2.761***	2.071***	3.299***
	(0.204)	(0.102)	(0.244)
Year 2014	3.267***	2.624***	4.047***
	(0.213)	(0.107)	(0.259)
Cut_1	11.725***	10.405***	
	(0.490)	(0.290)	
Cut_2	12.478***	11.959***	
	(0.493)	(0.295)	
Cut_3	14.844***	13.021***	
	(0.507)	(0.299)	
Cut_4		14.514***	
		(0.308)	
Observations	180,530	180,530	180,530
LL	-3,842	-10,665	-2,184

Model I: entry by fiber operators. Model II: entry by fiber operators and Numericable. Model III: entry by Orange.

The models of fiber entry I and II suggest that the availability of competing technologies in a local market has a significant impact on fiber entry. First, a greater number of LLU entrants has a significant and positive impact on fiber entry. In municipalities with many LLU entrants, Orange, Free and SFR have more incentives to deploy fiber networks.[40] Thus, the incentives to roll out fiber to differentiate from LLU competitors dominate the disincentives due to wholesale or business stealing effects. The estimation results of the logit model for Orange's decision to deploy fiber (Model III) confirm this finding. There is a significant and positive impact of the number of LLU competitors on fiber entry by Orange. We also explain this result by the incentives of Orange to provide consumers with services of higher quality and differentiate from LLU competitors.

We also estimated alternative versions of Model I to account for possible endogeneity of the number of LLU competitors and heterogeneity in the attractiveness of municipalities. First, we replaced the LLU variable by its lagged values, thus losing the first year of data. The estimation results were very similar, with a positive coefficient for the number of LLU operators. Apart from endogeneity, there may be also correlation between the number of fiber and LLU entrants driven by local market characteristics. We use for each municipality the total number of 2G, 3G and 4G antennas and the number of years since the launch of DSL services to control for their attractiveness. We obtain similar estimates for the coefficients of the LLU and cable variables. We also estimated our models for a reduced sample of municipalities with population greater than 300 households, which yielded similar results. Finally, dropping from the estimation municipalities without LLU in 2014 (i.e., less attractive municipalities) does not change the results.[41]

In Models I and III, we find that fiber entry is more likely in areas where the cable operator Numericable upgraded its network to provide high speed broadband services. According to

[40] In Model I, the number of LLU competitors excludes SFR and Free to assess the impact of other LLU competitors on fiber deployment. However, the impact of LLU on fiber entry is similar when SFR and Free are counted as LLU competitors. At the same time, Numericable does not provide unbundled DSL services for residential households and is not counted among LLU entrants.

[41] We also have information on the number of unbundled lines in municipalities but for year 2014 only. All three regressions are estimated for year 2014 only using the share of unbundled lines instead of the number of LLU entrants. The estimated coefficient for the number of unbundled lines is also positive.

discussions with industry experts, the customer acquisition strategies of fiber operators are more aggressive in municipalities which are covered by cable. Our result suggests that firms deploy fiber to secure the migration of their DSL consumers to fiber, who may be otherwise lost to cable. Being first in the market is critical to build a customer base and recoup the investment costs. Moreover, this also indicates that fiber operators recognize that consumers care about the connection speed.

In all three models, we find that upgrading DSL lines to the VDSL technology, a process which started in 2013, has a negative impact on fiber deployment. The negative effect suggests that fiber and VDSL connections are substitutes for operators. When operators have the option of investing in the VDSL technology they have less incentives to deploy fiber networks. Furthermore, since VDSL deployment is much faster, when one firm deploys VDSL, its competitors have an incentive to react quickly and deploy the same technology. Unfortunately, we do not know the identity of the firms which deploy VDSL, and therefore we are unable to separate these two effects.

The socio-economic characteristics of local markets affect fiber entry. The main variable which influences entry is the market size measured by the number of households in the local market. The population density has also a significant positive impact on fiber entry. This means that fiber entry is more profitable in densely populated areas. The negative and increasing coefficients of the interaction terms of population density and year dummies indicate that it becomes easier over time to enter areas with lower densities of population. The share of flats in the total number of residencies has a positive impact on fiber entry, which may reflect lower costs of deploying fiber in areas with many apartment blocks. Finally, we find that a higher level of income has a positive impact on fiber entry.

We use the model estimates to compute entry thresholds for LLU and fiber entrants. For each market i in period t we calculate entry thresholds for respectively $n = 1, 2, 3, 4, 5+$ LLU and $n = 1, 2, 3$ fiber operators by solving for the critical market size which sets the profits to zero: $S_{it}^{n} = \exp((-X_{it}\beta_t + \mu^n I(N_{it} = n))/\alpha_t)$. The thresholds are market specific and show large variation depending on the values of the variables which impact profits. The average entry thresholds for LLU are shown in Table 19, and those for fiber in Table 20. These numbers represent an average across all municipalities of the minimum size of local market, which is required to accommodate a given number of LLU and fiber operators.

Table 19: LLU entry thresholds

year	entrant 1	entrant 2	entrant 3	entrant 4	entrant 5
2011	1,136	2,963	43,061	104,200	250,799
2012	928	2,416	34,951	84,447	202,943
2013	545	1,494	24,910	63,076	158,819
2014	526	1,460	25,220	64,614	164,600

The average entry thresholds for LLU are much smaller than for fiber, which reflects the lower scale of investment required to enter the market. As discussed in Section 3, LLU operators rely on the incumbent's last-mile copper network, which substantially reduces the capital investments needed for entry. Moreover, the average entry thresholds for LLU decrease substantially over time. This reduction in entry thresholds may result from a decline in the cost of technology and equipments. It may be also the effect of regulations which have reduced the wholesale costs of LLU for alternative operators. Finally, there was a change in the regulation of bitstream access in France in 2011, which may have led operators to favor LLU over bitstream access.[42] We also observe a large decrease in the average entry thresholds for the first and second fiber entrant.

Our estimation results of the fiber entry model show that fiber entry is positively influenced by the number of LLU operators. We conduct counterfactual simulations to compute fiber entry thresholds in the absence of other LLU operators than Free and SFR. The upper panel in Table 20 shows current entry thresholds and the lower panel shows predicted entry thresholds in the absence of LLU operators which do not deploy fiber. In the latter case, our simulations suggest that the average entry thresholds in year 2014 would be higher by about 6%.

[42]In 2011, the French regulator ARCEP published a new decision for bitstream access removing the obligation of cost orientation in areas with wholesale competition.

Table 20: Fiber entry thresholds

year	entrant 1	entrant 2	entrant 3
2010	102,301	138,053	361,146
2011	75,384	103,851	290,272
2012	72,429	107,648	383,849
2013	68,103	111,619	544,737
2014	53,271	89,280	468,066
Without LLU competitors			
year	entrant 1	entrant 2	entrant 3
2010	107,821	145,502	380,633
2011	80,370	110,719	309,470
2012	78,554	116,752	416,311
2013	75,373	123,535	602,888
2014	59,440	99,620	522,274

The entry thresholds represent an average across all municipalities of a minimum size of local market, which is required to accommodate a given number of fiber operators. The upper panel shows current entry thresholds and the lower panel shows predicted entry thresholds in a situation in which there were no LLU competitors at all.

7 Conclusion

We analyze the impact of LLU on fiber investments using panel data on 36,066 municipalities in metropolitan France in years 2010-2014. We estimate two models of entry into local markets by: (i) the incumbent and two other operators using fiber technology and (ii) operators seeking wholesale access to the legacy telecommunications network via local loop unbundling. We also estimate the determinants of the incumbent's decision to deploy fiber.

We find that fiber entry is more likely in areas in which there are many LLU competitors. We explain this by domination of the incentives to differentiate the offer and provide consumers with services of higher quality over the wholesale and business stealing effects. Moreover, the presence of upgraded cable has a positive impact on fiber deployment. Firms using DSL technology may fear being preempted by the cable operator, which encourages them to deploy fiber in areas covered by cable. This result indicates that being first in the market is critical to build consumer base and recoup investments. In addition, we find that the deployment of VDSL technology, which provides higher Internet speed on the copper network, slows down fiber deployment. Thus, firms choose to upgrade copper lines on the legacy network instead of investing in fiber networks. But also when LLU competitors upgrade to VDSL technology, fiber operators may have less (or more as in the case of cable) incentives to enter with fiber. Unfortunately, we do not know the identity of firms which use VDSL technology to separate these two effects. We also observe in the data that fiber deployment by SFR and Free is always preceded by entry via LLU. In general, firms which have invested into LLU in an area have lower incremental cost of investing into fiber.

Our results have important policy implications as they show that competition with LLU operators does not impede fiber entry. Moreover, we show that the main variables which influence fiber deployment are the market size and density of population. The market size required for the first and each additional operator to enter the market decreases over time, which implies that entering less densely populated municipalities becomes easier over time. Entry thresholds for LLU operators are substantially smaller than for fiber operators, which reflects the scale of investment required to enter the market. Our results also suggest that despite a decrease in the fiber entry thresholds, the vast majority of municipalities in France are and will remain unprofitable for fiber deployment. There is therefore a need for public involvement to achieve the Digital Agenda's high speed broadband deployment objectives. For instance, policy makers can stimulate fiber deployment by allowing firms to co-invest which will reduce entry costs. Moreover, they should ensure that the investment profitability will not be reduced by wholesale access regulation. Private operators will be more prone to invest into fiber in less densely populated area if they can commercially set the wholesale access fee. This conclusion supports ARCEP policy of not regulating NGA infrastructure access, which is different from the European Commission's Recommendation. In other areas, where market characteristics show that the local markets are not economically profitable for private deployment, there is a rationale for public investment. We show that private operators' decisions to enter into local markets depend on the expectations on potential revenues which are determined by cost of deployment and "quality" of demand. Therefore, there are grounds for the use of demand stimulation policy, which by enhancing the demand, will indirectly enhance operators incentives to invest.

References

Ahlfeldt, G., Koutroumpis, P. and T. Valletti (2014). "Speed 2.0 – Evaluating access to universal digital highways," *Journal of the European Economic Association*, forthcoming.

Bacache, M., Bourreau, M. and G. Gaudin (2014). "Dynamic Entry and Investment in New Infrastructures: Empirical Evidence from the Fixed Broadband Industry," *Review of Industrial Organization*, 44(2), 179–209.

Berry, S. (1992). "Estimation of a Model of Entry in the U.S. Airline Industry," *Econometrica*, 60(4), 889–917.

Berry, S. and P. Reiss (2007). "Empirical Models of Entry and Market Structure," In: Armstrong, M. and R. Porter (eds), *Handbook of Industrial Organization*, Elsevier, Volume 3, 1845–1886.

Bouckaert, J., van Dijk, T. and F. Verboven (2010). "Access Regulation, Competition, and Broadband Penetration: An International Study," *Telecommunication Policy*, 34, 661–671.

Bourreau, M., Cambini, C. and P. Dogan (2012). "Access pricing, competition, and incentives to migrate from "old" to "new" technology," *International Journal of Industrial Organization*, 30(6), 713–723.

Bourreau, M., Cambini, C. and P. Dogan (2014). "Access regulation and the transition from copper to fiber networks in telecoms," *Journal of Regulatory Economics*, 45(3),233–258.

Bresnahan, T. and P. Reiss (1991a). "Entry and Competition in Concentrated Markets," *Journal of Political Economy*, 95, 977–1009.

Bresnahan, T. and P. Reiss (1991b). "Empirical models of discrete games," *Journal of Econometrics*, 48(1), 57–81.

Brito, D., Pereira, P. and J. Vareda (2012). "Incentives to invest and to give access to non-regulated new technologies," *Information Economics and Policy*, 24(34), 197–211.

Cardona, M., Schwarz, A., Yurtoglu, B.B. and C. Zulehner (2009). "Demand Estimation and Market Definition for Broadband Internet Services," *Journal of Regulatory Economics*, 35(1), 70–95.

Crandall, R., Ingraham, A. and H. Singer (2004). "Do unbundling policies discourage CLEC facilities-based investment," *Topics in Economic Analysis & Policy*, 4(1), Article 14.

Crandall, R. and G. Sidak (2007). "Is Mandatory Unbundling the Key to Increasing Broadband Penetration in Mexico? A Survey of International Evidence," Mimeo.

Czernich, N., Falck, O., Kretschmer, T., and L. Woessmann (2011). "Broadband Infrastructure and Economic Growth," *The Economic Journal*, 121, 505–532.

Dauvin, M. and L. Grzybowski (2014). "Estimating broadband diffusion in the EU using NUTS 1 regional data," *Telecommunications Policy*, 38(1), 96–104.

Denni, M. and H. Gruber (2007). "The Diffusion of Broadband Telecommunications in the U.S. – The Role of Different Forms of Competition," *Communications & Strategies*, 68, 139–157.

Distaso, W., Lupi, P. and F.M. Manenti (2006). "Platform Competition and Broadband Uptake: Theory and Empirical Evidence from the European Union," *Information Economics and Policy*, 18, 87–106.

Economides, N., Seim, K. and V.B. Viard (2008). "Quantifying the benefits of entry into local phone service," *RAND Journal of Economics*, 39, 699–730.

Goldfarb, A. and M. Xiao (2011). "Who Thinks about the Competition? Managerial Ability and Strategic Entry in US Local Telephone Markets," *American Economic Review*, 101(7), 3130-3161.

Grajek, M. and L.H. Röller (2012). "Regulation and Investment in Network Industries: Evidence from European Telecoms," *The Journal of Law and Economics*, 55(1), 189–216.

Greenstein, S. and M. Mazzeo (2006). "The role of differentiation strategy in local telecommunication entry and market evolution: 1999-2002," *Journal of Industrial Economics*, 54, 323–350.

Gruber, H. and P. Koutroumpis (2013). "Competition Enhancing Regulation and Diffusion of Innovation: The Case of Broadband Networks," *Journal of Regulatory Economics*, 43(2), 168–195.

Gruber, H. and F. Verboven (2001). "The Diffusion of mobile telecommunications services in the European Union," *European Economic Review*, 45, 577–588.

Grzybowski, L., Nitsche, R., Verboven, F. and L. Wiethaus (2014). "Market definition for broadband internet in Slovakia Are fixed and mobile technologies in the same market?" *Information Economics and Policy*, 28, 39–56.

Guthrie, G. (2006). "Regulating Infrastructure: The Impact on Risk and Investment," *Journal of Economic Literature*, 44, 925–972.

Hausman, J. and G. Sidak (2005). "Did Mandatory Unbundling Achieve its Purpose? Empirical Evidence from Five Countries," *Journal of Competition Law and Economics*, 1(1), 173–245.

Hausman, J., Sidak, G. and H. Singer (2001). "Cable Modems and DSL: Broadband Internet Access for Residential Customers," *American Economic Review*, 91, 302–307.

Hazlett, T. and C. Bazelon (2005). "Regulated Unbundling of Telecommunications Networks: A Stepping Stone to Facilities-Based Competition?" Mimeo.

Lambrecht, A., Seim, K. and B. Skiera (2007). "Does uncertainty matter? Consumer behavior under three-part tariffs," *Marketing Science*, 26, 698–710.

Lee, S. and J.S. Brown (2008). "The Diffusion of Fixed Broadband: An Empirical Analysis," NET Institute Working Paper No. 08-19.

Lee, S., Lee, S. and M. Marcu (2011). "An empirical analysis of fixed and mobile broadband diffusion," *Information Economics and Policy*, 23, 227–233.

Miravete, E. (2002). "Estimation demand for local telephone service with asymmetric information and optional calling plans," *Review of Economic Studies*, 69, 943–971.

Miravete, E. and L.H. Röller (2004). "Competitive nonlinear pricing in duopoly equilibrium: The early US cellular telephone industry," Working paper, University of Pennsylvania.

Narayanan, S., Chintagunta, P. and E. Miravete (2007). "The role of self selection, usage uncertainty and learning in the demand for local telephone service," *Quantitative Marketing and Economics*, 5(1), 1–34.

Nardotto, M., Valletti, T. and F. Verboven (2015). "Unbundling the incumbent: Evidence from UK broadband," *Journal of the European Economic Association*, 13, 330–362.

Nitsche, R. and L. Wiethaus (2011). "Access regulation and investment in next generation networks – A ranking of regulatory regimes," *International Journal of Industrial Organization*, 29(2), 263–272.

Orazem, P., and M. Xiao (2006). "Do entry conditions vary over time? Entry and competition in the broadband market: 1999-2003," Working paper, University of Arizona.

Waverman, L., Meschi, M., Reillier, B., and K. Dasgupta (2007). "Access Regulation and Infrastructure Investment in the Telecommunications Sector: An Empirical Investigation," September 2007.

Xiao, M. and P. Orazem (2009). "Is Your Neighbor Your Enemy? Strategic Entry into the US Broadband Market," Mimeo.

Xiao, M. and P. Orazem (2011). "Does the Fourth Entrant Make Any Difference? Entry and Competition in the Early U.S. Broadband Market," *International Journal of Industrial Organization*, 29, 547–561.

Appendix

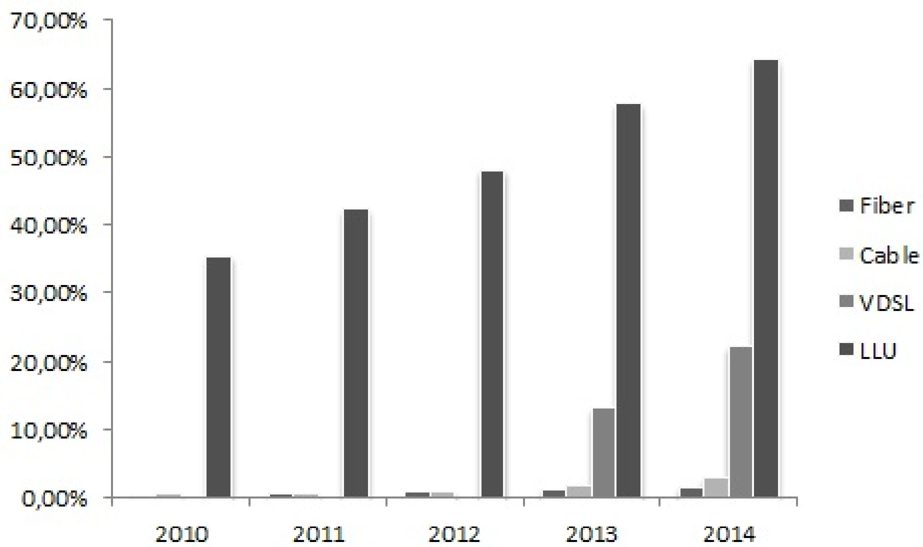
Table 21: Variable description (municipality-level data)

Variable Name	Description	Years	Source
Nb fiber	Number of fiber operators	2010-2014	Orange, SFR website, Free users' websites
Nb LLU	Number of LLU operators	2010-2014	Orange
Cable	Presence of upgraded cable	2010-2014	Numericable website
VDSL	Presence of VDSL lines	2010-2014	Orange
Households	Number of households (tsd)	2008-2012	INSEE
HH Density	Number of households per surface (tsd/km2)	2008-2012	INSEE
Share flats	Percentage of flats (%)	2008-2012	INSEE
Income	Average annual income (tsd Euros)	2010-2014	DGFIP, governement website

Table 22: Summary statistics (all years)

Variable	Obs	Mean	Std. Dev.	Min	Max
Nb fiber	180,530	0.019	0.206	0	3
Orange fiber	180,530	0.009	0.096	0	1
SFR fiber	180,530	0.007	0.083	0	1
Free fiber	180,530	0.003	0.053	0	1
Nb LLU	180,530	0.886	1.028	0	6
LLU	180,530	0.496	0.500	0	1
Cable	180,530	0.014	0.117	0	1
VDSL	180,530	0.071	0.256	0	1
Households	180,530	0.750	3.600	0.001	100
HH density	180,530	0.076	0.469	0.000	21.8
Share flats	180,530	0.089	0.141	0	1.00
Income	180,530	23.334	6.337	5.0	157.3

Figure 1: Percentage of municipalities in which deployment of broadband technology was reported per year



Number of municipalities for which our technology presence variable takes value one divided by total number of municipalities.

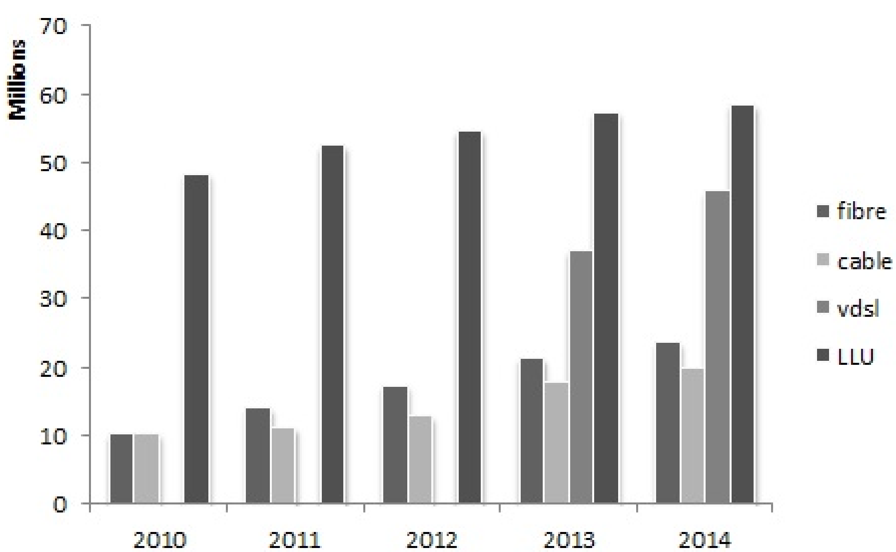
Table 23: Summary statistics by the number of fiber entrants in municipality (average values)

Nb fiber	Municipality	Density	Households	Share flats	VDSL	LLU entrants	Cable	Income
0	178,785	0.05	0.54	0.08	0.07	0.86	0.01	23,280
1	441	1.23	12.99	0.57	0.44	3.20	0.33	28,360
2	839	1.90	19.35	0.65	0.48	3.28	0.44	28,242
3	434	6.20	37.64	0.88	0.38	3.50	0.77	31,006

Table 24: Summary statistics by the number of LLU entrants in municipality (average values)

Nb LLU	Municipality	Density	Households	Share flats	VDSL	Nb fiber	Cable	Income
0	90,950	0.02	0.21	0.06	0.01	0.00	0.00	21,275
1	32,729	0.03	0.35	0.07	0.07	0.00	0.00	23,227
2	45,677	0.07	0.81	0.11	0.16	0.00	0.01	26,246
3	8,891	0.60	4.96	0.30	0.18	0.23	0.11	28,533
4	2,218	1.20	10.29	0.40	0.32	0.54	0.28	28,466
5 – 6	65	0.85	18.62	0.40	0.69	0.80	0.38	26,526

Figure 2: Potential population covered by a broadband technology per year (in millions)



Sum of population of municipalities for which our technology presence variable takes value one.

Figure 3: Number of municipality in which a fiber network has been deployed per year depending on the number of LLU operators

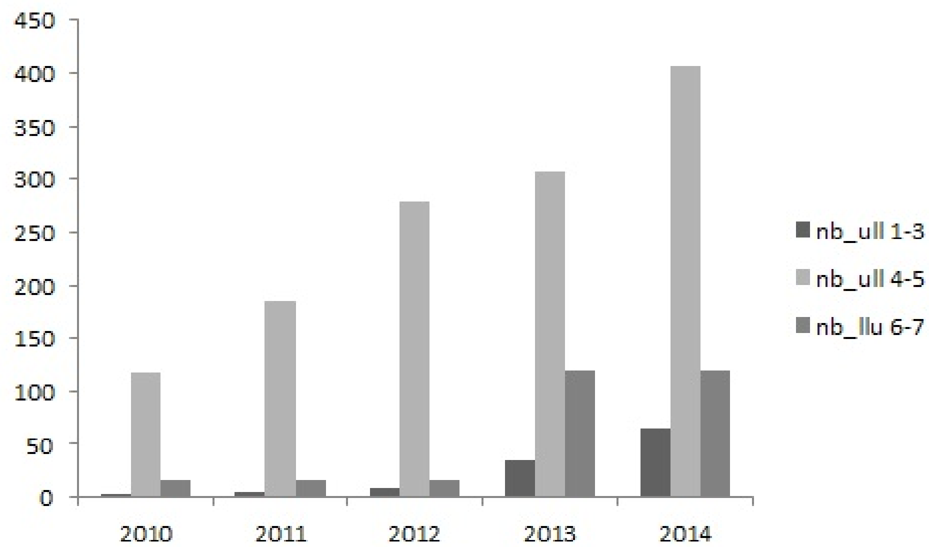


Table 25: Deployment of fiber in municipalities by Orange, SFR and Free

	Orange	SFR	Free	Total
2010	125	96	93	137
2011	195	156	101	206
2012	295	217	102	304
2013	452	344	104	461
2014	584	420	104	592

Table 26: Deployment of xDSL via LLU in municipalities by SFR, Free and Numericable

	SFR	Free	Other	Total
2010	6,404	8,487	6,509	12,826
2011	7,739	10,728	7,435	15,295
2012	9,586	12,894	7,922	17,367
2013	13,025	16,103	8,219	20,876
2014	14,141	19,488	8,610	23,216

Table 27: The number of observations (municipalities in years 2010-2014) with the presence of Orange, SFR and Free by the number of entries

Operators	Orange	SFR	Free	Total
0	0	0	0	178,785
1	407	14	20	441
2	824	796	57	839
3	434	434	434	434

Table 28: LLU entries and exits between periods

	Nb LLU_t						
Nb LLU_{t-1}	0	1	2	3	4	5	6
0	67,099	8,821	2,121	19	0	0	0
1	509	17,208	8,228	95	1	0	0
2	61	561	30,298	806	10	0	0
3	1	13	240	6,268	426	2	0
4	0	0	4	79	1,488	30	0
5	0	0	0	0	4	30	1
6	0	0	0	0	0	0	1

Change in the number of LLU operators in municipalities between two consecutive periods for all observations in years 2010-2014. Observations on the diagonal represent no change in the number of operators between two periods, above the diagonal represent exits and below the diagonal are entries.

Table 29: Fiber entries and exits between periods

	Nb $fiber_t$			
Nb $fiber_{t-1}$	0	1	2	3
0	178,816	0	0	0
1	193	248	0	0
2	285	48	506	0
3	14	15	68	337

Change in the number of fiber operators in municipalities between two consecutive periods for all observations in years 2010-2014. Observations on the diagonal represent no change in the number of operators between two periods, above the diagonal represent exits and below the diagonal are entries.

Part IV
Very High-Speed Broadband Networks and Local Economic Growth

Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence

Abstract

I use micro-level panel data on almost 5,000 municipalities in metropolitan France over the period 2010-2015 to estimate the impact of very high-speed broadband networks on some measures of local economic growth. I use a count modeling approach with time- and municipal-fixed effects to estimate whether the local presence of a very high-speed broadband network has an impact on business location, in terms of establishment creation. I show that municipalities, in which a very high-speed broadband network has been deployed, tend to be more attractive for new firms. However, this positive impact is only significant for the creation of establishments in the commerce, service and transportation sector. In addition, municipalities with a very high-speed broadband network provide a more favorable environment for entrepreneurship, as it has a positive effect on the creation of individually run companies.

Key Words: *Fiber; Very High-Speed Broadband; Local Economic Growth; Company Creation*

JEL Classification: L13, L50, L96

1 Introduction

Very high-speed broadband networks are seen as a key enabler for socio-economic development. Their roll-out has been made a priority worldwide and is considered as an investment for the future. Over the last few years, many countries, such as the US,[43] Australia,[44] Japan[45] and Mexico[46] have adopted a national broadband plan to ensure the whole coverage of their territory. In the European Union, the Commission has defined in 2013 a Digital Agenda for Europe, with the objective to provide by 2020 every household with access to at least a 30 Mbps connection and half of the households with a subscription at 100 Mbps.[47] The Digital Agenda for Europe distinguishes different ranges of broadband speeds: basic broadband (between 256 Kbps and 30 Mbps), fast broadband (above 30 Mbps and up to 100 Mbps) and ultra fast broadband (above 100 Mbps). Very high-speed broadband includes both fast and ultra-fast broadband with speed above 30Mbps. In September 2016, the Commission reiterated its vision to turn Europe into a Gigabit Society by 2025.[48]

Higher connection speeds would allow all users, households, businesses and administrations, regardless of their size or geographic location, to benefit from enhanced and more efficient broadband services. It shapes the way companies do business, enhancing their capacities and broadening their markets. It improves households' online experience, allowing them to use multiple connected devices at the same time, benefit from faster download speeds and carry on online transactions.

The contribution of this paper is to analyze whether very high-speed broadband availability has a causal impact on measures of local economic growth. Specifically, I investigate whether very high-speed broadband networks have an effect on the creation of new businesses of all non-farm market sectors operating locally. I highlight the impact of these networks on entrepreneurship, with a specific focus on the creation of sole proprietorships. I adopt a technology neutral

[43] "Connecting America: The National Broadband Plan, Federal Communications Commission," March 2010.
[44] "The National Broadband Network" April 2009, modified in 2013.
[45] "E-Japan Strategy" 2001.
[46] "Mexican Digital Agenda" 2011.
[47] "A Digital Agenda for Europe," European Commission, COM(2010) 245.
[48] "State of the Union 2016: Towards a Better Europe - A Europe that Protects, Empowers and Defends".

approach by including all technologies delivering very high-speed services: fiber optical network (Fiber to the Home; FttH) and upgraded cable (Fiber to the Last Amplifier; FttLA). To the best of my knowledge, this is the first paper to estimate the impact of very high-speed broadband networks on economic growth at a granular local level. The results provide policymakers with better insights on the impact of very high-speed broadband on the local economy.

This study relies on panel data covering 4,933 municipalities located in metropolitan France, over 6 years, from 2010 to 2015. Panel data allow to control for municipal- and time-specific heterogeneity. The three French largest cities, Paris, Lyon and Marseille are excluded from the analysis. These cities are attractive by themselves for companies and households. They are the three largest municipalities in terms of population and are the only one decomposed into arrondissements (districts), with their own mayor and municipal council. In addition, only municipalities with at least 2,000 inhabitants are included in the database.

To estimate the impact of very high-speed broadband networks on local economic growth, I use a count modeling framework with fixed effects. I also use matching estimators and difference-in-differences techniques as robustness checks. These evaluation methods are commonly used to estimate the average effect of a treatment or policy intervention.

I find evidence of the benefits of very high-speed broadband networks for local economic growth. They enhance municipalities attractiveness for new establishments from the tertiary sector, which rely more on ICTs. In addition, municipalities with a very high-speed broadband networks provide a more favorable environment for entrepreneurship, as it has a positive effect on the creation of sole proprietorships. However, I don't find any significant effect on the creation of new businesses in the industry or in the construction sectors.

The remainder of the paper is organized as follows. Section 2 discusses the relevant literature on the effect of broadband on economic growth. Section 3 presents the data. Section 4 introduces the econometric framework. Section 5 presents the estimation results. Finally, Section 6 concludes.

2 Literature Review

There is a substantial literature on the effect of ICT on GDP and more generally on economic growth at the national and regional level (see Czernich et al. (2014) and Kretschmer (2012) for literature reviews). It is widely accepted that, at the national level, ICT adoption has a positive effect on productivity. However, ICT is a fairly large category regrouping basic equipments along with different types of Internet connections from narrowband to broadband of all speeds and more advanced fiber-optical broadband technologies.

With the steadily growing international enthusiasm for broadband deployment and today for the roll-out of high-speed broadband networks, researchers are becoming more interested in evaluating the role of broadband on economic growth. There is an extensive range of macro-level studies which bring empirical evidence on the positive impact of broadband adoption on economic growth (see Bertschek et al. (2013), Greenstein et al. (2011) and Holt et al. (2009) for comprehensive literature reviews). Gruber et al. (2014) evaluate the net economic benefits that would derive from the achievement of the objectives of the 2020 Digital Agenda for Europe. They find that the economic benefits outweigh the costs of investment. Besides, they show that the economic benefits are only marginally appropriable by firms, as they mostly spill over to users and to the national economy. This result confirms other studies which found a positive impact of broadband availability on consumer surplus (see for example Crandall et al. (2001) and Dutz et al. (2009)). Thus, Gruber et al. (2014) show that there is a rationale for public subsidies in the roll-out of broadband networks. Other studies for the US have found a positive relation between broadband availability and employment (Crandall et al. (2007), Gillett et al. (2006)). However, there is limited empirical evidence of the effect of broadband availability on economic growth at the local level, especially in rural areas.

Usually, studies realized at the local-level assess the impact of ICT on variables of local economic growth (see, for example, Kolko (2012)). There are only few papers focusing specifically on the effect of broadband adoption on local economic growth. Czernich (2011 and 2014) for German municipalities and Jayakar et al. (2013) for eight States in the US find no evidence that broadband availability reduces the unemployment rate. On the contrary, Whitacre et al. (2014) find that broadband adoption, availability and download speeds have an impact on economic growth in rural areas. They use a propensity score matching estimator on local-level data for non-metropolitan US counties for the years 2001 to 2010. They highlight a positive impact on unemployment reduction and on median household income. They also show that rural areas with high levels of download speeds tend to attract more creative class workers and to have a lower poverty level.

As far as firms are concerned, the literature focuses on the impact of broadband on productivity. Haller et al. (2015) show that on average more productive firms are more likely to have a DSL broadband connection, but they find no evidence of an impact of broadband adoption on firms' productivity or on productivity growth. Similarly, Bertschek et al. (2013) find no effect on labor productivity, but they find a positive effect on firms' innovation activities. Akerman et al. (2015) show that broadband availability and adoption increases the productivity of skilled workers, acting as a skill complement and lowers the productivity of unskilled workers, acting as a substitute for routine tasks.

Only few studies analyze the effect of broadband on the attractiveness of a territory for firms. In her analysis, Mack (2014) evaluates the correlation between broadband speed and the establishment presence in Ohio. She finds a positive impact of broadband speed for agricultural and rural companies. However, she does not establish any causal relationship. Using local-level data, McCoy et al. (2016) analyze the impact of local infrastructure and of broadband networks on new business creation in Ireland, excluding the Dublin city region. They find that on average areas covered by broadband are more attractive for firms.

This paper is related to the latter stream of literature. However, most of the studies on the impact of broadband on local economic growth focus on the impact of old generation broadband technologies, such as DSL or co-axial cable technologies and ignore the new high-speed broadband technologies. I attempt to fill this gap by assessing the impact of very high-speed broadband technologies, including fiber optical technology (Fiber to the Home) and upgraded cable technology (DOCSIS 3.0 or Fiber to the Last Amplifier or FttLA). Besides, though realized at the local level, most of the studies are performed at a more aggregated level, which is either the State or the county. I use data on 4,933 municipalities over 6 years, from 2010 to 2015. To the best of my knowledge, this is the first paper, which at such a granular local level, analyzes the impact of very high-speed broadband network on local economic growth. I specifically focus on the effect of very high-speed broadband networks on the creation of new businesses at the local level.

3 The Data

The data used in this analysis come from a wide range of sources covering a period which spans from 2006 to 2015. Descriptive statistics are reported in the Annex.

3.1 Dependent Variables

Data on the number of establishment creations come from INSEE, the French National Institute for Statistics and Economics Studies. They have been collected for each municipality for the years 2008 to 2015. For each year, I have information for the three main non-farm market sectors: the industrial sector, the construction sector and the tertiary sector.

The construction sector is essentially an activity of deployment, installation or maintenance on the customer's work-site. The industrial sector is also implicated in network deployments, but to a lower extent than companies from the construction sector. The industrial sector regroups all activities combining factors of production (facilities, supplies, work, knowledge) to produce material goods intended for the market.

The tertiary sector encompasses a vast field of activities, ranging from commerce to administration, via transport, financial and real estate activities, services to business, personal services, education, health and social services. Therefore, I collected data for three sub-sectors of the tertiary sector: the commerce, transport and services; the provision of services to companies and the provision of services to households.

3.2 Very high-speed Broadband Networks

I also use a panel dataset on fiber deployment in metropolitan France (Corsica excluded) over 9 years, from 2006 to 2014. The data have been extracted from Orange's Information System, SFR's website and Free users' community websites. Orange is the historical fixed-line incumbent. It owns the legacy copper network, which is used to provide DSL broadband services. SFR and Free are alternative operators which do not possess their own copper network. They provide broadband services by leasing access to the incumbent's local access network via local loop unbundling (LLU).[49] All data on fiber deployments provide information at the municipal level, with each municipality identified by a unique geographic code (the INSEE code). I have information on 36,036 French municipalities out of the 36,192 municipalities counted in metropolitan France in 2014. For each municipality, I know whether Orange and/or SFR has deployed an FttH network.[50]

Regarding Free, the data have been extracted on an unofficial website updated by Free's users community.[51] The data are consistent with information gathered on other websites, as well as with Free's Annual Reports. For each municipality, I know whether there are active fiber connections from Free.

Data on cable upgrade to FttLA have been extracted from Numericable's website for the years 2010 to 2014. Numericable is the French cable-operator.[52] For each municipality, I know whether Numericable has upgraded its cable network to provide very high-speed broadband services.

3.3 Explanatory Variables and Controls

This dataset has been completed with two other sources. First, socio-demographic characteristics come from INSEE. I have economic data such as the unemployment rate at the municipal level

[49] Orange, SFR and Free are also the main competitors on the mobile market.

[50] The database used in this study is similar to the one used in Bourreau, Grzybowski and Hasbi "Unbundling the Incumbent and Entry into Fiber: Evidence from France". For further details upon the database construction and data collection, please refer to the aforementioned paper.

[51] See http://francois04.free.fr/ and http://serge.31.free.fr/.

[52] Numericable's cable network covers 30% of the population, living mostly in urban areas.

for the years 2006 to 2013. Information on the different socio-professional groups and diplomas have also been collected for the years 2006 to 2013. Some other municipality characteristics have also been extracted from INSEE databases, such as population density, number of households, number of housing or the municipal urbanization degree. These informations have all been collected by INSEE for the years 2006 to 2012.

Second, data on the average fiscal income per municipality has been collected from the General Direction of Public Finance's website (Gouvernment Taxes Services, DGFIP) for the years 2007 to 2014. The average fiscal income is measured in the previous year, as people pay taxes on the year before. In other words, the amount of taxes paid for the year 2015 is calculated on the income received in 2014.

4 Econometric Strategy

The choice of a location for a new company to operate is a fundamental decision, key to its success. Companies incur a fixed cost when settling down. The choice of the company is driven by cost factors, such as the tax regime in the locality, the availability of infrastructures, such as transportation infrastructures, broadband infrastructures, but also by the cost and availability of human capital. In addition, companies consider the potential demand in the market for their products or services.

4.1 Empirical Approach

The empirical literature on business location decisions is generally based on two approaches: discrete choice modeling and count modeling. The first discrete choice modeling approach is based on the analysis of business location decision as a function of firm characteristics, including the size and the industry sector, and alternative local characteristics, including population, human capital and infrastructures.[53] The unit of analysis is the company, whereas in the second count modeling approach, the unit of analysis is the territory. In this latter approach, the

[53]See Arauzo-Carod (2008) and Arauzo-Carod and Manjon-Antolin (2012) for a thorough discussion. For recent studies, see Alama-Sabater et al. (2011) and Siedschlag et al. (2013)

analysis consists in assessing how location characteristics can influence business location in the form of the count of businesses in each territorial unit.[54] The underlying assumption is that the number of new establishments that settle in a locality over a time period is determined by an equilibrium condition between a stochastic supply function representing the willingness of a company to start its business in the territory and a stochastic demand function for new firms in the territory.[55]

Given the type of data available, I implement a count model to address my main question, which is whether very high-speed broadband networks have a causal effect on some socio-demographical variables of policy relevance: the number of new establishments created locally for each year, disaggregated into the three main non-farm market sectors of the economy: the construction sector, the industrial sector and the tertiary sector. I also estimate whether the presence of these networks has an impact on entrepreneurship, with the creation of sole proprietorships.

I follow the econometric literature by using a fixed effects model to eliminate potential endogeneity stemming from time-varying and time-unvarying regressors. The count of new companies operating in a municipality for each time period are modeled as a function of the local characteristics, with municipal- and time-fixed effects.

Then, I have,

$$Y_{it+1} = \alpha + \delta \; superfastbb_{it} + \beta \; X_{it-2} + \gamma \; Z_{it-2} + year + \eta_i + \epsilon_{it}. \tag{15}$$

Where :

$$Y_{it+1} = 0, 1, 2, ... \tag{16}$$

Y_{it+1} is the count (or number) of new establishments operating in municipality i at time $t+1$. The variable of interest consists in a dummy variable, denoted $superfastbb_{it}$, which indicates

[54] See Jofre-Monseny et al. (2011) and Bhat et al. (2014).

[55] Following Becker and Henderson (2000), the equilibrium condition can be represented by a reduced form stochastic distribution for the count of new businesses.

whether a very high-speed broadband network has been deployed in municipality i at time t. I adopt a technology neutral approach by including all technologies through which very high-speed broadband services can be delivered: fiber optical network (FttH) and upgraded cable network (FttLA).[56]

X_{it-2} is a matrix of location characteristics for municipality i at time $t-2$ and Z_{it-2} a matrix of labor market characteristics for municipality i at time $t-2$. η_i is a time unvarying fixed effect describing the influence of specific municipal characteristics, which may affect the attractiveness of the municipality and therefore bias the outcome of interest.[57] For example, this can include a specific tax regime to attract companies, lower costs of capital, different regulations applying to real-estate, the presence of a specific regional policy. *year* is a dummy variable for each year capturing year specific fixed effects. Finally, ϵ_{it} is an i.i.d. standard error clustered at the municipal level, capturing unobserved factors.

4.2 Potential Endogeneity

As highlighted in the literature, there is a potential endogenous effect of broadband networks on company creation and more generally on economic activity, see, for example, Kolko (2012), Mack et al. (2011) and McCoy et al. (2016)). Economic activities are more likely to thrive in areas with enhanced broadband infrastructures. In the meantime, areas with better broadband infrastructures are more likely to attract economic activities. Therefore, this effect materializes mostly as reverse causality between the number of companies operating locally and very high-speed broadband availability.

In their analysis of the impact of local broadband infrastructures on new business establishment, McCoy and al. (2016) argue that the endogenous relationship that may exist between broadband networks and companies is more likely to affect the stock of existing companies rather than the flow of company creations. Operators would rather decide to roll-out a broadband net-

[56] Due to data constraints, I estimate the effect of very high-speed broadband networks at time t on the number of new establishments at time $t+1$. The latest data available for establishment creation is 2015. I estimate here a short-term effect. With longer dataset, it could be possible to estimate a medium or long-term effect.

[57] Due to data constraints, I estimate the effect of Z at time $t-2$ on the number of new establishments at time $t+1$. The latest data available for some variables included in matrix Z is 2012.

work in areas with a large number of companies and companies would rather operate in areas with improved broadband infrastructures.

To mitigate this endogeneity problem, they restrict their analysis to new firm in each year and control for the pre-existing employment levels for each area and for each time period. Similarly, to lessen this problem of endogenous relationship, I follow their argument and I estimate the impact of very high-speed broadband networks on the number of new establishments created in each year, instead on the total number of establishments operating locally. I also control for the pre-existing number of companies for each area and each year using a 2 years lagged variables. Nevertheless, I assume that my estimation results would likely suffer from endogeneity with coefficients being biased upward.

In addition, the local labor market variables may also suffer from reverse causality. It includes the proportion of people with a third-level diploma, the number of people from the different socio-professional groups and the unemployment rate. Households could choose to locate in areas with better job prospects and companies, in areas in which they could higher their labor forces.

To alleviate this concerns, I use 2 years lagged variables. I conduct robustness checks with lags of 3 years and 1 year, which give similar qualitative results. Besides, I estimate the impact of very high-speed broadband on local economic growth with other modeling approaches as robustness checks.

Moreover, omitted variables may also be a potential source of endogeneity. For example, operators may have higher incentive to deploy a very high-speed broadband network in areas in which they can benefit from a more favorable tax regime or in which there is higher demand for faster broadband services. To mitigate this problem, I follow the econometric literature by using time-varying and time-unvarying fixed effects.

4.3 Empirical Models

In their decision to settle in a locality, I expect firms to be influenced by the potential market size and the quality of demand, in terms of expected purchasing power. In addition, I expect that firms take into account the level of education and the composition of the population, in terms of qualification. I use lag variables of two years to control for potential issues of reverse causality.[58]

The model is estimated using a sub-dataset, which excludes the three main French agglomerations, Paris, Lyon and Marseille. They are the three largest municipalities in terms of population and are the only one decomposed into arrondissements (districts), with their own mayor and municipal council.[59] In addition, only municipalities with at least 2,000 inhabitants are included in the database. It is rather unlikely that private operators deploy a very high-speed broadband network in a municipality with less than 2,000 inhabitants. Therefore, the database includes 4,933 municipalities over 6 years, from 2010 to 2015.

For the number of establishment creations,

$$\begin{aligned} ln\_new\_establishment_{it+1} = \ & \alpha + \ \delta \ superfastbb_{it} + \ \beta_1 \ ln\_establishment_{it-2} \\ & + \beta_2 \ ln\_households_{it-2} + \ \beta_3 \ density_{it-2} + \ \beta_4 \ income_{it-2} + \ \gamma_1 \ unempl_{it-2} \\ & + \gamma_2 \ perc\_uni\_diploma_{it-2} + \ \gamma 3 \ socio\_professional\_groups_{it-2} + \ year + \ \eta_i + \ \epsilon_{it}, \end{aligned} \tag{17}$$

where $ln\_new\_establishment_{it+1}$ represents the number of new companies (in log) that have been created in municipality i at time $t+1$ and $establishment_{it-2}$ represents the number of establishments operating in municipality i at time $t-2$. As a matter of fact, the number of establishment in a locality is highly correlated with the number of establishment in the previous years. I control for firm characteristics by disaggregating the establishment into the three non-farm market sectors of the economy: the construction sector, the industrial sector and the tertiary sector.

[58] For all specifications different lags have been estimated, results are qualitatively similar.

[59] Population in 2013: Paris: 2.2 millions inhabitants, Marseille: 855,393 inhabitants, Lyon: 500,715 inhabitants, the fourth largest is Toulouse with 458,298 inhabitants, but there is no arrondissement in Toulouse.

I also add the number of households (in log) in municipality i at time $t-2$, which is a proxy for the market size, as well as the population density in municipality i at time $t-2$. Besides, I add the average fiscal income and the unemployment rate in municipality i at time $t-2$. Both variables are approximations for the quality of demand, in terms of purchasing power.

As education plays a role on the decision of firms to operate locally, I add the percentage of inhabitants with a diploma from superior education in municipality i at time $t-2$, as well as, the number of inhabitants of the different socio-professional groups in municipality i at time $t-2$, which are a proxy for the qualification of the population. There are 6 socio-professional groups: farmers (group 1), craft workers, retailers, and business owners (group 2), intermediate occupations (group 3), white collars (group 4), employees (group 5), blue collars (group 6).

In a second specification, I make a specific focus on entrepreneurship, by assessing the impact of very high-speed broadband networks on the creation of sole proprietorships, i.e. the creation of companies owned and run by one individual:

$$\begin{aligned} ln\_new\_proprietorship_{it+1} = \ & \alpha + \ \delta \ superfastbb_{it} + \ \beta_1 \ ln\_establishment_{it-2} \\ & + \beta_2 \ ln\_households_{it-2} + \ \beta_3 \ density_{it-2} + \ \beta_4 \ income_{it-2} \\ & + \gamma_1 \ unempl_{it-2} + \ \gamma_2 \ perc\_uni\_diploma_{it-2} + \ \gamma 3 \ perc\_no\_diploma_{it-2} \\ & + \gamma 4 \ socio\_professional\_groups_{it-2} + \ year + \ \eta_i + \ \epsilon_{it}, \end{aligned} \tag{18}$$

where $ln\_new\_proprietorship_{it+1}$ represents the number of new sole proprietorships (in log) that have been created in municipality i at time $t+1$. I add in the set of explanatory variables, the percentage of inhabitants with no diploma in municipality i at time $t-2$. As during a time of unemployment, some people which face difficulties to find a job, may decide to create their own business. This has been observed with the 2008 economic crisis, with an increase in the number of sole proprietorships (see descriptive statistics).

Nevertheless, I also estimate all specifications without the number of establishments operating in municipality i at time $t-2$ to ensure that this variable does not impact or hide the significance of others. Results are qualitatively similar in terms of sign and significance, they also display coefficients of similar amplitudes.[60] The same exercise has been made without the different socio-professional groups; results are also qualitatively similar.

I expect to find a positive average effect of very high-speed broadband networks on local economic growth. Municipalities would appear more attractive for companies, especially for those operating in the tertiary sector, in which most of the businesses using ICTs belong. This sector has been predicted to benefit the most from very high-speed broadband networks in the long-term, thanks to the creation of indirect jobs.

On the short-term, it is also expected that the roll-out of very high-speed broadband networks enhances activities in the construction sector. The increase in the number of companies from the construction sector could be the result of the construction of the infrastructure itself. The roll-out of a network may imply the creation of direct jobs, such as technicians, manual workers as civil engineering represents the major part of the work. Unlike companies from the construction sector which in the short-term encounter an increase in their workload, companies from the industrial sector have a more stable production pace. Therefore, I don't expect to find any significant effect of the presence of a very high-speed broadband network on the creation of these companies.

5 Estimation Results

Tables 30 shows the estimation results of the impact of very high-speed broadband on establishments creation and new proprietorships.

[60] Results are available upon request.

Table 30: Panel data estimation with fixed effects: establishment creation and new sole proprietorships

	new establishment	new ind	new construction	comm serv transp	service firms	service hh	self employment
superfastbb	0.0352***	0.0060	0.0248	0.0691***	0.0096	0.0197	0.0255***
	(0.007)	(0.018)	(0.017)	(0.013)	(0.012)	(0.013)	(0.008)
establishment	-0.1214***	-0.0875***	-0.1109***	-0.1280***	-0.1303***	-0.0855***	-0.1170***
	(0.009)	(0.017)	(0.017)	(0.016)	(0.016)	(0.016)	(0.010)
households	0.2468***	0.2164*	-0.0663	0.0690	0.5419***	0.2996***	0.2882***
	(0.058)	(0.116)	(0.114)	(0.098)	(0.096)	(0.097)	(0.061)
density	0.2160***	0.3278***	0.3081***	0.1493***	0.1601*	0.3028***	0.1883***
	(0.041)	(0.126)	(0.117)	(0.051)	(0.093)	(0.070)	(0.041)
income	0.0046***	0.0046	0.0124***	-0.0009	0.0086**	0.0103***	0.0042*
	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)
unemployment	-0.0051**	-0.0013	0.0021	-0.0035	-0.0105**	-0.0112**	0.0023
	(0.002)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.003)
no diploma							0.0065***
							(0.002)
diploma superior	0.0021	-0.0004	0.0055*	0.0001	0.0062**	0.0011	0.0064***
	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
craft workers	-0.0069**	-0.0007	-0.0257***	-0.0071	0.0021	-0.0055	-0.0064*
	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.004)
intermediate	-0.0031	-0.0025	-0.0051	-0.0032	-0.0072*	-0.0018	-0.0027
	(0.002)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.003)
white collars	0.0001	0.0058	-0.0063	0.0016	-0.0029	0.0040	0.0027
	(0.002)	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.002)
employees	-0.0018	0.0030	0.0001	-0.0063**	0.0006	-0.0035	0.0006
	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)
blue collars	-0.0004	0.0046	0.0020	-0.0011	0.0016	-0.0017	0.0004
	(0.002)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)
y2011	0.0254***	0.0191*	0.0423***	0.0143	-0.0178**	0.0788***	0.0266***
	(0.004)	(0.011)	(0.010)	(0.009)	(0.009)	(0.009)	(0.006)
y2012	-0.0530***	-0.0099	-0.0787***	-0.0348***	-0.1225***	-0.0129	-0.0309***
	(0.006)	(0.014)	(0.014)	(0.012)	(0.012)	(0.012)	(0.008)
y2013	-0.0494***	-0.0192	-0.1025***	-0.0332**	-0.1031***	0.0101	-0.0237***
	(0.007)	(0.016)	(0.016)	(0.014)	(0.014)	(0.014)	(0.009)
y2014	-0.1260***	-0.1115***	-0.3037***	-0.1013***	-0.1395***	-0.0456***	-0.1491***
	(0.008)	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)	(0.010)
Constant	3.7593***	0.5079**	1.6865***	2.8822***	2.0675***	1.8485***	2.7807***
	(0.096)	(0.219)	(0.211)	(0.181)	(0.186)	(0.190)	(0.172)
Observations	24,664	24,664	24,664	24,664	24,664	24,664	24,662
R-squared	0.051	0.008	0.056	0.012	0.014	0.010	0.048
Municipality	4,933	4,933	4,933	4,933	4,933	4,933	4,933

Standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

I find that the deployment of very high-speed broadband networks favors local economic development by increasing the number of new establishment created locally. Table 30 shows that the number of new establishments increases by an average of 3.5% with the presence of a very high-speed broadband network.

To better capture the effect of very high-speed broadband on the local economy, the establishments are disaggregated into the three main categories of the non-farm market sector: the industrial sector, the construction and the tertiary sector. The latter sector is divided in three sub-sectors: the commerce, service and transportation sector, the provision of services to firms and the provision of services to households.

As expected, municipalities benefit from the spill over of the local presence of very high-speed broadband networks, helping them to maintain and develop a healthy economic sector. However, the presence of very high-speed broadband networks does not have an impact on the creation of all types of establishments. I find a positive and significant impact only for the creation of establishments from the commerce, service and transportation sector, in which firms rely more on ICT to conduct their business. In this sub-sector, the number of new establishments increases by almost 7%.

I don't find any significant effect on the creation of establishments of any of the other two tertiary sub-sectors, i.e. the provision of services to companies and to households. The roll-out of a very high-speed broadband network does not have a significant impact on the attractiveness of a municipality for establishments from the industry and construction sectors.

However, I highlight the existence of a positive impact of very high-speed broadband networks on the creation of sole proprietorships, with an increase in new companies created and run by one individual by roughly 2.6%.

Estimation results tend to confirm the findings of McCoy et al. (2016), which highlight that on average areas covered by broadband are more attractive for firms. Besides, the estimation results are also in line with the empirical literature, especially the study from Gruber (2014), who finds that economic benefits from the achievement of the 2020 Digital Agenda for Europe mostly spill over to users and to the national economy.

Besides,Table 30 shows that, in their location choice, companies do take into account local market characteristics. On average, new establishments tend to locate in areas with a larger market size, in terms of the number of households and a higher population density. However, the total number of establishments operating locally has a negative effect on the creation of new ones. On average, the level of income has a positive impact on the attractiveness of a municipality for new establishments, unlike the unemployment rate. I also observe that sole proprietorships are more likely to be created in municipalities with a higher number of inhabitants having a diploma from the superior, but also with a higher number of inhabitants having no diploma. In a time of economic crisis, it is difficult for people without any diploma to find a job. However, the composition of the population, in terms of socio-professional groups, does not seem to play a role in the location decision of a firm. Besides, Table 30 shows a negative trend in the creation of new businesses of all non-farm market sectors. This trends reflects the aftermath of the 2008 economic crisis in France, with a decrease of the number of establishment creation.

5.1 Robustness Checks

In order to test the robustness of my results, I first conduct estimations on the same database as previously using the nearest neighbor (difference-in-differences) matching estimator method (Model 1). In addition, I estimate the same panel data model with fixed effects (Model 2) on a subsample, keeping only municipalities in which a very high-speed broadband network has been deployed in 2013 and municipalities in which no very high-speed broadband network has been deployed between 2010 and 2014. On the subsample, I also estimate a difference-in differences model (Model 3). Lag variables are used to attenuate potential endogeneity problems. For all specifications, different lags have been estimated and results are qualitatively similar. Besides, all specifications for Model 2 and Model 3 have been estimated without the number of establishments in municipality i at time $t-2$ and results are qualitatively similar.

Tables 32 shows estimation results for the average effect of very high-speed broadband networks on local economic growth. Table 31 shows covariate balance statistics and assesses the balance between the treatment and control groups in the means and in the variances.

Tables 34 shows results for the panel data model with fixed effects for deployments in 2013; Tables 35 provides estimation results for the difference-in-differences model for deployments in 2013. Figures 4 to 6 show the parallel trends assumption between the treated and the control group for some variables of local economic growth.

Table 36 provides an overview of the estimation results for all models.

5.2 Matching Estimator

Matching techniques are non-parametric estimators used to estimate average treatment effect (ATE). ATE are commonly used to measure the average impact of a treatment or a program intervention, by measuring the difference in outcome between a treated group and a control group (Rosenbaum and Rubin (1983)).

$Y_{it+1}(1)$, $(Y_{it+1}(0))$ denotes an outcome which is realized at time $t+1$ if municipality i receives (doesn't receive) at time t a treatment $d_{it} = 1$ $(d_{it} = 0)$.

The outcome of interest could either be the number of new establishments created locally or the number of new sole proprietorships. The treatment variable consists in a dummy variable indicating whether a treatment has been applied, i.e. whether a very high-speed broadband network is deployed in municipality i at time t. The control group consists in otherwise similar municipalities in terms of observable characteristics.

Then, the average treatment effect on the treated (ATT), which represents the average gain from the treatment for those who actually were treated, writes as follows

$$ATT = E(\Delta Y_{it+1}(1) \mid d_{it} = 1) - E(\Delta Y_{it+1}(0) \mid d_{it} = 1). \tag{19}$$

The first term represents the expected value of the outcome of interest, at time $t+1$, in municipalities in which a treatment has been received at time t, which is observable. However, the second term in Eq.(6) is non-observable. It represents the expected value of the outcome of interest, at time $t+1$, for the control group, had a treatment been received at time t. When evaluating the impact of a policy, or here of an investment decision, the researcher faces an identification issue. Besides, the treatment distribution may suffer from a selection bias. Considering the high costs of deployment, operators will select the municipalities in which to invest first depending on their return prospects. To alleviate these issues, matching estimators seek to reproduce the treatment group among the non-treated group using observable characteristics.

Then, the key parameter is to identify the relevant set of matches. Besides, to avoid reverse causality, I use lag variables of two years.

The set of relevant matches is:

$$ln\_households_{it-2},\ density_{it-2},\ income_{it-2},\ unempl_{it-2},\ perc\_estab\_commserv_{it},\ year. \quad (20)$$

The key variables for the matching are the number of households (in log), the population density, the average fiscal income and the unemployment rate all in municipality i at time $t-2$. In addition, to match municipalities with the same type of economy, I introduce the percentage of companies from the commerce and service sector in municipality i at time t.

I expect to find slightly higher effects than with the previous model, as the average effects are estimated on the treated population.

Table 31: Covariate for Balance Test

	Treated			Control			Balance
	Mean	Variance	Skewness	Mean	Variance	Skewness	Std-diff Var-ratio
estab_commserv_perc	65.25541	790.6751	-1.614831	62.59701	753.4786	-1.452932	.0956731 1.049366
density	1.543979	6.630078	4.605992	.2911635	.1078143	3.584272	.6825586 61.49535
households	1.193238	1.146193	.7648062	.4263445	.2899609	1.004472	.9050019 3.952924
income	26.73325	67.20517	2.088331	23.41929	32.74699	2.063607	.4687773 2.052255
unemployment	7.989886	9.152099	.7750062	7.835331	7.979583	.7992121	.052808 1.14694
no diploma	32.56171	66.95298	.2259355	37.06293	78.57766	.1195719	-.5276765 .8520612
diploma superior	26.32544	101.283	.9109169	19.99361	55.76456	1.113804	.7145427 1.816261

Table 31 provides a table of distributional test statistics for the means, variances and skewness of key variables included in the matching process. By comparing the distribution of the different variables between the treated and control group, I ensure that the two groups are similar in terms of observable characteristics. Besides, I assess the balance between the treatment groups in the means, by using the standardized difference, and in the variances, by using the variance ratio. Table 31 shows that the control group created through the matching is similar to the treated group, in terms of households number, population density, income, unemployment rate. The percentage of inhabitants with no diploma is slightly higher in the control group, while the percentage of inhabitants with a diploma from the superior is slightly higher in the treated group.

Table 32: Average treatment effect on the treated: establishment creation, new establishments in the industry and construction sectors

	new establishments	new ind	new construction
superfastbb	0.0527***	0.1020***	0.0381
	(0.018)	(0.034)	(0.026)
Observations	34,852	34,852	34,852

Standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 32 confirms the results obtained with the panel data model. I find that the number of new establishments increases by an average ofwith the presence of a very high-speed broadband network. Unlike in the previous estimation, I find a positive average impact on the creation of establishments in the industry sector, which increases by 10%. However, the impact of very high-speed broadband networks on the number of new establishments from the construction sector is still not significant.

Table 33: Average treatment effect on the treated: establishment creation in the tertiary sector and new sole proprietorships

	comm serv transp	service firms	service households	self-employment
superfastbb	0.0410*	0.0624***	0.0096	0.0386**
	(0.023)	(0.023)	(0.019)	(0.018)
Observations	34,852	34,852	34,852	34,850

Standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Similarly, I find that municipalities in which a very high-speed broadband network has been deployed are more attractive for establishments from the commerce, service and transportation sector. The creation of new establishments in this sub-sector increases by an average of 4%. Besides, unlike in the previous estimation, I find a positive effect of very high-speed broadband networks on the creation of establishments providing services to companies. Their number increases by an average of 6%.

Table 33 also confirms results from the panel data estimation as regard the creation of sole proprietorships. Municipalities in which a very high-speed broadband network has been deployed seem to favor entrepreneurship, with an average increase in the number of new sole proprietorships of 3.7%.

5.3 Panel Data Model with Fixed Effects and Difference-in-Differences for Deployments in 2013

A second robustness check has been conducted using the main model, but on a subsample (model 2). I still use the count modeling approach to estimate the impact of very high-speed broadband network on the creation of establishments and of sole proprietorships.

As previously, only municipalities with more than 2,000 inhabitants are included in the database. However, only municipalities in which a very high-speed broadband network has been deployed in 2013 and municipalities without a very high-speed broadband network between 2010 and 2014 are included in the sample in order to have the same structure as for model 3. In 2013, very high-speed broadband networks have been rolled-out in 430 municipalities, corresponding to 30% of the municipalities in the subsample. With the modification of the regulatory framework, private operators have intensified the deployment for this year compared to the years before, which is why the robustness check has been conducted for this time period. I use similar covariates as for the main econometric models, except for model 3 where the socio-professional variables are excluded for more coherence with the model structure.[61]

On this subsample, I run a third robustness check using a difference-in-differences model (model 3) for deployments occurring in 2013.[62] This model is estimated to validate the results obtained with the panel data model with fixed effects. Model 3 aims at comparing the outcome of interest, i.e., the number establishment creation or the number of new sole proprietorships, in the treated group (where a very high-speed broadband network has been deployed) and in the control group.

[61] Estimations have also been run including the socio-professional groups. The results are qualitatively similar, with slightly higher coefficients.

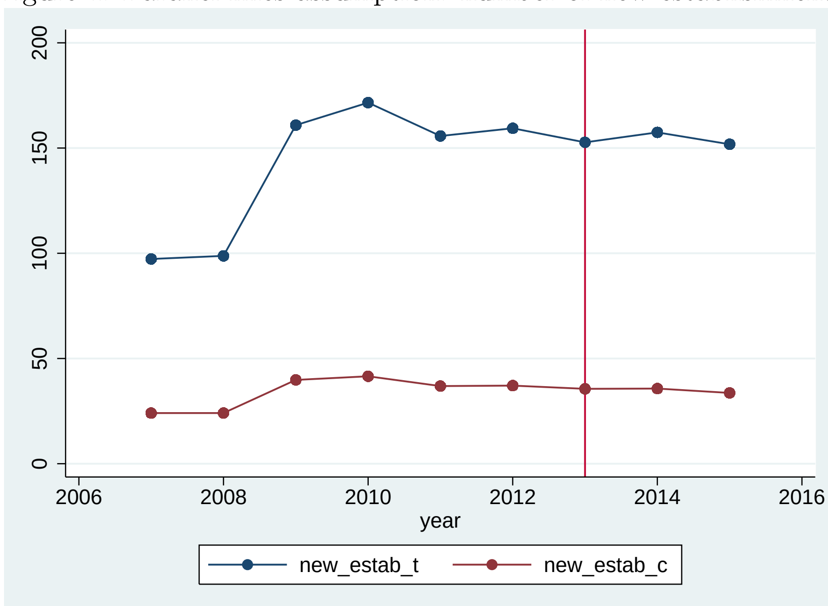
[62] There were not enough municipalities in which a network has been deployed in 2010, 2011 to set up alternative specifications using the difference-in-differences methods. Besides, I lack data for the year 2015 to define an additional specification for the year 2014.

$$ln\_Y_{it+1} = \alpha + \theta \, after_t + \delta \, (after_t * superfastbb_i) + \beta \, X_{it-2} + \gamma \, Z_{it-2} + year + \eta_i + \epsilon_{it}, \tag{21}$$

where $superfastbb_i$ indicates municipalities in which a very high-speed broadband network has been deployed and $after_t$ the time period after the deployment (after 2013). Therefore, δ represents the differences in outcome, which is due to the presence of a very high-speed broadband network. As previously, X_{it-2} is a matrix of location characteristics for municipality i at time $t-2$ and Z_{it-2} a matrix of labor market characteristics for municipality i at time $t-2$, η_i is a time unvarying fixed effect, $year$ a time fixed effect and ϵ_{it} an iid standard error, clustered at the municipal level.

The key assumption in the difference-in-differences methods is that the treated and the control groups follow a parallel trend in the pre-treatment period. Absent treatment, both groups would have evolved the same way. Therefore, the difference in the outcome variable in the post-treatment period is assumed to be due to the treatment effect. Figures 4 to 6 show the parallel trends assumption for the number of new establishments, the number of new establishments from the commerce, service and transportation sector, as well as for the number of new sole proprietorships.

Figure 4: Parallel lines assumption: number of new establishments



Figures 4 to 6 show that for all these variables, the parallel trend assumption is respected in the pre-treatment period. I also highlight a small change in the number of establishment creation after 2013, which increases slightly in the treated group, compared to the control group in which the number of establishment creation seems to be stable.

Figure 5 shows the same change in trends after 2013 for the number of new establishments from the commerce, service and transportation sector created in treated municipalities.

I also observe from Figure 6 a small change in trends for the number of new sole proprietorships in the year following the treatment.

Figure 5: Parallel lines assumption: number of new establishments from the commerce, service and transportation sector

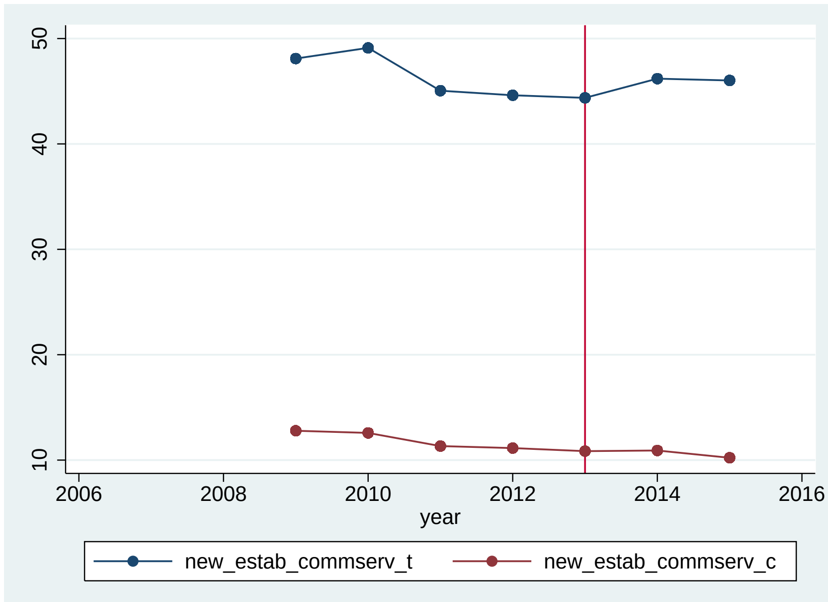
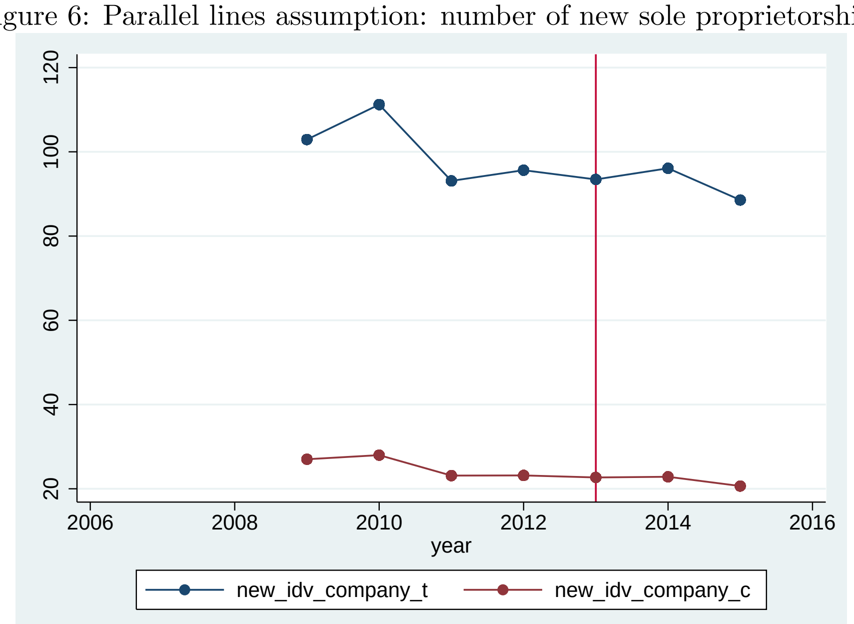


Figure 6: Parallel lines assumption: number of new sole proprietorships



Considering the dataset used in the subsample, I expect to find slightly higher effects than with the main model.

Table 34: Model 2 - Panel data estimation with fixed effects: establishment creation and new sole proprietorships, deployments in 2013

	new establishment	new ind	new construction	comm serv transp	service firms	service hh	self employment
superfastbb	0.0610***	0.0508**	0.0237	0.1078***	0.0229	0.0281	0.0525***
	(0.010)	(0.025)	(0.026)	(0.019)	(0.017)	(0.020)	(0.012)
establishment	-0.1235***	-0.0903***	-0.1252***	-0.1311***	-0.1338***	-0.0695***	-0.1177***
	(0.010)	(0.019)	(0.020)	(0.019)	(0.019)	(0.019)	(0.012)
households	0.3265***	0.2118	-0.0459	0.1977	0.6633***	0.3619***	0.3875***
	(0.080)	(0.155)	(0.141)	(0.133)	(0.134)	(0.133)	(0.080)
density	0.5829***	0.5633	1.1973***	0.6997***	0.4779*	0.4910	0.5061**
	(0.153)	(0.499)	(0.369)	(0.240)	(0.246)	(0.325)	(0.214)
income	0.0071***	0.0092*	0.0160***	0.0036	0.0086*	0.0124**	0.0058*
	(0.002)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.003)
unemployment	-0.0036	0.0037	0.0030	-0.0039	-0.0088	-0.0099*	0.0024
	(0.003)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.004)
no diploma							0.0056**
							(0.002)
diploma superior	0.0002	-0.0013	0.0006	-0.0028	0.0040	0.0020	0.0044
	(0.002)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)
craft workers	-0.0058*	-0.0001	-0.0253***	-0.0036	0.0046	-0.0105	-0.0055
	(0.003)	(0.007)	(0.008)	(0.006)	(0.007)	(0.007)	(0.004)
intermediate	-0.0043	-0.0056	-0.0033	-0.0037	-0.0085	-0.0052	-0.0020
	(0.003)	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)	(0.003)
white collars	0.0012	0.0072*	-0.0060	0.0039	-0.0045	0.0053	0.0020
	(0.002)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.003)
employees	-0.0007	0.0054	-0.0005	-0.0005	-0.0010	-0.0029	0.0016
	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
blue collars	-0.0023	0.0044	0.0011	-0.0032	-0.0038	-0.0004	-0.0012
	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)
y2011	0.0179***	0.0173	0.0301**	0.0068	-0.0247**	0.0665***	0.0186**
	(0.006)	(0.013)	(0.013)	(0.011)	(0.012)	(0.012)	(0.007)
y2012	-0.0646***	-0.0064	-0.0864***	-0.0547***	-0.1399***	-0.0227	-0.0442***
	(0.008)	(0.017)	(0.017)	(0.015)	(0.016)	(0.016)	(0.010)
y2013	-0.0718***	-0.0523***	-0.1206***	-0.0686***	-0.1222***	0.0021	-0.0484***
	(0.009)	(0.020)	(0.020)	(0.018)	(0.019)	(0.018)	(0.012)
y2014	-0.1486***	-0.1209***	-0.3117***	-0.1383***	-0.1542***	-0.0604***	-0.1709***
	(0.010)	(0.022)	(0.022)	(0.020)	(0.021)	(0.020)	(0.013)
Constant	3.4143***	0.2406	1.2412***	2.2472***	1.9156***	1.5457***	2.5281***
	(0.124)	(0.305)	(0.270)	(0.225)	(0.223)	(0.253)	(0.217)
Observations	16,329	16,329	16,329	16,329	16,329	16,329	16,327
R-squared	0.053	0.008	0.052	0.015	0.014	0.008	0.047
Municipality	3,266	3,266	3,266	3,266	3,266	3,266	3,266

Robust standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 35: Difference-in-Difference: establishments creation, deployments in 2013

	new establishments	new ind	new construction	comm serv transp	service firms	service hh	self employment
_diff	0.0552***	0.0508	0.0285	0.1061***	0.0110	0.0224	0.0556**
	(0.021)	(0.033)	(0.037)	(0.033)	(0.032)	(0.031)	(0.023)
establishment	0.0024***	0.0033***	0.0033***	0.0025***	0.0024***	0.0017***	0.0021***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
households	0.8588***	0.5447***	0.6752***	0.9417***	0.9321***	0.9657***	0.8415***
	(0.007)	(0.011)	(0.013)	(0.011)	(0.011)	(0.011)	(0.008)
density	-0.0700***	-0.1455***	-0.0426***	-0.0705***	-0.0504***	-0.0943***	-0.0588***
	(0.005)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.006)
income	-0.0017*	-0.0164***	-0.0173***	0.0030**	0.0105***	-0.0109***	-0.0054***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
unemployment	0.0299***	-0.0008	0.0210***	0.0609***	0.0114***	0.0134***	0.0422***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
no diploma							-0.0098***
							(0.001)
diploma superior	0.0279***	0.0152***	0.0258***	0.0136***	0.0403***	0.0342***	0.0220***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
y2011	-0.0143	0.0101	0.0121	-0.0319**	-0.0644***	0.0465***	-0.0209**
	(0.009)	(0.014)	(0.016)	(0.014)	(0.014)	(0.014)	(0.010)
y2012	-0.1076***	0.0310**	-0.0779***	-0.1315***	-0.1900***	-0.0464***	-0.1014***
	(0.010)	(0.015)	(0.017)	(0.015)	(0.014)	(0.014)	(0.010)
y2013	0.0988***	0.0646***	0.2037***	0.0981***	0.0545***	0.0853***	0.0000
	(0.009)	(0.014)	(0.016)	(0.014)	(0.014)	(0.014)	(0.000)
y2014	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.1544***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)
time	-0.2452***	-0.0807***	-0.3350***	-0.2862***	-0.2603***	-0.1310***	-0.1452***
	(0.010)	(0.015)	(0.018)	(0.015)	(0.015)	(0.015)	(0.011)
treated	-0.0606***	-0.0847***	0.0006	-0.0632***	-0.0477**	-0.1063***	-0.0471***
	(0.016)	(0.024)	(0.028)	(0.024)	(0.024)	(0.023)	(0.017)
Constant	2.1966***	0.4477***	0.7158***	0.7981***	0.3164***	0.8338***	2.2306***
	(0.022)	(0.033)	(0.038)	(0.033)	(0.032)	(0.031)	(0.044)
Observations	16,329	16,329	16,329	16,329	16,329	16,329	16,327
R-squared	0.792	0.440	0.517	0.661	0.688	0.647	0.761
Mean control t(0)	2.197	0.448	0.716	0.798	0.316	0.834	2.231
Mean treated t(0)	2.136	0.363	0.716	0.735	0.269	0.728	2.183
Diff t(0)	-0.0606	-0.0847	0.000632	-0.0632	-0.0477	-0.106	-0.0471
Mean control t(1)	1.951	0.367	0.381	0.512	0.0562	0.703	2.085
Mean treated t(1)	1.946	0.333	0.410	0.555	0.0195	0.619	2.094
Diff t(1)	-0.00543	-0.0339	0.0292	0.0430	-0.0367	-0.0839	0.00854

Robust standard errors in parentheses: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

I find that with the presence of a very high-speed broadband network, the number of new establishments increases by an average of 6% for model 2 and 5.5% for model 3. Having a look at the different non-farm market sectors, I show that the number of establishment creation increases by an average of 5% (model 2) in the industry sector; it is not significant for model 3. However, there is no significant impact of very high-speed broadband networks on establishment creation in the construction sector for both models.

As regards the tertiary sector, I observe a large effect of very high-speed broadband networks on establishment creation in the commerce, service and transportation sector, which increases by an average of 10% (for both model 2 and model 3). However, there is no significant effects on the other sub-sectors. Very high-speed broadband networks also have a positive impact on the number of new sole proprietorships which increases by an average of 5.3% (model 2) and 5.6% (model 3).

Estimation results from the difference-in-differences model confirm the results obtained with the panel data model with fixed effects.

Table 36 provides a summary of the effects of very high-speed broadband networks on local economic growth for each model and specification.

Table 36: Summary of effects

	Panel FE	ATT	Panel FE 2013	diff_2013
new estab	3.5%	5.2%	6.1%	5.5%
new industry	X	10.2%	5.1%	X%
new construction	X	X	X	X%
new comm serv transp	6.9%	4.1%	10.8%	10.6%
new service firms	X	6.2%	X	X
new service households	X	X	X	X
new individual_comp	2.6%	3.9%	5.3%	5.6%

X: results are not significant

6 Conclusion

Very high-speed broadband networks are considered by policy makers to be a significant factor of economic growth in many sectors of the economy. There is a large consensus among economists to support the benefits of infrastructure investment for the national economy. Many countries worldwide have adopted a national broadband plan, in which they set ambitious objectives for broadband availability.

This paper analyzes whether the presence of a very high-speed broadband network has a causal impact on local economic growth. I adopt a technology neutral approach to estimate whether very high-speed broadband networks, either fiber optical network (Fiber to the Home;

FttH) and upgraded cable (Fiber to the Last Amplifier; FttLA) have an impact on the creation of new local businesses of all non-farm market sectors and on the creation of sole proprietorships.

This study relies on micro-level panel data covering almost 5,000 municipalities located in metropolitan France, over 6 years, from 2010 to 2015. The three French largest cities, Paris, Lyon and Marseille are excluded from the analysis. These cities are attractive by themselves for companies and households. They are the three largest municipalities in terms of population and are the only one decomposed into arrondissements (districts), with their own mayor and municipal council. In addition, only municipalities with at least 2,000 inhabitants are included in the database.

As infrastructure investment produces spillovers, it affects all sectors of the national economy. However, the economic benefits vary significantly across sectors. The estimation results confirm that the presence of very high-speed broadband networks enhances municipality attractiveness for the creation of new businesses. As foreseen by policy makers and economic analysts, very high-speed broadband networks have on average a positive impact on the creation of establishments operating in the commerce, service and transportation sector, where indirect jobs requiring ICT skills are mostly found. However, I don't find any significant effect on establishment creation in the construction and industry sectors.

I observe a positive effect on the creation of sole proprietorships. Municipalities in which a very high-speed broadband network has been deployed seem to provide a favorable environment for the creation of companies owned and run by one individual.

A limitation of this paper, though, is that the causal relation I attend to estimate between the presence of very high-speed broadband networks and the number of establishments operating locally and more generally economic activity may be subject to endogeneity. I try to mitigate this problem by using the number of establishment creation instead of the total number of establishments operating locally. Besides, I use lagged variables to control for reverse causality. Therefore, the estimation results may suffer from an upward bias with coefficients being overestimated.

Another limitation of the paper is that the deployment of very high-speed network is fairly new. As a result, it is only possible, at this stage, to estimate the short-term effects of their presence on local economic growth. However, it fills a gap in the literature by providing empirical evidence of the impact on next generation broadband technologies on economic growth at the local level.

Thus, this paper highlights the benefits of very high-speed broadband networks on local economic growth, providing further grounds for policy makers to stimulate investments from private operators. Besides, local government may also consider subsidizing or deploying their own very high-speed broadband networks to bring their benefits in areas were private investment is unlikely to occur. By financially supporting the deployment of broadband networks in areas which are not attractive for private operators, local government may help to open up small or medium municipalities, contributing to their economic development.

References

Ahlfeldt, G., Koutroumpis, P. and T. Valletti (2017). "Speed 2.0 – Evaluating access to universal digital highways," *Journal of the European Economic Association*, 15(3), 586–625.

Akerman, A., Gaarder, I. and M. Mogstad (2015) "The Skill Complementarity of Broadband Internet," *The Quarterly Journal of Economics*, 130, 1781–1824

Alama-Sabater, L., Artal-Tur, A., and J.M. Navarro-Azorin, (2011) "Industrial Location, Spatial Discrete Choice Models and the Need to Account for Neighbourhood Effects," *The Annals of Regional Science*, 47, 393-418.

Arauzo-Carod, J. M. and M. C. Manjon-Antolin (2012) "(Optimal) Spatial Aggregation in the Determinants of Industrial Location," *Small Business Economics*, 39, 645-658.

Arauzo-Carod, J. M. (2008) "Industrial Location at a Local Level: Comments on the Territorial Level of the Analysis," *Tijdschrift voor Economische en Sociale Geografie*, 99, 193-208.

Becker, S. and A. Ichino (2002) "Estimation of Average Treatment Effects Based on Propensity Scores," *The Stata Journal*, 2, 358–377

Bertschek, I., Cerquera, D. and G. J. Klein (2013). "More Bits- More Bucks? Measuring the Impact of Broadband Internet on Firm Performance," *Information Economics and Policy*, 25, 190–203.

Bertschek, I., Hueschelrath, K., Kauf, B. and T. Niebel (2016). "The Economic Impacts of Telecommunications Networks and Broadband Internet: A survey," *Review of Network Economics*, 14, 201–227.

Crandall, R. W. and Jackson, C. (2003) "The $500 Billion Opportunity: The Potential Economic Benefit of Widespread Diffusion of Broadband Internet," in *Down the Wire: Studies* *n the Diffusion and Regulation of Telecommunications Technologies*, edited by Shampine, L. Nova Science Publisher.

Crandall, R. W., Litan, R. E. and W. Lehr (2007) "The Effects of Broadband Deployment on Output and Employment: A Cross-Sectional Analysis of U.S. Data" *Issues in Economic Policy*, The Brooklin Institution, Number 6.

Czernich, N., Falck, O., Kretschmer, T. and L. Wößmann (2011). "Broadband Infrastructure and Economic Growth," *Economic Journal*, 121, 505–532.

Czernich, N. (2014). "Does Broadband Internet Reduce the Unemployment Rate? Evidence for Germany," *Information Economics and Policy*, 29, 32–45.

Dimelis, S. P. and S. K. Papaionnou (2011). "ICT Growth Effect at the Industry Level: A comparison between the US and the EU," *Information Economics and Policy*, 23, 37–50.

Dutz, M. Orszag, J. and Robert, W. (2009). "The Substantial Consumer Benefit of Broadband Connectivity for us Households," Compass Lexecon *Internet Innovation Alliance*

Gillet, S.E., Lehr, W.H., Osario, C.A. and M.a; Sirbu (2006) "Measuring the Economic Impact of Broadband Deployment. Final Report," National Technical Assistance, Training, Research and Evaluation Project No. 99-07-13829.

Greenstein, S. and R. C. McDevitt (2011). "The Broadband Bonus: Estimating Broadband Internet's Economic Value," *Telecommunications Policy*, 35, 617–632.

Grimes, A., Ren, C. and P. Stevens (2012). "The Need for Speed: Impacts of Internet Connectivity on Firm Productivity," *Journal of Productivity Analysis*, 37, 187–201.

Gruber, H., Hätönen, J. and P. Koutroumpis (2014). "Broadband Access in the EU: An Assessment of Future Economic Benefits," *Telecommunications Policy*, 38, 1046–1058.

Hagén, H. O., Glantz, J. and M. Nilsson (2008). "ICT Use, Broadband and Productivity.," *Yearbook on Productivity*, (Statistics Sweden), 37–70.

Haller, A. H. and S. Lyons (2015). "Broadband Adoption and Firm Productivity: Evidence from Irish Manufacturing Firms," *Telecommunications Policy*, 39, 1–13.

Hitt, L. and P. Tambe (2007). "Broadband Adoption and Content Consumption," *Information Economics and Policy*, 19, 362–378.

Holt, L. and M. Jamison (2009). "Broadband and Contributions to Economic Growth: Lessons from the US Experience," *Telecommunications Policy*, 33, 575–581.

Imbens, G. (2004). "Nonparametric estimation of average treatment effects under exogeneity. A review," *Review of Economics and Statistics*, 86, 4-29.

Jayakar, K. and E.A. Park (2013) "Broadband Availability and Employment: An Analysis of County-Level Data from the National Broadband Map," *Journal of Information Policy*, 3, 183-200.

Kolko, J. (2012). "Broadband and Local Growth," *Journal of Urban Economics*, 71, 100–113.

Koutroumpis P. (2009). "The Economic Impact of Broadband on Growth: A Simultaneous Approach," *Telecommunications Policy*, 33, 471–485.

Kretschmer T. (2009). "Information and Communication Technologies and Productivity Growth: A Survey of the Literature," *OECD Digital Economy Papers*, 195, 471–485.

McCoy, D., Lyons, S., Morgenroth, E., Palcic, D. and L. Allen (2016). "The Impact of Local Infrastructure on New Business Establishments,"Mimeo.

Mack, A. E. (2014). "Businesses and the Need for Speed: The Impact of Broadband Speed on Business Presence," *Telematics and Informatics*, 31, 617–627.

Mack, A. E. and Rey, S. J. (2014). "An econometric approach for evaluating the linkages between broadband and knowledge intensive firms," *Telecommunications Policy*, 38, 105–118.

Mack, A. E., Anselin, L. and Grubesic, T. H. (2011). "The importance of broadband provision to knowledge intensive firm location," *Regional Science Policy & Practice*, 3, 17–35.

Röller, L. H. and L. Waverman (2001). "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach," *American Economic Review*, 91(4), 909–923.s

Rosenbaum, P. R. and D. B. Rubin (1983). "The Central Role of the Propensity Score in Observational Studies for Causal Effects," *Biometrika*, 70, 41–45

Siedschlag, I., Zhang, X., and Smith, D. (2013). "What determines the location choice of multinational firms in the information and communication technologies sector?" *Economics of Innovation and New Technology*, 22, 581–600.

Van Der Ie, M., Verbrugge, S, Driesse, M. and. and M. Pickavet (2015). "Identifying and Quantifying the Indirect Benefit of Broadband Networks for E-Government and E-Business: A Bottom-Up Approach," *Telecommunications Policy*, 39, 176–191.

Vu, K. M. (2011). "ICT as a Source of Economic Growth in the Information Age: Empirical Evidence from 1996-2005 Period," *Telecommunications Policy*, 35, 357–372.

Whitacre, B., Gallardo, R. and S. Strover (2014). "Broadband's Contribution to Economic Growth in Rural Areas: Moving Towards a Causal Relationship," *Telecommunications Policy*, 38, 1001–1023.

Appendix

Table 37: Data sources

Data	time-period	Source
Fibre deployment by Orange	2010-2014	Orange's information system
Fibre deployment by SFR	2010-2014	SFR's website
Fibre deployment by Free	2010-2014	Free users' community + Free annual Reports
Cable upgrade to FttLA	2010-2014	Numericable's website
Copper upgrade to VDSL	2010-2014	Orange's information system
Population and population density	2006-2012	INSEE
Number of establishments	2009-2015	INSEE
Number of new establishments	2008-2015	INSEE
Number of new establishments per sector	2008-2015	INSEE
Number of new individual companies	2009-2015	INSEE
Unemployment rate (employment zone)	2010-2015	INSEE
Unemployment rate (municipality)	2006-2013	INSEE
Socio-professional groups	2006-2013	INSEE
Diploma	2006-2013	INSEE
Average fiscal income	2008-2015	DGFIP

Table 38: Summary Statistics

superfastbb		new estab	new ind	new construction	comm serv transp	serv firm	serv hh	self-employment
0	number	40136	30503	30503	30503	30503	30503	30507
	mean	53.74798	3.164476	7.954234	17.03232	15.43491	12.37249	35.521
	sd	93.84598	5.056969	13.81333	30.31258	28.87787	19.6356	58.23732
	min	0	0	0	0	0	0	0
	max	2854	154	422	684	1140	650	1675
1	number	4556	4456	4456	4456	4456	4456	4456
	mean	291.8479	11.22195	35.08954	80.13106	97.59358	58.62118	170.6194
	sd	582.0718	22.13058	78.23895	150.4043	214.3319	122.598	355.2885
	min	2	0	0	0	0	0	2
	max	6895	272	1382	1781	2629	1519	4609
Total	number	44692	34959	34959	34959	34959	34959	34963
	mean	78.02041	4.19151	11.413	25.07512	25.90715	18.26751	52.73915
	sd	218.2463	9.588983	32.06984	64.24479	85.63102	49.89729	145.1681
	min	0	0	0	0	0	0	0
	max	6895	272	1382	1781	2629	1519	4609

Table 39: Evolution of company creations in France

	2002-2008	2008-2010	2010-2011	2011-2015
Industry	23%	124.5%	-15.7%	-12.3%
Construction	61.5%	65.6%	-11.5%	-21.8%
Commerce (retail)	50.1%	81.1%	-13.2%	-21.3%
Commerce (wholesale)	9.3%	10.4%	-13%	-2.3%
Accommodation restaurant	45.5%	33.5%	-5.8%	10.2%
Transportation	33.5%	27.2%	-1.9%	127.8%
Information and communication	59.1%	138.3%	-13%	-2.1%
Services to households	109.7%	212.5%	-22.8%	-28.9%
		2009-2010	2010-2011	2011-2015
Sole proprietorships		7.9%	-16.8%	-5.7%

Sources: INSEE

Part V
General Conclusion

Conclusion

In this last chapter, I briefly summarize my main results and give directions for further research projects.

1 Review of the Main Results

1.1 Universal Service Obligation and Public Payphone Use

In Chapter 2, I analyze whether universal service obligations are still relevant for the provision of public payphones in a context of technological changes. Universal service is a public policy ensuring that everyone can access basic communications services at a reasonable quality and an affordable price regardless of revenue or geographic location. However, considering the availability of affordable alternative means of communications, the relevance to keep providing public payphones under the scope of universal service is questioned. For example, mobile telephony has become widely used and alternative means of telephony have also emerged with Voice over IP (VoIP).

I investigate what is the effect of universal service obligations on public payphone use in the period 2005-2009, with a particular focus on vulnerable end-users, among them low-income households. The second question addressed in the paper is what would happen if public payphones were removed from the scope of universal service.

The first main finding is that universal service obligations do not have a significant impact on public payphone use. Only when a minimum number of payphones, depending on the density of population (i.e., coverage obligations), is imposed, this impact becomes positive. The second main finding is that if universal service obligations had been absent, the use of payphones would have decreased on average, in the European Union between 2005 and 2009, by 15 percent.

Based on the results for 2005-2009 and on the evolution of the electronic communications market between 2009 and 2017, it is possible to conjecture what could happen, in terms of public payphone use, if universal service obligations were removed in the EU in 2017.

Two opposing effects are potentially at play: a substitution effect and a composition effect. First, given the decline in mobile phone prices and the emergence of low-cost offers, one can conjecture that the substitution between payphones and mobile phones is stronger in 2017 than it was in 2009. The second potential effect is a composition effect. Due to the substitution between payphones and mobile phones, the composition of the payphones' user base is due to have changed. Therefore in 2017, compared to 2009, a higher share of public payphones users could be made of low-income individuals, less elastic to a change in payphone regulation.

If in 2017 the substitution effect has a higher impact than the composition effect on the percentage of public payphone use, the decline in their use following a change in regulatory policy could be higher than 15 percent. However, it would apply to a smaller number of payphones users. As a result, removing payphones from the scope of universal service would still have a relatively low welfare cost (in terms of reduced usage) in 2017.

1.2 Local Loop Unbundling and Entry into Fiber

In Chapter 3, co-authored with M. Bourreau and L. Grzybowski, I analyze what are the determinants of entry into local fiber markets. We estimate specifically how competition via local loop unbundling (LLU) influences entry and the deployment of fiber infrastructures.[63]

We study what is the impact of LLU-based competition, in terms of the number of LLU operators, on the incentives to invest into fiber. Besides, we analyze how the competition from alternative technologies, such as upgraded cable or VDSL, impacts operators' incentives to invest into fiber.

We find that the local market presence of LLU operators has a positive impact on entry by fiber operators. We also show that the competition from upgraded cable stimulates fiber deployment. Fiber operators may seek to avoid that the cable-operator benefits from a first-mover advantage and preempt the market. In addition, we find that the deployment of the VDSL technology, which provides higher Internet speed on the copper network, slows down fiber

[63]Local loop unbundling refers to a regulatory policy, which allow alternative operators to use the incumbents copper network, at a regulated price, to provide broadband services.

deployment. Thus, firms may choose to upgrade copper lines on the legacy network instead of investing in fiber networks.

Our results show that the competition from LLU operators does not impede fiber entry. The main variables that influence entry are the market size and the population density. The market size required for the first and each additional operator to enter the market decreases over time, which implies that entering less densely populated municipalities becomes easier over time. Entry thresholds for LLU operators are substantially smaller than for fiber operators, which reflects the scale of investment required to enter the market.

Despite a decrease in the fiber entry thresholds, the vast majority of municipalities in France are and will remain unprofitable for fiber deployment. There is therefore a need for public involvement to achieve the Digital Agenda's objectives. For instance, policy makers can stimulate fiber deployment by promoting co-investment to reduce entry costs.

We also show that private operators' decisions to enter into fiber depend on the expectations on potential revenues which are determined by the deployment cost and "quality" of demand. Therefore, there are grounds for the use of demand stimulation policy, which by enhancing the demand, will indirectly enhance operators' incentives to invest.

1.3 Impact of Very High-Speed Broadband on Local Economic Growth

In Chapter 4, I analyze whether very high-speed broadband availability has an impact on some measures of local economic growth. Specifically, I investigate whether very high-speed broadband networks, i.e., fiber networks (FttH) and upgraded cable networks (FttLA or DOCSIS 3.0) have an effect on the creation of new businesses, with a specific focus on sole proprietorships.

I find evidence of benefits of very high-speed broadband networks for local economic growth. They enhance municipalities attractiveness for establishments belonging to the tertiary sector, which rely more on ICTs. However, I do not find any significant impact of the creation of establishments from the industry or the construction sectors.

Besides, I observe a positive effect on sole proprietorships. Municipalities in which a very high-speed broadband network has been deployed seem to provide a favorable environment for the creation of companies owned by one individual.

Thus, this paper highlights the benefits of very high-speed broadband networks on local economic growth, providing further grounds for policy makers to stimulate investments from private operators. Besides, local government may also consider subsidizing or deploying their own very high-speed broadband networks to bring their benefits in areas were private investment is unlikely to occur.

2 Future Projects

Broadband and especially very high-speed broadband are considered as vehicles for economic growth and development. For these reasons, many countries worldwide have adopted a national broadband plan, in which they set ambitious objectives for broadband availability. Public initiative networks could play a role in enhancing their positive impacts locally. Public investment in broadband network is viewed as a policy instrument to bring down the digital divide by providing higher bandwidth in less densely populated municipalities, enhancing their attractiveness for both companies and households. They are the main contributors in the achievement of national broadband plans. Gruber et al. (2014) evaluate the net economic benefits that would derive from the achievement of the objectives of the 2020 Digital Agenda for Europe. They highlight the rationale for public subsidies in the roll-out of broadband networks. Briglauer et al. (2017) confirm this result for employment in rural areas for Bavaria in Germany.

However, considering the high investment cost, it is particularly interesting and relevant to assess whether these benefits are revealed by a thorough economic analysis. Similarly to the analysis of the impact of very high-speed broadband deployed by private operators on local economic growth, the assessment of the impact of public initiative networks is a highly relevant policy question.

I have materials ready for further studies regarding the impact of public broadband networks on local economic growth at the municipality level for France. For the need of my studies, I have built comprehensive and unique micro-level panel databases on fiber deployments, the presence of alternative technologies and competitors.

In addition, many questions remain to be answered as regards the articulation between public and private investments. Investment into broadband and very high-speed broadband networks is a good candidate for such an analysis. I could investigate what are the relations between public and private investments: are they complements or substitutes? Another question would be to assess whether public investment is crowding-in or crowding-out private investment in less densely populated areas, especially in medium and small towns, where private investment is likely to occur, but with a delay, in the form of co-investment. See among others Ford (2007), Bauer (2010) and Dregger et al (2016). A similar analysis has been conducted by Wilson (2016) for the US. Using simulation techniques, the author finds evidence that public investment may crowd out private investment resulting in a welfare loss. I could add to this research area by checking if Wilson's (2016) findings are also valid in the case of France, in which the regulatory framework and the market structure is different.

References

Bauer, J. (2010). "Regulation, public policy, and investment in communications infrastructure," *Telecommunications Policy*, 34, 65–79.

Briglauer, W., Dürr, N., Falck, O. and Hüschelrath, K. (2016). "Does State Aid for Broadband Deployment in Rural Areas Close the Digital and Economic Divide?," Mimeo.

Dregger, C. and Reimers. H.E. (2016) "Does Municipal Supply of Communications Crowd-Out Private Communications Investment? An Empirical Study," *Economic Modelling*, 58, 154–158.

Ford, G.H. (2007) "Does a Municipal Electric's Supply of Communications Crowd Out Private Communications Investment? An Empirical Study," *Energy Economics*, 29, 467–478.

Gruber, H., Hätönen, J. and P. Koutroumpis (2014). "Broadband Access in the EU: An Assessment of Future Economic Benefits," *Telecommunications Policy*, 38, 1046–1058.

Wilson, K. (2016) "Does Public Competition Crowd Out Private Investment? Evidence from Municipal Provision of Internet Access," Mimeo.

Les politiques publiques face aux changements technologiques

Maude HASBI

RESUME : Cette thèse aborde plusieurs sujets relatifs à l'impact de la régulation sectorielle sur la concurrence et l'investissement dans le secteur des communications électroniques. En particulier, cette thèse soulève des questions relative à la pertinence de la régulation, lorsque celle-ci est imposée à de technologies anciennes, notamment lorsque des technologies plus efficaces et plus modernes sont disponibles sur le marché à un prix abordable. Cette thèse permet également d'analyser comment la régulation sectorielle affecte la concurrence entre technologies et indirectement l'investissement des opérateurs privés. Des analyses plus complètes sont proposées en ce qui concerne le marché du haut et du très haut débit. J'y estime dans quelle mesure l'impact de la concurrence (via le dégroupage de la boucle locale cuivre) vient affecter les incitations à investir des opérateurs dans les réseaux en fibre optique. Enfin, cette thèse permet d'évaluer l'impact des réseaux très haut débit sur la croissance économique au niveau local, en termes d'impact sur les créations d'entreprises et les créations d'entreprises unipersonnelles. Cette dernière étude a pour objectif de quantifier les bénéfices économiques provenant du déploiement de ces réseaux de nouvelle génération.

MOTS-CLEFS : Politique publique, Régulation, Concurrence, Investissement, Haut et Très Haut débit.

ABSTRACT : This thesis approaches several issues related to the impact of sector-specific regulation on competition and investments in the electronic communication sector. More specifically, it raises the question of the relevance of regulation when applied to an old technology, when enhanced and affordable alternative technologies are available. It also analyzes how regulation affects competition between technologies and indirectly operators' investments. Further analyses are provided for the fixed broadband market, with an assessment of the effect of competition via local loop unbundling on operators' incentives to invest into fiber networks. Finally, this thesis evaluates the impact of very high-speed broadband networks on local economic growth, in terms of establishment creation and sole proprietorship creation. It attempts to quantify the economic benefits stemming from the roll-out of next generation access networks.

KEY-WORDS : Public Policy, Regulation, Competition, Investment, High-Speed and Very High-Speed Broadband

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY