Public policy in the digital age: evidence from telecommunications and digital platforms

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A Clara Inés, Leonardo y Juan Manuel

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A Daniel

« [...] Bénéficier des vertus du marché requiert souvent de s'écarter du laissez-faire ».

« Au-delà de l'extraordinaire progrès technologique qu'elle induit, synonyme de gain de temps et de pouvoir d'achat, l'économie numérique comporte des dangers qu'il nous faut bien mesurer ».

Jean Tirole[1]

[1] Tirole, J. (2016). Économie du bien commun. Presses universitaires de France, Chapters 2 and 14. Translation by the author: *"[...] Benefiting from the virtues of the market often requires a departure from laissez-faire". "Beyond the extraordinary technological progress that it induces, synonymous with saving time and purchasing power, the digital economy involves dangers that we must carefully measure".*

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Introduction générale

Avez-vous déjà rencontré des problèmes de connexion à l'Internet lorsque vous travailliez à domicile ou que vous étiez en vidéoconférence ? Avez-vous déjà été désagréablement surpris par une facture onéreuse de téléphone portable au retour d'un voyage à l'étranger ? Avez-vous déjà eu du mal à trouver un moyen de transport après une sortie nocturne et vous êtes-vous demandé où se trouvent tous les taxis ? Si votre réponse à la première question est négative, vous vivez probablement dans une zone densement peuplée ou vous êtes déjà équipé du très haut débit. Si votre réponse à la deuxième question est négative, vous n'avez peut-être jamais utilisé vos services mobiles à l'étranger, vous avez été averti de ne pas le faire ou vous résidez et voyagez actuellement dans l'Espace économique européen. Si votre réponse à la troisième question est négative, vous possédez peut-être un véhicule, ou vous êtes un adepte des plateformes de véhicule de transport avec chauffeur (VTC). Si la réponse à toutes les questions précédentes est négative, alors vous avez beaucoup de chance, ou vous êtes probablement trop jeune pour avoir vécu les premières étapes de la transformation numérique.

Les questions précédentes donnent des exemples d'opportunités et de défis posés par la mondialisation et la numérisation de l'économie mondiale.[2] Nos activités quotidiennes reposent de plus en plus sur l'utilisation des technologies numériques

[2] La numérisation est définie comme "la conversion d'un texte, d'une image ou d'un son en une forme numérique qui peut être traitée par un ordinateur" (traduit de l'anglais à partir de la définition dans le dictionnaire anglais Oxford).).

qui modifient nos relations humaines, mais aussi nos interactions dans un large éventail d'activités comme le commerce, les transports, les médias, la santé, le travail et l'éducation, pour n'en citer que quelques-unes.[3] Cette transformation numérique est perçue comme une source d'opportunités et la pandémie de la COVID-19 n'a fait que l'amplifier. Comme l'indique l'OCDE, *"... Peut-être jamais notre dépendance mondiale à l'égard des technologies numériques n'avait touché tous les aspects de la société ... "*.[4]

Cependant, cette révolution numérique pose de nombreux défis. L'un d'entre eux, essentiel, est le besoin sous-jacent d'une connectivité rapide et fiable pour tous. Comme l'explique également l'OCDE, *"[...] ces activités basées sur l'internet et nécessitant une large bande passante alimentent la demande de connectivité de haute qualité et mettent en lumière les fractures numériques existantes, renforçant la nécessité d'une approche plus inclusive de la transformation numérique.*[5] En outre, les interactions numériques suscitent des préoccupations croissantes. Les décideurs politiques sont particulièrement inquiets par la concentration croissante et le pouvoir de marché des plateformes numériques, leurs impacts sociétaux, mais aussi les questions de fiabilité, de sécurité, de confidentialité, de responsabilité et de droits de propriété des données.[6]

Dans ce contexte, les politiques publiques peuvent être des outils puissants pour aider à exploiter pleinement le potentiel de l'économie numérique.[7] Pour en revenir

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[3]Pour une discussion détaillée sur la façon dont la numérisation change l'économie mondiale, voir : Tirole, J. (2016), *Economie du bien commun*, chapitre 14.

[4]Zhongming, Z., Linong, L., Wangqiang, Z. & Wei, L. (2020). OECD Digital Economy Outlook 2020 (traduit de l'anglais).

[5]Ibidem.

[6]Pour une discussion sur les défis sociétaux de l'économie numérique, voir : Tirole, J. (2016), *Economie du bien commun*, chapitre 15.

[7]L'OCDE définit l'économie numérique comme "l'ensemble des activités économiques qui reposent sur l'utilisation d'intrants numériques, notamment les technologies numériques, l'infrastructure numérique, les services et les données numériques, ou qui sont considérablement améliorées par cette utilisation. Elle fait référence à tous les producteurs et consommateurs, y compris les pouvoirs publics, qui utilisent ces intrants numériques dans leurs activités économiques". Voir : OECD (2020), *Roadmap toward a Common Framework for Measuring the Digital Economy*, rapport technique, p. 5 (traduit de l'anglais).

aux questions soulevées au début de cette introduction, les décideurs politiques de l'ère numérique sont confrontés à des questions politiques plus larges, telles que : comment garantir l'accès de tous à des réseaux de télécommunications rapides et fiables ? Comment faire en sorte que chaque consommateur et chaque entreprise ait la possibilité de participer à l'économie numérique et de tirer le meilleur parti des technologies numériques ? Quel est l'impact des plateformes numériques sur les marchés traditionnels et les consommateurs ? Ces questions de politique publique sont au cœur de questions de recherche plus spécifiques abordées dans cette thèse de doctorat.

Les interventions publiques sont souvent nécessaires. Toutefois, elles s'accompagnent également de coûts et de risques. Leur bonne conception repose de plus en plus sur une théorie économique solide, mais elle nécessite également une grande quantité et une grande qualité d'informations, qui ne sont souvent pas totalement disponibles *ex ante*. Ainsi, l'évaluation *ex post* joue un rôle important dans le processus dynamique d'adaptation de l'intervention publique afin de rendre les politiques plus efficaces et efficientes.

Cette thèse de doctorat étudie des questions de politique publique dans le contexte de la transformation numérique de l'économie mondiale. Elle examine des situations nouvelles et des interventions publiques dans les secteurs des télécommunications et du numérique affectant la mobilité des personnes et leur intégration dans l'économie numérique.

Cette introduction générale donne d'abord un aperçu de l'intervention publique dans les économies de marché, souligne son rôle dans les secteurs des télécommunications et des plateformes numériques et discute de l'importance de l'évaluation *ex post* (1). Ensuite, elle présente la motivation et la contribution de chaque chapitre de la thèse (2).

1. L'intervention publique dans l'économie numérique : rôle, défis et évaluation empirique

Cette section se propose de fournir les éléments clés pour comprendre la place et les apports de cette thèse de doctorat. Dans un premier temps, nous rappelons quelques principes de base de l'intervention publique dans les économies de marché (1.1). Deuxièmement, nous donnons un aperçu de l'intervention publique sur le secteur des télécommunications et sur les plateformes numériques (1.2). Troisièmement, nous décrivons les principaux défis et risques de l'intervention publique (1.3). Enfin, nous soulignons l'importance de l'évaluation *ex post* et de l'adaptation des interventions publiques (1.4).

1.1. Principes de base de l'intervention publique dans les économies de marché

Une économie de marché est un système dans lequel la libre interaction entre les individus (demande) et les entreprises (offre) détermine les décisions et les résultats économiques.[8] Les économistes sont d'accord en général sur le fait que, dans certaines conditions, ce type d'économie tend à produire de meilleurs résultats en termes d'efficacité, de productivité et d'innovation. La liberté de choix et la concurrence sont quelques-uns des principes fondamentaux des économies de marché. Toutefois, les économistes s'accordent également à dire que l'intervention publique est souvent nécessaire. À partir des travaux précurseurs de Musgrave (1957 ; 1959), les économistes distinguent l'intervention publique en trois branches de fonction : allocation, distribution et stabilisation. Ainsi, la plupart des économies du monde autorisent différents degrés d'intervention publique.

[8] Les fondements du concept d'économie de marché reposent sur les travaux théoriques des économistes classiques tels qu'Adam Smith, David Ricardo, Jean-Baptiste Say, entre autres.

Cette thèse de doctorat porte principalement sur le cas des politiques d'allocation en réponse aux défaillances du marché. C'est-à-dire, lorsque les marchés libres ne permettent pas une production ou une allocation efficace des biens et/ou services. Dans un second plan, cette thèse porte également sur les politiques de redistribution.

Les défaillances du marché se produisent lorsqu'un ou plusieurs des mécanismes par lesquels les marchés fonctionnent efficacement échouent.[9] Deux types de défaillances du marché sont particulièrement intéressants pour comprendre la pertinence des questions abordées dans cette thèse de doctorat. Le premier est le cas des monopoles naturels, où une seule entreprise agit en tant que fournisseur sur le marché, généralement en raison de coûts d'investissement irrécupérables élevés et/ou d'économies d'échelle.[10] Les industries de réseau, qui font l'un des objets de cette thèse de doctorat, ont été traditionnellement classées comme des monopoles naturels. Plus largement, cela concerne l'exercice et le contrôle du pouvoir de marché, qui sont au cœur du domaine de l'organisation industrielle en économie.[11] Le deuxième type de défaillance du marché pertinent pour cette thèse de doctorat se produit en présence d'externalités. Il s'agit d'une situation dans laquelle le comportement d'une personne (ou d'une entreprise) affecte le bien-être d'une autre, sans qu'aucune compensation ne soit attribuée dans les prix.[12] Les plateformes numériques, qui sont un autre sujet de cette thèse, reposent sur les effets de réseau. C'est le cas lorsque les utilisateurs se soucient de la participation et des décisions d'utilisation des autres utilisateurs. [13]

[9] Les économistes étudient depuis longtemps les défaillances du marché, héritant d'une longue tradition théorique d'économistes du bien-être tels que Arthur C. Pigou et Paul A. Samuelson, pour n'en citer que quelques-uns. Parmi les domaines qui étudient activement les sources et les remèdes politiques aux défaillances du marché, nous pouvons citer l'économie publique, l'organisation industrielle et l'économie de l'environnement.

[10] Les économies d'échelle sont des réductions proportionnelles des coûts obtenues lorsque le niveau de production augmente. Cela signifie qu'il y a une diminution des coûts par unité lorsque la quantité totale de production est plus élevée.

[11] Voir : Tirole, J. (2015). "Market Failures and Public Policy". American Economic Review, 105 (6): 1665-82.

[12] D'autres types de défaillances du marché apparaissent en présence d'asymétries d'information, de biens publics, de problèmes de coordination et de biens tutélaires.

[13] Voir : Belleflamme & Peitz (2018), Platforms and Network effects. In Handbok of Game

Schématiquement, l'intervention publique peut avoir lieu avant la constitution d'une situation problématique (*ex ante*) ou en réaction à une situation ou un comportement observé (*ex post*). L'objectif ici n'est pas de passer en revue tous les types d'interventions, mais de décrire brièvement quelques actions politiques ciblées sur les marchés qui sont au cœur des questions étudiées dans cette thèse de doctorat.

La première est la réglementation sectorielle *ex ante* qui vise à surveiller et à contrôler un secteur ou une entreprise afin d'assurer la transparence pour les investisseurs et une concurrence efficace. Elle fournit aux acteurs économiques des règles d'action. Deux des trois chapitres de cette thèse de doctorat portent sur l'intervention réglementaire.

Le deuxième type d'intervention publique est la politique de concurrence, qui vise à garantir que la concurrence ne soit pas restreinte ou affaiblie d'une manière préjudiciable à la société. Dans un souci de clarté, rappelons que la politique de concurrence s'appuie sur différents instruments. En Europe, il s'agit de la politique antitrust[14], du contrôle des concentrations [15] et du contrôle des aides d'État.

Un chapitre de cette thèse de doctorat porte sur la question du contrôle des aides d'État, qui consiste à évaluer tout avantage conféré par les autorités nationales aux entreprises sur une base sélective.[16] Les aides d'État, qui sont une forme d'intervention publique, peuvent prendre différentes formes (par exemple, des sub-

Theory and ndustrial Organization, Corchon, L and Marini, M eds); Edward Elgar.

[14]La politique antitrust interdit les accords anticoncurrentiels entre deux ou plusieurs opérateurs indépendants du marché. La fixation des prix par les concurrents en est un exemple. Dans l'UE, la politique antitrust interdit également les comportements abusifs des entreprises qui occupent une position dominante sur un marché donné. Les prix prédateurs et les rabais de fidélité sont des exemples de pratiques abusives. Voir : www.ec.europa.eu/competition-policy/antitrust/antitrust-overview_en.

[15]Le contrôle des concentrations vise à examiner les projets de fusions afin de prévenir les effets néfastes sur la concurrence. En pratique, si certaines fusions peuvent apporter des avantages à l'économie, d'autres peuvent réduire la concurrence et risquent de nuire aux consommateurs. Ainsi, les autorités de la concurrence évaluent les effets potentiels des fusions proposées et décident de les approuver ou de les interdire. Voir : www.ec.europa.eu/competition-policy/mergers/mergers-overview_en.

[16]Voir l'article 107, paragraphe 1, du traité sur le fonctionnement de l'Union européenne (TFUE).

ventions, des réductions d'intérêts et d'impôts, des garanties). Elles ont la particularité de créer un risque de distorsion de la concurrence ou d'affecter les échanges entre États membres. Ainsi, les aides d'État sont généralement interdites par la Commission européenne. Toutefois, les aides d'État peuvent être autorisées en présence de défaillances du marché ou pour des raisons d'intérêt économique général. Il existe donc des exemptions pour des objectifs politiques spécifiques.[17] Le contrôle des aides d'État de l'UE nécessite généralement une notification et une approbation préalables par la Commission européenne. Depuis 2012, avec la réforme de modernisation des aides d'État de l'UE, la Commission européenne accorde plus de poids aux évaluations *ex post* des aides d'État, notamment à l'évaluation des distorsions du marché que les aides d'État peuvent introduire.

Le troisième type d'intervention politique dans cette thèse concerne la réglementation des plateformes. En particulier, nous étudions les questions pertinentes pour l'amélioration de la mobilité, de la sécurité et de l'inclusion dans les politiques de transport.

Ainsi, cette thèse de doctorat couvre trois types différents de politiques publiques.

1.2. Intervention publique sur le secteur des télécommunications et les plateformes numériques

Des arguments faisant appel à l'ampleur des investissements en infrastructures et à d'autres caractéristiques des télécommunications ont traditionnellement été utilisés pour justifier l'existence de monopoles d'État dans ce secteur. Toutefois, l'évolution rapide de la technologie et la mondialisation de l'économie ont entraîné une tendance internationale à la libéralisation. Une nouvelle approche de la fourniture de services

[17] Pour plus d'informations sur les objectifs politiques pour lesquels les aides d'État peuvent être considérées comme compatibles, voir la législation européenne relative aux aides d'État, disponible à l'adresse suivante : https://ec.europa.eu/competition-policy/state-aid/legislation_en.

de télécommunications, fondée sur le marché, a été introduite dans de nombreux pays, à commencer par les États-Unis au milieu des années 1990.[18] Dans l'UE, le secteur a été ouvert à la concurrence à la fin des années 90. En France, la libéralisation a eu lieu officiellement en janvier 1998, sauf pour les services téléphoniques locaux, qui ont été libéralisés plus tard avec la boucle locale radio et le dégroupage.[19]

Malgré la libéralisation, l'intervention publique reste cruciale pour le bon fonctionnement du secteur des télécommunications. Les motifs sont nombreux, tout comme les domaines d'intervention. Par exemple, l'intervention publique sous forme de réglementation est nécessaire pour l'octroi des licences d'utilisation du spectre (bien public), pour superviser l'interconnexion des nouveaux entrants avec les opérateurs historiques (monopole naturel) et pour faciliter l'accès aux réseaux des opérateurs historiques (contrôle du pouvoir de marché). En outre, une intervention publique peut également être nécessaire pour remédier à l'absence d'incitations à la fourniture de services de télécommunications dans les zones où les coûts sont particulièrement élevés et les revenus ou la demande en volume faibles (service universel). La raison en est que la plupart des pays continuent de considérer les télécommunications comme un service public essentiel, du moins dans une certaine mesure, notamment en raison de la mondialisation et de la numérisation de l'économie mondiale. Dans l'UE, un régime d'aides d'État pour le haut débit a été introduit dans le but de permettre l'accès à des réseaux de télécommunications rapides et fiables dans les endroits où le marché ne fournit pas l'infrastructure nécessaire.[20]

Les pays disposent généralement de leur propre autorité nationale de régulation des télécommunications, qui intervient principalement sur les marchés de gros. Ensuite,

[18] Voir : Crandall, R. W. (2000). *Telecommunications Liberalization: The US Model, in: Gander, J. P. (2000). "Deregulation and Interdependence in the Asia-Pacific Region".* National Bureau of Economic Research East Asia Seminar on Economics, Volume 8: Takatoshi Ito and Anne O. Krueger, editors; National Bureau, Journal of Asian Economics, Elsevier, vol. 11(4), pages 477-478.

[19] Voir l'examen par le Sénat, en 2001, de la loi 96/659 sur la réglementation des télécommunications, disponible à l'adresse suivante : http://www.senat.fr/rap/r01-273/r01-27328.html.

[20] Voir : https://digital-strategy.ec.europa.eu/en/policies/broadband-state-aid.

l'intervention réglementaire dans le secteur est complétée par la politique de concurrence.[21] Dans l'UE, la Commission européenne propose et met en œuvre des paquets réglementaires, qui définissent des règles communes applicables dans tous les États membres. En outre, depuis sa création en 2009, l'Organe des régulateurs européens des communications électroniques (ORECE ou 'BEREC" pour ces sigles en anglais) vise à garantir une application cohérente du cadre réglementaire de l'UE dans tous les États membres et à promouvoir un marché intérieur unique efficace.[22] En France, l'Autorité nationale de régulation est l'ARCEP (*Autorité de régulation des communications électroniques, des postes et de la distribution de la presse*). Elle a été créée le 5 janvier 1997, initialement sous le nom d'*Autorité de régulation des télécoms* (ART).[23]

Deux des trois chapitres de cette thèse de doctorat portent sur le secteur des télécommunications. Le premier chapitre évalue l'impact d'un règlement européen majeur sur les opérateurs et les utilisateurs de télécommunications mobiles. Le deuxième chapitre étudie un programme d'aide d'État visant à faciliter le déploiement de réseaux très haut débit rapides et fiables dans les zones rurales, qui sont nécessaires pour soutenir le développement du monde numérique.

Le secteur des télécommunications, en particulier les réseaux à haut débit, est le fondement de la société de l'information et de l'économie numérique. Chaque information échangée et chaque transaction ou activité sur l'internet repose sur les technologies de l'information et de la communication. Dans la pratique, ces technologies sont rendues possibles par la numérisation, qui a entraîné d'énormes changements dans de nombreuses facettes de la société moderne.

Avec la numérisation et la connectivité accrue, nous avons assisté à l'émergence

[21] Par exemple, les fusions entre opérateurs de télécommunications sont minutieusement examinées et les accords et abus anticoncurrentiels sont sanctionnés par les autorités de la concurrence (ordre public ; contrôle du pouvoir de marché).

[22] Voir : https://berec.europa.eu/eng/about_berec/what_is_berec/

[23] Voir : https://www.arcep.fr/larcep/nos-missions.html

de nouvelles formes de production, de consommation et d'interaction. L'essor des plates-formes numériques, l'utilisation des technologies numériques pour modifier les modèles économiques des entreprises, ainsi que pour améliorer les activités des organisations du secteur public (administration en ligne), et la réalisation de transactions commerciales sur l'internet (commerce électronique), ne sont que quelques exemples.

Les plateformes numériques ont apporté des avantages considérables à la société et jouent actuellement un rôle important dans la vie quotidienne de nombreux individus.[24] Elles ont permis une diminution des coûts de recherche et de transaction, elles ont potentialisé les communications et elles ont également révélé la valeur du contenu généré par les utilisateurs. Cependant, l'observation d'une concentration et d'un pouvoir de marché croissants des plateformes numériques a suscité l'inquiétude des autorités publiques. C'est notamment le cas des plateformes ayant un role dit de "gatekeepers".[25] Ces préoccupations s'ajoutent aux inquiétudes concernant les activités illégales et la désinformation qui se produisent par leur intermédiaire.

Les autorités de la concurrence du monde entier poursuivent activement l'examen antitrust des plateformes numériques et les initiatives visant à adapter les critères de contrôle des concentrations à leurs spécificités. En outre, les décideurs politiques continuent d'ouvrir la voie à une réforme législative et à une réglementation *ex ante*. Dans l'UE, la loi sur les services numériques (DSA pour ces sigles en anglais) et la loi sur les marchés numériques (DMA pour ces sigles en anglais) proposées par la Commission européenne avec des projets de textes publiés le 15 décembre

[24]Une plateforme numérique peut être définie au sens large comme une "entreprise qui utilise l'internet pour permettre des interactions entre utilisateurs afin de générer de la valeur à partir de ces interactions". Sa principale caractéristique est la présence d'effets de réseau positifs. Voir : Belleflamme Peitz (2018), Plateformes et effets de réseau. In Handbok of Game Theory and Industrial Organization, Corchon, L and Marini, M eds) ; Edward Elgar.

[25]Ces plateformes agissent comme des barrières à l'entrée, contrôlant l'entrée de tous les côtés du marché. La définition des *gatekeepers* dans la loi sur les marchés numériques peut être consultée en ligne à l'adresse suivante : https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en.

2020, devaient être votées par le Parlement européen au moment de la rédaction de cette thèse. Les législations proposées visent à réguler les plateformes numériques avec un rôle de *gatekeeper*. Elles s'inscrivent dans une tendance internationale à l'intervention publique des plateformes numériques.[26]

Les applications de location de véhicule avec chauffeur sont des exemples de plateformes numériques actives dans le secteur des transports urbains. Ces plateformes permettent de fournir des services similaires à ceux des taxis en mettant en relation les conducteurs et les passagers directement via une application, sans avoir besoin d'un centre de répartition.[27] Elles ont perturbé de nombreux marchés locaux où les taxis (traditionnellement réglementés) représentaient la principale offre de transport privé. Bien qu'elles soient censées apporter de nombreux gains d'efficacité économique, elles se sont heurtées à l'opposition des acteurs traditionnels du transport et ont suscité des inquiétudes de la part des autorités publiques quant aux externalités négatives (par exemple, congestion, pollution et sécurité). Les applications de location de véhicule avec chauffeur (du moins certaines de leurs offres, comme le service "UberPop" d'Uber) ont fait l'objet d'interdictions ou de suspensions dans plusieurs endroits du monde. Elles ont suscité un débat réglementaire sur l'opportunité d'imposer des normes de qualité et des règles minimales pour assurer la sécurité routière et une concurrence loyale. Par exemple, le gouvernement français a annoncé en 2021 la création de l'Autorité des relations sociales des plateformes d'emploi (ARPE), une autorité publique chargée de réguler les relations sociales entre les plateformes et les travailleurs indépendants. Elle vise les plateformes de mobilité (services de location de véhicule avec chauffeur et de livraison avec deux roues).

Dans le troisième chapitre de cette thèse de doctorat, nous étudions l'impact des

[26] Voir : www. Digital-strategy.ec.europa.eu/en/policies/digital-services-act-package.

[27] Pour une description plus détaillée de ces services, voir International Transport Forum (2018), The Economics of Regulating Ride-Hailing and Dockless Bike Share. Document de travail.

plateformes de location de véhicule avec chauffeur sur la sécurité routière. Nous visons à mieux informer le débat de politique publique sur les impacts sociétaux de la location de véhicule avec chauffeur et le besoin de politiques concernant la sécurité et la mobilité.

1.3. Défis et risques de l'intervention publique

Dans les sections précédentes, nous avons examiné la raison d'être de l'intervention publique dans les économies de marché, et dans le cas spécifique des télécommunications et des plateformes numériques. Dans cette section, nous souhaitons insister sur le fait que l'intervention publique ne devrait intervenir que dans des circonstances exceptionnelles : lorsque les marchés ne sont pas efficaces et que, dans le même temps, une intervention sur le marché améliorerait l'efficacité.[28]

Dans la pratique, l'intervention publique a un coût. Toutes les interventions du secteur public sont financées en dernier ressort par les impôts des particuliers et des entreprises. La théorie économique nous apprend que les taxes faussent les marchés et génèrent une perte sèche.[29] Les ressources publiques étant limitées et devant être réparties sur un large éventail de domaines d'intervention, l'intervention publique doit également faire face à des compromis. Il est donc nécessaire de s'assurer que les interventions publiques apporteront des améliorations et des avantages qui compenseront leurs coûts.

En outre, les interventions publiques génèrent des risques. Comme le secteur pub-

[28] En économie, le concept d'efficacité (de Pareto) fait référence à une situation dans laquelle *"il n'existe aucun moyen d'améliorer la situation d'un consommateur sans aggraver celle d'un autre consommateur. Pour de nombreux cas d'intérêt, les résultats efficaces de Pareto peuvent être considérés comme ceux qui maximisent la somme des avantages économiques moins les coûts"*. Voir : Varian, H. R. (1992). Microeconomic Analysis. New York: Norton, pp 222-223.

[29] En économie, le concept de perte sèche due à la fiscalité désigne le montant du surplus total (des producteurs et des consommateurs) qui est perdu en raison d'une diminution de la production suite à l'introduction d'une taxe. Cette diminution du surplus est perdue pour les producteurs et les consommateurs et n'est pas récupérée sous forme de recettes publiques. Pour une explication formelle, voir : Varian, H.R. (2010), Intermediate Microeconomics : a modern approach, 8e édition, WW Norton Company.

lic est confronté aux mêmes difficultés que le marché, notamment à des problèmes d'asymétrie d'information, les interventions peuvent être soit inefficaces (aucun gain d'efficacité n'est réalisé), soit préjudiciables (il y a des pertes d'efficacité).[30] Le secteur public est souvent moins bien placé que les marchés pour savoir comment les consommateurs et les entreprises évaluent les biens et les services ou pour anticiper la manière dont ils réagiraient à une intervention particulière. Ainsi, l'intervention publique peut décourager les efforts privés, évincer les investissements privés ou générer des réactions stratégiques de la part des acteurs privés. Enfin, il existe également un risque de capture réglementaire. C'est-à-dire lorsque les intérêts individuels l'emportent sur les intérêts publics dans la conception et la mise en œuvre de l'intervention publique (ou de l'absence d'intervention).

Cette thèse de doctorat aborde des questions liées à la conception et à l'efficacité des interventions publiques. Le premier chapitre évalue les effets et les réactions stratégiques potentielles résultant d'une réglementation. Le deuxième chapitre évalue l'efficacité d'une intervention publique pour le déploiement de réseaux de fibre optique dans des zones où les opérateurs privés ne sont pas incités à investir par eux-mêmes. Le troisième chapitre étudie un effet potentiel d'une plateforme numérique sur les individus, qui, selon nous, devrait être pris en compte dans la conception de la réglementation.

L'intervention publique sous forme de réglementation sectorielle et de politique de concurrence n'est pas statique. Elle évolue en s'adaptant aux nouveaux défis liés à la numérisation et à la mondialisation de l'économie mondiale. Dans ce contexte, les développements de la théorie économique aident à comprendre les mécanismes, ainsi qu'à rationaliser et à anticiper les comportements. Cependant, la théorie économique n'aborde pas actuellement les questions pertinentes pour les politiques publiques au même rythme que les développements technologiques. Cela est particulièrement vrai

[30]Voir : GLA Economics (2006). *The rationale for public sector intervention in the economy.* Rapport technique, p. 28.

dans le cas des plateformes numériques. En outre, la théorie économique met parfois en évidence des effets ou des situations potentiels ambigus, ce qui rend certaines questions de nature empirique.

1.4. Évaluation *ex post* et adaptation des interventions publiques

Les développements de l'analyse économique empirique et les contributions à l'analyse des relations causales ont révolutionné la recherche en économie. Cela a été récemment mis en évidence par l'attribution du prix de la Banque de Suède en sciences économiques en mémoire d'Alfred Nobel 2021 aux lauréats David Card, Joshua D. Angrist et Guido W. Imbens pour leurs contributions dans ce domaine. L'analyse empirique fournit des outils pertinents pour évaluer les effets des changements dans les conditions du marché qui affectent la conception de l'intervention publique ou pour évaluer les effets des interventions publiques elles-mêmes. Elle offre la possibilité de fournir des preuves pour la conception de meilleures politiques et réglementations. Comme le décrit Jean Tirole, lauréat du prix de la Banque de Suède en sciences économiques en mémoire d'Alfred Nobel 2014 : *"Les prédictions d'... [un] modèle peuvent... être testées économétriquement et éventuellement en laboratoire ou sur le terrain. Au final, le caractère raisonnable et la robustesse des hypothèses de modélisation, ainsi que la qualité de l'ajustement empirique, déterminent le degré de confiance des économistes dans leurs recommandations aux décideurs publics pour l'intervention, et aux entreprises pour la conception de leur modèle économique."* [31]

Dans cette thèse de doctorat, nous utilisons différentes méthodes économétriques et stratégies d'identification pour l'analyse causale. Leur conception et l'interprétation des résultats sont nourries par les enseignements de la théorie économique. Premièrement, nous appliquons des modèles de régression et des stratégies de doubles différences qui utilisent des observations répétées pour contrôler les facteurs omis

[31] Tirole, J. (2015). *Market Failures and Public Policy.* American Economic Review, 105 (6): 1665-82.

non observés. Deuxièmement, nous utilisons des régressions de prix hédoniques, qui modélisent les produits comme un ensemble d'attributs et sont couramment employés pour étudier les changements de prix dans différentes industries. Troisièmement, nous utilisons des modèles empiriques dits "structurels'. Plus précisément, nous estimons un modèle d'entrée sur le marché pour tenir compte de l'endogénéité de la structure du marché, un problème qui biaise les estimations dans certaines analyses causales.

Cette thèse de doctorat étudie des questions liées aux impacts causaux qui affectent *infine* la mobilité des personnes et leur intégration dans l'économie numérique. Le premier chapitre étudie l'impact du règlement européen de l'itinérance internationale sur les revenus et les prix des opérateurs mobiles. Ce règlement affecte la mobilité à travers le continent et l'intégration au sein du marché commun. Le deuxième chapitre évalue l'efficacité des aides d'État pour le déploiement du très haut débit en France. Cette politique publique a un impact sur la mobilité des travailleurs et des entreprises. Elle affecte également l'intégration des personnes vivant dans les zones rurales et moins densément peuplées dans l'économie numérique mondiale. Le troisième chapitre étudie l'impact des applications de location de voiture avec chauffeur sur la sécurité routière, qui affecte la mobilité des individus dans les villes. Il traite également d'une meilleure intégration des besoins spécifiques des femmes dans la planification des transports. Les trois chapitres sont liés à l'objectif de permettre un accès équitable pour tous aux avantages de la numérisation.

2. Résumé des objectifs et des contributions par chapitre

Cette thèse de doctorat n'a pas pour but de couvrir tous les aspects de la politique publique dans l'économie numérique. Elle vise plutôt à étudier des cas spécifiques afin de fournir des éléments pertinents pour les politiques publiques. Elle est composée de trois chapitres.

Le premier chapitre évalue l'impact de la réglementation de l'itinérance internationale mise en place dans l'Union européenne (UE) sur les revenus et les prix de détail des opérateurs mobiles. Le deuxième chapitre étudie les déterminants de l'entrée en fibre optique par les opérateurs de télécommunications et évalue l'efficacité et l'impact d'un programme d'aide d'État pour le déploiement de réseaux à très haut débit en France. Le troisième chapitre étudie les défis de la politique des transports en présence de plateformes de location de véhicule avec chauffeur. Plus précisément, il évalue l'impact de ces plateformes sur l'incidence des accidents mortels et des décès dus à l'alcool au volant, en utilisant le Chili comme étude de cas. Dans ce chapitre, nous étudions les effets hétérogènes des accidents mortels en fonction du genre afin de déterminer si les plateformes de location de véhicule avec chauffeur comme Uber peuvent contribuer à atténuer le biais de genre dans le transport urbain.

Le choix de ces politiques et questions spécifiques a été inspiré par l'observation des défis posés par la transformation numérique de l'économie mondiale et l'identification de questions de politique publique qui manquaient de preuves provenant d'études empiriques rigoureuses. En outre, il a été influencé par la disponibilité d'un ensemble de bases de données riches et uniques que nous pouvons exploiter pour alimenter le débat de politique publique. En définitive, les sujets de cette thèse traduisent ma passion personnelle pour l'économie, en particulier l'organisation industrielle, la politique publique et l'analyse empirique. Je suis convainque que ces questions ouvrent la porte à des pistes de recherche intéressantes et pertinentes pour l'avenir.

Chapitre 1 : Impact de la réglementation de l'itinérance sur les revenus et les prix des opérateurs mobiles

Dans le secteur des télécommunications mobiles, l'une des principales interventions réglementaires dans le monde a été la réduction des tarifs de terminaison d'appel des lignes fixes vers les téléphones mobiles.[32] C'est-à-dire les paiements d'interconnexion entre opérateurs mobiles permettant aux consommateurs d'un réseau d'effectuer un appel vers un autre consommateur connecté à un réseau différent. La raison en est qu'un opérateur mobile, même s'il est en concurrence avec d'autres opérateurs mobiles, détient un monopole sur l'acheminement des appels vers ses abonnés et fixera donc des tarifs de terminaison d'appel mobile (MTR pour ces sigles en anglais) élevés (Genakos Valletti, 2011). L'idée que chaque réseau mobile est un goulot d'étranglement pour les clients qui reçoivent des appels a justifié la réglementation qui fixe des plafonds aux tarifs de terminaison. En Europe, la réglementation des tarifs de terminaison d'appel mobile a commencé avec le cas du Royaume-Uni à la fin des années 90.

Au-delà des restrictions sur les tarifs de terminaison d'appel mobile, l'UE a mis en place une réglementation sur les services d'itinérance internationale. Ces services permettent aux utilisateurs de services de téléphonie mobile de passer et de recevoir des appels vocaux, d'envoyer et de recevoir des SMS, ou d'accéder à des services de données lorsqu'ils voyagent à l'étranger. Le règlement couvre à la fois les marchés de gros (transactions entre opérateurs) et de détail (services fournis par les opérateurs de télécommunications aux consommateurs) dans l'UE. Le premier règlement sur l'itinérance a été mis en œuvre en 2007 et d'autres ont été appliqués progressivement jusqu'à ce que le règlement "Roam-Like-At-Home" fixe les frais d'itinérance au détail à zéro en 2017. En octobre 2021, le Parlement européen a voté favorablement pour la prolongation proposée par la Commission européenne du régime réglementaire actuel, qui doit expirer en juin 2022.[33]

[32] D'autres fronts importants de l'intervention publique sur les marchés des télécommunications mobiles sont le contrôle des fusions et l'attribution des fréquences.

[33] Au moment de la rédaction de cette thèse, le Parlement européen devrait encore parvenir à un accord sur les nouvelles règles avec les pays de l'UE au sein du Conseil, avant qu'elles ne puissent entrer en vigueur. Voir : https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vln7f7hgscx1?ctx=vg9pj7ufwbwe&tab=1&start_tab1=10.

L'une des principales motivations de la réglementation européenne sur l'itinérance était l'observation de tarifs d'itinérance très élevés avant 2007. Dans la pratique, il existe un problème de goulot d'étranglement comme celui observé dans le cas de la terminaison d'appel mobile. Dans le contexte de l'itinérance internationale, les opérateurs des pays étrangers sont soumis à des contraintes concurrentielles limitées lorsqu'ils facturent des tarifs de gros. Cette situation ouvre la possibilité de pratiquer des prix de monopole pour l'accès à leurs réseaux. Les opérateurs nationaux étant eux-mêmes des goulots d'étranglement pour les services d'itinérance destinés aux consommateurs nationaux, les prix de gros excessifs pourraient être répercutés sur les consommateurs du marché de détail national. Ainsi, un double problème de marginalisation peut se poser.

Une autre motivation importante pour la réglementation de l'itinérance internationale a été la consolidation du marché unique numérique de l'UE.[34] Il s'agit de l'une des stratégies prioritaires de la Commission européenne visant à garantir aux citoyens de l'UE un accès efficace et sécurisé aux biens et services numériques. Elle vise à maximiser le potentiel de croissance de l'économie numérique de l'UE et ses avantages pour les entreprises et les consommateurs.[35] Dans ce contexte, les prix élevés de l'itinérance pour les consommateurs à travers l'UE ont été perçus comme un obstacle à la mobilité, à l'intégration et au commerce des personnes au sein du marché commun.

Bien que l'intervention publique et la réglementation puissent être nécessaires dans différentes situations, il existe toujours un compromis entre leurs avantages potentiels et leurs effets néfastes. La réalisation des objectifs prévus et leur efficacité dépendent des incitations offertes aux différents acteurs et du bon fonctionnement de la pression concurrentielle entre eux. Les évaluations *ex post* sont essentielles

[34] Voir : https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2021)662599.

[35] Voir : https://eufordigital.eu/discover-eu/the-eu4digital-initiative/

pour évaluer leur impact, corriger les problèmes éventuels et éclairer la conception des politiques futures.

Dans le cas de la réglementation des tarifs de terminaison d'appel mobile, une préoccupation majeure est apparue : la réduction du niveau des tarifs de terminaison d'appel mobile pourrait potentiellement augmenter le niveau des prix pour les abonnés mobiles. Cet effet est connu dans la littérature sous le nom de "waterbed effect". Plus précisément, en réduisant la rente qui peut être tirée de la terminaison d'appel, la réglementation pourrait inciter les opérateurs à se faire une concurrence moins agressive pour les utilisateurs finaux, et donc à fixer des prix plus élevés. Il s'agit là d'un problème potentiel bien identifié dans la théorie et qui fait l'objet d'hypothèses depuis longtemps.[36]

Dans le cas de la réglementation de l'itinérance internationale, il y a également le risque d'un effet de "waterbed". En réduisant les frais d'itinérance et en fixant à zéro les prix de détail de l'itinérance, les opérateurs pourraient se livrer une concurrence moins féroce pour attirer les consommateurs qui voyagent et augmenter leurs prix nationaux pour compenser leurs pertes d'itinérance. Ainsi, le règlement pourrait avoir des effets néfastes pour les utilisateurs qui ne voyagent pas. L'effet de "waterbed" viendrait s'ajouter à d'autres distorsions potentielles soulignées par les opposants au règlement. À savoir, un risque de surconsommation (un prix nul pour l'itinérance est inférieur au coût de la prestation du service) et le risque de compromettre la rentabilité de long terme des opérateurs mobiles.

[36]Genakos et Valletti (2011) ont analysé cette question de manière empirique et ont trouvé des preuves d'un effet de "waterbed" pour le cas de plus de 20 pays sur la période 2002-2006. Plus tard, Genakos et Valletti (2015) ont étudié la même question en utilisant un panel plus large couvrant 27 pays sur la période 2002-2011. Ils ont constaté que le phénomène de "waterbed" devient insignifiant en moyenne et au fil du temps en raison de la nature changeante de l'industrie, le trafic de mobile à mobile ayant dépassé le trafic de fixe à mobile.

Contributions du premier chapitre

Ce chapitre, co-écrit avec Lukasz Grzybowski, étudie l'impact du règlement européen de l'itinérance internationale sur les revenus et les prix des opérateurs mobiles dans l'UE. Il vise à quantifier l'effet de la réglementation sur les revenus des opérateurs de téléphonie mobile et à évaluer si l'effet de "waterbed" est apparu en raison de la réglementation. Nous appliquons une approche de doubles différences et estimons des régressions de prix hédoniques en utilisant des données détaillées au niveau des opérateurs et des forfaits mobiles. Nous constatons que la réglementation a réduit les revenus par utilisateur des opérateurs mobiles. Cependant, nous ne trouvons aucune preuve d'une augmentation significative des tarifs au cours de la dernière phase de la réglementation (pas d'effet de "waterbed"). L'ensemble des règlements de l'UE sur l'itinérance a été considéré comme un grand succès politique et un pilier crucial pour la consolidation du marché unique numérique de l'UE. Il a également suscité des oppositions et des débats à chaque étape de sa mise en œuvre. Cependant, près de quinze ans après la mise en œuvre du premier règlement en 2007, et plus de quatre ans après la mise en œuvre du dernier règlement appelé "Roam-Like-At-Home" (RLAH) en juin 2017, les évaluations empiriques rigoureuses de ses effets sont rares.

L'impact du règlement européen de l'itinérance internationale a été examiné principalement dans des rapports techniques reposant sur des analyses descriptives. C'est le cas des études menées par/pour l'ORECE et la Commission européenne. La principale limite de ce type d'études est le manque de méthodes empiriques rigoureuses pour évaluer l'impact causal du règlement. Notre travail vise à combler cette lacune. Ce faisant, il contribue à la littérature étudiant l'impact des interventions réglementaires sur les marchés des télécommunications (par exemple, Genakos Valletti, 2011 et Genakos Valletti, 2015). En outre, elle contribue à la littérature qui analyse les questions liées à la concurrence et à la réglementation dans le secteur des télécommunications à l'aide de régressions de prix hédoniques (par exemple, Karamti Grzybowski, 2010 ; Greenstein McDevitt, 2011 ; Wallsten Riso, 2014 ; Calzada Martinez-Santos, 2014 ; Nicolle et al., 2018).

Deux études académiques récentes et en cours examinent les effets de la réglementation Roam-Like-At-Home. Godihno de Matos, Quinn et Peukert (2021) utilisent le changement réglementaire introduit par le Roam-Like-At-Home pour étudier les gains de surplus du consommateur liés à l'utilisation de l'internet mobile. En utilisant des données au niveau individuel provenant d'un opérateur mobile européen, ils constatent que le surplus du consommateur augmente lorsque la consommation individuelle d'internet mobile augmente lors des déplacements. Canzian et al. (2021) évaluent l'impact de la réglementation Roam-Like-At-Home sur le trafic et les revenus d'itinérance de l'Espace économique européen. Ils constatent qu'elle a considérablement augmenté les volumes d'itinérance internationale et les recettes de gros, avec des effets hétérogènes sur les volumes et les recettes du trafic de détail et de gros. En complétant leur analyse à l'aide d'un cadre théorique, ils concluent que les gains de surplus du consommateur découlant de la réglementation sont importants et compensent largement les pertes de bénéfices. Enfin, ils étudient si le Roam-Like-At-Home a entraîné l'apparition d'un effet de "waterbed". En ligne avec nos résultats, ils n'observent pas d'augmentation des prix domestiques suite à la réglementation.

Ces études sont complémentaires de notre travail sur quatre points. Premièrement, elles se concentrent principalement sur la consommation en itinérance (trafic de données), alors que nous étudions les revenus et les prix des opérateurs mobiles. Deuxièmement, elles étudient spécifiquement les effets de la réglementation Roam-Like-At-Home (mise en œuvre en 2017), alors que notre analyse des revenus couvre l'ensemble des réglementations sur l'itinérance mises en œuvre depuis 2007. Troisièmement, elles utilisent des sources de données et des stratégies empiriques différentes. Quatrièmement, Canzian et al. (2021) peuvent distinguer les effets de la réglementation sur les revenus de gros et de détail des opérateurs mobiles, alors que nous nous concentrons sur les revenus globaux - en raison des limitations des données - et les réactions stratégiques potentielles des opérateurs mobiles.

En définitive, ce chapitre contribue au débat sur la réglementation des télécommunications mobiles. Il fournit un élément de preuve pour aider à informer les décideurs politiques sur l'effet potentiel de futures réglementations, comme la proposition d'extension de la réglementation sur l'itinérance actuellement examinée au moment de la préparation de cette thèse.

Chapitre 2 : Entrée en fibre optique et aides d'État pour le déploiement du très haut débit : le cas de la France

L'accès à des connexions internet rapides et fiables est devenu déterminant à l'ère du numérique. Les technologies de l'information et de la communication sont appliquées à un large éventail d'entreprises et de transactions, ainsi qu'aux fonctions et procédures gouvernementales. Ainsi, l'économie mondiale et les activités quotidiennes sont de plus en plus numérisées.

Dans ce contexte, l'investissement dans le haut débit, notamment dans les réseaux à très haute capacité, a été et reste crucial. Ces réseaux sont la base du monde numérique. En Europe, l'investissement dans ces réseaux (principalement basés sur les technologies de la fibre optique et du câble) est une priorité depuis plus d'une décennie. La Commission européenne a fixé des objectifs spécifiques de couverture en haut et très haut débit depuis 2010. Le dernier objectif en date est de fournir un accès au très haut débit (vitesse de 100 Mbs ou plus) à tous les ménages de l'UE d'ici 2025.

Cependant, la transition vers le très haut débit a été lente en raison de caractéristiques liées à l'offre et à la demande. Du côté de l'offre, les réseaux à très haute capacité entraînent d'importants coûts d'investissement fixes et irrécupérables, les opérateurs doivent faire face à un coût d'opportunité du déploiement en raison des recettes provenant d'autres réseaux existants (l'effet dit de "remplacement") et il existe une concurrence de la part des fournisseurs de services Internet utilisant d'autres technologies. Du côté de la demande, les coûts de transfert et la faible volonté de payer pour des vitesses plus élevées ont généré une incertitude quant à l'adoption de la fibre optique dans les premiers stades de sa diffusion.

En outre, le déploiement des réseaux très haut débit a été particulièrement lent dans les zones rurales, révélant une fracture numérique. Dans ces zones, les opérateurs privés sont confrontés à des coûts de déploiement particulièrement élevés et à une demande limitée ou incertaine, ce qui rend les investissements économiquement non viables pour eux. Toutefois, des externalités positives peuvent rendre le déploiement du très haut débit socialement souhaitable. Comme les acteurs privés ne les internalisent pas, il peut y avoir une défaillance de marché.

Une intervention publique est donc nécessaire dans ces zones pour libérer les investissements dans la fibre optique. Un encadrement géographique et technique des déploiements par les Autorités nationales de régulation ou la possibilité de co-investissements sont quelques formes d'intervention. En outre, un soutien financier public pour le déploiement de réseaux très haut débit dans des zones spécifiques est également possible. Ces dernières sont encadrées par le régime d'aides d'État de l'UE pour le haut débit et peuvent prendre la forme de subventions directes, d'abattements fiscaux ou d'autres types de conditions de financement préférentielles.

En France, depuis 2013, le gouvernement soutient la conception et le financement des réseaux de fibre optique par le biais du Plan France Très Haut Débit. Ce Plan prévoit environ 3 milliards d'euros d'aides publiques pour aider à combler le déficit de rentabilité dans les zones locales où l'investissement privé ne semble pas viable.

Son objectif ultime est de fournir une couverture en fibre optique à domicile pour tous d'ici 2025.

Contributions du deuxième chapitre

L'objectif de ce chapitre, co-écrit avec Marc Bourreau et Lukasz Grzybowski, est double. Premièrement, nous étudions les déterminants de l'entrée en fibre optique par les opérateurs privés de télécommunications. La compréhension des facteurs affectant la diffusion de la fibre est cruciale pour guider les déploiements restants et contribuer à informer les politiques de déploiement des technologies futures, mais aussi des réseaux de fibre dans d'autres pays. Deuxièmement, nous cherchons à évaluer l'efficacité du Plan France Très Haut Débit et son impact sur le déploiement de la fibre. L'évaluation *ex post* est une opportunité pour améliorer la conception, l'efficacité et l'efficience des programmes d'aide. Plus précisément, elle permet de pondérer les effets bénéfiques des régimes d'aide par rapport aux distorsions potentielles du marché qu'ils peuvent introduire.

Pour ce faire, nous exploitons des bases de données riches sur le déploiement de la fibre, les aides de l'État et les caractéristiques locales de plus de 34 000 communes en France métropolitaine sur la période 2014-2019. Concernant les déterminants de l'entrée en fibre, nous identifions la taille du marché et le revenu comme des caractéristiques importantes qui augmentent l'attractivité des marchés locaux. En outre, nous trouvons des preuves d'une forte dépendance géographique dans le processus d'entrée, la présence d'un effet de remplacement du réseau de cuivre existant influençant les décisions d'entrée et une augmentation de la facilité d'entrée au fil du temps. De plus, nous constatons que l'entrée de la fibre optique devient plus facile avec le temps. En ce qui concerne l'évaluation du Plan France Très Haut Débit, nous constatons qu'il a été globalement efficace et qu'il a permis d'augmenter la couverture en fibre optique dans les communes aidées au début de la période d'analyse.

Ainsi, ce chapitre contribue à différents courants de la littérature. Le premier courant étudie les caractéristiques du marché qui influencent l'entrée sur les marchés locaux des télécommunications (par exemple, Greenstein et Mazzeo, 2006 ; Xiao et Orazem, 2011 ; Goldfarb et Xiao 2011 ; Wilson, Xiao et Orazem, 2021). Outre l'impact de la demande et des changements de coûts sur l'entrée, la littérature met en évidence l'influence de la différenciation, des coûts irrécupérables, de la capacité stratégique des dirigeants et des menaces d'entrée. En outre, un courant de littérature connexe analyse l'impact de l'entrée sur les résultats des marchés des télécommunications (par exemple, Economides, Seim et Viard, 2008 ; Nardotto, Valletti et Verboven, 2015 ; Bourreau, Grzybowski et Hasbi, 2019). Cette littérature s'est concentrée sur les effets de l'entrée sur les prix, la variété, le bien-être des consommateurs, le déploiement et l'adoption de nouvelles technologies et la qualité des services. Nous contribuons à cette littérature en identifiant les déterminants de l'entrée en fibre en France et en examinant le rôle des aides publiques sur l'entrée sur les marchés locaux des télécommunications.

Le deuxième courant de la littérature étudie les investissements dans les réseaux de fibre optique de nouvelle génération. Il se concentre sur l'impact de la réglementation sectorielle sur le déploiement des réseaux en fibre optique (par exemple, Fabritz et Falck, 2013 ; Bacache, Bourreau et Gaudin, 2014 ; Briglauer, 2015 ; Briglauer, Cambini et Grajek, 2018 ; et Briglauer, Cambini, Gugler et Stocker, 2021). La conclusion générale de cette littérature est que des réglementations plus strictes ont tendance à nuire aux investissements, au déploiement et à l'adoption. Ce chapitre contribue à cette littérature en analysant le rôle des aides d'État, qui sont une autre forme d'intervention publique. Plus précisément, nous analysons l'impact des aides d'État dans le déploiement des réseaux de fibres optiques de nouvelle génération.

Le troisième courant de littérature auquel nous contribuons étudie l'impact des aides d'État sur le déploiement des réseaux très haut débit. Cette littérature comprend des études de cas d'États membres de l'Union européenne (par exemple, Matteucci (2019) pour le déploiement de la première génération de haut débit en Italie ; Briglauer et al. (2019) et Duso et al. (2021) pour le déploiement du haut débit en Allemagne). Elle comprend également des études transnationales comme Briglauer et Grajek (2021), qui étudient l'efficacité des programmes d'aide publique pour le déploiement de nouveaux de fibre optique dans 32 pays de l'OCDE. Wilson (2021) étudie le cas des États-Unis en se concentrant sur l'impact des investissements publics dans les infrastructures à haut débit sur les investissements privés. Nous contribuons à cette littérature en évaluant l'efficacité des aides publiques pour le déploiement des réseaux de fibre optique en France en utilisant des données de niveau micro.

Enfin, et plus largement, nous cherchons à contribuer à une meilleure conception, efficacité et efficience des régimes d'aides d'État pour le déploiement du haut débit.

Chapitre 3 : La politique des transports à l'ère numérique : le cas des plateformes de location de voiture avec chauffeur au Chili

La numérisation a permis l'émergence de services innovants basés sur des plateformes qui ont créé de nouvelles opportunités pour les entreprises et les consommateurs. Dans le domaine de la mobilité locale, les applications de location de voiture avec chauffeur comme Uber, Lift ou Cabify, sont devenues une alternative aux services de transport traditionnels, en particulier les taxis.

Plusieurs caractéristiques de ces applications génèrent des gains d'efficacité transactionnelle qui les rendent attrayantes pour les utilisateurs. Tout d'abord, elles permettent le suivi de la localisation et la possibilité de la partager avec d'autres en temps réel. Deuxièmement, elles utilisent des systèmes de notation destinés à garantir la sécurité et la qualité du service. Troisièmement, elles offrent la possibilité d'attendre dans un endroit sûr l'arrivée du véhicule et les paiements sont automatiques dans la plupart des cas. Quatrièmement, dans certains cas, ils optimisent les allocations en adaptant les prix aux fluctuations de l'offre et de la demande. Cinquièmement, dans certaines villes, ils sont moins chers que les taxis traditionnels.

Malgré ces caractéristiques, les applications de location de voiture avec chauffeur ont suscité l'opposition des acteurs historiques présents dans le secteur des transports et ont créé des inquiétudes chez les décideurs politiques. Les principales inquiétudes portent sur le fait que ces applications peuvent entraîner une plus grande congestion, une distraction des conducteurs et, par conséquent, augmenter la probabilité d'accidents. Des mois et des années après l'introduction des services de location de voiture avec chauffeur, les villes ont été témoins de manifestations d'opposition, principalement de la part de l'industrie des taxis. Un débat houleux sur la réglementation a vu le jour et, dans plusieurs endroits, les autorités locales ont décidé de suspendre ou d'interdire ces services.

Dans le cadre du débat réglementaire sur les applications de location de voiture avec chauffeur, et plus largement de la politique des transports, ces services présentent des avantages potentiels inexplorés. En particulier, il est possible qu'ils contribuent à résoudre, ou du moins à atténuer, les problèmes auxquels sont confrontées les femmes. Premièrement, il est désormais admis que “le transport n'est pas neutre du point de vue du genre”.[37] La raison en est que les motifs et modes d'utilisation, d'accès et les besoins spécifiques des femmes ne sont pas systématiquement pris en compte dans la planification des transports. Deuxièmement, les caractéristiques de sécurité présentées par les applications de location de voiture avec chauffeur peuvent sembler particulièrement pertinentes pour les femmes, car elles expriment davantage de préoccupations en matière de sécurité dans les transports que les hommes. Les préoccupations des femmes en matière de sécurité dans les transports sont vraies

[37] Cette idée a été largement discutée par la Banque mondiale. Voir : https://blogs.worldbank.org/transport/transport-not-gender-neutral.

tant dans les pays en développement que dans les pays développés.[38] Troisièmement, dans des pays comme le Chili, la pertinence des applications de location de voiture avec chauffeur pourrait être accrue par le fait que les femmes conduisent beaucoup moins que les hommes.

Contributions du troisième chapitre

Dans ce chapitre, co-écrit avec Vicente Lagos et Christine Zulehner, nous explorons la possibilité que les applications de location de voiture avec chauffeur puissent créer une opportunité d'atténuer le biais de mobilité existant contre les femmes, en particulier dans les pays en développement. Pour ce faire, nous nous concentrons sur les accidents liés à la conduite en état d'ivresse (c'est-à-dire les accidents causés par des personnes conduisant sous l'influence de l'alcool) et les décès qui y sont liés. La raison en est qu'ils fournissent une mesure concrète de la sécurité routière pour laquelle des données détaillées sont disponibles. En outre, ils offrent un cadre dans lequel la théorie économique éclaire les mécanismes expliquant les différents résultats potentiels. Nous étudions le cas du Chili où Uber a commencé ses activités à Santiago en 2014 et où les autorités donnent accès à des données détaillées sur les accidents.

Nous utilisons une approche de doubles différences et un modèle de régression de Poisson et nous constatons que la présence du service UberX à Santiago a réduit de manière significative les accidents mortels liés à la conduite en état d'ivresse et les décès dans ce type d'accidents. Nos estimations par genre révèlent que la disponibilité d'UberX a réduit de manière significative le nombre de décès de passagers féminins et le nombre de décès de conducteurs masculins pendant la nuit.

Ce chapitre contribue d'abord à la littérature économique étudiant les impacts sociétaux des applications de location de voiture avec chauffeur. Cette littérature

[38] Voir par exemple : European Parliament (2006), Uteng (2012), European Institute for Gender Equality (2016), and Allen, et al. (2017).

examine différents domaines tels que la congestion du trafic (Li et al. 2016 ; Henao Marshal, 2018 ; Tirachini Gomez-Lobo, 2018), les règles de sécurité (Anil Fisher Ellison, 2017), les frictions de recherche et l'appariement (Shapiro, 2018 ; Bian, 2018 ; Vergara-Cobos, 2018), la fréquentation des transports en commun (Hall et al., 2018), les revenus des chauffeurs de taxi (Berger et al., 2018) et l'aléa moral (Liu et al., 2018). Au sein de cette littérature, ce chapitre contribue spécifiquement à la littérature empirique qui étudie l'impact de location de voiture avec chauffeur sur les accidents et les décès en général et en état d'ivresse.

Les études précédentes de ce dernier courant de la littérature se sont concentrées sur les effets des applications de location de voiture avec chauffeur sur la sécurité routière aux États-Unis aux niveaux national et local (Greenwood et Wattal, 2017 ; Morrison et al., 2017 ; Peck, 2017 ; Brazil et Kirk, 2016 ; Dills et Mullholland, 2018 ; Barrios et al., 2020). Leurs résultats pointent dans des directions différentes. Certaines études trouvent des preuves d'une diminution des taux de mortalité par accident après l'introduction de ces services, tandis que d'autres ne trouvent aucun effet, voire une augmentation dans certains cas. Notre travail contribue à la littérature et au débat sur la réglementation en fournissant des preuves de l'impact des applications de location de voiture avec chauffeur sur les accidents mortels liés à l'alcool au volant dans une région géographique différente, avec des problèmes spécifiques de qualité et de disponibilité des alternatives de transport traditionnelles. De manière plus remarquable, il contribue à la littérature en étudiant les impacts potentiels des applications de location de voiture avec chauffeur en fonction du genre et du rôle des individus (conducteurs vs. passagers). À notre connaissance, notre étude est la première à examiner l'impact de ces applications sur les accidents de la route et les décès dans des pays en voie de développement et à étudier les différences potentielles dans les impacts selon le genre et le rôle.

Ce chapitre contribue également à la littérature étudiant la relation entre la mobilité et le genre (par exemple Duchene, 2011 ; Peters, 2013 ; Castillo et al., 2013 ; Ng Acker, 2018 ; Quinones, 2020). Cette littérature étudie les différences d'utilisation et de besoins en matière de transport selon le genre et identifie la sécurité comme un problème spécifique qui restreint la mobilité des femmes. Notre travail montre non seulement que les applications de location de voiture avec chauffeur peuvent diminuer les accidents mortels et les décès dus à l'alcool au volant et représentent donc des alternatives de transport pertinentes, en particulier pour les femmes, mais il peut également servir de preuve supplémentaire qu'un biais de mobilité lié au genre existe et doit être abordé.

En définitive, nous espérons que ce travail contribuera à la conception de meilleures politiques en aidant à comprendre le comportement des individus face au risque et les compromis des nouvelles alternatives de mobilité apportées par la numérisation. En présence d'un biais de mobilité à l'encontre des femmes dans le secteur des transports, nous sommes convaincus que ce chapitre est particulièrement pertinent lors de l'examen et de la conception de la politique actuelle sur la réglementation des applications de transport à domicile et des politiques globales de transport et d'urbanisme, tant dans les pays développés que dans les pays en voie de développement.

General Introduction

Have you ever experienced Internet connection problems while working from home or having a video-call? Have you ever been unpleasantly surprised by an onerous mobile telephone bill after returning from a trip abroad? Have you ever had trouble finding a means of transportation after going out at night and wondered where all taxis cabs are?

If your answer to the first question is negative, you probably live in a densely populated area or you are already equipped with ultrafast broadband. If your response to the second question is no, you may have never used your mobile services while traveling abroad, you have been warned not to do so, or you currently reside and travel within the European Economic Area. If your answer to the third question is negative, you possibly own a vehicle, or you are an adept of ride-hailing platforms. If the answer to all previous questions is negative, then you are very lucky, or you are likely too young to have lived during the first stages of the digital transformation.

The previous questions portray examples of opportunities and challenges brought by the globalization and digitization of the world economy.[39] Our daily activities increasingly rely on the use of digital technologies which are changing our human relationships, but also our interactions across a wide range of activities like trade, transport, media, health, work and education, just to cite a few.[40] This digital

[39] Digitization is defined as "the conversion of text, pictures, or sound into a digital form that can be processed by a computer" (See: Oxford English Dictionary).

[40] For an insightful discussion on how digitization is changing the world economy, see: Tirole,

transformation is perceived as a source of opportunities and the COVID-19 pandemic has only amplified it. As stated by the OECD, *"... Perhaps never before has our global dependency on digital technology touched all aspects of society ... "*.[41]

However, this digital revolution introduces numerous challenges. An essential one is the underlying need of fast and reliable connectivity for all. As the OECD also explains, *"[...] these Internet-based and bandwidth-intensive activities fuel demand for high-quality connectivity and lay bare existing digital divides, reinforcing the need for a more inclusive approach to the digital transformation"*.[42] Moreover, there are growing concerns surrounding digital interactions. Policy makers are especially concerned by the increasing concentration and market power of digital platforms, by their societal impacts, but also by issues of trust, security, confidentiality, liability and data property rights.[43]

In this context, public policies, can be powerful tools to help enable the full potential of the digital economy.[44] Returning to the questions raised at the beginning of this introduction, policy makers in the digital age face broader policy questions, such as: how to guarantee access to fast and reliable telecommunications networks for all? How to ensure that every consumer and business has the chance to participate in the digital economy and take the best out of digital technologies? What is the impact of digital platforms on traditional markets and consumers? These policy questions are at the heart of more specific research questions addressed in this doctoral thesis.

Public interventions are often necessary. However, they also come with costs and

J. (2016), *Economie du bien commun*, chapter 14.

[41]Zhongming, Z., Linong, L., Wangqiang, Z. & Wei, L. (2020). OECD Digital Economy Outlook 2020.

[42]Ibidem.

[43]For a discussion on the societal challenges of the digital economy, see: Tirole, J. (2016), *Economie du bien commun*, chapter 15.

[44]The OECD defines the digital economy as "all economic activity reliant on, or significantly enhanced by the use of digital inputs, including digital technologies, digital infrastructure, digital services and data. It refers to all producers and consumers, including government, that are utilizing these digital inputs in their economic activities". See: OECD (2020), Roadmap toward a Common Framework for Measuring the Digital Economy, technical report, p. 5.

risks. Their proper design increasingly relies on solid economic theory, but it also requires a large amount and quality of information, which is often not totally available *ex ante*. Thus, *ex post* evaluation has an important role in the dynamic process of adapting public intervention to make more effective and efficient policies. This doctoral thesis studies questions relevant for public policies in the context of the digital transformation of the world economy. It examines new situations and public interventions on the telecommunications and digital sectors affecting people's mobility and their integration in the digital economy.

This general introduction first provides an overview of public intervention in market economies, highlights its role in the telecommunications and digital platforms sectors and discusses the importance of *ex post* evaluation (1). Then, it presents the motivation and the contribution of each chapter of the thesis (2).

1. Public intervention in the digital economy: role, challenges and empirical evaluation

This Section intends to provide the key elements to understand the place and contributions of this doctoral thesis. First, we recall some basic principles of public intervention in market economies (1.1). Second, we provide an overview of public intervention on the telecommunications sector and on digital platforms (1.2). Third, we describe the main challenges and risks of public intervention (1.3). Finally, we highlight the importance of *ex post* evaluation and adaptation of public interventions (1.4).

1.1. Basic principles of public intervention in market economies

A market economy is a system in which the free interaction between individuals (demand) and businesses (supply) drives economic decisions and outcomes.[45] Economists broadly agree that, under some conditions, this type of economies tend to produce better outcomes in terms of efficiency, productivity, and innovation. The freedom of choice and competition are some of the fundamental principles of market economies. However, economist also agree that public intervention is often necessary. From the seminal work of Musgrave (1957; 1959), economists distinguish public intervention into three branches of function: allocation, distribution and stabilization. Thus, most economies in the world allow different degrees of public intervention.

This doctoral thesis mainly relates to the case of allocation policies in response to market failures. That is, when free markets do not allow for an efficient production or allocation of goods and/or services. In a second plane, this thesis also relates to redistribution policies.

Market failures arise when one or several of the mechanisms through which markets work efficiently fail.[46] Two types of market failure are of particular interest to understand the relevance of the questions addressed in this doctoral thesis. The first one is the case of natural monopolies, where only one firm acts as a supplier in the market, typically due to high sunk costs of investment and/or economies of scale.[47] Network industries, which are one focus of this doctoral thesis, were traditionally categorized as natural monopolies. More broadly, this relates to the exercise and

[45] The foundations of the market economy concept lay on the theoretical work of classical economists such as Adam Smith, David Ricardo, Jean-Baptiste Say, among others.

[46] Economists have long studied market failures, inheriting from a long theoretical tradition of welfare economists such as Arthur C. Pigou and Paul A. Samuelson, just to cite a few. Examples of fields actively studying the sources and policy remedies for market failures include Public Economics, Industrial Organization and Environmental Economics.

[47] Economies of scale are proportional savings in costs attained when the level of production increases. This means that there is a decrease in costs per unit when the total amount of output produced is higher.

control of market power, which are at the heart of the Industrial Organization field in Economics.[48] The second type of market failure relevant for this doctoral thesis occurs in the presence of externalities. This is a situation where the behavior of a person (or firm) affects the wellbeing of another, and no compensation is attributed in prices.[49] Digital platforms, which are another focus of this thesis, rely on network effects. That is when users care about participation and usage decisions of other users.[50]

Schematically, public intervention can take place before a problematic situation is constituted (*ex ante*) or as a reaction to an observed situation or behavior (*ex post*). The aim here is not to review all types of interventions, but to briefly describe some targeted policy actions on markets that are at the heart of the questions studied in this doctoral thesis.

The first one is *ex ante* sectoral regulation, which seeks to monitor and control a sector or business to provide investors with transparency and ensure effective competition. It provides economic players with rules for action. Two of the three chapters in this doctoral thesis relate to regulatory intervention.

The second type of public intervention is competition policy, which aims to ensure that competition is not restricted or undermined in a way that is detrimental to society. For the sake of clarity, let us remind that competition policy relies on different instruments. In Europe these are: antitrust policy[51], merger control[52] and

[48]See: Tirole, J. (2015). "Market Failures and Public Policy". American Economic Review, 105 (6): 1665-82.

[49]Other types of market failures arise in the presence of information asymmetries, public goods, coordination problems, and merit goods.

[50]See: Belleflamme & Peitz (2018), Platforms and Network effects. In Handbok of Game Theory and Industrial Organization, Corchon, L and Marini, M eds); Edward Elgar.

[51]Antitrust policy prohibits anti-competitive agreements between two or more independent market operators. An example is price-fixing by competitors. In the European Union (EU), antitrust policy also prohibits abusive behavior by companies holding a dominant position on a given market. Predatory pricing and loyalty rebates are examples of abusive practices. See: www.ec.europa.eu/competition-policy/antitrust/antitrust-overview_en.

[52]Merger control seeks to examine proposed mergers to prevent harmful effects on competition. In practice, while some mergers can bring benefits to the economy, some may re-

State aid control.

One chapter of this doctoral thesis relates to the question of State aid control, which consists on the evaluation of any advantage conferred by national authorities to companies on a selective basis.[53] State aid, which is a form of public intervention, can take different forms (e.g., grants, interest and tax reliefs, guaranties). It has the distinctive feature of creating the risk of distorting competition or affecting the trade between Member States. Thus, State aid is generally prohibited by the European Commission. However, State aid may be authorized in the presence of market failures or by reasons of general economic interest. Thus, exemptions for specific policy objectives exist.[54] The EU State aid control generally requires prior notification and approval by the European Commission. Since 2012, with the EU State aid modernization reform, the European Commission places more weight on *ex post* evaluations of State aid, especially on the assessment of market distortions that State aid may introduce.

The third type of policy intervention in this thesis relates to the regulation of platforms. In particular, we study questions relevant for the improvement of mobility, safety and inclusion in transport policies.

Thus, this doctoral thesis covers three different types of public policies.

duce competition and risk harming consumers. Thus, competition authorities assess the potential effects of proposed mergers and decide whether to approve them or prohibit them. See: www.ec.europa.eu/competition-policy/mergers/mergers-overview_en.

[53]See Article 107(1) of the Treaty on the Functioning of the European Union (TFEU).

[54]For information on the policy objectives for which State aid can be considered compatible, see the EU legislation relevant to State aid, available at: https://ec.europa.eu/competition-policy/state-aid/legislation_en.

1.2. Public intervention on the telecommunications sector and digital platforms

Arguments appealing to the magnitude of infrastructure investments and other characteristics of telecommunications were traditionally used as justification for the existence of state-owned monopolies in the sector. However, rapid changes in technology and an increased globalization of the world economy resulted in an international trend towards liberalization. A new market-based approach to the supply of telecommunications services was introduced in many countries, starting in the US in the mid-nineteens.[55] In the EU, the sector was opened to competition in the late nineties. In France, liberalization officially occurred in January 1998 except for local telephone services, which were liberalized later with the local radio loop and unbundling.[56]

Despite liberalization, public intervention remains crucial for the proper functioning of the telecommunications sector. The motives are numerous, as are the areas of intervention. For instance, public intervention in the form of regulation is needed for spectrum license granting (public good), to oversee the interconnection of entrants with incumbent operators (natural monopoly) and to facilitate access to incumbents' networks (control of market power). Furthermore, public intervention may also be required to address the lack of incentives for the provision of telecommunications services in areas with particularly high costs and low income or volume demand (universal service). The reason is that most countries continue to consider telecommunications as an essential public service, at least to some extent, especially due to globalization and digitization of the world economy. In the EU, a State aid

[55] See: Crandall, R. W. (2000). Telecommunications Liberalization: The US Model, in: Gander, J. P. (2000). "Deregulation and Interdependence in the Asia-Pacific Region". National Bureau of Economic Research East Asia Seminar on Economics, Volume 8: Takatoshi Ito and Anne O. Krueger, editors; National Bureau, Journal of Asian Economics, Elsevier, vol. 11(4), pages 477-478.

[56] See the 2001 Senate review of the Telecommunications Regulatory Act 96/659, available at: http://www.senat.fr/rap/r01-273/r01-27328.html

scheme for broadband was introduced with the aim of enabling access to fast and reliable telecommunications networks in places where the market does not provide the necessary infrastructure.[57]

Countries usually have their own National Telecommunications Regulatory Authority, which intervenes primarily in wholesale markets. Then, regulatory intervention in the sector is complemented with competition policy.[58] In the EU, the European Commission proposes and implements regulatory packages, which define common rules that apply across Member States. Moreover, since its creation in 2009, the Body of European Regulators for Electronic Communications (BEREC) aims to ensure a consistent application of the EU regulatory framework across Member States and promotes an effective internal single market.[59] In France, the National Regulatory Authority is ARCEP (*Autorité de régulation des communications électroniques, des postes et de la distribution de la presse*). It was created on 5 January 1997, initially under the name of *Autorité de régulation des télécoms* (ART).[60]

Two out of the three chapters of this doctoral thesis deal with the telecommunications sector. The first chapter evaluates the impact of a major EU regulation on mobile telecommunications operators and users. The second chapter studies a State aid program to help deploy fast and reliable broadband networks in rural areas, which are necessary to sustain the development of the digital world.

The telecommunications sector, especially broadband networks, are the foundation of the information society and the digital economy. Every piece of information exchanged and any transaction or activity on the Internet relies on information and communication technologies. In practice, these technologies are enabled by

[57]See: https://digital-strategy.ec.europa.eu/en/policies/broadband-state-aid.

[58]For example, mergers between telecommunications operators are meticulously scrutinized and anticompetitive agreements and abuses are sanctioned by competition authorities (law and order; control of market power).

[59]See: https://berec.europa.eu/eng/about_berec/what_is_berec/

[60]See: https://www.arcep.fr/larcep/nos-missions.html

digitization, which has brought enormous changes to many facets of the modern society.

With digitization and increased connectivity, we have seen the emergence of new forms of production, consumption and interaction. The rise of digital platforms, the use of digital technologies to change companies' business models, as well as to improve the activities of public sector organizations (eGovernment), and the carry-out of commercial transactions on the internet (eCommerce), are just some examples.

Digital platforms have brought considerable benefits to society and they currently play an important role in many individuals' daily lives.[61] They have enabled a decrease of search and transaction costs, they have potentiated communications, and they have also unveiled the value of user-generated content. However, the observation of increasing concentration and market power of digital platforms has generated concern by public authorities. This is especially the case of platforms having a role of "gatekeepers".[62] These concerns are added to worries about illegal activities and disinformation happening through them.

Competition authorities around the world actively pursue antitrust scrutiny of digital platforms and initiatives to adapt merger control criteria to their specificities. Moreover, policy makers continue to pave the way towards legislative reform and *ex ante* regulation. In the EU, the Digital Services Act (DSA) and Digital Markets Act (DMA) proposed by the European Commission with draft texts published on 15 December 2020, were due to be voted by the European Parliament when writ-

[61] A digital platform can be broadly defined as an "undertaking which uses the Internet to enable interactions between users so as to generate value from these interactions". Its key characteristic is the presence of positive network effects. See: Belleflamme & Peitz (2018), Platforms and Network effects. In Handbok of Game Theory and Industrial Organization, Corchon, L and Marini, M eds); Edward Elgar.

[62] These platforms act as barriers to entry, controlling the entry on all sides of the market. The definition of gatekeepers in the Digital Markets Act can be found online at: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en.

ing this dissertation. The proposed legislations aim at regulating digital platforms with a gatekeeper role. They echo other international developments for the public intervention of digital platforms.[63]

Ride-hailing apps are examples of digital platforms active in the urban transport sector. These platforms allow the provision of taxi-like services by linking drivers and passengers directly through an app, without the need of a dispatch center.[64] They disrupted many local markets where traditional regulated taxi industries represented the main private transportation offer. Although they are believed to introduce numerous economic efficiencies, they have faced opposition by traditional transportation players and have generated concerns by public authorities regarding negative externalities (e.g., congestion, pollution, safety). Ride-hailing applications (at least some of their offers, like Uber's "UberPop" service) have been subject to bans or suspensions in several locations around the world. They generated a regulatory debate on the opportunity of imposing minimum quality standards and rules to ensure road safety and fair competition. For example, the French government announced in 2021 the creation of the *Autorité des relations sociales des plateformes d'emploi* (ARPE), a public authority in charge of regulating social relations between platforms and self-employed workers. It targets mobility platforms (ride-hailing and two-wheel delivery services).

In the third chapter of this doctoral thesis we study the impact of hide-hailing platforms on road safety. We aim at better informing the public policy debate on the societal impacts of ride-hailing and the need for policies regarding security and mobility.

[63]See: www. Digital-strategy.ec.europa.eu/en/policies/digital-services-act-package.

[64]For a more detailed description of these services, see International Transport Forum (2018), The Economics of Regulating Ride-Hailing and Dockless Bike Share. Discussion Paper.

1.3. Challenges and risks of public intervention

In the previous sections we discussed the rationale for public intervention in market economies, and in the specific case of telecommunications and digital platforms. In this section, we aim to stress the fact that public intervention should only occur under exceptional circumstances: when markets are not efficient and, at the same time, market intervention would improve efficiency.[65]

In practice, public intervention comes at a cost. All public sector intervention is financed ultimately with taxes to individuals and businesses. Economic theory tells us that taxes distort markets and generate a deadweight loss.[66] As public resources are limited and need to be allocated across a large spectrum of intervention areas, public intervention also faces tradeoffs. Thus, it is necessary to ensure that public interventions will make improvements and bring benefits that outweigh their costs.

Moreover, public interventions generate risks. As the public sector faces the same difficulties as the market, particularly information asymmetry problems, interventions can be either ineffective (no efficiency gains are made) or detrimental (there are efficiency losses).[67] The public sector is often worse than markets at knowing how consumers and firms value goods and services or at anticipating how they would respond to a particular intervention. Thus, public intervention may discourage private efforts, crowd out private investments, or generate strategic reactions by private players. Finally, there is also the risk of regulatory capture. That is, when

[65] In economics, the concept of (pareto) efficiency refers to a situation where *"there is no way to make one consumer better off without making some other consumer worse off. For many cases of interest, Pareto efficient outcomes can be thought of as those that maximize the sum of economic benefits minus costs"*. See: Varian, H. R. (1992). Microeconomic Analysis. New York: Norton, pp 222-223.

[66] In economics, the concept of deadweight loss from taxation refers to the amount of total surplus (from both producers and consumers) that is lost due to a decrease in output following the introduction of a tax. That decrease in surplus is lost to producers and consumers and it is not recovered in the form of government revenues. For a formal explanation, see: Varian, H.R. (2014), Intermediate Microeconomics: a modern approach, WW Norton & Company.

[67] See: GLA Economics (2006). The rationale for public sector intervention in the economy. Technical report, p. 28.

individual interests override the public interests in the design and implementation of public intervention (or the absence of it).

This doctoral thesis addresses questions related to the design and efficiency of public interventions. The first chapter assesses the effects and potential strategic reactions resulting from a regulation. The second chapter evaluates the efficiency of public intervention for the deployment of fiber networks in areas where private operators do not have incentives to invest on their own. The third chapter studies one potential effect of a digital platform on individuals, which we believe should be considered in regulatory design.

Public intervention in the form of sectoral regulation and competition policy is not static. It evolves as it adjusts to the new challenges associated with digitization and globalization of the world economy. In this context, developments in economic theory help understand mechanisms, as well as rationalize and anticipate behaviors. However, economic theory does not currently address policy relevant questions at the same rate as technological developments occur. This is particularly true in the case of digital platforms. Moreover, economic theory sometimes points at ambiguous potential effects or situations, making some questions of empirical nature.

1.4. *Ex post* evaluation and adaptation of public interventions

Developments in economic empirical analysis and contributions to the analysis of casual relationships have revolutionized research in economics. This has been recently highlighted by the award of the 2021 Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel to laureates David Card, Joshua D. Angrist and Guido W. Imbens for their contributions in this area. Empirical analysis provides relevant tools for the evaluation of the effects of changes in market conditions which affect the design of public intervention or to assess the effects of public interventions themselves. It offers an opportunity to provide evidence for the design of better policies and regulations. As described by Jean Tirole, laureate of the 2014 Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel: *"The predictions of ... [a] model can ... be tested econometrically and possibly in the lab or the field. In the end, the reasonableness of, and robustness to modeling assumptions and the quality of empirical fit determine how confident economists are in making recommendations to public decision-makers for intervention, and to companies for the design of their business model."*[68]

In this doctoral thesis we use different econometric methods and identification strategies for causal inference. Their design and the interpretation of the results are nurtured by insights from the economic theory. First, we apply regression models and difference-in-differences strategies that use repeated observations to control for unobserved omitted factors. Second, we use hedonic price regressions, which model products as a bundle of attributes and are commonly employed to study price changes in different industries. Third, we use empirical models of market structure. More precisely, we estimate a model of market entry to account for the endogeneity of market structure, an issue that biases estimates in certain causal analyses.

This doctoral thesis studies questions related to casual impacts that ultimately affect peoples' mobility and integration in the digital economy. The first chapter studies the impact of the EU roaming regulation on mobile operators' revenues and prices. This regulation affects people's mobility across the continent and their integration within the common market. The second chapter assesses the efficiency of State aid for broadband in France and its impact on fiber deployment. This public policy has an impact on workers' and businesses mobility. It also affects the integration of people living in rural and less densely populated areas into the global digital economy. The third chapter studies the impact of ride-hailing on road safety, which

[68]Tirole, J. (2015). "Market Failures and Public Policy". American Economic Review, 105 (6): 1665-82.

affects the mobility of individuals in cities. It also deals with the better integration of women-specific needs in transportation planning. The three chapters are somehow related to the goal of allowing equitable access and benefits of digitization for all.

2. Summary of Objectives and Contributions by Chapter

This doctoral thesis is not intended to cover all aspects of public policy in the digital economy. Rather, it aims at studying specific cases to provide relevant evidence for public policy. It is composed of three chapters.

The first chapter assesses the impact of the roaming regulation implemented in the European Union (EU) on mobile operators' revenues and retail prices. The second chapter studies the determinants of fiber entry by telecommunications' infrastructure operators and evaluates the efficiency and the impact of a State aid program for the deployment of ultra-fast broadband networks in France. The third chapter studies challenges of transport policy in the presence of ride-hailing platforms. Specifically, it assesses the impact of these platforms on the incidence of drunk-driving fatal crashes and fatalities, using Chile as a case study. In this chapter we study heterogeneous effects in fatalities by gender to examine whether ride-hailing platforms like Uber may help mitigate the gender mobility bias in transportation.

The choice of these specific policies and questions was inspired by the observation of challenges imposed by the digital transformation of the world economy and the identification of policy questions which lacked evidence from rigorous empirical studies. Moreover, it was influenced by the availability of a set of rich and unique databases that we can exploit to inform the policy debate. Ultimately, the topics of this dissertation translate my personal passion for economics, especially industrial organization, public policy and empirical analysis. I believe that these questions open the door to interesting and relevant avenues for future research.

Chapter 1: Impact of roaming regulation on revenues and prices of mobile operators in the EU

In the mobile telecommunications sector, one of the main regulatory interventions worldwide has been the cut of termination rates of calls from fixed lines to mobile phones.[69] That is, the interconnection payments between mobile operators allowing consumers in one network to complete a call to another consumer connected to a different network. The reason is that a mobile operator, even if competing against other mobile operators, holds a monopoly over delivering calls to its subscribers and will therefore set high mobile termination rates (MTRs) (Genakos & Valletti, 2011). The idea that each mobile network is a bottleneck for customers receiving calls created a rationale for regulation which sets caps over termination rates. In Europe, the mobile termination rates regulation started with the UK case in the late nineties.

Beyond restrictions on mobile termination rates, the EU has implemented regulations on international roaming services. These services allow mobile phone users to make and receive voice calls, send and receive SMS, or access data services when travelling abroad. The regulation covers both, the wholesale (transactions between operators) and the retail (services provided by telecom operators to consumers) markets in the EU. The first roaming regulation was implemented in 2007 and others were applied gradually until the Roam-Like-At-Home regulation set retail roaming charges to zero in 2017. In October 2021, the European Parliament voted favorably for the extension proposed by the European Commission of the current regulatory regime, which is due to expire in June 2022.[70]

[69] Other important fronts of public intervention in mobile telecommunications markets are merger control and spectrum allocation.

[70] When writing this dissertation, the European Parliament would still have to reach an agreement on the new rules with the EU countries in the Council, before they could enter into force. See: https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vln7f7hgscx1?ctx=vg9pj7ufwbwe&

One of the main motivations for the EU roaming regulations was the observation of very high roaming tariffs before 2007. In practice, there is a bottleneck issue like the one observed in the case of mobile call termination. In the context of international roaming, operators in foreign countries face limited competitive constraints when charging wholesale tariffs. This situation opens the possibility of charging monopoly prices for the access to their networks. As domestic operators are themselves bottlenecks for roaming services to domestic consumers, excessive wholesale prices could be passed on to consumers in the domestic retail market. Thus, a double marginalization problem may arise.

Another important motivation for roaming regulations has been the consolidation of the EU digital single market.[71] This is one of the priority strategies of the European Commission to ensure effective and secure access to digital goods and services by EU citizens. It seeks to maximize the growth potential of the EU digital economy and its benefits for businesses and consumers.[72] In this context, high roaming prices to consumers across the EU were perceived as an obstacle to peoples' mobility, integration and trade within the common market.

Although public intervention and regulation may be necessary in different situations, there is always a trade-off between their potential benefits and harmful effects. Achieving their foreseen objectives and efficiently depends on the incentives offered to various players and the proper functioning of competitive pressure among them. *Ex post* evaluations are crucial to assess their impact, correct eventual issues and inform future policy design.

In the case of mobile termination rates regulation, a major concern emerged that reducing the level of mobile termination rates could potentially increase the level of

tab=1&start_tab1=10.

[71] See: https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2021)662599.

[72] See: https://eufordigital.eu/discover-eu/the-eu4digital-initiative/

prices for mobile subscribers. This effect is known in the literature as the "waterbed effect". More precisely, by cutting the rent that can be made of call termination, the regulation could provide incentives to operators to compete less aggressively for final users, and thus fix higher prices. This is a potential issue well identified in theory and long hypothesized.[73]

In the case of roaming regulation, there is also the risk of a waterbed effect. By cutting roaming fees and setting roaming retail prices to zero, operators could compete less fiercely to attract travelling consumers and raise their domestic prices to compensate for their roaming losses. Thus, the regulation could have detrimental effects for non-traveling users. The waterbed effect would come on top of other potential distortions pointed out by opponents to the regulation. That is, a risk of overconsumption (a zero price for roaming is below the cost of providing the service) and a risk of compromising mobile operators' long-run profitability.

Contributions of the first chapter

This chapter, co-written with Lukasz Grzybowski, studies the impact of the EU roaming regulation on revenues and prices of mobile operators in the EU. It aims at quantifying the effect of the regulation on mobile operators' revenues and evaluates whether the waterbed effect has arisen due to the regulation. We apply a difference-in-differences approach and estimate hedonic price regressions using detailed operator and plan-level data. We find that the regulation decreased mobile operator's revenues per user. However, we find no evidence of significant increases in tariffs during the latest phase of the regulation (no waterbed effect).

The set of EU roaming regulations has been considered a great political success and

[73] Genakos and Valletti (2011) analyzed this question empirically and found evidence of a waterbed effect for the case of more than 20 countries over the period 2002-2006. Later, Genakos and Valletti (2015) studied the same question using a larger panel covering 27 countries over the period 2002-2011. They found that the waterbed phenomenon becomes insignificant on average and over time due to the changing nature of the industry, whereby mobile-to-mobile traffic surpassed fixed-to-mobile traffic.

one crucial pillar for the consolidation of the EU digital single market. It has also generated opposition and debates at each step of the implementation of the set of regulations. However, after almost fifteen years from the implementation of the first regulation in 2007, and more than four years after the implementation of the latest regulation called "Roam-Like-At-Home" (RLAH) in June 2017, rigorous empirical evaluations of their effects are scant.

The impact of the EU roaming regulation has been examined mainly in technical reports relying on descriptive analyses. This is the case of studies conducted by/for the BEREC and the European Commission. The main limitation of this type of studies is the lack of rigorous empirical methods to assess the causal impact of the regulation. Our work seeks to fill in this gap. In doing so, it contributes to the literature studying the impact of regulatory interventions on the telecommunications markets (e.g., Genakos & Valletti, 2011 and Genakos & Valletti, 2015). Moreover, it contributes to the literature that analyzes competition and regulation-related questions in the telecommunications industry using hedonic price regressions (e.g., Karamti & Grzybowski, 2010; Greenstein & McDevitt, 2011; Wallsten & Riso, 2014; Calzada & Martinez-Santos, 2014; Nicolle et al., 2018).

Two recent ongoing academic studies examine the effects of the Roam-Like-At-Home regulation. Godihno de Matos, Quinn and Peukert (2021) use the regulatory change introduced by the Roam-Like-At-Home legislation to study the consumer surplus gains from using mobile internet. Using individual level data from one European mobile operator, they find that consumer surplus increases as individual mobile internet consumption increases when traveling. Canzian et al. (2021) evaluate the impact of the Roam-Like-At-Home regulation on the European Economic Area's roaming traffic and revenues. They find that it substantially raised international roaming volumes and wholesale revenues, with heterogeneous effects on retail and wholesale traffic volumes and revenues. By completing their analysis with a theoretical framework, they conclude that gains in consumer surplus from the regulation are large and far compensate for profit losses. Finally, they study whether Roam-Like-At-Home resulted in a waterbed effect. In line with our findings, they do not observe increases of domestic prices as a result of the regulation.

These studies are complementary to our work in four fronts. First, they focus mainly on roaming consumption (data traffic), while we study revenues and prices of mobile operators. Second, they study specifically the effects of the Roam-Like-At-Home regulation (implemented in 2017), while our analysis of revenues covers the whole set of roaming regulations implemented since 2007. Third, they use different data sources and empirical strategies. Fourth, Canzian et al. (2021) can disentangle the regulation's effects on wholesale and retail revenues of mobile operators, while we focus on overall revenues - due to data limitations- and mobile operators' potential strategic reactions.

This chapter ultimately contributes to the regulatory debate on mobile telecommunications. It provides a piece of evidence to help inform policy makers on the potential effect of future regulations as the proposed extension of the roaming regulation currently under scrutiny by the time of the preparation of this dissertation.

Chapter 2: Entry Into Fiber and State Aid for the Deployment of High-Speed Internet: Evidence from France

Access to fast and reliable internet connections has become decisive in the digital era. Information and communication technologies are being applied to a wide range of businesses and transactions, as well as government functions and procedures. Thus, the world economy and day-to-day activities are increasingly digitized.

In this context, the investment in broadband, especially very-high capacity networks, has been and remains crucial. These networks are the basis of the digital world. In

Europe, the investment in these networks (mainly based on fiber optics and cable technologies) has been a priority for more than a decade. The European Commission has set specific objectives of broadband and ultrafast broadband coverage since 2010. The latest target in place is to provide access to ultrafast broadband (speeds of 100 Mbs or more) to all EU households by 2025.

However, the transition to ultrafast broadband access has been slow due to supply and demand side features. On the supply side, very-high capacity networks entail large fixed and sunk investment costs, operators face an opportunity cost of deployment due to revenues from other existing networks (the so-called "replacement effect") and there is competition from Internet services providers using other technologies. On the demand side, switching costs and a low willingness to pay for higher speeds generated uncertainty about adoption in the early stages of fiber diffusion.

Moreover, the deployment of very-high capacity networks has been particularly slow in rural areas, revealing a digital divide. In these areas, private operators face particularly high deployment costs and limited or uncertain demand, making investment economically non-viable for them. However, positive externalities may make the deployment of ultra-fast broadband socially desirable. As private players do not internalize them, a market failure could be in place.

Thus, public intervention is necessary in these zones to release fiber investments. A geographic and technical framing of deployments by National Regulatory Authorities or the possibility of co-investments are some forms of intervention. In addition, public financial support for broadband network deployment in specific zones is also possible. The latter are framed under the EU State aid scheme for broadband and can take the form of direct grants, tax rebates or other types of preferential financing conditions.

In France, since 2013 the government has supported the design and funding of fiber networks through the *Plan France Très Haut Débit* (French Broadband Plan). This Plan foresees around 3 billion euros of State aid to help close the profitability gap in local areas where private investment does not seem viable. Its ultimate objective is to provide fiber-to-the-home (FTTH) coverage for all by 2025.

Contributions of the second chapter

The purpose of this chapter, co-written with Marc Bourreau and Lukasz Grzybowski, is twofold. First, we study the determinants of fiber entry by private telecommunications operators. Understanding the factors affecting fiber diffusion is crucial to guide the remaining deployments and help inform policies for the deployment of future technologies, but also of fiber networks in other countries. Second, we aim to assess the efficiency of the French Broadband Plan and its impact on fiber deployment. *Ex post* evaluation is an opportunity to continuously improve the design, the effectiveness and efficiency of aid schemes. More precisely, it helps weight the beneficial effects of aid schemes relative to the potential market distortions they may introduce.

To do this, we exploit a rich dataset on fiber deployment, State aid and local characteristics of more than 34,000 municipalities in Mainland France over the period 2014-2019. On the determinants of fiber entry, we identify market size and income as important characteristics that increase the attractiveness of local markets. Moreover, we find evidence of a strong geographic dependence in the fiber entry process, the presence of a replacement effect from the legacy copper network influencing entry decisions and an increase in the ease of entry over time. On the evaluation of the French Broadband Plan, we find that it was rather efficient and helped increase fiber coverage in aided municipalities at the beginning of the period of analysis.

Thus, this chapter contributes to different streams of the literature. The first stream studies the market characteristics influencing entry in local telecommunications markets (e.g., Greenstein and Mazzeo, 2006; Xiao and Orazem, 2011; Goldfarb and Xiao 2011; Wilson, Xiao and Orazem, 2021). Besides demand and cost shifters impacting entry, the literature highlights the influence of differentiation, sunk costs, managers' strategic ability and entry threats. Moreover, a related stream of literature analyzes the impact of entry in outcomes in telecommunications markets (e.g., Economides, Seim and Viard, 2008; Nardotto, Valletti and Verboven, 2015; Bourreau, Grzybowski and Hasbi, 2019). This literature has focused on the effects of entry on prices, variety, consumer welfare, the deployment and adoption of new technologies and service quality. We contribute to this literature by identifying the determinants of fiber entry in France and examining the role of State aid on entry into local telecommunications markets.

The second stream of literature studies investments in next-generation access (NGA) fiber networks. Its focus is on the impact of sectoral regulation on the deployment of fiber networks (e.g., Fabritz and Falck, 2013; Bacache, Bourreau and Gaudin, 2014; Briglauer, 2015; Briglauer, Cambini and Grajek, 2018; and Briglauer, Cambini, Gugler and Stocker, 2021). The overall finding of this literature is that more stringent regulations tend to harm investments, deployment and adoption. This chapter contributes to this literature by analyzing the role of State aid, which is another form of public intervention. More precisely, we analyze the impact of State aid in the deployment of NGA fiber networks.

The third stream of literature to which we contribute investigates the impact of State aid on the deployment of broadband networks. This literature includes case studies of European Union member states (e.g. Matteucci (2019) for the deployment of first generation of broadband in Italy; Briglauer et al. (2019) and Duso et al. (2021) for broadband deployment in Germany). It also includes cross-country studies like Briglauer and Grajek (2021), which study the effectiveness of State aid programs for the deployment of new fiber broadband networks in 32 OECD countries. Wilson

(2017) studies the U.S. case with a focus on the impact of public investment in broadband infrastructure on private investment. We contribute to this literature by assessing the efficiency of State aid for the deployment of fiber networks in France using micro-level data.

Finally, and more broadly, we seek to contribute to a better design and efficiency of State aid schemes for broadband.

Chapter 3: Transport Policy in the Digital Age: Insights from the Entry of Ride-Hailing Platforms in Chile

Digitization has allowed the emergence of innovative platform-based services which have created new opportunities for businesses and consumers. In the area of local mobility, ride-hailing apps like Uber, Lift or Cabify, became an alternative to traditional transportation services, specially taxi cabs.

Several features of these apps generate transactional efficiencies that make them appealing for users. First, they allow the tracking of location and the possibility to share it with others in real time. Second, they use rating systems intended to ensure safety and high-quality service. Third, they provide the possibility to wait somewhere safe until the vehicle arrives and payments are automatic in most of the cases. Fourth, in some cases they optimize allocations by adapting prices to demand and supply fluctuations. Fifth, in some cities they are cheaper that traditional taxi-hires.

Despite these features, ride-hailing apps have generated opposition from historical players present in the transportation sector and have created worries among policy makers. The main concerns are that these apps may produce greater congestion, driver distraction and consequently increase the likelihood of crashes. Months and years after the introduction of ride-hailing services, cities have witnessed protests in opposition, mainly from the taxi industry. A heated regulatory debate has arisen, and in several locations, local authorities have decided to suspend or to ban these services.

Within the regulatory debate on ride-hailing apps, and more broadly of transportation policy, there are potential unexplored advantages of these services. In particular, it is possible that they help tackle, or at least mitigate, issues faced especially by women. First, it is now accepted that "transportation is not gender neutral".[74] The reason is that women-specific patterns of use, access and needs are not systematically addressed in transport planning. Second, the safety features depicted by ride-hailing apps may seem especially relevant for women as they express more safety concerns in transportation compared to men. Women's safety concerns in transportation are true in both the developing and the developed world.[75] Third, in places like Chile, ride-hailing apps' relevance might be increased by the fact that women drive considerably less than men do.

Contributions of the third chapter

In this chapter, co-written with Vicente Lagos and Christine Zulehner, we explore the possibility that ride-hailing apps may create an opportunity to attenuate the existent mobility bias against women, especially in developing countries. To do so, we focus on drunk-driving crashes (i.e., crashes caused by people driving under the influence of alcohol) and related fatalities. The reason is that they provide a concrete measure of road safety for which detailed data is available. Moreover, they offer a setting where economic theory sheds light on the mechanisms explaining different potential outcomes. We study the case of Chile where Uber started operations in Santiago in 2014 and the authorities provide access to detailed crash level data.

[74]This idea has been broadly discussed by the World Bank. See: https://blogs.worldbank.org/transport/transport-not-gender-neutral

[75]See for instance: European Parliament (2006), Uteng (2012), European Institute for Gender Equality (2016), and Allen, et al. (2017).

We use a difference-in-differences approach and a Poisson regression model and we find that the presence of the UberX service in Santiago significantly reduced drunk-driving fatal crashes and fatalities in these types of crashes. Our estimations by gender reveal that UberX's availability significantly reduced the number of female passengers' fatalities and the number of male drivers' fatalities at night.

This chapter contributes first to the economic literature studying the societal impacts of ride-hailing. This literature examines different areas such as traffic congestion (Li et al. 2016; Henao & Marshal, 2018; Tirachini & Gomez-Lobo, 2018), safety regulations (Anil & Fisher Ellison, 2017), search frictions and matching (Shapiro, 2018; Bian, 2018; Vergara-Cobos, 2018), public transit ridership (Hall et al., 2018), taxi drivers' earnings (Berger et al., 2018) and moral hazard (Liu et al., 2021). Within this literature, this chapter specifically contributes to the empirical literature studying the impact of ride-hailing on overall and drunk-driving crashes and fatalities.

Previous studies in the latter stream of the literature have focused on the effects of ride-hailing apps on road safety in the US at the national and local levels (Greenwood & Wattal, 2017; Morrison et al., 2018; Peck, 2017; Brazil & Kirk, 2016; Dills & Mullholland, 2018; Barrios et al., 2020). Their results point in different directions. Some studies find evidence of a decrease in crash fatality rates after the introduction of ride-hailing services, while others find no effect or even an increase in some cases. Our work contributes to the literature and the regulatory debate by providing evidence on the impact of ride-hailing on drunk-driving fatal outcomes in a different geographical region with specific quality and availability issues of traditional transport alternatives. More remarkably, it contributes to the literature by studying the potential impacts of ride-hailing by gender and by individuals' roles in a ride (drivers vs. passengers). To our knowledge, our study is the first to examine the impact of ride-hailing on traffic crashes and fatalities in the developing world and to study potential heterogeneous effects by gender and role. This chapter also contributes to the literature studying the relationship between mobility and gender (e.g. Duchene, 2011; Peters, 2013; Castillo et al., 2013; Ng & Acker, 2018; Quinones, 2020). This literature studies differences in transportation uses and needs by gender and identifies safety as a gender-specific issue restricting women's mobility. Our work not only shows that ride-hailing apps may decrease drunk-driving fatal accidents and fatalities and thus represent relevant transportation alternatives especially for women, but it can also serve as further evidence that a gender mobility bias exists and needs to be addressed.

Ultimately, we hope that this work will contribute to the design of better policies by helping understand individuals' behavior face to risk and the trade-offs of new mobility alternatives brought by digitization. In the presence of a mobility bias against women in the traditional transport sector, we believe that this novel evidence is particularly relevant when considering and designing the current policy about ride-hailing apps' regulation and overall transportation and urban policies, both in developed and in developing countries.

CHAPTER 1

Impact of roaming regulation on revenues and prices of mobile operators in the EU*

*This chapter was written with Lukasz Grzybowski (Telecom Paris, Institut Polytechnique de Paris). We are grateful to Maya Bacache, Marc Lebourges and David Salant for comments and useful suggestions. We thank Ivan Celaya for research assistance in data collection. This chapter has also benefited from discussions with participants at the 2019 AFREN Doctoral Workshop, the 2020 Doctoral Workshop on the Economics of Digitization at Télécom Paris, the 2020 ERSA Seminar on IO and the Economics of Digitization Transformation, the 69th Annual Meeting of the French Economic Association, the 2021 Workshop on Digital and Innovation Economics at Trouville and the 15th International Conference on Competition and Regulation – CRESSE. All errors are our own.

Abstract

In this chapter we empirically assess the impact of the EU roaming regulation on mobile operators' average revenues per user (ARPU) and retail prices. Using a difference-in-differences approach, hedonic price regressions and detailed operator and plan-level data, we find that the regulation decreased mobile operator's revenues per user, while it had no impact on tariffs during the latest phase of the regulation.

Key words:Roaming; Mobile telecommunications; Regulation.
JEL classification: L13, L50, L96.

1.1 Introduction

Roaming regulation implemented in years 2007-2017 is considered a success story in the European Union (EU) and a decisive step towards the consolidation of the EU digital single market.[1] First, in 2007, the European Commission introduced regulations, which capped the maximal roaming fee that mobile users had to pay for voice services, as well as the wholesale tariffs for outgoing calls. In the following years, further regulations capped roaming charges for SMS and data, both at the retail and wholesale levels. Finally, in June 2017, the Commission implemented the "Roam Like at Home" (RLAH) regulation, which equalized roaming fees for voice, SMS and data with prices that mobile users pay for these services in their home countries. Since this last regulation was implemented, users of mobile services in the EU do not need to worry about being surprised by high mobile bills after trips abroad within the European Economic Area (EEA).[2],[3]

Back in the middle 2000s, following complaints about excessive prices for roaming services and lack of transparency in the market, the European Commission started monitoring prices and evaluating different policy options for a regulation of roaming within the EU.[4] The European Commission's investigation revealed that on average, international roaming prices were four times higher than those of national mobile calls. Such price differences were however not explained by differences in the costs of service provision. According to the European Commission's findings, on average retail charges for a roamed call were five times higher than the actual cost of providing the wholesale service (50% higher than the average inter-operator tariffs).[5] The main concerns were that operators in foreign countries face limited competitive

[1]The EU roaming regulation concerns international roaming services. International roaming allows mobile subscribers to make and receive calls, send and receive SMS or use data services when travelling occasionally outside the geographic coverage area of their home network. The use of these services abroad is done based on the network of a mobile operator in the visited country.

[2]In order to prevent abuses or anomalous use of roaming services - such as permanent roaming at domestic prices -, the RLAH regulation contains two provisions: a fair use policy and a sustainability derogation. The first provision aims to ensure that roaming is used only when periodically travelling in the EEA. The second intends to avoid domestic price increases in the case where an operator cannot provide roaming services without the application of a surcharge, given its price-cost model at the domestic level. This is subject to the approval by the national regulatory authority.

[3]The European Economic Area covers EU Member States and also includes Norway, Iceland and Liechtenstein.

[4]See: Falch (2012).

[5]See: Commission Staff Working Paper SEC(2006) 925.

constraints when charging wholesale tariffs to the domestic operators of consumers using their networks. This situation would make them bottlenecks and open the possibility of charging monopoly prices for the access to their networks. As domestic operators are themselves bottlenecks for roaming services to domestic consumers (once the latter already have a subscription for local services), excessive wholesale prices for roaming could in turn be passed on to consumers in the domestic retail market and a double marginalization problem may arise. In this context, the EU roaming regulations were conceived with the objective of achieving substantial reductions in international roaming charges in the EU and intensifying competition in the European mobile telecommunications markets.

While the regulations have greatly benefited millions of travelling consumers in the EU, they do not come without important risks and challenges. In the words of BEREC, *"[...] there are substantial trade-offs between the policy objectives of promoting greater use of roaming services, protecting competition, protecting investments and, importantly, protecting European consumers"*.[6] First, there exist diverse travel and consumption patterns across Member States, coupled with significant variations on the level of tariffs and costs of different mobile operators across Member States.[7],[8] Thus, imposing the exact same price caps across Member States and ultimately equalizing retail roaming charges with domestic prices could in practice introduce distortions in national competition and challenge the sustainability of certain mobile operators. Second, there was an increase in consumers' use of roaming services encouraged by the regulation, which increased the wholesale bill of the operators and put pressure on the network capacity.[9] This increase in demand and investment needs arrives in a context where wholesale tariffs are also capped and

[6]See: BEREC, International Roaming Analysis of the impacts of "Roam Like at Home" (RLAH), BoR (14) 209, December 2014, page 2.

[7]For instance, according to the Flash Eurobarometer 2018 "The end of roaming charges one year later", 46% of respondents had travelled to another EU country within the last 12 months, while 53% had not travelled to another EU country during this period. Travelling habits vary considerably across countries: in Luxembourg (85%), Austria (78%) and Slovenia (75%) respondents had travelled to another EU country at least once in the last 12 months, compared to 26% of respondents in Greece, 28% in Portugal and 30% in Spain.

[8]Costs differences are explained mainly by differences in spectrum costs, labor and property costs, coverage obligations, geographies, drivers of demand for network capacity, etc.

[9]The rapid and massive increase in demand for mobile consumption while travelling in the EU/EEA is documented in different reports, including the European Commission's Report on the implementation of Regulation (EU) 531/2012 of the European Parliament and of the Council of 13 June 2012 on roaming on public mobile communications networks within the Union, as amended by Regulation (EU) 2015/2120 and Regulation (EU) 2017/920, COM(2018) 822 final.

decrease over time. Such dynamics can significantly affect the competition conditions at the national level, impose constraints on investment incentives and lead to potential strategic reactions by mobile operators. In particular, mobile operators could attempt to recoup lost revenues and profits by adjusting upwards domestic prices. In such case, consumers who do not travel abroad would be worse off as a result of roaming regulation with higher domestic bills and no compensation through lower roaming fees.[10] This unintended distributional effect was one of the main concerns expressed by BEREC during the consultation period preceding the adoption of RLAH regulation.[11] Note that this distributional effect can be rationalized as a waterbed effect similar to the one discussed in the literature studying regulation of mobile termination rates.[12]

Even though roaming regulation was a successful political move and had a great economic impact on both consumers and mobile operators, so far there are scant rigorous empirical studies on its impact on prices of mobile services, and consequences for revenues and profits of mobile operators. This chapter is an attempt to provide such evidence based on detailed operator-level data on average revenue per user (ARPU) and plan tariffs of a large number of European and non-European operators in OECD countries. The non-EU operators were not affected by roaming regulation and are included in this analysis as a control group.[13]

There are reasons why such analysis has not been conducted so far. First, reliable

[10] According to estimates reported by BEREC in 2014, an average EU citizen spent 5.7 days abroad in another Member State. The percentage of EU citizens who never travel abroad was estimated at 36%, with large variation across countries. Source: BEREC, International Roaming Analysis of the impacts of "Roam Like at Home" (RLAH), BoR (14) 209, December 2014.

[11] See: BEREC, International Roaming Analysis of the impacts of "Roam Like at Home" (RLAH), BoR (14) 209, December 2014.

[12] See: Genakos and Valletti (2011) and Genakos and Valletti (2015).

[13] The impact of roaming regulation on the telecommunications market has been analyzed mainly in studies conducted by BEREC, the European Commission or on their behalf. For instance, a report from July 2011 by the European Commission explains how BEREC collected data to study the consequences of European regulations. See: Commission Staff Working Paper, Impact Assessment of Policy Options in Relation to the Commission's Review of the Functioning of Regulation (EC) N°544/2009 of the European Parliament and of the Council of 18 June 2009 on Roaming on Public Mobile Telephone Networks within the Community. After the implementation of RLAH regime, the European Commission has published three documents reviewing the roaming market: (1) On 12 December 2018 an interim Report to the European Parliament and the Council on the implementation of the RLAH rules over the first 18 months, (2) on 28 June 2019 a Staff Working Paper Document on the findings of the review of the rules of fair use policy and the sustainability derogation and (3) on 29 November 2019 a Report to the European Parliament and the Council on the review of the roaming market. All these reports mainly rely on a descriptive analysis.

information on ARPU is not easily available. We combine such data for years 2004-2018 for a large number of operators using different sources. Second, the pricing of mobile services is complex including a range of different services sold as bundles, which also change frequently. Likewise, international price information is not easily available and requires substantial data collection effort. We use a large database of tariff plans from a number of operators for years 2014-2017. Moreover, there are also substantial differences across EU countries with respect to consumption patterns of mobile services and traveling patterns, which make it difficult to assess how benefits of roaming regulation are distributed across countries and between segments of population within the country.[14] Due to lack of detailed information on the demand side, we are not able to assess welfare effects of roaming regulation and how it is distributed across Member States, which is an interesting avenue for further research.

Our analysis is carried out in the following steps. First, we put together a database including information on ARPU for 111 European and non-European mobile operators in 33 OECD countries on a quarterly basis for years 2004-2018. We estimate a number of specifications using a difference-in-differences approach, in which we assess whether roaming regulations impacted ARPU of mobile operators in the EU. We compare the quarters before and during roaming regulation and as a control group use information on a number of mobile operators from non-European OECD countries, which were not affected by the regulation. In one model specification we assess the impact of roaming regulation from the start in 2007 and find that it led to lower ARPU of mobile operators in the EU. When exploring the effect of different phases of the regulation, we see that the decrease in ARPU is gradual, but is uncertain for the latest phase of the regulation. The results are robust when different control variables are included and for ARPU measured with and without considering purchasing power parities (PPP).

[14] For instance, BEREC's analysis based on the Eurobarometer Household Survey shows that in 2014, 75% of households in Italy have prepaid subscriptions in contrast to Denmark where 83% of households have postpaid subscriptions. Moreover, Eurostat and Eurobarometer data shows that the average number of days spent abroad for citizens of different Member States ranges from less than 1 day per year in Greece to 27 days per year in Luxembourg, and there is a general trend of greater travel from Northern to Southern Member States than vice versa. Source: BEREC, International Roaming Analysis of the impacts of "Roam Like at Home" (RLAH), BoR (14) 209, December 2014.

Next, we estimate hedonic price regressions using a large number of tariff plans on a quarterly basis between January 2014 and December 2017 for 12 mobile operators from selected OECD countries including EU Member States. The pricing information is much shorter than our ARPU data set because such data is not readily available on a cross country basis. Thus, the earlier some roaming regulation was already in place in the whole period and we can only assess the impact on prices of the latest roaming regulation (RLAH regime) which took place in June 2017. In the first stage, the regressions include a number of covariates to control for differences in quality of mobile services offered in different countries. In particular, we create a set of dummy variables, which account for different data and minutes allowance included in tariff plans, as well as length of contract. We estimate the regressions for all tariff plans, including prepaid and postpaid segments. In the second stage, using quality-adjusted price indices from the first stage, we estimate a number of difference-in-differences models with non-EU countries being our control group. Our results suggest that the latest phase of the regulation had no impact on mobile operators' tariffs. Thus, the potential upward adjustment of domestic prices by mobile operators - feared by the authorities - does not seem to have taken place after the entry into force of the RLAH regime.

This chapter makes an important policy contribution since, to the best of our knowledge, it is the first academic work which relies on detailed operator-level data to assess empirically the impact of one of the key regulations implemented at the European Union level. We show that the regulation had a significant impact on revenues of mobile operators in the EU in comparison to mobile operators based in OECD countries outside the EU. We also show that roaming regulation does not seem to have affected retail mobile prices in the EU.

This chapter contributes to the following streams of literature. First, it contributes to the literature studying the impact of regulation on outcomes in telecommunications markets. Among studies on the impact of regulation on prices of telecommunications services, Genakos and Valletti (2011) analyze how the regulatory intervention to cut fixed-to-mobile (F2M) termination rates impacts mobile retail prices. Using panel data of prices and profit margins for mobile operators in more than 20 countries in a period of over six years, they find that a reduction in F2M termination rates leads to an increase in retail prices, which they call the "waterbed" effect.[15] In a more recent paper by the same authors, Genakos and Valletti (2015) estimate the impact of regulation of F2M termination rates on mobile phone bills using a large panel covering 27 countries. They find that the "waterbed" phenomenon becomes insignificant on average over the 10-year period, 2002-2011. They argue that this is due to the changing nature of the industry, whereby mobile-to-mobile traffic surpassed fixed-to-mobile traffic.[16] Recently, Canzian et al. (2021) evaluate the impact of the Roam-Like-at-Home regulation (latest phase of the EU roaming regulation) on EEA roaming traffic. Using detailed data from BEREC for the period 2016-2019, they find that RLAH substantially raised international roaming volumes and wholesale revenues, with large and heterogeneous effects on retail and wholesale traffic volumes and revenues. Based on the empirical results and a theoretical framework, they conclude that gains in consumer surplus from RLAH are large and far outweigh profit losses. Moreover, as an extension to their main analysis and using data from Teligen, they study whether the RLAH involved a waterbed effect. Consistent with our results, they find that RLAH does not seem to have induced operators to raise their domestic prices.

Second, we contribute to the literature using hedonic price regressions in application to the telecommunications industry. The hedonic price model is based on the idea that any product can be viewed as a bundle of attributes. Firms and consumers trade with each other to determine the price attached to each attribute (see Griliches (1961) and Rosen (1974) for a formal presentation of this model in perfectly competitive framework). Hedonic price regressions were commonly used to study price changes in different industries. There is also a number of empirical studies for telecommunications markets including Karamti and Grzybowski (2010) and Nicolle et al. (2018) for mobile prices in France; Greenstein and McDevitt (2011) for broadband industry in the U.S.; Wallsten and Riso (2014) for broadband services in

[15]They obtained information on retail prices from a consultancy firm Teligen, which collects telecommunications pricing data. The prices are expressed in terms of three representative usage baskets (heavy, medium and low) based on a number of characteristics (number of calls and messages, average call length, time and type of call, etc.) which are then held fixed across countries and over time. The "waterbed" effect suggests that pressing down prices in one part of firms' operations causes another set of prices to rise.

[16]More than a decade ago there was a burgeoning theoretical literature on the impact of mobile termination rates on prices, which started with the seminal works of Armstrong (1998) and Laffont et al. (1998). For surveys, see Armstrong (2002) and Laffont and Tirole (2001).

OECD countries; Calzada and Martinez-Santos (2014) for broadband prices in 15 EU countries.

The reminder of this chapter is organized as follows. Section 1.2 discusses the main changes in mobile telecommunications industry in the EU. Section 1.3 presents the data used in the estimation. Section 1.4 introduces the econometric framework. Section 1.5 presents the estimation results. Finally, Section 1.6 concludes.

1.2 Regulation of the Mobile Industry in the EU

This section describes the EU roaming regulation and the main events that took place in the mobile telecommunications industry in Europe in years 2004-2018 covered by our data.

The main regulatory measures implemented in recent years at the EU level relate to international roaming services. International roaming is a service that allows mobile phone users, by means of using a visited network, to automatically make and receive voice calls, send and receive SMS, or access data services when travelling occasionally outside the geographical coverage area of their home network. The roaming market is divided into wholesale and retail markets. Wholesale market corresponds to transactions between operators based on agreements, which are signed between them.[17],[18] Retail market corresponds to the roaming services provided by telecom operators to mobile users.

Before June 2017, mobile users in Europe had to pay additional fees to use mobile services when travelling abroad. Since 15 June 2017, additional fees were abolished for European mobile users travelling within the countries of the European Economic Area. This is known as "Roam Like At Home" (RLAH).

While the entry into force of RLAH regime is the most recent and symbolic regulatory event relating to international roaming in the EU, the origins of the regulation

[17] Such agreements are generally bilateral and consist of two parts: "inbound roaming" and "outbound roaming". Inbound roaming is the situation where foreign customers use an operator's network in the home territory, while outbound roaming refers to customers of the operator in the home territory who go abroad and use the network of another operator.

[18] The first roaming agreement was signed in 1992 between Vodafone UK and Telecom Finland. See: GSMA, Brief History of GSM and the GSMA, available online at: https://www.gsma.com/aboutus/history.

date back to the years 2000. Following complaints about excessive rates and lack of transparency for international roaming, in 2005 the European Commission started monitoring international roaming prices. In a study published in 2006, the European Commission revealed that, on average, international roaming prices were four times higher than those of national mobile calls. Moreover, on average, retail charges for a roamed call were five times higher than the actual cost of providing the wholesale service (50% higher than the average inter-operator tariffs).[19] Consequently, in 2006 the European Commission launched a consultation to collect feedback on broad roaming principles and frame concepts for the roaming regulation.[20] In 2007, the first roaming regulation was implemented by the Commission.[21]

Roaming regulation in the EU was carried out in stages. After the first stage in 2007, setting wholesale and retail price limits for calls made and received while abroad ("Eurotariff"), further regulations entered into force in 2009, 2012, 2015 and 2017. Table A.1 in the Appendix provides a list of different roaming regulations. These regulations reviewed and set rules for further reductions in wholesale and retail price caps for calls, but they also introduced price caps for SMS and mobile internet. Other provisions of these regulations include automatic protections against data roaming bill shocks and structural measures aiming to foster competition on the roaming market and drive roaming prices further down. In particular, in 2013 the European Commission adopted a legislative package for building a "Connected Continent" and ultimately for creating a "Telecoms Single Market".[22] This package translated later in 2015 into the adoption of the end of roaming charges (to be applied in 2017) and the adoption of fair use policy on roaming at domestic price in 2016.[23],[24]

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[19]See: Commission Staff Working Paper SEC(2006) 925

[20]See: https://ec.europa.eu/digital-single-market/en/roaming-charges-what-has-european-commission-done-so-far

[21]Regulation (EC) No 717/2007 of the European Parliament and of the Council of 27 June 2007 on roaming on public mobile telephone networks within the Community and amending Directive 2002/21/EC

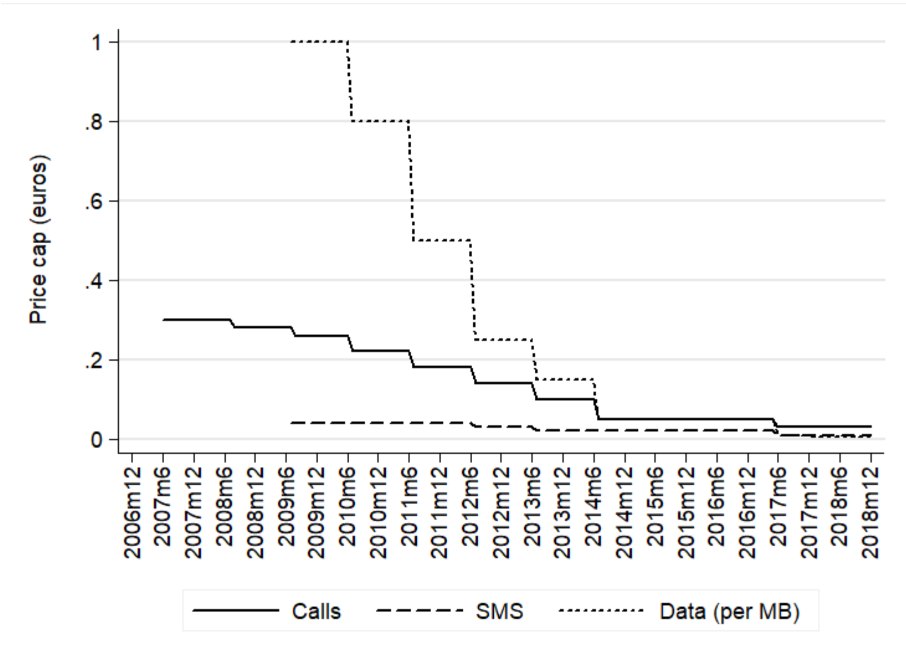
[22]See: https://ec.europa.eu/digital-single-market/en/node/67489/roaming

[23]For a chronological summary about the European Commission's actions concerning roaming charges, visit: https://ec.europa.eu/digital-single-market/en/roaming-charges-what-has-european-commission-done-so-far

[24]The fair use policy consists on limits to the use of roaming services that subscribers can consume. Those limits aim to prevent abusive or anomalous use of roaming services, which are intended only for occasional use. Note also that in 2010 the BEREC (Body of European Regulators for Electronic Communications) was created with the aim of assuming the role of "super regulator" with the mission to coordinate and advise National Regulatory Authorities (NRAs). This body

Figures 1 and 2 illustrate the evolution of Eurotariffs set by the regulation since June 2007 to December 2018 for both wholesale and retail markets. At the retail level, after ten years of regulation the price for an outgoing call went down from 0.49 Euros per minute to zero. The price for one SMS fell from 0.11 Euros in 2009 to zero after June 2017 and 1MB of data went down from a maximum of 0.70 euros in 2012 to zero after the RLAH regime entered into force.

Figure 1: Roaming regulation: Evolution of wholesale price caps



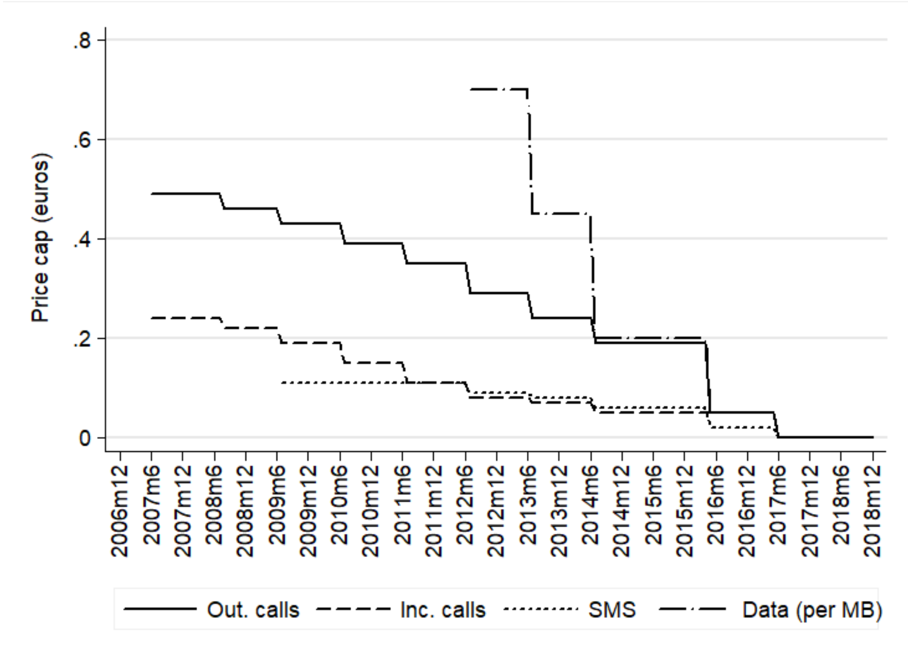
Source: Own elaboration based on EU roaming regulations (see Table A.1)

Beyond roaming regulation, telecommunications markets worldwide have been subject to regulatory intervention since the early 2000s. In particular, regulators have worried about termination rates for calls made to mobile networks. These termination rates correspond to the wholesale services telecommunication networks sell to each other to terminate calls that originate and end in different networks. Over the years, regulators have repeatedly intervene to set caps with the aim to cut these charges, which appeared to be too high to foster competition and benefit final consumers. Unlike the EU roaming regulation, which imposed the same wholesale and retail price caps to all operators within countries in the EEA, mobile termination rates (MTR) regulation has been applied at different moments in time, and with different degrees of "toughness" across and within countries.[25] In most OECD coun-

has also a right of veto over so-called important decisions taken by the NRAs.

[25] See Genakos and Valletti (2015) for a chronology of the mobile termination rate regulation

Figure 2: Roaming regulation: Evolution of retail price caps



Source: Own elaboration based on EU roaming regulations (see Table A.1)

tries, the price caps for termination rates are set on the basis of long-run incremental costs (LRIC) following bottom-up approach. This approach takes into account network design (technologies and coverage), traffic (volume, busy-hour characteristics) and cost (CAPEX, OPEX, asset lifetime).[26] Figure 3 illustrates the average decline over time of mobile termination rates for EU and other OECD countries.[27]

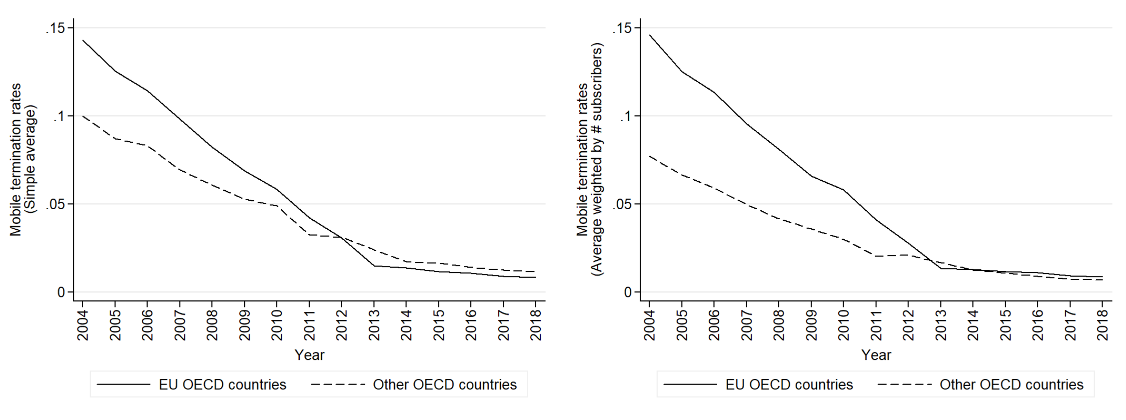
Following different waves of consolidation in the telecommunications sector, another important front of policy intervention has been merger control. In the EU, these mergers have been subject to review by the national competition authorities or by the European Commission. Table A.5 in the Appendix presents a list of mergers between mobile network operators in our sample of 33 OECD countries between 2004 and 2018. In practice, mergers alter competition in the market and may affect

on 27 OECD countries and an example of differences in caps within France.

[26]Based on the European Commission's Recommendation from 2009, MTRs should be set on a "pure LRIC" basis, i.e., reflecting the long run incremental cost exclusive of any fixed and common costs. See "Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU - Implications for Industry, Competition and Consumers (07/05/2009)".

[27]EU countries which belong to the OECD include: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom. Other OECD countries include: Australia, Canada, Chile, Israel, Japan, Mexico, New Zealand, Switzerland, Turkey, USA.

Figure 3: Evolution of Mobile Termination Rates in EU and other OECD countries (Euros)



(a) Simple average

(b) Weighted average

Source: Own elaboration based on reports from the European Commission, BEREC, OECD and mobile subscriber data from OVUM

revenues and prices of mobile network operators in different ways.

Entry into the mobile telecommunications market has been another major event changing the competitive landscape in different countries around the world. Table A.4 in the Appendix provides the date and identity of operators that entered the mobile market in countries in our sample during the period 2004 to 2018. Note that entry is not free in this market. Barriers to entry are high as the necessary infrastructure to support the services requires large investments and the allocation of spectrum is also a prerequisite.

Finally, an important development during our period of study is the granting of licenses and the subsequent deployment of 4G networks. In practice, spectrum policy is an important lever in the hands of policy makers to affect the structure of mobile markets and innovation. From the perspective of mobile network operators, while the deployment of the 4G networks creates new commercial opportunities and modifies the competitive environment, it also entails important investments putting extra pressure on their budgets. Tables A.2 and A.3 in the Appendix present the date of 4G service commercial roll-out for each operator in our database during the period 2004 to 2018.

1.3 The Data

For our analysis of revenues we matched several data sources over the period from the first quarter of 2004 to the third quarter of 2018. First, we used data from OVUM to get information on ARPU and number of subscriptions at the operator level. Second, we used data from GSMA to complement missing information on ARPU in OVUM's database. Third, we used the World Bank to gather information about population, purchasing power parities (PPP), exchange rates, Gross Domestic Product (GDP) and surface for each OECD country covered by OVUM. Fourth, from our own research on the internet we collected information about the dates of entries and mergers of mobile network operators (MNO) in each country, as well as the dates of 4G commercial service launches for each MNO in our database (see respectively Tables A.4, A.5, A.2 and A.3 in the Appendix).[28] Fifth, using reports from the European Commission, the BEREC and the OECD we gathered information about mobile termination rates (MTRs) at the country level.[29] Table 1.1 presents the number of countries and operators in our database and Table 1.2 presents summary statistics of ARPU and country level variables. Our level of observation is a country-operator-quarter.

Table 1.1: Analysis of ARPU - Number of countries and operators considered

	Total	Regulated	Non-regulated
Number of countries	33	23	10
Number of operators	111	76	35

[28]In total, there were 21 mergers in countries included in our database and during our period of study. The total number of entries is 13. Regarding 4G, all operators in our sample deployed 4G services at some point in time, except one. The average number of quarters with 4G service availability is 22.6 (in reference to a total period of 59 quarters covered by our data).

[29]The reports from the European Commission and the BEREC provide information about MTRs at the operator and country levels only concerning countries included in the European Economic Area (EEA) and Switzerland (although not always available throughout the period 2004-2018). Regarding OECD countries outside the EEA, which we use as control group in our analysis, we used two OECD reports providing information about MTRs from 2004 to 2012 and for 2014 and 2017. These reports only provide information at the country level. In order to keep our sample unchanged, we treated missing values in the following way. First, we used linear interpolation. Second, when missing values corresponded to the first years of the period we assumed that MTRs were the same as the first MTR we observe. Third, when a missing value concerned the year 2018, we assumed that the MTR was the same as in 2017. Note that information about MTRs at the operator level for OECD countries outside the EEA is not readily available from public sources. For this reason, we use information about MTRs at the country level when including this variable in some of our regressions. Also, note that Canada (from 2004 to 2014) and the US (since 2017) present MTRs equal to zero. Thus, before taking the logarithm of MTRs, which we include in our regressions, we applied a linear transformation by adding 1 to MTRs in levels.

Table 1.2: Analysis of ARPU - Summary statistics at the operator and country levels

	Obs.	Mean	Std. Dev.	Min	Max
ARPU (Euros)	6,285	22.9	11.6	2.4	68.1
ARPU (Euros PPP)	6,285	23.6	10.4	4.3	110.0
Population (in millions)	1,947	36.2	58.7	1.3	328.2
Population density	1,947	120	109	2.6	411
GDP per capita (Euros)	1,947	27,315	15,388	4,867	79,128
GDP per capita (Euros PPP)	1,947	26,480	8,876	9,194	53,413
MTR (Euros)	1,947	0.05	0.05	0.00	0.30
MTR (Euros PPP)	1,947	0.07	0.07	0.00	0.35

For our analysis of prices we matched information from three different sources over the period comprised between the first quarter of 2014 and the fourth quarter of 2017. First, we used Tarifica to get information about tariffs and plan characteristics. This information is available for several mobile plans for one mobile operator per country. In total, we count 12 OECD countries in our database (thus a total of 12 mobile operators), 6 concerned by the regulation, 6 unconcerned. Table A.9 in the Appendix presents the list of countries and operators covered in the database. Second, we used OVUM to gather information about the Herfindahl-Hirschman Index (HHI) of the mobile telecommunications market in each country. Third, we used the World Bank to collect information about population, purchasing power parities (PPP), exchange rates, GDP, surface, number of fixed broadband subscriptions and proportion of urban population for each OECD country covered by Tarifica data. Our level of observation is a country-operator-plan-quarter. Table 1.3 presents summary statistics of tariffs and characteristics of plans in our database.[30] Table 1.4 presents summary statistics at the country level.

[30] Note that 3,191 plans in our database present infinite minute allowances, 4,417 present infinite SMS allowances and 29 contain data allowances significantly greater than 100 GB, which we assume to correspond to infinite data allowance. The are 3,394 and 8,102 prepaid and postpaid plans, respectively.

Table 1.3: Analysis of Tariffs - Summary Statistics - Plan Level

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tariff (USD PPP)	11,496	60.7	81.0	0.5	790
Tariff (USD)	11,496	52.2	78.6	0.3	790
Prepaid plan	11,496	0.3	0.5	0	1
Voice included	11,496	0.6	0.5	0	1
Data validity (prepaid)	3,394	51.6	82.2	1	365
Credit value included (prepaid)	3,394	0.2	0.4	0	1
Contract length (postpaid)	8,102	10.1	9.7	1	24
Minutes allowance	8,305	154.3	312.1	0	1600
SMS allowance	7,079	54.9	186.7	0	1500
Data allowance (in GB)	11,467	7.8	15.3	0	100

Table 1.4: Analysis of Tariffs - Summary Statistics - Country Level

Variable	Obs.	Mean	Std. Dev.	Min	Max
HHI	192	0.3	0.1	0.3	0.5
Fixed Broadband (subs. per 100 people)	192	29.3	9.2	10.5	43.8
GDP per capita (USD PPP)	192	38,492	10,823	17,253	59,532
GDP per capita (USD)	192	35,162	15,603	8,450	62,328
Population Density	192	99.9	89.7	3.1	272.9
Urban (% of total population)	192	79.3	7.3	60.1	87.5

1.4 Empirical Analysis

1.4.1 Difference-in-Differences Regression

We use a difference-in-differences (DID) estimation to assess how roaming regulation impacted ARPU of mobile network operators. In the estimation, we use data for selected $i = 1, ..., N$ mobile network operators from OECD countries. We divided them into treatment and control group, where treatment group, denoted by $G_i = 1$, includes selected EU operators falling under the roaming regulation and control group, denoted by $G_i = 0$, consists of selected non-European operators we observe in the data periods before roaming regulation, $R_t = 0$, and during roaming regulation, $R_t = 1$. The estimated model can be specified as follows:

$$ln(y_{it}) = \alpha + \delta(G_i * R_t) + \eta_t + \lambda_i + \phi X_{it} + \varepsilon_{it} \tag{1.1}$$

where y_{it} is the dependent variable, ARPU, for mobile operator i in quarter t. The estimated parameters include a constant term denoted by α. The parameter of interest providing the effect of the regulation is denoted by δ. The operator and time fixed effects are denoted respectively as λ_i and η_t. ϕ denotes a vector of parameters corresponding to different control variables. Depending on the specification, control variables include: (i) GDP per capita, (ii) population density, (iii) dummy variables identifying mergers and acquisitions in the mobile market in each country, (iv) a dummy variable identifying the entry of a new mobile operator in a given country and (v) a dummy variable identifying 4G commercial roll-out period for each operator in our sample. The error term ε_{it} is assumed to be normally distributed. The DID estimator is unbiased when the model is correctly specified and the error term is uncorrelated with the other explanatory variables. In particular, there should be no correlation with $G_i \cdot R_t$, which is called common trends assumption. When common trends assumption is violated, i.e., y_{it} follows a different trend for the EU operators than for non-EU operators outside the regulation period, the DID estimator will be biased (for a discussion see Meyer (1995)).

The difference-in-differences estimator is defined as the difference in average outcome in the treatment group before and after treatment minus the difference in average outcome in the control group before and after treatment as follows:

$$\hat{\delta}_{DD} = \bar{y}_1^T - \bar{y}_0^T - (\bar{y}_1^C - \bar{y}_0^C) \tag{1.2}$$

1.4.2 Hedonic Price Regression

To assess the impact of the latest phase of the roaming regulation (RLAH) on mobile retail tariffs, we use an hedonic price regression approach.

In the first step, we estimate the impact of tariff characteristics and the interaction between country and quarterly dummy variables on the cost of tariffs, based on the following hedonic price regression:

$$y_{ict} = \alpha + \beta X_{ict} + \delta_{ck}\mathbf{I}(k = t) + u_{ict} \tag{1.3}$$

where y_{ict} denotes the list price of plan i in country c, which was available in quarter-year t. The estimated coefficients δ_{ck} of the country-time dummy variables $\mathbf{I}(k = t)$ represent the quality-adjusted price indices for each country in our sample. These coefficients are used as dependent variable in the second stage of the analysis.

The vector of tariff characteristics X_{ict} includes: (i) a dummy variable identifying plans including voice, (ii) a dummy variable identifying prepaid plans, (iii) an interaction variable identifying plans including voice that are prepaid, (iv) dummy variables for prepaid data validity (in number of days: less than 15, 15 to 29, 30 to 59, 60 to 180 and equal or greater than 180), (v) dummy variables for postpaid plans contract length (in number of months: 1, 6, 12, 18, 24), (vi) a dummy variable for credit value greater than zero of prepaid plans, (vii) dummy variables for minutes allowances (in number of minutes: greater than zero to 50, 51 to 100, 101 to 150, 151 to 200, 201 to 300, 301 to 400, 401 to 500, 501 to 1600, greater than 1600), (viii) dummy variables for message allowances (in number of SMS: 1 to 50, 51 to 100, 101 to 200, 201, to 250, 251 to 500, 501 to 750, 751 to 1000, 1001 to 1500, greater than 1500), and (ix) dummy variables for data allowance (in GB: 0.01 to 0.249, 0.25 to 0.49, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 to 12, 13 to 15, 15 to 19, 20 to 24, 25 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 99 and equal or greater than 100). The normally distributed error term is denoted by u_{ict}, and the vector of coefficients $\gamma = (\alpha, \beta, \delta)$ is estimated using ordinary least squares (OLS).

In the second step, we regress the quality-adjusted price index for each country δ_{ct} on a set of competition, regulation and socio-demographic variables. We use a difference-in-differences approach, as follows:

$$\delta_{ct} = \gamma + \theta Z_{ct} + \lambda(G_c * RLAH_t) + \beta_c + \eta_t + \varepsilon_{ct} \tag{1.4}$$

where Z_{ct} denotes a set country-level control variables, including: (i) the Herfindahl-Hirschman Index for the mobile market (HHI), (ii) the number of fixed broadband subscriptions per 100 people, (iii) GDP per capita and (iv) population density. The share of urban population is also included in the analysis instead of population density in an alternative specification. G_c is an indicator variable denoting the group of regulated countries in our sample, $RLAH_t$ is an indicator variable of the last phase of the regulation, β_c is a vector of country fixed effects and η_t is a vector of quarter-year fixed effects. The parameter of interest providing the effect of the last phase of the regulation on tariffs is denoted by λ. Finally, ε_t is normally distributed error term.

1.5 Estimation Results

1.5.1 Analysis of Revenues

Results from our baseline model (1.1) are reported in Table 1.5. Columns (1) to (3) present the results from our main specifications when the dependent variable is the logarithm of mobile network operators' ARPU in Euros. As a robustness check, columns (4) to (6) present the results for specifications where the dependent variable is the logarithm of mobile network operators' ARPU in Euros PPP.

In columns (1) and (4) no control variables are included in the estimation except for time and operator fixed effects. Columns (2) and (5) take into account the effect of mergers and acquisitions on operators' ARPU. Columns (3) and (6) report the results including as additional control variables the logarithm of GDP per capita, the logarithm of population density, a dummy variable for the commercial roll-out of 4G services and a dummy variable for the entry of a new mobile operator in a given country. In all 6 specifications we find a negative and statistically significant effect of the regulation on operators' ARPU. This effect is comprised between -9.3% and -20% depending on the specification.[31] GDP per capita, as can be expected, has a positive and significant impact on operators' ARPU. The effect of entry of a new mobile operator in a country on operators' ARPU is negative as expected, but it is only significant in the specification considering ARPU in Euros PPP as dependent variable. Population density and 4G commercial rollout do not appear to have any statistically significant impact on operators ARPU on average.

To explore potential differentiated effects throughout the more than ten years of regulation, we distinguish the effect of different phases of the regulation in alternative specifications. Based on the entry into force dates of the different regulations adopted since 2007 and on the scheduled decreases of wholesale and retail tariffs, we define the following 5 phases: (1) from the fourth quarter of 2007 to the third quarter of 2009, (2) from the fourth quarter of 2009 to the second quarter of 2012, (3) from the third quarter of 2012 to the second quarter of 2014, (4) from the third quarter of 2014 to the second quarter of 2017 and (5) from the third quarter of 2017

[31] We translate the effects into percentage terms by applying the formula: $exp(\delta) - 1$.

Table 1.5: OLS estimates of the impact of the EU roaming regulation on operators' Average Revenues per User - Entire regulation period

Dep. Variable	Log(ARPU euros)			Log(ARPU euros PPP)		
	(1)	(2)	(3)	(4)	(5)	(6)
Did regu since 2007q4	-0.224***	-0.183***	-0.135***	-0.134**	-0.113*	-0.0981**
	(0.0523)	(0.0572)	(0.0477)	(0.0555)	(0.0648)	(0.0482)
Log (GDP per capita)			0.479***			0.413*
			(0.111)			(0.211)
Log(Population Density)			0.0985			0.0868
			(0.357)			(0.373)
Entry			-0.0771			-0.121*
			(0.0619)			(0.0700)
4G Commercial Rollout			-0.00581			-0.0146
			(0.0245)			(0.0231)
Constant	3.262***	3.262***	-1.838	3.427***	3.426***	-1.044
	(0.0263)	(0.0255)	(1.947)	(0.0272)	(0.0268)	(2.835)
Mergers		Yes	Yes		Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Operator Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,285	6,285	6,285	6,285	6,285	6,285
R-squared	0.551	0.589	0.619	0.637	0.653	0.667
Number of operators	111	111	111	111	111	111

Notes: Robust standard errors are in parenthesis. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

onwards.[32] DID coefficients are reported with respect to the period prior to the first phase of the regulation (i.e., from the first quarter of 2004 to the third quarter of 2007).

Table 1.6 reports our DID results from specification equation (1.1), considering the different phases of the regulation. Different specifications are reported in the same order as in the previous table. Regarding operators' ARPU in Euros (columns (1) to (3) in Table 1.6), although the coefficients have a negative sign, the regulation does not appear to have any statistically significant effect during its first phase (fourth quarter of 2007 to third quarter of 2009). On the contrary, for the subsequent four periods we find a negative and statistically significant effect of the regulation. This effect appears to be gradual, except for the last period (third quarter of 2017 onwards) for which coefficients are negative and statistically significant, but smaller in absolute terms with respect to the coefficients corresponding to the previous period.

Results regarding operators' ARPU in Euros PPP are qualitatively similar. In column (4), where no control variables other that time and operators fixed effects are considered, we find a negative and statistically significant effect of the first four periods of the regulation on operators' ARPU, and no statistically significant effect during the last period. This effect appears to be gradual. In column (5), where we also take into account the effect of mergers and acquisitions on operators' ARPU, the regulation seems to have significantly decreased regulated operators' ARPU only during its second and third periods. In column (6), which reports the results including as additional control variables the logarithm of GDP per capita in Euros PPP, the logarithm of population density, a dummy variable for the commercial roll-out of 4G services of each operator and a dummy variable for the entry of a new mobile operator in a given country, we find a negative and significant effect of the second, third and fourth periods of the regulation on operators' ARPU, and no significant effect during the first and last periods.

Our results suggest that roaming regulations decreased mobile operators' ARPU over the period between the fourth quarter of 2007 and the third quarter of 2018, in particular during the second, third and fourth periods of the regulation. The

[32] See Figures 1 and 2 and Table A.1 in the Appendix.

average effect of the regulation on EU mobile operators' ARPU in Euros is -12.6% and on ARPU in Euros PPP is -9.3%, when considering the specification including all control variables in the regression. The absence of effect during the first phase of the regulation can be explained by the fact that it only concerned voice services. The most stringent measures of the regulation related to data services began in 2009 and 2012, for wholesale and retail price caps respectively, while price caps on voice and SMS services continued to decrease gradually. The absence or lower magnitude of the effect during the last phase of the regulation may imply a different story. In line with a waterbed effect mechanism, mobile operators might have adapted their behavior during this period. In particular, mobile operators might have increased domestic mobile retail tariffs. This possibility makes it relevant to look at the impact of the RLAH regulation on mobile operators' tariffs, which we do in Section 1.5.2. Another possibility is a change in consumer behavior since the RLAH regulation. Different reports published by the European Commission after the implementation of the RLAH regime reveal a rapid and massive increase in roaming consumption in the EU/EEA after 15 June 2017.[33] In this context, subscribers might purchase extra data or upgrade to plans with more allowances, thus increasing revenues per user of mobile operators in the EU with respect to the period preceding RLAH.

The key identifying assumption of the DID estimation method is that had the regulation not been implemented, ARPU of regulated and non-regulated operators would have, conditional on the control variables included in the regression, followed the same evolution. Figure A.2 in the Appendix represents the evolution of average residuals from the estimation of equation (1.1) in the group of regulated and non-regulated countries over time, for ARPU in Euros and ARPU in Euros PPP.[34] It shows that both groups follow parallel trends prior to the regulation. During the first phase of the regulation, both groups seem to continue the same trend, but at some point the trends differ and even inverse.

We further verify whether the parallel trends assumption is satisfied by running a

[33] See for example the Report From the Commission to the European Parliament and the Council on the review of the roaming market of 29 November 2019, p. 6.

[34] Average residuals by group are reported based on the estimation including as control variables: GDP per capita, population density, dummy variables identifying mergers and acquisitions in the mobile market in each country, a dummy variable identifying the entry of a new mobile operator in a given country and a dummy variable identifying 4G commercial roll-out period for each operator in our sample.

Table 1.6: OLS estimates of the impact of the EU roaming regulation on operators' Average Revenues per User - Five regulation periods

Dep. Variable	Log(ARPU euros)			Log(ARPU euros PPP)		
	(1)	(2)	(3)	(4)	(5)	(6)
Did regu 2007q4-2009q3	-0.0320	-0.0251	-0.0435	-0.0736**	-0.0609	-0.0554
	(0.0364)	(0.0395)	(0.0356)	(0.0333)	(0.0367)	(0.0354)
Did regu 2009q4-2012q2	-0.223***	-0.189***	-0.155***	-0.125***	-0.0986*	-0.0907*
	(0.0483)	(0.0530)	(0.0510)	(0.0456)	(0.0541)	(0.0470)
Did regu 2012q3-2014q2	-0.309***	-0.265***	-0.225***	-0.187***	-0.153**	-0.146**
	(0.0625)	(0.0718)	(0.0670)	(0.0637)	(0.0769)	(0.0633)
Did regu 2014q3-2017q2	-0.311***	-0.270***	-0.238***	-0.167**	-0.155	-0.156**
	(0.0691)	(0.0797)	(0.0763)	(0.0772)	(0.0957)	(0.0777)
Did regu since 2017q3	-0.207***	-0.182**	-0.166**	-0.0909	-0.0942	-0.100
	(0.0764)	(0.0849)	(0.0816)	(0.0879)	(0.109)	(0.0873)
Log (GDP pc PPP)			0.391***			0.377*
			(0.116)			(0.210)
Log(Population Density)			-0.169			-0.0540
			(0.337)			(0.361)
Entry			-0.0757			-0.125*
			(0.0620)			(0.0706)
4G Commercial Rollout			-0.00207			-0.0132
			(0.0236)			(0.0228)
Constant	3.263***	3.262***	0.146	3.427***	3.426***	-0.0991
	(0.0263)	(0.0255)	(1.912)	(0.0272)	(0.0268)	(2.796)
Mergers		Yes	Yes		Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Operator Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,285	6,285	6,285	6,285	6,285	6,285
R-squared	0.576	0.607	0.628	0.641	0.655	0.669
Number of operators	111	111	111	111	111	111

Notes: Robust standard errors are in parenthesis. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

placebo test, as suggested by Autor (2003). The test consists in introducing placebo treatments in the estimation equation at all periods except one. The following equation is estimated:

$$ln(y_{it}) = \alpha + \sum_{j \neq 2006q4-2007q3} \delta_j (G_i \cdot I(t=j)) + \eta_t + \lambda_i + \phi X_{it} + \varepsilon_{it} \qquad (1.5)$$

where as before y_{it} represents ARPU for mobile operator i in quarter t. G_i represents the group of regulated countries, η_t are time-specific dummies, λ_i are operator specific fixed effects, X_{it} is a vector including the same set of control variables as in equation (1.1), and ε_{it} is the error term. The sum includes time dummies for all periods, except the year just before the entry into force of the first phase of the regulation (from 2006q4 to 2007q3). In equation (1.5), all coefficients δ_j with j preceding the last period before the regulation (from 2006q4 to 2007q3) are placebo tests for whether the regulation had an effect on ARPU between the two groups of countries prior to the regulation, which by definition should not be the case.

The estimated coefficients δ_j are plotted in Figure A.3 in the Appendix for both ARPU in Euros and ARPU in Euros PPP. They suggest that there is no difference between the two groups before the regulation. None of the coefficients for periods preceding the entry into force of the regulation are significant (at 5% significance level), which confirms the parallel trends assumption. We note that after its first phase, the regulation decreased mobile operators' ARPU gradually, except for the last phase. This is consistent with a step-wise decrease in the wholesale and retail caps set by the regulation (see Figures 1 and 2 in section 1.2).

As a robustness test, Table A.7 in the Appendix presents the OLS results of the same specifications from Table 1.5, including as additional control variable mobile termination rates (MTR) at the country level.[35] In practice, MTRs constituted an important front of regulatory intervention in the telecommunications market, in particular during the decade of the 2000s and the beginning of the 2010s, which

[35] MTRs at the operator level are available for mobile operators belonging to EU countries from reports published by the European Commission and the BEREC. Nonetheless, to our knowledge, this information is not publicly available at the operator level for other OECD countries outside the EU. We have thus considered average MTRs at the country level as reported by the European Commission, the BEREC and the OECD.

could explain part of the decrease in ARPU which we observe.[36] In general, there is a decreasing trend of MTRs in most of the OECD countries in our analysis, but with a different magnitude, which could explain differences in ARPU's evolution in the group of regulated and non-regulated countries.

When including MTRs in our regressions, in four out of six specifications, the coefficient representing the effect of the EU roaming regulation is negative and statistically significant (columns 1 to 4 in Table A.7). In the remaining two specifications, which consider ARPU in Euros PPP as dependent variable, the coefficient is negative but non-statistically significant (columns 5 and 6 in Table A.7). Note that how to consider the effect of MTR regulation on revenues during the period 2004-2018 is not a straightforward endeavour. First, systematic information about MTRs at the operator level is not readily available for operators in OECD countries outside the EU. This data availability limitation constraints us to use information at the country level. Second, the share of MNO's revenues from data services has increased sharply during the period. This suggests that the impact of MTR regulation on revenues, if ever existent, should be decreasing over time as it only concerns voice services (see Figure A.4 in the Appendix). After reminding the need for caution when analyzing the effect of MTR regulation on revenues during the 2004-2018 period, we consider that these results are in line with the negative and statistically significant effect of the EU roaming regulation in our main specifications.

Beyond MTR regulation, there might be very different regulatory trends across OECD countries in our analysis regarding other intervention fronts (e.g, cost of capital, universal services, access regulation, etc.) affecting the costs of providing mobile services. Such differentiated trends could also explain differences in the evolution of mobile operators' ARPU in EEA countries relative to those in OECD countries outside the EEA. As an additional robustness test, Table A.8 in the Appendix presents the OLS results of the same specifications from Table 1.5, including as additional control variable an index of product market regulation (PMR) specific to the telecommunications sector.[37] The OECD PMR indicators are, to the best of our

[36] For instance, at the European level, the average MTR decreased by 86% between January 2004 and January 2014 (from around 14 to 2 euro-cents). Calculations based on: BEREC, BoR (19) 91, Termination rates at the European level, January 2019.

[37] Sector specific PMR indicators measure countries' regulatory stance and track reform progress over time. In particular, they measure the regulatory barriers to firm entry and

knowledge, the only regulatory indicators specific to the telecommunications sector providing sufficient historic data to carry-out our difference-in-differences analysis. However, they do not include information about three countries in our sample: USA, Latvia and Lithuania. We are thus forced to exclude them from the test. In all 6 specifications from Table A.8, we find a negative and statistically significant effect of the regulation on operators' ARPU, similar in magnitude to the coefficients on Table 1.5. We believe these results are not driven by the exclusion of USA, Latvia and Lithuania from the sample. Very similar results hold when estimating the specifications on Table 1.5 without the PMR index and using the restricted sample.[38]

Finally, we also test for differences in the effect of the regulation for incumbent relative to non-incumbent operators and for big operators relative to small ones. The results suggest that there is no specific effect in neither case. Moreover, we checked whether mobile operators in countries with higher tourism flows were more or less impacted by the regulation. The results suggest that operators in countries with a higher number of departures per capita within the group of regulated countries have a higher ARPU during the regulation period. This result is consistent with a particular decrease in roaming wholesale expenditure in countries with a high proportion of departures per capita in the EU. On the contrary, operators in countries with a higher number of net arrivals per capita within the group of regulated countries have a particularly lower ARPU during the regulation period. This result could be explained by roaming wholesale revenues that decrease relatively more in those countries due to the regulation.[39]

1.5.2 Analysis of Tariffs

Table 1.7 reports the OLS results from our hedonic price model (1.3), using as dependent variables tariffs in US dollars (column 1) and tariffs in US dollars PPP (column 2). The coefficient of the dummy variable for the presence of voice minutes in the tariff plan is positive and statistically significant, which implies that plans in-

competition at the level of individual sectors. We use the index for "E-communications" within the "Network Sector PMR indicators – Time series" produced by the OECD. See: https://www.oecd.org/economy/reform/indicators-of-product-market-regulation/. Other indicators of regulatory activity or intensity exist (e.g., "ICT Regulatory Tracker" by the ITU). However, to the best of our knowledge, no other indicator covers a sufficiently long period as the one needed for our difference-in-differences analysis.

[38] These results are not reported here due tu space constraints, but are available upon request.

[39] The table results corresponding to this last set of tests are not reported here due to space constraints, but are available upon request.

cluding voice are more expensive. The coefficient of the dummy variable for prepaid plans is negative but not significant for tariffs in USD and statistically significant at the 10% level for tariffs in USD PPP. Nonetheless, the coefficient of the interaction term identifying prepaid plans with voice included is negative and significant, which indicates that prepaid plans including voice are cheaper than postpaid plans including voice. Almost all coefficients for dummy variables for prepaid plans, which identify different number of days of data validity are positive but non statistically significant. Only the coefficient for data validity greater than 180 days is positive and significant for both tariffs in USD and USD PPP, which indicates that prepaid plans with validity of more than 180 days are more expensive. Prepaid plans which include credit are also more expensive than those without credit.

Regarding postpaid plans, contract length does not seem to influence in a monotonic way the price of tariff plans. The coefficients of dummy variables identifying different minute allowances are almost all non-statistically significant, except for allowance between 500 and 1600 minutes, which is positive and statistically significant. Also, tariff plans with infinite minute allowances do not appear to be more expensive. The majority of coefficients for different SMS allowances are non-statistically significant. Not surprisingly, this suggests that the inclusion of more or less SMS allowances does not affect the price of tariff plans. Finally, as expected, prices increase gradually with the inclusion of greater data allowances. In particular, coefficients identifying data allowances above 1GB are all positive and statistically significant. Thus, data allowance is the main factor which impacts the price of tariff plans.

Figure 4 illustrates the evolution of country-quarter interaction dummies from our hedonic regression in Table 1.7, which represent the quality-adjusted price indices for each country in our sample. We use them as dependent variables in the second stage of our analysis.[40]

[40] The quality-adjusted price indices shown in this figure correspond to the regression based on tariff plans in USD. They are very similar to those obtained from the regression based on tariff plans in USD PPP.

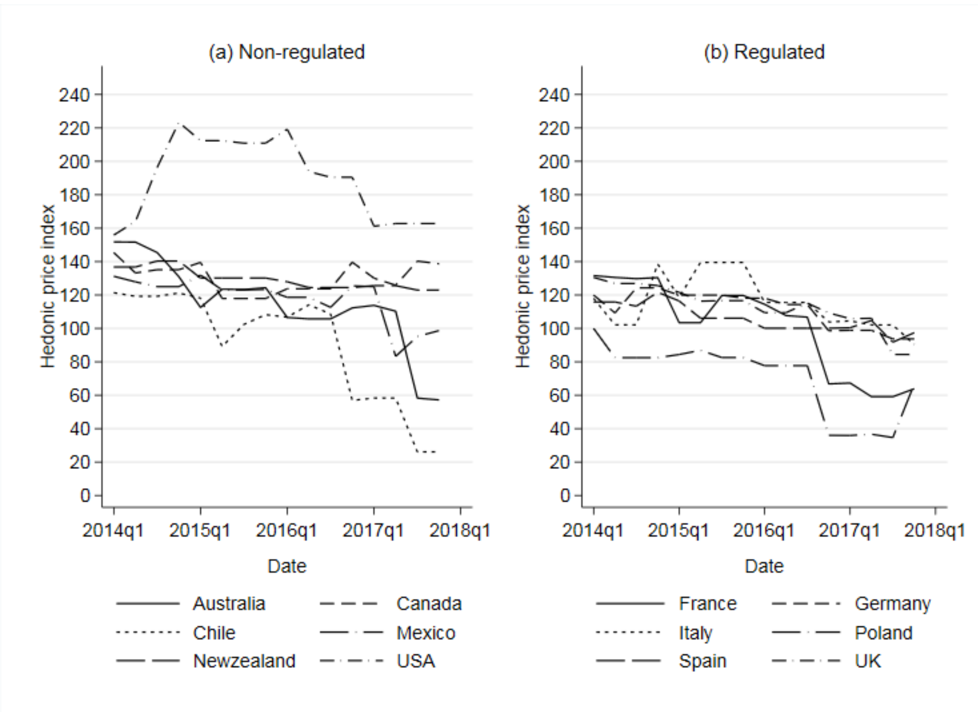
Table 1.7: OLS estimates of Hedonic Price Regression for All Tariffs

	(1)		(2)	
Dep. Variable	Tariff USD		Tariff USD PPP	
Voice	27.69***	(7.521)	29.55***	(8.358)
Voice * Prepaid	-17.16***	(6.093)	-16.09**	(6.652)
Prepaid	-8.705	(7.516)	-17.09*	(8.957)
Prepaid data validity (days)				
PrepaidV [15,30)	6.355	(7.949)	8.670	(8.730)
PrepaidV [30,60)	6.546	(4.647)	12.61**	(5.601)
PrepaidV [60,180)	7.574	(10.63)	15.01	(11.03)
PrepaidV (>180]	52.44***	(11.95)	61.14***	(13.39)
Postpaid contract length (months)				
PostL 6	-10.12*	(5.418)	-18.47**	(6.986)
PostL 12	-1.650	(2.537)	-0.116	(2.995)
PostL 18	0.982	(2.364)	5.620**	(2.571)
PostL 24	2.584	(3.100)	1.552	(3.287)
Credit included	24.05***	(7.871)	25.85***	(8.484)
Minutes allowance				
Minutes (0,50]	-7.599*	(4.260)	-5.232	(4.898)
Minutes (50,100]	-3.297	(5.350)	-4.021	(5.410)
Minutes (100,150]	-5.786	(4.414)	-5.458	(4.925)
Minutes (150,200]	-2.118	(4.131)	-3.278	(4.816)
Minutes (200,300]	-0.969	(5.118)	0.239	(5.775)
Minutes (300,400]	-0.896	(6.199)	-2.301	(7.617)
Minutes (400,500]	4.641	(4.419)	6.900	(5.476)
Minutes (500,1600]	16.77***	(4.674)	26.44***	(6.505)
Minutes (>1600)	5.199	(5.005)	6.949	(5.301)
SMS allowance				
SMS (0,50]	-8.206	(6.252)	-4.719	(9.155)
SMS (50,100]	-9.897	(6.780)	-16.12*	(8.652)
SMS (100,200]	1.575	(8.543)	-1.317	(11.35)
SMS (200,250]	-6.585	(6.507)	-4.584	(8.761)
SMS (250,500]	-7.429	(8.253)	-7.109	(11.65)
SMS (500,750]	-14.64**	(6.379)	-16.49**	(7.498)
SMS (750,1000]	-5.238	(5.787)	0.110	(6.691)
SMS (1000,1500]	-1.035	(4.752)	11.46	(9.793)
SMS (>1500]	-8.646	(5.626)	-7.150	(7.353)
Data allowance (GB)				
Data [0.01,0.25)	8.534**	(3.705)	11.65**	(5.334)
Data [0.25,0.5)	5.121	(3.420)	7.427*	(3.891)
Data [0.5,1)	5.183	(4.296)	-0.175	(4.581)
Data [1,2)	8.667**	(3.260)	9.340**	(3.754)
Data [2,3)	14.63***	(4.085)	18.20***	(4.382)
Data [3,4)	22.13***	(3.956)	28.09***	(6.252)
Data [4,5)	17.00**	(6.421)	22.85***	(7.276)
Data [5,6)	33.59***	(4.886)	39.72***	(6.027)
Data [6,7)	28.99***	(6.441)	39.49***	(7.772)
Data [7,8)	41.57***	(5.887)	46.69***	(5.480)

Dep. Variable	(1) Tariff USD		(2) Tariff USD PPP	
Data [8,9)	33.42***	(6.185)	45.02***	(8.814)
Data [9,10)	47.43***	(9.133)	62.52***	(6.058)
Data [10,11)	46.52***	(4.078)	57.18***	(5.903)
Data [11,13)	38.71***	(7.830)	52.80***	(11.63)
Data [13,15)	39.54***	(10.73)	58.97***	(15.89)
Data [15,20)	46.00***	(6.555)	54.58***	(7.196)
Data [20,25)	56.80***	(5.599)	64.58***	(6.743)
Data [25,30)	56.94***	(8.565)	67.98***	(9.219)
Data [30,40)	86.78***	(14.76)	96.96***	(15.22)
Data [40,50)	111.1***	(24.37)	120.2***	(24.17)
Data [50,60)	157.9***	(33.82)	171.0***	(32.87)
Data [60,100)	282.1***	(52.26)	291.9***	(51.61)
Data (>100]	262.8**	(103.1)	268.7**	(104.0)
Constant	-13.61	(10.82)	-3.695	(12.46)
Country-quarter dummies	Yes		Yes	
Observations	11,496		11,496	
R-squared	0.647		0.633	

Notes: Clustered standard errors at the country-year level are in parenthesis. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Figure 4: Quarterly Coefficients for All Tariffs - Quality-Adjusted Price Index by Country



The results from the second stage of our price analysis, which correspond to estimating equation (1.4), are reported in Table 1.8 for tariff plans in USD and USD

PPP, respectively. In columns (1) and (4) no control variables are included in the estimation except for quarter and country fixed effects. Columns (2) and (5) present the results of regressions which take into account HHI, fixed broadband penetration (fixed broadband subscriptions per 100 people), GDP per capita and population density as control variables. Columns (3) and (6) report the results of the regressions including the same control variables, except for population density which is replaced by the proportion of urban population in the country. We find that the coefficients corresponding to our measure of concentration (HHI) are positive and statistically significant. The coefficients for fixed broadband penetration are non-statistically significant. The coefficients of GDP per capita and population density are positive and statistically significant. The proportion of urban population presents positive coefficients, but it is only statistically significant when considering tariffs in USD PPP. Finally, the interaction term on RLAH, which identifies the effect of the last phase of the regulation on quality-adjusted prices, is positive but non-statistically significant in all the specifications. This result suggests that quality-adjusted prices in selected EU countries did not change after the latest phase of the roaming regulation.

This final result suggests that the potential negative distributional effects of RLAH feared by policy makers have not materialized. Moreover, it seems in line with the idea that the fair use policy and sustainability derogation rules introduced with the RLAH regime have adequately worked as safeguards to avoid distortions on domestic markets. The fair use policy aims at ensuring that roaming at domestic prices is not used permanently, only when periodically travelling in the EEA. For this purpose, mobile operators can set limits to the use of roaming services.[41] A sustainability derogation consists of an exceptional permission granted to the operator by

[41] A mobile operator may ask its customers for a proof of residence in, or stable link with, the EEA country where it provides services and issues the SIM card to be used at domestic prices when travelling abroad. An operator may also check that the SIM card is used more in its home Member State than abroad. If such a fair use policy is applied and, during a time window of at least four months, the customer has roaming consumption prevailing over domestic consumption, the operator has to alert the customer to verify whether there is any abusive or anomalous use of roaming services at domestic prices. After a period of 14 days or more, from the date of the alert, the operator may apply small roaming surcharges linked to the wholesale price caps if the customer continues to consume mobile services abroad. Operators may also apply a volume safeguard on roaming data consumed at domestic prices. Beyond that volume, the operator may apply a small roaming surcharge not exceeding the wholesale roaming price cap on data. The main objective is to allow for the continuous development of the best data offers, in particular unlimited data allowances plans. See: Commission Staff Working Paper SWD(2019) 288 final, page 3.

its national regulatory authority (NRA) to apply surcharges for roaming services.[42]

Table 1.8: OLS estimates of the impact of the RLAH phase of EU roaming regulation on tariffs

	Tariff USD			Tariff USD PPP		
	(1)	(2)	(3)	(4)	(5)	(6)
Did RLAH	5.856	3.107	4.564	5.576	0.348	1.292
	(5.334)	(4.794)	(5.830)	(5.209)	(5.390)	(5.514)
HHI		281.9***	239.1***		284***	235.2***
		(62.652)	(62.184)		(59.718)	(68.591)
Fixed Broadband (subs. per 100 people)		0.616	0.955		-0.757	-1.205
		(1.809)	(1.732)		(1.714)	(1.779)
GDP per capita		1.656***	1.46***		3.045***	3.267***
		(0.381)	(0.318)		(1.021)	(0.862)
Population Density		2.326***			2.312***	
		(0.612)			(0.582)	
Urban (% of population)			1.472			8.830*
			(4.117)			(4.734)
Constant	84.09***	-312***	-105.3	81.94***	-341.7***	-572.1**
	(5.491)	(90.925)	(241.703)	(6.936)	(83.533)	(278.093)
Quarter Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	192	192	192	192	192	192
R-squared	0.837	0.850	0.848	0.793	0.808	0.807

Notes: Bootstrap standard errors in parenthesis (100 repetitions). Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

[42]This provision is exceptional and only applies in specific circumstances. The main objective is to avoid domestic price increases. For this purpose, the operator must demonstrate that the provision of roaming services without the application of a surcharge would not be sustainable with its current domestic charging model. In that case, the National Regulation Authority may authorize the operator to apply a small roaming surcharge for one year. In order to prolong such an authorization, the operator must renew its application yearly. See: Commission Staff Working Paper SWD(2019) 288 final, pages 3 and 4.

1.6 Conclusion

Using detailed operator and tariff plan-level data, we assess the impact of EU roaming regulation on the average revenue per user and on the quality adjusted prices set by mobile network operators. The EU roaming regulation has been an important effort for pursuing the consolidation of a digital single market in the EU, whose impact and potential unintended consequences have been debated since its beginning.

Our results suggest that ARPU of EU mobile network operators has decreased by 12.6% since 2007 due to the regulation (over a period of ten years). When considering power purchasing parities, the decline of ARPU is quantified at 9.3%. Although a possible waterbed effect could have prompted mobile network operators to increase their domestic retail tariff plans after the RLAH regime entered into force, we find no evidence of such response.

Our results entail important policy implications, especially in the context of the proposed extension of the current regulatory regime, which is due to expire in June 2022. First, they suggest that in its quest for substantially reducing international roaming charges in the EU and promoting greater use of roaming services, the European Commission has succeeded to avoid unintended increases in domestic tariffs. This means that, at least up to some extent, the potential negative distributional effects of RLAH pointed out by BEREC in 2014 do not seem to have materialized. Moreover, this suggests that the fair use policy and sustainability derogation rules have adequately worked as safeguards to avoid distortions on domestic markets, as foreseen by the regulation and argued in several reports.[43] Second, our results suggest that mobile network operators have absorbed the effects of the regulation and have seen their revenues per user decrease over the course of the regulation period. An important consideration is that the observed decrease in ARPU could have translated into a decrease in mobile operators' profits, which we cannot verify due to limited data on profits.[44] The risks of such potential effect include lowering the quality of mobile operators' offers and reducing incentives to invest. Regarding the former, qualitative studies suggest that overall, the availability of operators'

[43]See: Commission Staff Working Paper SWD(2019) 288 final.

[44]The reason why we do not address this question directly is that information about mobile operators' profits is scarcer and less complete than information about revenues.

tariff plans and their domestic tariff structures have been largely unchanged after the regulation.[45] As regards to the latter, to our knowledge no formal studies exist and there is no sufficient evidence allowing to conclude on this.

Thus, to balance the short-run benefits of the EU roaming regulation with its long-run consequences, the extent to which the regulation has affected mobile operators' incentives to provide high quality offers and to invest in their networks is an important question that is worth the attention of policy makers. Likewise, due to significant differences across Member States in travel and consumption patterns, as well as in mobile operators' cost structures, it is imperative to assess whether the regulation has introduced any distortions across the EU countries. Finally, the assessment of welfare effects of roaming regulation and how it is distributed across Member States is an interesting avenue of further research, which we do not address here due to lack of detailed information about demand for roaming services.

[45] See: Commission Staff Working Paper SWD(2019) 288 final.

Appendices

A1 Additional Tables and Figures

Table A.1: EU Roaming Regulations

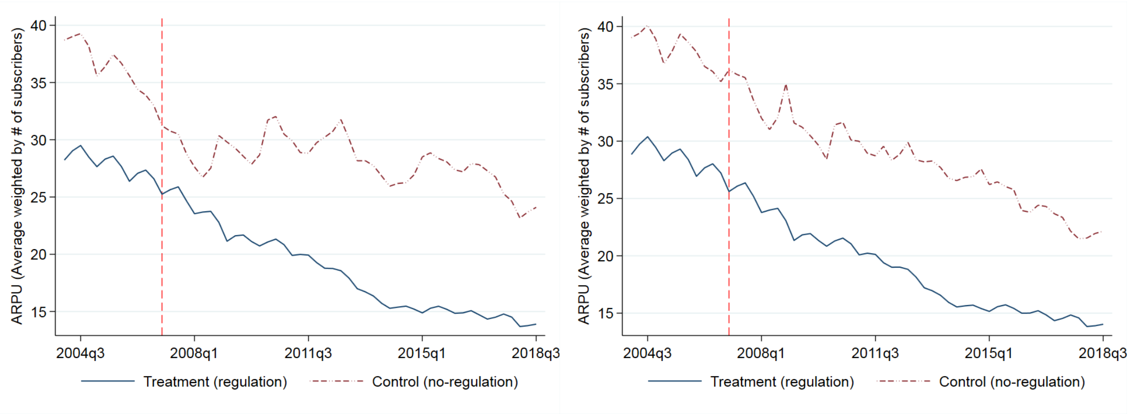
Title and reference	Date of document	Date of effect
Regulation (EC) No 717/2007 of the European Parliament and of the Council of 27 June 2007 on roaming on public mobile telephone networks within the Community and amending Directive 2002/21/EC	27/06/2007	30/06/2007
Regulation (EC) No 544/2009 of the European Parliament and of the Council of 18 June 2009 amending Regulation (EC) No 717/2007 on roaming on public mobile telephone networks within the Community and Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services	18/06/2009	02/07/2009
Regulation (EU) No 531/2012 of the European Parliament and of the Council of 13 June 2012 on roaming on public mobile communications networks within the Union Text with EEA relevance	13/06/2012	01/07/2012
Regulation (EU) 2015/2120 of the European Parliament and of the Council of 25 November 2015 laying down measures concerning open internet access and amending Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services and Regulation (EU) No 531/2012 on roaming on public mobile communications networks within the Union (Text with EEA relevance)	25/11/2015	29/11/2015
Commission Implementing Regulation (EU) 2016/2286 of 15 December 2016 laying down detailed rules on the application of fair use policy and on the methodology for assessing the sustainability of the abolition of retail roaming surcharges and on the application to be submitted by a roaming provider for the purposes of that assessment (Text with EEA relevance)	15/12/2016	17/12/2016
Regulation (EU) 2017/920 of the European Parliament and of the Council of 17 May 2017 amending Regulation (EU) No 531/2012 as regards rules for wholesale roaming markets	17/05/2017	12/06/2017

Table A.2: Analysis of ARPU: List of treated countries and mobile network operators with respective 4G commercial launch dates

Country	Operator	4G commercial launch date	4G Quarter of effect
Austria	A1 Telekom Austria	November 2010	2010Q4
	Hutchison 3G Austria	November 2014	2014Q4
	Orange Austria	November 2014 (acq. by 3)	2014Q4
	T-Mobile Austria	July 2011	2011Q3
Belgium	Orange Belgium	March 2014	2014Q2
	Proximus Belgium	November 2012	2012Q4
	Telenet	October 2013	2013Q4
Czech Republic	O2 Czech Republic	June 2012	2012Q4
	T-Mobile Czech Republic	October 2013	2013Q4
	Vodafone Czech Republic	December 2013	2014Q1
Denmark	HI3G Denmark	September 2012	2012Q4
	TDC Mobil	October 2011	2011Q4
	Telenor Denmark	March 2013	2013Q2
	Telia Denmark	December 2010	2011Q1
Estonia	EMT Estonia	December 2010	2011Q1
	Elisa Estonia	February 2013	2013Q1
	Tele2 Estonia	November 2012	2012Q4
Finland	DNA Finland	December 2011	2012Q1
	Elisa Finland	December 2010	2011Q1
	Telia Company Finland	November 2010	2010Q4
France	Bouygues Telecom	October 2013	2013Q4
	Numericable-SFR	November 2012	2012Q4
	Orange France	April 2013	2013Q2
Germany	E-Plus	March 2014	2014Q2
	O2 Germany	July 2011	2011Q3
	T-Mobile Germany	April 2011	2011Q2
	Vodafone D2	December 2010	2011Q1
Greece	Cosmote	November 2012	2012Q4
	Vodafone Greece	June 2013	2013Q3
	WIND Hellas	March 2015	2015Q2
Hungary	T-Mobile Hungary	January 2012	2012Q1
	Telenor Hungary	July 2012	2012Q3
	Vodafone Hungary	November 2014	2014Q4
Ireland	O2 Ireland	June 2015	2015Q3
	Three Ireland (Hutchison)	September 2013	2013Q4
	Vodafone Ireland	October 2013	2013Q4
	eir Mobile	September 2013	2013Q4
Italy	Iliad Italy	May 2018	2018Q2
	Telecom Italia	November 2012	2012Q4
	Vodafone Italia	November 2012	2012Q4
	Wind	January 2014	2014Q1
	Wind Tre	January 2014	2014Q1
Latvia	Bite Latvia	May 2015	2015Q2
	LMT	May 2011	2011Q2
	Tele2 Latvia	December 2013	2014Q1
	Telekom Baltija	Non available	
Lithuania	Bite Lithuania	April 2015	2015Q2
	Omnitel	April 2011	2011Q2
	Tele2 Lithuania	March 2013	2013Q2
Netherlands	KPN Mobile	May 2012	2012Q2
	T-Mobile Netherlands	May 2012	2012Q2

Country	Operator	4G commercial launch date	4G Quarter of effect
	Vodafone Libertel	May 2012	2012Q2
Norway	Telenor Mobil	October 2012	2012Q4
	Telia Norway	December 2009	2010Q1
Poland	Orange (Poland)	September 2013	2013Q4
	P4	Novemeber 2013	2013Q4
	Plus (Cyfrowy Polsat SA)	September 2012	2012Q4
	T-Mobile Poland	June 2014	2014Q3
Portugal	MEO Portugal	March 2012	2012Q2
	NOS	March 2012	2012Q2
	Vodafone Portugal	March 2012	2012Q2
Slovakia	Orange Slovak Republic	July 2014	2014Q3
	T-Mobile Slovak Republic	November 2013	2013Q4
Slovenia	A1 Slovenia	July 2012	2012Q3
	Mobitel Slovenia	March 2013	2013Q2
Spain	Orange Spain	July 2013	2013Q3
	Telefonica Moviles	February 2013	2013Q1
	Vodafone Espana	May 2013	2013Q2
Sweden	HI3G	April 2012	2012Q2
	Tele2 Sweden	November 2010	2010Q4
	Telenor Sweden	November 2010	2010Q4
	TeliaSonera Sweden	December 2009	2010Q1
UK	O2 (UK)	August 2013	2013Q3
	Orange UK	October 2012	2012Q4
	T-Mobile UK	October 2012	2012Q4
	Vodafone UK	August 2013	2013Q3

Figure A.1: Evolution of ARPU by group (average weighted by number of subscribers)



(a) ARPU in Euros

(b) ARPU in Euros PPP

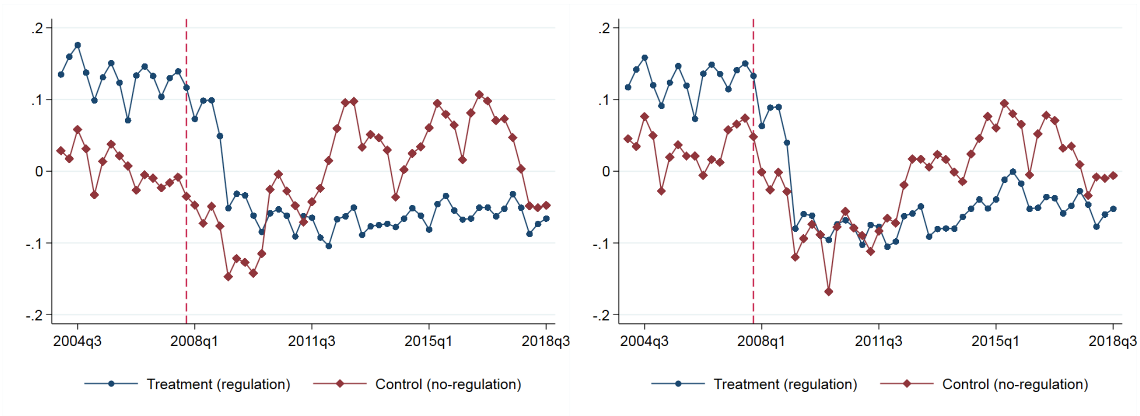
Table A.3: Analysis of ARPU: List of control countries and mobile network operators with respective 4G commercial launch dates

Country	Operator	4G commercial launch date	Quarter of effect
Australia	Optus	September 2012	2012Q4
	Telstra	September 2011	2011Q4
	VHA	June 2013	2013Q3
Canada	Bell Wireless Affiliates	September 2011	2011Q4
	MTS Mobility	September 2012	2012Q4
	Rogers Wireless Communications	July 2011	2011Q3
	SaskTel Mobility	January 2013	2013Q1
	Telus Mobility	February 2012	2012Q1
Chile	Claro Chile	June 2013	2013Q3
	Entel Chile	March 2014	2014Q2
	Movistar Chile	November 2013	2013Q4
Israel	Cellcom Israel	August 2014	2014Q3
	Hot Mobile	January 2015	2015Q1
	Partner Communications	July 2014	2014Q3
	Pelephone	August 2014	2014Q3
Japan	KDDI	September 2012	2012Q4
	NTT DoCoMo	December 2010	2011Q1
	Softbank Mobile	February 2012	2012Q1
Mexico	AT&T Mexico	October 2014	2014Q4
	Movistar Mexico	October 2012	2012Q4
	Nextel Mexico	April 2015	2015Q2
	Telcel Mexico	December 2012	2013Q1
New Zealand	Spark New Zealand	November 2013	2013Q4
	Vodafone New Zealand	February 2013	2013Q1
Switzerland	Salt	May 2013	2013Q2
	Sunrise	June 2013	2013Q3
	Swisscom Mobile	November 2012	2012Q4
Turkey	Turk Telekom	April 2016	2016Q2
	Turkcell	April 2016	2016Q2
	Vodafone Turkey	April 2016	2016Q2
USA	AT&T Mobility USA	September 2011	2011Q4
	Sprint Nextel USA	July 2012	2012Q3
	T-Mobile US	Septembre 2010	2010Q4
	US Cellular	March 2012	2012Q2
	Verizon Wireless	December 2010	2011Q1

Table A.4: Mobile network operator entries since 2004 - OECD countries in our sample

Country	**Operator**	**Date**	**Quarter of effect**
Chile	Nextel (WOM)	May 2006	2006Q2
France	Free	January 2012	2012Q1
Ireland	Three Ireland	July 2005	2005Q3
Israel	Golan Telecom	May 2012	2012Q2
Italy	Iliad	May 2018	2018Q2
Latvia	SIA Bite Latvia	January 2005	2005Q1
New Zealand	2degrees	August 2009	2009Q3
Norway	Network Norway (Ice)	September 2007	2007Q4
Poland	Play	February 2007	2007Q1
Slovakia	O2	February 2007	2007Q1
Slovenia	Telematch (Tusmobil)	October 2007	2007Q4
Spain	Yoigo	December 2006	2007Q1
Ukraine	Lifecell	January 2005	2005Q1

Figure A.2: Parallel trends assumption - Evolution of average residuals from full regression by group



(a) ARPU in Euros

(b) ARPU in Euros PPP

Table A.5: Mobile network operator mergers since 2004 - OECD countries in our sample

Country	**Operator**	**Date**	**Quarter of effect**
Australia	Hutchison Australia's operations (3) were merged with Vodafone Australia to form VHA.	June 2009	2009Q3
Austria	Mobile and Tele.ring merger.	April 2006	2006Q2
Austria	Hutchison Whampoa acquired Orange Austria.	February 2013	2013Q1
Chile	Telefonica acquired Bellsouth and merged it with its mobile subsidiary Telefonica Movil. They formed what is called today as Movistar Chile.	February 2005	2005Q1
Germany	Takeover of E-Plus by Telefonica Germany.	October 2014	2014Q4
Ireland	O2 was merged into Hutchison Whampoa's subsidiary Three Ireland.	March 2015	2015Q2
Italy	Merger between Wind Telecomunicazioni and 3 Italy to create a sole new company Wind Tre.	November 2016	2016Q4
Mexico	Nextel and Lusacell dissapear to form AT&T Mexico, after the succesive acquisitions of Lusacell (January 2015) and Nextel (April 2015).	April 2016	2016Q2
Netherlands	KPN Mobile and Telfort merge after KPN's acquisition of Telfort.	August 2005	2005Q3
Netherlands	Deutsche Telekom (T-Mobile) acquires Orange Netherlands.	September 2007	2007Q4
Netherlands	T-Mobile Netherlands acquires Tele2 Netherlands.	January 2019	2019Q1
Norway	Tele2 was acquired by TeliaSonera, Network Norway was divested to Ice.	November 2015	2015Q4
UK	Orange UK merged with Deutsche Telekom's T-Mobile UK to form a joint venture (EE).	April 2010	2010Q2
USA	Western Wireless merged with Alltel Corporation.	August 2005	2005Q3
USA	AT&T acquisition of Dobson Cellular with market transition in December 2007.	February 2008	2008Q1
USA	T-Mobile acquired SunCom, which brand was phased out in September 2008.	September 2008	2008Q4
USA	Verizon Wireless acquired RCC (Rural Cellular Corporation).	January 2009	2009Q1
USA	The remaining activity of Alltel was acquired by AT&T.	January 2013	2013Q1
USA	T-Mobile acquires Metro PCS.	May 2013	2013Q2
USA	AT&T acquired Leap Wireless.	July 2013	2013Q3
USA	Verizon Wireless acquired Cincinnati Bell.	October 2014	2014Q4

Table A.6: Summary statistics by group at the country level - focus on 2007q3 (quarter before the regulation)

	Group	Mean	Std. Dev.	Min	Max
Population (in millions)	Control	69.9	92.7	4.2	301.0
	Treatment	20.3	24.1	1.3	80.9
Population density	Control	105.1	127.4	2.7	336.6
	Treatment	123.5	100.6	12.2	395.9
GDP per capita (Euros)	Control	23537.41	13499.8	6902.3	46429.2
	Treatment	26336.56	14267.6	8222.1	62218.7
GDP per capita (Euros PPP)	Control	25631.1	10704.0	11539.8	40997.5
	Treatment	26407.6	8372.1	13835.5	46066.2
ARPU in euros	Control	28.1	11.4	9.8	41.9
	Treatment	26.2	9.2	7.2	42.1
ARPU in euros PPP	Control	32.3	9.5	16.9	42.9
	Treatment	27.9	5.7	12.7	36.2
Number of operators per country	Control	3.5	1.0	2.0	5.0
	Treatment	3.3	0.8	2.0	5.0

Table A.7: OLS estimates of the impact of the EU roaming regulation on operators' Average Revenues per User including the effect of Mobile Termination Rates

Dep. Variable	Log(ARPU euros)			Log(ARPU euros PPP)		
	(1)	(2)	(3)	(4)	(5)	(6)
Did regu since 2007q4	-0.156***	-0.130**	-0.0956**	-0.0980*	-0.0812	-0.0599
	(0.0516)	(0.0502)	(0.0392)	(0.0526)	(0.0595)	(0.0400)
Log(MTR+1)	2.257***	2.341***	2.185***	1.138***	1.188***	1.849***
	(0.563)	(0.671)	(0.643)	(0.352)	(0.409)	(0.483)
Log(GDP pc PPP)			0.449***			0.656***
			(0.107)			(0.197)
Log(Population Density)			-0.00801			-0.0955
			(0.331)			(0.318)
Entry			-0.0769			-0.113
			(0.0617)			(0.0713)
4G commercial Rollout			-0.0110			-0.0240
			(0.0238)			(0.0228)
Constant	2.990***	2.979***	-1.363	3.262***	3.253***	-2.965
	(0.0744)	(0.0896)	(1.848)	(0.0594)	(0.0690)	(2.528)
Mergers		Yes	Yes		Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Operator Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,285	6,285	6,285	6,285	6,285	6,285
R-squared	0.575	0.610	0.637	0.649	0.663	0.688
Number of idop	111	111	111	111	111	111

Notes: Robust standard errors are in parenthesis. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.8: OLS estimates of the impact of the EU roaming regulation on operators' Average Revenues per User including the effect of regulatory intensity

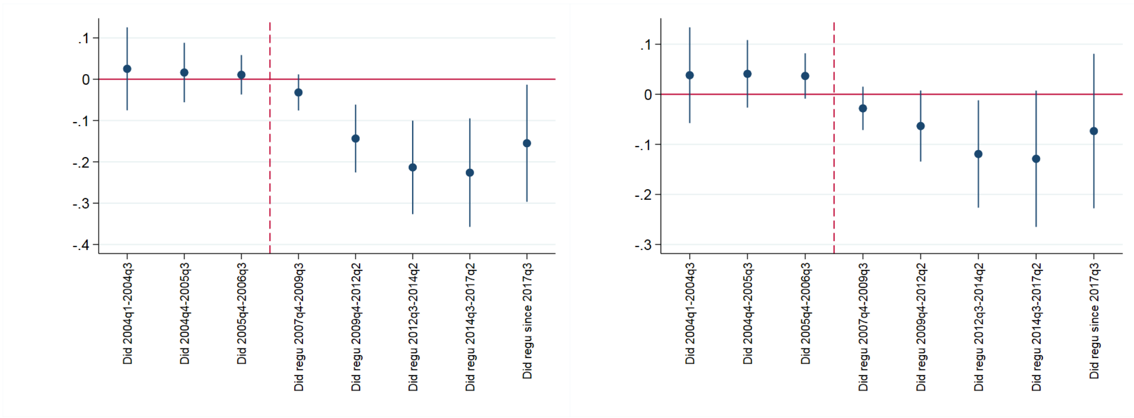
Dep. Variable	Log(ARPU euros)			Log(ARPU euros PPP)		
	(1)	(2)	(3)	(4)	(5)	(6)
Did regu since 2007q4	-0.231***	-0.191***	-0.132***	-0.135**	-0.118*	-0.0938*
	(0.0551)	(0.0569)	(0.0498)	(0.0559)	(0.0596)	(0.0490)
Regulatory Intensity Index	-0.00159	-0.0284	0.0259	0.0323	0.0177	0.0358
	(0.0487)	(0.0517)	(0.0523)	(0.0516)	(0.0605)	(0.0472)
Log (GDP per capita)			0.479***			0.427*
			(0.115)			(0.222)
Log(Population Density)			0.223			0.158
			(0.407)			(0.406)
Entry			-0.0604			-0.103
			(0.0645)			(0.0745)
4G Commercial Rollout			-0.00185			-0.0137
			(0.0221)			(0.0204)
Constant	3.287***	3.323***	-2.411	3.375***	3.395***	-1.559
	(0.0673)	(0.0730)	(2.177)	(0.0665)	(0.0778)	(2.789)
Mergers		Yes	Yes		Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Operator Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,595	5,595	5,595	5,595	5,595	5,595
R-squared	0.598	0.630	0.655	0.666	0.681	0.693
Number of operators	99	99	99	99	99	99

Notes: Robust standard errors are in parenthesis. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.9: Analysis of tariffs - list of treatment and control countries and mobile operators

Treated	Control
France Orange	Australia Telstra
Germany T-Mobile	Canada Rogers Wireless
Italy TIM	Chile Movistar
Poland Orange	Mexico Telcel
Spain Movistar	New Zealand Vodafone
UK EE	USA Verizon Wireless

Figure A.3: Parallel trends assumption - Placebo test - Time relative to the regulation



(a) ARPU in Euros (b) ARPU in Euros PPP

Figure A.4: Evolution of average data revenue share of MNOs in the OECD by group of regulated and non-regulated countries

Note: Own calculations based on OVUM data. The number of countries and operators considered changes over time depending on the availability of information about total revenues, data revenues and number of subscribers per operator. Considering these caveats, the figure shows the general trend observed for all operators in the database. The vertical dashed line represents the start date of the EU roaming regulation.

Figure A.5: Evolution of Quality-Adjusted Price Index by Group

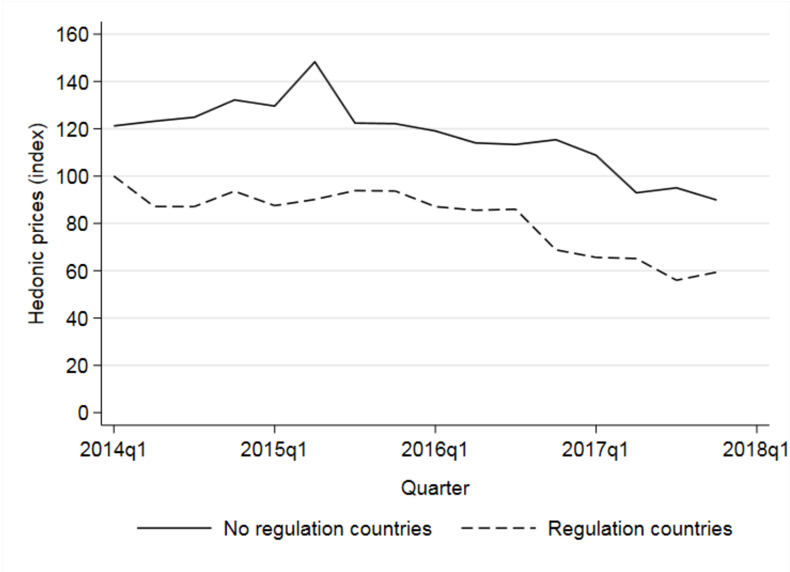
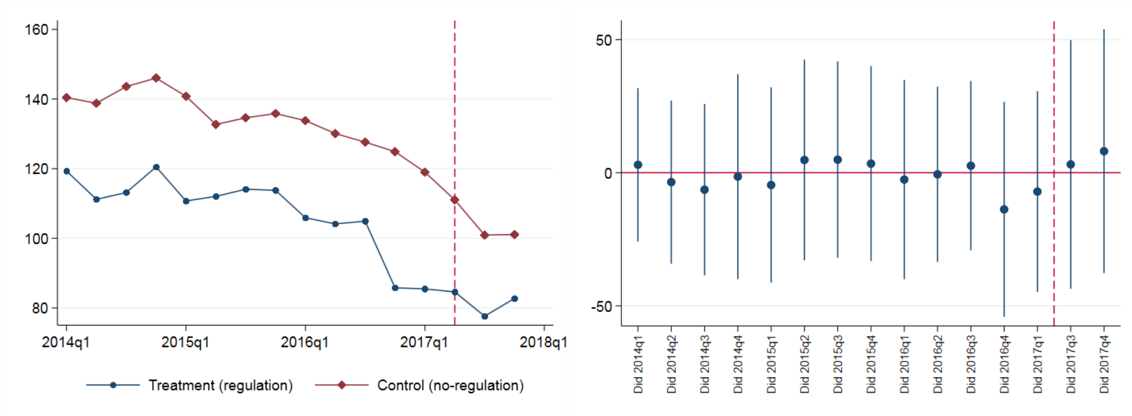


Figure A.6: Parallel trends assumption - Time relative to the latest phase of the regulation



(a) Average residuals by group (b) Placebo test

CHAPTER 2

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

*This chapter was written with Marc Bourreau and Lukasz Grzybowski (Telecom Paris, Institut Polytechnique de Paris). It was prepared in the context of the State aid evaluation program undertaken by *France Stratégie*, from which we acknowledge financial support. We thank Zichuan Li for his research assistance and participants to the 2021 Digital Economics Summer School organized by the *Association Francophone de Recherche en Economie Numérique* (AFREN) and to the 2021 Doctoral Workshop on the Economics of Digitization at Telecom Paris for helpful comments. All errors are our own.

Abstract

This chapter evaluates the impact of State aid granted to local authorities in France through the French broadband scheme *Plan France Très Haut Débit*. We exploit a rich dataset containing information about fiber deployment, State aid and socio-demographic characteristics of more than 34,000 municipalities in Mainland France over the period 2014-2019. First, we study the determinants of entry into fiber and evaluate the efficiency of the plan by means of a structural model of entry. Second, we assess the impact of State aid on deployment. We find that the plan was rather efficient and helped increase fiber coverage in aided municipalities at the early stages of fiber deployment.

Key words: High-Speed Broadband; State Aid; Market Entry.
JEL classification: K23, L13, L51, L96.

2.1 Introduction

Since the launch of a Digital Agenda for Europe in 2010, the European Union (EU) has set concrete goals for nationwide broadband coverage as well as next generation access networks coverage. Such networks are considered of strategic importance for the consolidation of a digital single EU market, to foster economic and social development and to close the digital and economic divide in rural areas.[1]

European Union Member States can provide support for the deployment of broadband networks, subject to certain conditions. In particular, financial support must comply with the EU State aid scheme.[2] As such, public subsidies are allowed in places where market failure exist -private operators do not have incentives to deploy on their own- and where investments may bring significant improvements to local markets.

In this context, France has notified a total of 13.9 billion euros of State aid budget between 2003 and 2018 for the deployment of broadband and NGA broadband to the European Commission (Bourreau et al., 2020a). In particular, France launched in 2013 the *Plan France Très Haut Débit* (hereafter the "French Broadband Plan"), a national plan for very high-speed broadband.[3] The Plan aims to provide at least 30 Mbps of fixed Internet for all by the end of 2022 and fiber for all by 2025. It foresees around 3 billion euros of State aid between 2013 and 2022 within an overall investment of 21 billion euros from public and private actors.

In this chapter we study the efficiency and the impact on fiber coverage of State aid granted to local authorities through this Plan. First, we study the determinants of entry into fiber and evaluate the efficiency of the plan. We understand efficiency here as the ability of the plan to grant aid only to municipalities where entry would

[1] High-speed broadband infrastructures are expected to stimulate growth and job creation, through increased productivity and by stimulating innovation in products and services. See: Röller and Waverman (2001), Czernich, Falck, Kretschmer and Woessmann (2011) and Ahlfeldt, Koutroumpis and Valletti (2017), among others, for empirical evidence on the positive impact of telecommunications infrastructures, and in particular broadband infrastructures, on growth and jobs.

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

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

not occur otherwise. Second, we assess the impact of State aid on fiber deployment, controlling for the endogeneity of fiber entry. This chapter makes part of the *ex post* evaluation of the French Broadband Plan required by the European Commission to comply with its State aid scheme.

We use panel data over the period 2014-2019 containing information about fiber deployment, number of infrastructure operators, state aid and socio-demographic characteristics of more than 34,000 municipalities in Mainland France.[4] We adopt a two-step empirical approach. In the first step, we build a model of fiber entry by infrastructure operators in local municipalities. We find that local market characteristics, such as the size of the market and income, are important determinants of fiber entry. We also find that there is a strong geographic dependence in fiber entry and the presence of a replacement effect from the legacy copper network in fiber entry decisions. Prior investment in neighbouring municipalities is a very strong determinant of investment, which suggests that cost factors play a more important role than demand factors. Finally, we find that entry becomes easier over time.

Based on the estimates of the entry model, we compute "entry thresholds", which we use to evaluate the efficiency of the French Broadband Plan in providing State aid in places where entry would have not occurred otherwise. We find that the Plan was rather efficient. In 80% of cases, State aid benefited municipalities where entry was not expected during the year when State aid became effective. When considering the possibility of entry after State aid took effect, its effectiveness is 64%. Thus, early entry and crowding-out of private investments cannot be ruled-out. However, we argue that they seem difficult to foresee in a context of high uncertainties surrounding investment costs and demand at the early stages of fiber diffusion and the presence of a replacement effect from the legacy copper network.

In the second step of our empirical approach, we analyze how State aid affects fiber deployment. We use a two-stage Heckman selection model to account for the endogeneity of fiber entry. We find that the French Broadband Plan seems to have allowed higher fiber coverage rates in aided municipalities, especially at the beginning of the period of analysis. This effect decreases over time.

[4]Our analysis does not include Corse and overseas territories of France.

Thus, our results suggest that the French Broadband Plan has been successful in helping achieve the broad objectives of ultra-fast broadband deployment set by the EU, while limiting possible distortions in local markets. In addition, broadband deployment within the Plan could have spillovers and initiate investments in neighbouring areas, which is suggested by our estimates.

The remainder of the chapter is organized as follows. In Section 2.2, we review the relevant literature and discuss our contribution. In Section 2.3, we remind the objectives of the Digital Agenda for Europe, we provide an overview of the EU State aid scheme and we describe the main features of the French Broadband Plan. In Section 2.4 we describe our data sets. In Section 2.5, we introduce the econometric framework, and in Section 2.6 we present the estimation results. Section 2.7 concludes.

2.2 Literature Review

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

First, the chapter relates to the literature on entry into local telecommunications markets. Using a latent variable representation of a market's profitability, this literature investigates the market characteristics influencing entry. In addition to the demand and cost shifters influencing entry (e.g., market size and population density), the literature highlights the role of differentiation (Greenstein and Mazzeo, 2006), sunk costs (Xiao and Orazem, 2011), managers' strategic ability (Goldfarb and Xiao, 2011), and entry threats (Wilson, Xiao and Orazem, 2021). A related strand of literature analyzes the impact of entry in telecommunications markets. For example, Nardotto, Valletti and Verboven (2015) show that entry into local markets by alternative LLU operators in the UK in 2005-2009 did not foster the adoption of the new broadband technology but increased the quality of service to the benefit of consumers. More recently, Bourreau, Grzybowski and Hasbi (2019) study the impact of competition on the legacy copper network on the deployment of very high speed broadband in France. The authors find that a higher number of LLU competitors in a municipality implies lower incentives to deploy and expand coverage of high-speed broadband with speed of 30 Mbps or more. We contribute to this literature by investigating the role of State aid on entry into local telecommunications markets. We also consider entry through fiber deployment in local markets where legacy broadband (ADSL) services are already available.

Second, this chapter contributes to the empirical literature on investment in next-generation access (NGA) fiber networks. This literature focuses on the impact of sectoral regulation on the deployment of fiber networks (see, e.g., Bacache, Bourreau and Gaudin (2014), Briglauer (2015), and Briglauer, Cambini and Grajek (2018)). In particular, Briglauer et al. (2018) use data on incumbent telecommunications operators and cable operators for 27 European member states for the period 2004-2014, and show that more stringent access regulation harms investment by incumbent telecommunications operators. In a similar vein, Fabritz and Falck (2013) find that deregulation positively affected the roll-out of fiber by the incumbent telecommunications operators in the UK in 2007-2013. More recently, Briglauer, Cambini, Gugler and Stocker (2021) study the impact of net neutrality regulations on fiber and cable infrastructure investment and subscriptions. Using data on 32 OECD countries for 2003-2019, they find that these regulations have reduced investment and subscriptions. This chapter contributes to this stream of literature by considering another form of public intervention, State aid. We then analyze the impact of State aid in the deployment of NGA fiber networks.

Finally, this chapter is related to the literature on the impact of State aid on the deployment of broadband networks. This literature focuses mainly on case studies of European Union member states. Matteucci (2019) discusses the effect of the Italian State aid plan for deploying the first generation of broadband. He argues that State aid allowed to expand broadband coverage in rural areas, but with a delay compared to other areas. Briglauer et al. (2019) assess the impact of a State aid program introduced by the German State of Bavaria in 2010 and 2011 to improve broadband availability in rural areas. The authors find that aided municipalities have higher broadband coverage at a higher speed than non-aided municipalities. The increase in broadband coverage does not, on average, benefit the local population in terms of increased local jobs per capita or wages. However, these effects are heterogeneous according to the skill groups. Duso et al. (2021) study the impact of State aid broadband plans implemented in Germany between 2011 and 2013 on broadband availability and competition. They find that State aid has improved broadband coverage in the targeted areas. They also show that the number of Internet access providers has increased in the municipalities receiving aid compared to non-aided municipalities. Therefore, State aid has not distorted (local) competition. Finally, Briglauer and Grajek (2021) use cross-country data to study the effectiveness of State aid programs for the deployment of new fiber broadband networks. Using data from 32 OECD countries for 2002-2019, they find that State aid significantly increased broadband coverage and GDP growth. In another recent paper, Wilson (2017) studies the impact of public investment in broadband infrastructure on private investment using nationwide U.S. data. He estimates demand for internet technologies which is combined with a dynamic oligopoly model of private and public firms' entry and investment decisions. He finds that public investment crowds out private investment to some extent. However, this effect is dominated by a dynamic preemption effect, whereby the threat of public provision of broadband induces private firms to invest preemptively. We contribute to this literature by studying the efficiency of State aid for the deployment of fiber networks in France using micro-level data.

2.3 State Aid for Broadband and the French Broadband Plan

2.3.1 EU Digital Agenda and State Aid for Broadband

In May 2010, the European Union (EU) announced its Digital Agenda to boost Europe's economy and consolidate the EU digital single market. At the time, Europe was lagging behind other regions in terms of fast and reliable digital networks.[5] Moreover, coverage with very-high capacity fiber networks capable of delivering ultra-fast broadband[6] was much smaller in rural areas than in urban areas, revealing a persistent digital divide.[7]

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

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

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

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

Most importantly, in rural and less densely populated areas, there may be a market failure for the provision of ultra-fast broadband. While deployment costs are higher than in dense urban areas, the potential demand might be low and/or uncertain. Thus, private operators may have no incentive to deploy ultra-fast broadband networks in these areas. However, it may be socially desirable to cover these areas due to high economic and social benefits not internalized by market players.

As demand for fast and reliable connectivity increases and the digital divide becomes visible, the need for widespread deployment of very-high capacity networks has become a primary objective. The 2010 Digital Agenda for Europe defined the objective of providing at least 50% of European households with access to ultra-fast broadband by 2020. In 2016, the EU updated its target, with the objective that by 2025, all EU households have access to ultra-fast broadband.[8]

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

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

2020, p. 10-11.

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

of certain goods."[9] Such aids are subject to control by the European Commission as they may be incompatible with the common market.

State aid control is intended to ensure that the positive effects of the aid outweigh possible distortions of competition. For broadband specifically, EU State aid schemes must achieve a higher level or faster rate of coverage and penetration in areas where a market failure exists. State aid should also not be granted in areas where market operators have already invested or would normally choose to invest. Otherwise, they would crowd out private investment and distort competition. Moreover, they must ensure that service providers can use publicly funded infrastructure on a non-discriminatory basis. Given their scope and the underlying risks of competition distortion, State aid schemes are subject to *ex post* evaluation. This chapter has been developed as part of the evaluation plan undertaken under the leadership of France Stratégie to assess the impact of the French State aid scheme for ultra-fast broadband deployment.

2.3.2 The French Broadband Plan

In 2013, the French government launched the *Plan France Très Haut Débit* (hereafter, the "French Broadband Plan"). This plan aims to support the design and funding of broadband infrastructure in France, mainly based on fiber-to-the-home (FTTH) networks.[10] In line with the Digital Agenda for Europe, the program aims to cover all French households and businesses with Internet speeds of at least 30Mbps by 2022 and provide FTTH coverage for all by 2025.

Under this program, the French territory is divided into private and public initiative zones. Private initiative zones are areas where fiber deployment does not require public funding. In very densely populated areas, the deployment of fiber networks is expected to be driven by infrastructure-based competition.[11] In some less densely

[9]State aid can take the form of direct grants, tax rebates, soft loans and other types of preferential financing conditions. See: European Commission, "EU Guidelines for the application of State aid rules in relation to the rapid deployment of broadband networks," 2013/C 25/01.

[10]The plan can also help fund certain operations aiming for speed upgrades by modernizing the copper local loop. Local authorities commit to make these operations temporary and part of a broader plan to deploy FTTH networks. Moreover, the plan can provide resources for terrestrial or satellite wireless networks in specific areas or help upgrade fiber networks deployed before the program's launch, which are non-compliant with current regulations. See: "Investissements d'Avenir – Développement de l'Economie Numérique. France Très Haut Débit, Réseaux d'initiative publique," March 2017, p. 24 and 38.

[11]Very dense areas were defined by ARCEP in 2009 as a list of 148 municipalities. In 2013,

populated areas, major telecommunications operators have also expressed their intention to deploy very-high capacity networks without public support. They commit to offer open access to their networks through co-investment and standard access (line rental).[12]

Public initiative zones are rural areas where no private investment is planned for the deployment of fiber networks. With the support of the State and the EU, local authorities, commit to cover these areas by forming partnerships with private operators. Access to the subsidized network must be open and non-discriminatory and is under review by the French regulator, ARCEP. Figure 7 shows the distribution of zones in the fourth quarter of 2020.

Public authorities estimated that a total investment of 21 billion euros over 10 years, from both public and private sources, was necessary to achieve the objectives set by the French Broadband Plan.[13] Within this total investment, the program consolidates a State budget of around 3 billion euros to support the deployment of public initiative networks (*"Réseaux d'initiative publique"* or "RIP" by its French acronym). Eligibility for State funding is subject to examination by the ANCT (*"Agence Nationale de la Cohésion des Territoires"*, previously *"Agence du Numérique"*).[14] State subsidies are paid in several installments, spread over several years, at the rate of the construction of the network and after proof that the networks have been built in accordance with current regulations and technical specifications. Projects are designed at the department or supra-department level and applications are under

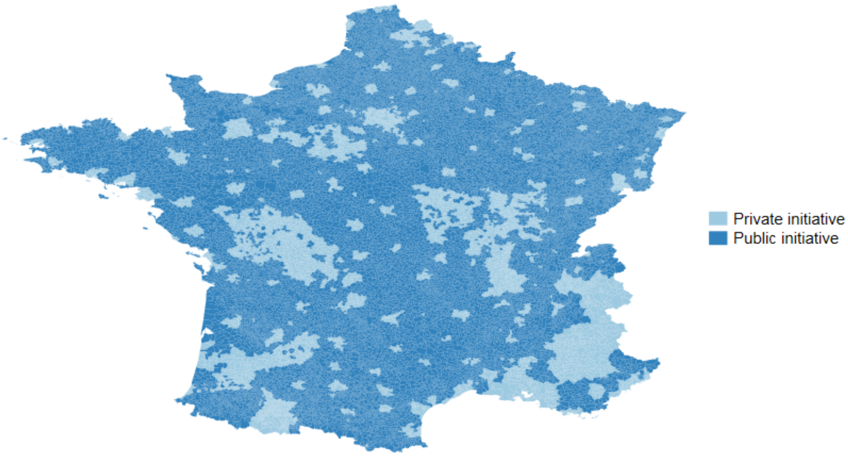
ARCEP revised the list, reducing the number of municipalities to 106 due to the absence of deployment or infrastructure-based competition in some municipalities. See: Bourreau, M., Hoernig, S., & Maxwell, W. (2020). Implementing Co-Investment and Network Sharing. CERRE Report.

[12] In 2011, the French government launched a call for expressions of interest in FTTH investment ("Appel à manifestation d'intérêt à investir" or "AMII" for its French acronym). Two operators (the historical operator, Orange, and an alternative operator, SFR), declared in which municipalities within the less densely populated areas they were interested to invest in the next five years. These municipalities are called "AMII" areas. Later, in late 2017, the French government introduced a new scheme by which departments or local authorities could launch calls for expressions of interest for local projects ("Appel à manifestation d'engagements locaux" or "AMEL" for its French acronym). The objective was to identify the zones left outside the AMII scheme where private operators were willing to deploy FTTH networks initially at the charge of local authorities. These municipalities are called "AMEL" areas.

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

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

Figure 7: Public and private initiative zones for fiber coverage in France as of the fourth quarter of 2020.



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

the responsibility of local authorities.[15]

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

2.4 Data

This chapter combines several data sources, which we describe in detail in the remainder of this section. First, we use data on FTTH infrastructure provided by ARCEP. Second, we build a database on State aid at the municipality level using information from the ANCT. Third, we collect information on socio-economic and geographic characteristics of municipalities from INSEE (French National Institute for Statistics and Economic Studies). Fourth, we use information from AVICCA

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

(French association dedicated to local authorities involved in electronic communications and audiovisual) to identify the type of zone of each municipality (public, private or mixed). Fifth, we use information on the quality of the French copper network provided by the incumbent operator Orange.

Data on FTTH infrastructure. We received data from ARCEP on the geographic location, deployment status, and the identity of the fiber infrastructure operator for more than 16 million buildings in France as of June 2020.[16] We aggregate this data at the municipality level using the geographic location of each building. The data also contains information about the date of availability of the mutualization point (MP) of each building. Based on this information, we recover the dynamics of fiber deployment. We focus on the availability date of the MP of the building as it indicates whether the costliest part of the fiber optics network is already deployed.[17] For each quarter between 2014-2019, we observe the number of fiber operators and the number of FTTH lines deployed in each municipality of Mainland France. To estimate the fiber coverage rate in each municipality, we use publicly available data from ARCEP on the total number of dwellings (hereafter "lines") in each municipality in 2020.[18] We define the fiber coverage rate as the ratio between the number of lines deployed and the total number of lines in the municipality.

Figure 8 presents the evolution of FTTH deployment in France in public, private and mixed initiative zones. By the end of 2019, more than 60% of French households are covered with fiber (i.e., the mutualization point of the building is available). However, while coverage is slightly more than 80% in private and mixed initiative zones, it is less than 30% in public initiative zones. Panels (a) and (b) of Figure 9 illustrate the distribution of fiber coverage in the first period (2014Q1) and the last period (2019Q4) covered by our data. They suggest that there is some geographical dependence in fiber deployment and that the process occurs gradually in clusters

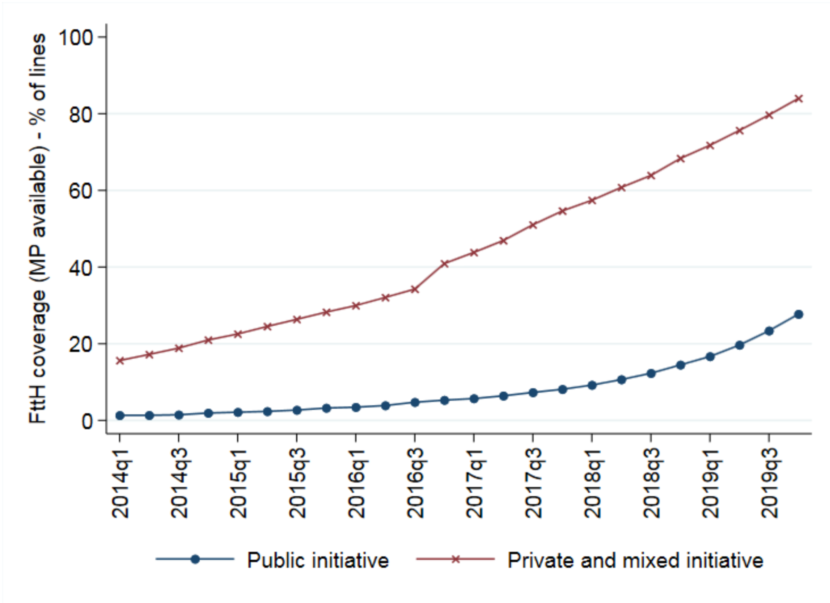
[16] We exclude from the database buildings with the status "abandoned".

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

[18] The data was retrieved on 20 May 2021 from the following website: https://www.data.gouv.fr/en/datasets/ma-connexion-internet/. For a few municipalities, the total number of lines provided by ARCEP is considerably different than the one provided by AVICCA. In these cases, we keep the source that yielded the number of lines closer to the number of households in the municipality. For some remaining cases in which the number of lines deployed is greater than the total number of lines in the municipality, we set the former equal to the latter.

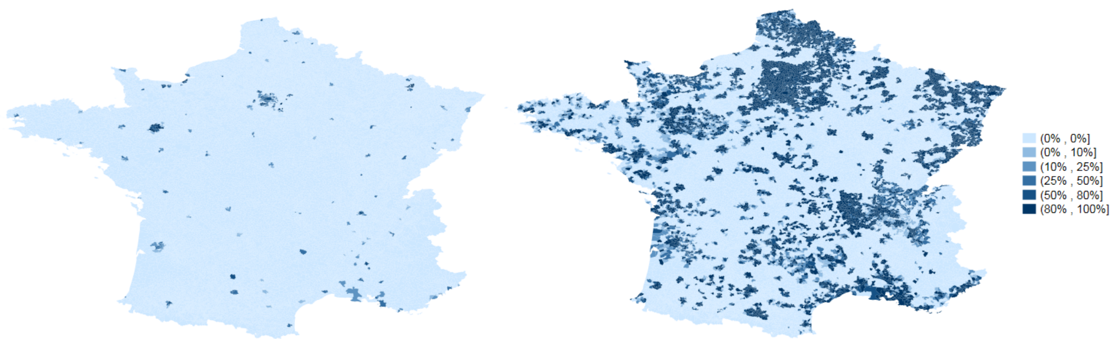
of municipalities. To account for geographic dependence in fiber deployment and potential spillover effects, we calculate the average fiber coverage in neighboring municipalities in the previous quarter for each municipality.[19]

Figure 8: Evolution of fiber deployment in France



Source: ARCEP.

Figure 9: Fiber coverage in Mainland France municipalities (rate of connectable lines - 2014Q1 and 2019Q4)



(a) 2014Q1 (b) 2019Q4

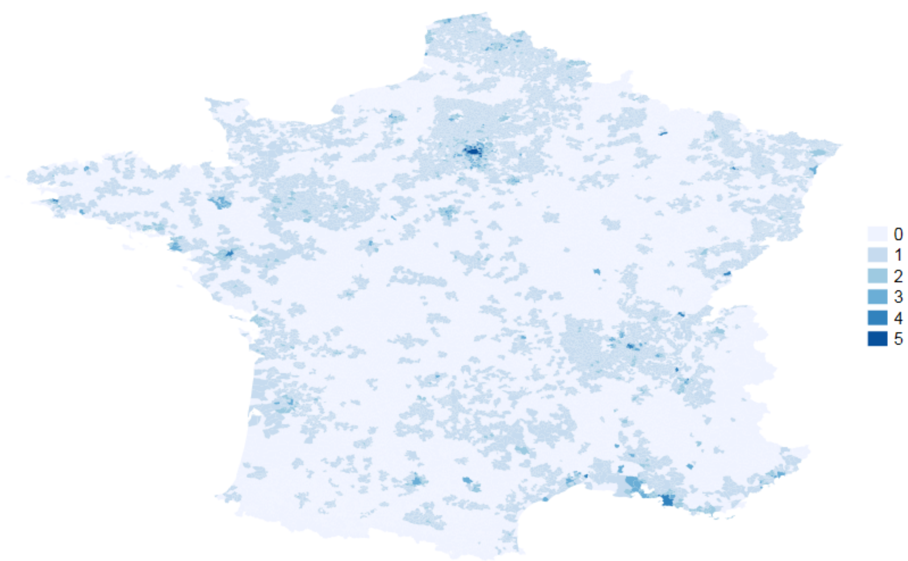
[19]Neighboring municipalities are those who have a contagious boundary with a given municipality. The list of neighboring municipalities as of January 2021 in Mainland France was retrieved on 22 June 2021 from the following website: www.data.gouv.fr/en/datasets/liste-des-adjacences-des-communes-françaises.

Table 2.1 presents the number of municipalities with different numbers of infrastructure operators for the period 2014-2019. Figure 10 illustrates the number of infrastructure operators in each municipality of Mainland France in the fourth quarter of 2019. We notice that there are only a few municipalities with two or more infrastructure operators. Moreover, Table 2.2 shows that there is a large number of entries and no exits by fiber infrastructure operators in Mainland France during the period 2014-2019.

Table 2.1: Number of municipalities with presence of infrastructure operators

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

Figure 10: Number of infrastructure operators at the municipality level - 2019Q4



Source: ARCEP.

Data on State aid. We received two sets of information from the ANCT on State aid in the context of the French Broadband Plan. The first database includes information about the decisions made by the Prime Minister on projects presented

Table 2.2: Fiber entry and exit

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

Note: 826,632 observations for 34,443 municipalities. We observe entry, but no exit.

by local authorities requesting State aid.[20] For each project, this database contains information about: (i) the departments concerned; (ii) the type of decision (preliminary agreement, final decision, other); (iii) the date of the decision; (iv) the reference number of the decision; (v) the amount of aid granted and (vi) a dummy variable indicating whether the decision was valid as of January 2021. Second, for each project submitted by local authorities we recovered a "proxy" file which the ANCT used to calculate the amount of aid eligible when examining the project. Each proxy file contains an approximation of the number of lines that would benefit from the Plan in each municipality.

We combine these two sets of information to construct a database identifying the municipalities in Mainland France benefiting from State aid. Unfortunately, we were unable to access any readily available data indicating the amount and timing of effective State aid disbursements. In practice, they occur over time as local authorities make official requests and present proof of the network construction. Thus, for our analysis we consider that State aid was effective when the first FTTH line is deployed in the municipality.[21]

As of January 2021, there are 82 projects (74 in Mainland France) with a valid State aid decision (either preliminary or final). They represent a total amount of State aid of 3.02 billion euros (2.82 billion euros for Mainland France). In this chapter we focus on the total amount of State aid confirmed by the Prime Minister through final decisions, which is 2.58 billion euros for Mainland France. The reason is that

[20] Projects are conceived at the department or supra-department level.

[21] On average, we observe the first deployment on an aided municipality four quarters (one year) after the date of the aid granting decision by the Prime Minister.

preliminary decisions can be subject to sensible changes throughout the scrutiny process by the ANCT and cannot give way to disbursements. Figures 11 and 12 illustrate how the 2.58 billion euros of State aid are divided by year of final decision and by region. Figure 13 presents the amount of aid by region relative to the population in public initiative zones.

Although the French Broadband Plan started in 2013, a large proportion of State aid was granted between 2016 and 2019. The final decisions published during these four years represent 2.2 billion euros and account for 85% of the total amount of State aid granted since the beginning of the Plan. The year 2019 on its own accounts for 29% (702.81 million euros). Among 13 regions in Mainland France, the Auvergne-Rhône-Alpes region is by far the region receiving the greatest amount of aid in absolute terms (480.9 million euros, 18.7% of total aid). It is followed by Occitanie (316.4 million euros, 12.3% of total aid) and Nouvelle Aquitaine (310.3 million euros, 12.0% of total aid). Provence-Alpes-Côte d'Azur is the region receiving the lowest amount of State aid in absolute terms (50.9 million euros, 2% of total aid). When looking at the amount of State aid per capita in public initiative zones, Bourgogne-Franche-Comté is the first region with 178.2 euros of State aid per capita, followed by Auvergne-Rhône-Alpes with 141.6 euros per capita. Île-de-France is the region with the lowest aid per capita (40.9 euros).

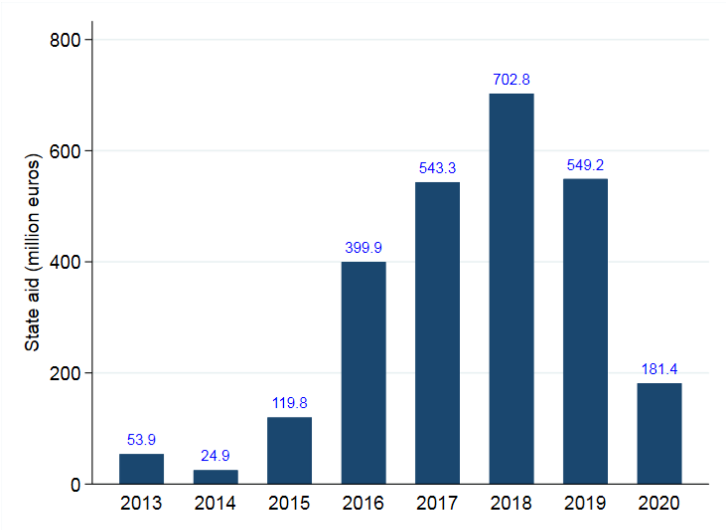
Table 2.3 presents the cumulative number of municipalities benefiting from State aid in Mainland France during the period 2014-2019. By the end of 2019, 6,771 municipalities had benefited from State aid. Figure 14 shows the geographic location of aided municipalities.

Table 2.3: Cumulative number of municipalities with State aid

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

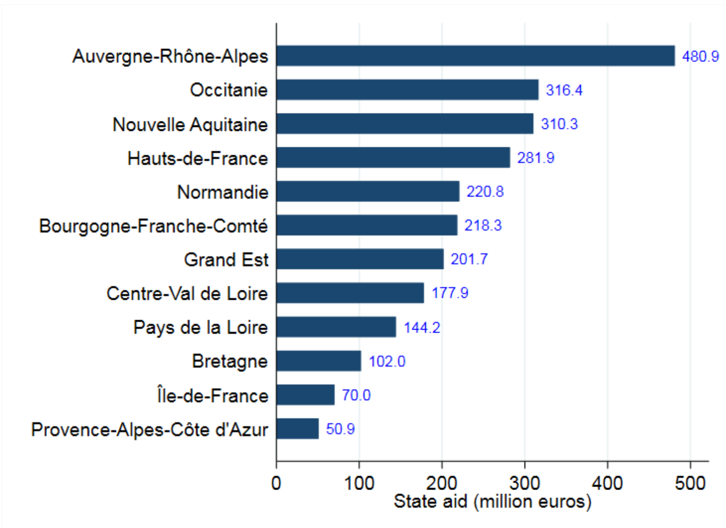
Data on socio-economic characteristics of municipalities. We obtained socio-economic information at the municipality level from the French National Institute for Statis-

Figure 11: State aid by year of the final decision by the Prime Minister



Source: ANCT.
Only final decisions for Mainland France are considered

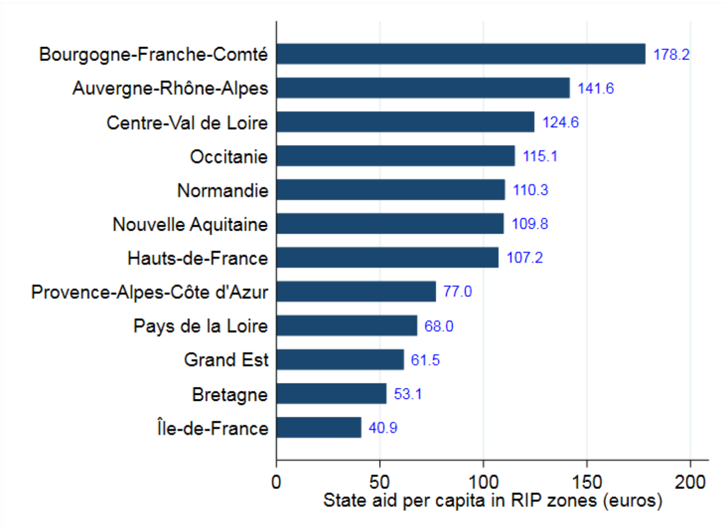
Figure 12: State aid by region



Source: ANCT.
Only final decisions for Mainland France are considered

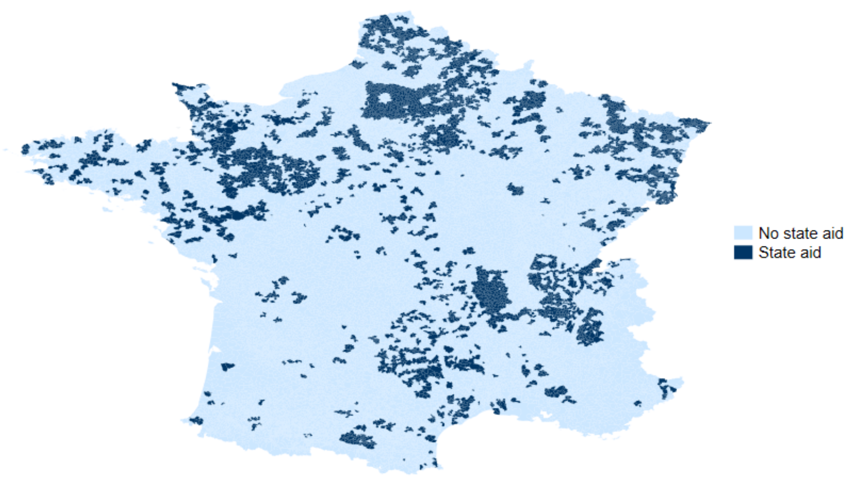
tics and Economic Studies (INSEE). In particular, we have municipal-level data on the population size (defined as the number of households). This information is published with a two-year delay and is available only until 2017. Since firms do not have access to more recent statistics, we consider that they make their entry

Figure 13: State aid per capita in public initiative zones by region



Source: ANCT.
Only final decisions for Mainland France are considered

Figure 14: Municipalities benefiting from State aid as of 2019Q4



Source: ANCT.

decisions based on demographic information with a two-year lag. In addition, we have information on the median household income per municipality in the years 2014-2017.[22]

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

Data on zone types. We retrieved data on the type of zone of each municipality in Mainland France from AVICCA.[23] Using this information, we are able to identify whether a municipality belongs to a public, private or mixed initiative zone in the context of fiber deployment. By the end of 2020, 80% of municipalities in Mainland France (40% of population) were categorized as public initiative zones. Figure 7 shows the distribution of zones in a map.

Data on the quality of the copper network. Information on the quality of the legacy copper network in each municipality was obtained from the French incumbent operator Orange. We use this information to proxy for the opportunity cost incumbent operators may face when deploying next-generation networks due to their revenues from the legacy copper network (the so-called "replacement effect"). In general, broadband signals traveling along a copper line from an exchange point to a customer's location suffer attenuation. This is called copper loss and translates into a reduction of speed on DSL access. The further a customer is from the exchange, the more copper loss they can experience. In our data, municipalities are assigned to the following intervals of copper network quality (measured in decibels, dB): 20dB and below (outstanding); 20-30dB (excellent); 30-40dB (very good); 40-50dB (good); 50-60dB (poor and may experience connectivity issues); and 60dB or above (bad, will experience connectivity issues). Figure 15 shows the distribution of copper network quality categories across the French territory.

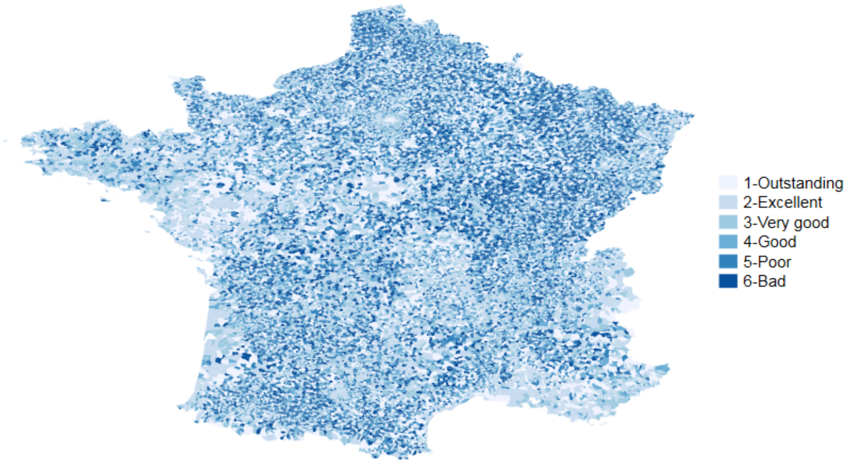
We merged these different data sets using the unique INSEE code for each municipality. After merging, we have information on 34,443 municipalities in Mainland France for the years 2014-2019, at a quarterly pace, resulting in a total of 826,632 observations.[24] Table 2.4 reports summary statistics for the variables used in the analysis.

household income in the department.

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

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

Figure 15: Copper network quality



Source: Calculations based on data from Orange.

Table 2.4: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Number of infrastructure operators	826,632	0.11	0.36	0	5
Number of households (thousands)	826,632	0.76	3.37	1	100
Fiber coverage (%)	826,632	0.07	0.23	0	1
State aid (dummy)	826,632	0.04	0.21	0	1
Income (euros)	826,632	20,326.94	3,419.35	9,958.30	48,310
Public initiative zone (dummy)	826,632	0.80	0.40	0	1
Private initiative zone (dummy)	826,632	0.20	0.40	0	1
Mixed initiative zone (dummy)	826,632	0.00	0.05	0	1
Copper line quality - outstanding	826,632	0.18	0.39	0	1
Copper line quality - excellent (dummy)	826,632	0.16	0.37	0	1
Copper line quality - very good (dummy)	826,632	0.14	0.35	0	1
Copper line quality - good (dummy)	826,632	0.18	0.39	0	1
Copper line quality - poor (dummy)	826,632	0.16	0.37	0	1
Copper line quality - bad (dummy)	826,632	0.17	0.37	0	1

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

2.5 Econometric Models

In this section, we present the econometric models. First, we set up a model of fibre entry, which allows us to estimate the determinants of the fibre entry decision. Next, using the estimates from on the entry model we calculate entry thresholds, which we use to assess the efficiency of the French Broadband Plan. Finally, we introduce a reduced-form model of fiber coverage, in which we take into account the endogeneity of fibre entry through a control function approach.

2.5.1 Fibre Entry

We set up a model of entry similar to the one used by Bourreau et al. (2019) to study the demand-side and supply-side factors that influence LLU entry in France. However, our focus is on the analysis of fiber entry by infrastructure operators. We assume that at the end of each time period operators decide whether to enter into "new" local markets and deploy fibre network to the homes in the next period. They form expectations about market demand, costs and competition with other operators. These expectations are fulfilled in equilibrium, and the marginal operator enters the market. We draw inferences on the profit determinants assuming a free entry equilibrium, where operators enter a local market if and only if it is profitable for them to do so, i.e., expected gross profits outweigh the entry costs. As mentioned earlier, we do not observe exists in our data and thus entry is a final decision.[25]

The number of fibre entrants in municipality i at time t is denoted as $N_{it} = n \in \{0, 1, 2, 3, 4, 5\}$. The discounted future stream of profits of an operator facing n competitors in market i at time t can be written as:

$$\bar{\pi}_{it}^{n} = \alpha S_{it} + \sum_{b_k \in B} \alpha_{b_k} S_{it} \times \mathbb{1}\{S_{it} \in b_k\} + X_{it}\beta - \mu^{n} + \epsilon_{it} \equiv \pi_{it}^{n} + \epsilon_{it}, \qquad (2.1)$$

where S_{it} is the market size approximated by the number of households. To allow for non-linear market size effects due to economies of scale in fiber deployment, we

[25]Some of the fixed costs of entry into local markets may be sunk. The identification of sunk costs requires a comparison of entry thresholds for markets where entry took place with thresholds for markets where there was no entry. The sunk costs imply that less demand is needed for an incumbent to continue operations than is needed to support a new entrant. Unfortunately, we do not observe exists in our data. Thus, we focus on the estimation of the entry model without sunk costs.

introduce differential effects by market size intervals that we call "bands". To do so, we define $B = \{b_1, b_2, b_3, b_4, b_5\}$ as a set of five households size bands, where $b_1 = [0, 2,000)$, $b_2 = [2,000, 5,000)$, $b_1 = [5,000, 10,000]$, $b_1 = [10,000, 20,000]$, and $b_5 = +20,000$. Next, we denote X_{it} a vector of other characteristics of municipalities, which are potential demand or supply determinants of profits (including income, the type of zone, the quality of the legacy copper network and the fiber coverage in neighboring municipalities). We also include a set of department dummy variables to allow for firms' profits to differ across geographic locations due to other factors.[26] Finally, μ^n represents the negative effect on profits from the n^{th} firm, and ϵ_{it} is the error term which has a standard normal distribution. The profits, π^n_{it}, are not observed and represent a latent variable.

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

Since there is only a small number of markets with two or more infrastructure operators, as shown in Table 2.1, we truncate the number of entrants to one, which simplifies our entry model. In equilibrium, in market i at time t there is entry of at least one fibre network $N_{it} = 1+$ when the following condition is satisfied: $\bar{\pi}^1_{it} > 0$, which using the profit specification (2.1) yields:

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

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

$$Pr(N_{it} = 1+) = \Phi(\alpha S_{it} + \sum_{b_k \in B} \alpha_{b_k} S_{it} \times \mathbb{1}\{S_{it} \in b_k\} + X_{it}\beta - \mu^1), \qquad (2.2)$$

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

[26] In 2021, there are 94 departments in Mainland France, excluding Corsica.

function:

$$\hat{\theta} = \arg\max \sum_{i=1}^{M} \sum_{t=1}^{T} [y_{it} \ln(Pr(N_{it} = 1 + |\theta)) + (1 - y_{it}) \ln(Pr(N_{it} = 0|\theta))], \quad (2.3)$$

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

We define $\hat{S}_{it}$ to be the necessary number of households in municipality i at period t to support the total of $N_{it} = 1+$ fibre networks, which we compute using the estimates $\hat{\theta}$ as follows:

$$\hat{S}_{it} = \frac{\hat{\mu}^1 - X_{it}\hat{\beta}}{\alpha + \sum_{b_k \in B} \alpha_{b_k} \mathbb{1}\{S_{it} \in b_k\}}, \quad (2.4)$$

We use the "entry threshold" defined above to assess the efficiency of the French Broadband Plan.

2.5.2 Deployment of fiber

In our model of fiber deployment we abstract from modeling the strategic decisions of operators regarding the roll-out of networks using alternative technologies (e.g. DSL and cable). We estimate a reduced-form equation for the share of households in a given municipality with access to ultra-fast broadband through fiber:

$$y_{it} = \rho SA_{it} + \gamma Z_{it} + u_{it}, \quad (2.5)$$

where y_{it} denotes the share of households in municipality i and period t with fiber coverage (i.e., the mutualization point is available); SA_{it} is an indicator variable of State aid in municipality i and period t; and Z_{it} is a set of control variables that may determine coverage, including demand and cost shifters.

When estimating equation (2.5) we need to correct for a potential sample selection bias. That is, the fact that fiber coverage y_{it} is only observed when there is at least one infrastructure operator present in the municipality ($N_{it} = 1+$ in our entry model). To take this into account, we follow a control function approach in two stages as in Heckman (1979). More specifically, in the first stage we estimate the entry model discussed in the previous section (Model I). In the second stage, the following modified coverage equation is estimated for the sample of municipalities with positive coverage:

$$y_{it} = \rho SA_{it} + \gamma Z_{it} + \sigma_{u\epsilon}\lambda(S_{it}, X_{it}; \hat{\theta}) + \varepsilon_{it}. \tag{2.6}$$

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

$$\begin{aligned} E(y_{it}|X_{it}, S_{it}, Z_{it}) &= \rho SA_{it} + \gamma Z_{it} + E(u_{it}|N_{it} > 0), \\ &= \rho SA_{it} + \gamma Z_{it} + \sigma_{u\epsilon}\lambda(S_{it}, X_{it}; \theta), \end{aligned} \tag{2.7}$$

where $\theta = (\alpha, \beta, \mu^1)$ is the parameter vector from the entry model and $\sigma_{u\epsilon}$ is the covariance between u_{it} and ϵ_{it}. The hazard function (inverse Mills ratio), denoted by $\lambda(S_{it}, X_{it}; \theta)$ is computed using the entry model estimates:

$$\lambda(S_{it}, X_{it}; \hat{\theta}) \equiv E(\epsilon_{it}|\hat{\pi}^n_{it} > -\epsilon_{it}) = \frac{\phi(\hat{\pi}^n_{it})}{\Phi(\hat{\pi}^n_{it})}. \tag{2.8}$$

Thus, in equation (2.6) we exploit the fact that the error term u_{it} can be decomposed into the sum of two terms and written as $u_{it} = \sigma_{u\epsilon}\lambda(S_{it}, X_{it}; \hat{\theta}) + \varepsilon_{it}$, where by construction ε_{it} is mean zero conditional on S_{it}, X_{it} and Z_{it}.

The municipality characteristics included in the estimation of equation (2.6) are the same as in the model of fibre entry, except for market size and the dummy variable identifying municipalities where there is no fiber coverage in neighboring municipalities in the previous period. These are our exclusion restrictions discussed below.

The Heckman selection model needs exclusion restrictions. That is, at least one variable which determines entry of fibre operators, but is not correlated with the error term in the coverage equation for fiber. Market size makes markets more attractive for deploying fiber, but it should not affect the share of population covered by fiber. In other words, the share of population covered with fiber should be comparable in smaller and larger municipalities, conditional on the presence of infrastructure fiber operators in these municipalities. Moreover, the presence of fiber coverage in neighboring municipalities influences fiber entry as fiber backbones should allow to enter in several municipalities at the same time, but it may not have a direct impact on the level of coverage in the municipality. We expect only the level of coverage in neighboring municipalities in the previous period to influence the level of coverage in the municipality. This is because we expect it to reflect the advancement of deployment works in specific areas. Although, we do not expect a direct impact of market size on the deployment of fiber, it may be correlated with omitted municipality-specific characteristics. To mitigate this issue, we use in the estimation a set of municipality characteristics and department dummy variables. In the estimation we also include year dummy variables.

Equation (2.6) is first estimated using ordinary least squares (OLS) for comparison and then using the Heckman procedure described above.

2.6 Estimation Results

Our estimation is done in the following steps. First, we estimate the fibre entry model using the maximum likelihood estimator in equation (2.3). Second, based on the estimates from the entry model, we compute entry thresholds as described in equation (2.4). We use them to assess the efficiency of the French Broadband Plan. Third, we also use the estimates from the entry model to compute the correction term (2.8). Fourth, we use ordinary least squares to estimate the coverage equation (2.6). This equation includes the number of fibre entrants and the correction term from the entry model (2.8). We also use local market characteristics, and time and department dummy variables in the estimation as discussed above.

2.6.1 Fiber Entry

Table 2.5 shows the estimation results of our model of fibre entry using panel data for 34,406 municipalities over the period 2014-2019.[27] In practice, there are few municipalities with two or more infrastructure operators (2.1% of municipalities in the fourth quarter of 2019). Thus, there is not enough variation in the number of infrastructure operators and we focus on the presence of at least one infrastructure

[27] All municipalities in departments Hauts-de-Seine and Paris have had fiber entry since the beginning of the period. Therefore, as we estimate our model using department dummies, they are excluded from the analysis. This reduces the initial sample of 34,443 municipalities to 34,406.

operator in the municipality. Our dependent variable is either 0 when no infrastructure operator is present in the municipality, or 1 when one or more infrastructure operators are present. Moreover, State aid is one of the determinants for fiber entry in public initiative zones. However, we cannot include it in our regressions as it predicts perfectly entry in municipalities receiving State aid. More precisely, every time a municipality is identified as benefiting from State aid, a fiber network operator is systematically present. Thus, we estimate three different models using alternative assumptions on municipalities benefiting from State aid. Model I is estimated using a restricted sample of 27,601 out of 34,406 municipalities which never received State aid during the period of analysis. This approach assumes that State aid is assigned randomly within the public initiative zone.[28] Model II is estimated by setting the number of infrastructure operators to zero whenever a municipality benefits from State aid. It assumes that in the absence of State aid, entry would have not occurred in aided municipalities. Model III is estimated using the full sample of municipalities. As State aid is not included as a control variable, this model assumes that entry would have occurred in any case in municipalities benefiting from State aid, independently of State aid.

The results of the three models are qualitatively similar. We find that the market size (measured as the number of households in the municipality) significantly and positively affects fibre entry. This effect is non-linear and decreases with market size as suggested by the coefficients of the interactions between market size and market size bands. We also find that a higher level of income has a positive and statistically significant impact on fibre entry, indicating a higher demand for broadband in richer municipalities. In the estimation we also include two variables to test the intuition of geographic dependence in fiber entry suggested by the graphical analysis of deployment (cf. section 2.4). First, we use a dummy variable identifying municipalities where there is no fiber coverage in neighboring municipalities in the previous period. Its coefficient is negative and statistically significant, which indicates that the absence of fiber coverage in contiguous municipalities reduces the likelihood of entry. Second, we use a continuous variable on the average fiber coverage in neighboring municipalities in the previous period. It is positive and statistically significant, which implies that higher coverage in contiguous municipalities increases the likeli-

[28]This implies that the likelihood of entry should be alike in aided municipalities which have similar characteristics as non-aided municipalities.

Table 2.5: Fiber entry in municipalities - presence of at least 1 infrastructure operator

Dep. Var: Number of operators (0,1+)	(I)	(II)	(III)
Nb Households	0.511***	0.427***	0.523***
	(0.0684)	(0.0517)	(0.0577)
Nb Households interactions (ref: < 2,000)			
Nb Households * [2,000 ; 5,000)	-0.155***	-0.124***	-0.183***
	(0.0439)	(0.0337)	(0.0371)
Nb Households * [5,000 , 10,000)	-0.268***	-0.215***	-0.281***
	(0.0589)	(0.0443)	(0.0488)
Nb Households * [10,000 ; 20,000)	-0.340***	-0.272***	-0.349***
	(0.0638)	(0.0483)	(0.0540)
Nb Households * (> 20,000]	-0.419***	-0.345***	-0.432***
	(0.0651)	(0.0497)	(0.0553)
Log(Income)	0.638***	0.520***	0.408***
	(0.177)	(0.138)	(0.144)
No coverage in neighbor dummy t-1	-0.870***	-0.989***	-0.821***
	(0.0414)	(0.0498)	(0.0377)
Level of coverage in neigbor t-1	3.260***	1.790***	3.263***
	(0.216)	(0.207)	(0.111)
Year dummies (ref 2014)			
2015	0.210***	0.255***	0.242***
	(0.0532)	(0.0481)	(0.0497)
2016	0.518***	0.579***	0.545***
	(0.0700)	(0.0741)	(0.0628)
2017	0.691***	0.711***	0.732***
	(0.0939)	(0.0913)	(0.0709)
2018	0.835***	0.860***	0.972***
	(0.120)	(0.138)	(0.0788)
2019	1.020***	0.832***	1.189***
	(0.172)	(0.155)	(0.0913)
Type of initiative zone (ref: public)			
Private initiative	0.921***	1.020***	0.184*
	(0.138)	(0.109)	(0.0968)
Mixed initiative	1.676***	1.574***	0.956***
	(0.466)	(0.356)	(0.367)
Copper loss (ref: <=20dB)			
20dB-30dB excellent	0.0904*	0.0631*	0.0975***
	(0.0473)	(0.0371)	(0.0355)
30dB-40dB very good	0.201***	0.136***	0.169***
	(0.0547)	(0.0431)	(0.0433)
40dB-50dB good	0.278***	0.224***	0.265***
	(0.0628)	(0.0442)	(0.0432)
50dB-60dB poor	0.343***	0.253***	0.336***
	(0.0535)	(0.0427)	(0.0422)
>=60dB bad	0.272***	0.213***	0.339***
	(0.0676)	(0.0593)	(0.0486)
μ_1	9.533***	8.349***	6.032***
	(1.830)	(1.448)	(1.474)
Department fixed effects	Yes	Yes	Yes
Observations	662,424	825,744	825,744
LL	-49921	-73325	-102454

Note: Robust standard errors in parentheses (clustered at the department level). Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively hood of entry. We interpret this result as a confirmation of geographic dependence in fiber entry and deployment. In practice, infrastructure operators have to roll out fiber backbone, which is the nerve centre of the fiber network. Then, it is possible that when we observe a sufficient share of municipalities covered it is because the backbone is already built, which makes it easier (less costly) to cover additional contiguous municipalities.

The coefficients of yearly dummies are positive, statistically significant and they increase over time. This suggests that entry becomes easier over time, which may be due to technological progress decreasing deployment costs, but also to an increase of demand for fiber as higher speeds and connection reliability become increasingly necessary. Unsurprisingly, entry is more likely in private and mixed initiative zones with respect to public initiative zones. Furthermore, municipalities with a lower quality of the legacy copper network experience more entry than municipalities with outstanding quality. This reflects the opportunity cost operators face when deploying next-generation networks due to their revenues from the legacy copper network (the so-called "replacement effect"). Finally, we include in the estimation a set of department dummy variables which are highly significant. They control for other factors determining the attractiveness of municipalities which belong to the same departments and do not vary over time.

In other unreported specifications of our model we used surface area, employment rate, number of jobs, age categories and active population by socio-professional categories as explanatory variables. None of them appear to affect fiber entry significantly. In fact, these factors loose their significance when we use coverage in neighboring municipalities as a control variable in our model. We also tried estimating a model with random effects for municipalities which however does not converge.

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

The three models we estimate may present different biases. In Model I, State aid might not be granted randomly. In particular, there might be political factors or differences in the engagement of local representatives influencing the location and timing of State aid. This question is the object of another ongoing research project. In Model II, it is possible that some aided municipalities would have experienced fiber entry in the absence of State aid. In principle, this should not be the case. State aid is supposed to help fill in the profitability gap in places with market failure where private investment does not occur spontaneously. However, in practice this is uncertain. As technology evolves, demand and cost uncertainty decreases and operators learn from previous experiences, fiber deployment may become viable in places initially considered non-viable. The underlying mechanism is similar to the one explaining why certain municipalities initially included in the public initiative zone became part of the private initiative zone (under the AMEL scheme) after 2017. Moreover, whether the French Broadband Plan was efficient in providing State aid in places where entry would not occur otherwise is at the heart of our research question. Model III presents the opposite extreme case to Model II. It assumes that fiber entry would have occurred in aided municipalities in any case, independently from State aid, which is not realistic. It is only reported for comparison.

Although State aid may not be assigned randomly within the public initiative zone, our preferred model is Model I, as it provides the best entry predictions among the three models (see Table A.2 for a comparison of prediction rates across models and years). Moreover, Models II and III represent extreme cases of entry assumptions for municipalities benefiting from State aid. Model I makes correct predictions in 97% of cases. However, its prediction accuracy diminishes over time, in particular for the last two years (2018-2019) and for the cases of effective entry. This suggests, that there are additional factors that we do not include in our model that may explain why entry accelerates at the end of the period. For instance, a higher increase of demand for ultra-fast broadband in recent years may explain this. However, non-economic reasons such as 'political will' may explain as well.[29]

[29] For instance, in 2021, Brittany's local authority responsible for FTTH deployment signed an agreement with the consortium in charge of deploying the fiber network in the public initiative zones of the region. Its objective is to accelerate deployment after complaints by local inhabitants and majors of delays in access to ultra-fast broadband. See: https://www.lesechos.fr/pme-regions/bretagne/les-retards-du-reseau-tres-haut-debit-breton-exaspere-entreprises-et-elus-1353384.

With this caveats in mind, we use the estimates from Model I to compute entry thresholds for each municipality, which we use to assess the efficiency of the French Broadband Plan.

2.6.2 Entry thresholds and efficiency of the French Broadband Plan

Based on the estimates of Model I in the previous section, we compute "entry thresholds", that is, the minimum market size required to support fiber entry in a municipality at a particular point in time. In our model, market size is given in number of households. We report average entry thresholds and market size for all municipalities in our sample and for municipalities with entry in Table 2.6. The average number of households required to sustain fiber entry was initially close to 8,000, but it decreased to around 4,000 at the end of the period. Xiao and Orazem (2011) and Nardotto et al. (2015) also report entry thresholds for LLU that decrease over time. As they do, we consider that these falling entry thresholds may either stem from declining investment costs, or from an increase in demand, or indeed from a combination of both. The decline in investment costs may be due to technology improvements or learning by doing in the construction of fiber networks.[30] Average entry thresholds in municipalities where entry occurred are in general lower than those of all municipalities, except in 2014. They are overall consistent with market size in order of magnitude.

Table 2.6: Average entry thresholds and market size

	All municipalities		Municipalities with entry	
Year	Entry thresholds	Market size	Entry thresholds	Market size
2014	7970	718	9919	7566
2015	7436	718	6889	2179
2016	6647	718	6555	3034
2017	5950	749	5248	2286
2018	5191	749	4550	846
2019	4074	749	3535	714

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

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

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

old predicted by Model I with the market size of each municipality. In principle, municipalities benefiting from State aid would present a market size which is lower than the minimum market size required for the market to be profitable for private operators. If indeed this is the case, then we consider that the French Broadband Plan allocated State aid efficiently. Otherwise, the plan may have allowed for early entry or it may have introduced a market distortion by crowding out private investments.

Table 2.7 reports (i) the number of municipalities benefiting from State aid for the first time in each year; (ii) among them, those with entry thresholds higher than market size; and (iii) the proportion of aided municipalities for which we consider that the French Broadband Plan was efficient, resulting from ratio between (ii) and (i). When considering contemporary entry predictions and State aid, our results suggest that the French Broadband Plan was rather efficient. Overall, in 80% of cases, the market size of municipalities benefiting from State aid was lower than the entry threshold predicted by our model in the year when State aid started to be effective. Thus, in these markets entry by private operators was not expected in the given year.

However, as entry thresholds decrease over time, spontaneous entry by a private operator could have occurred in some State aid municipalities after the year when State aid took effect. To explore this possibility, we focus on the cumulative number of municipalities with State aid in each year and proceed to the same comparative analysis as in Table 2.7. We report the results in Table 2.8, which confirm that this has been the case. For 64% of municipalities which benefited from State aid between 2014 and 2019 our model does not predict entry during the period. For the remaining 36% of municipalities, two (non-exclusive) scenarios are possible: (i) entry occurred earlier than the market would have allowed; (ii) there was crowding out of private investments. However, it is also important to remind that our model does not predict entry perfectly. Therefore, some of these cases could be explained by prediction error inherent to our model.

Thus, we consider that the French Broadband Plan was rather efficient in providing aid where there was a market failure for the provision of ultra-fast broadband during the period 2014-2019. In particular, this is true when we only consider entry thresh-

Table 2.7: Efficiency analysis - Number and proportion of municipalities where State aid was necessary on a given year

Year	New municipalities with State aid	New aided municipalities with entry threshold higher than market size	State aid efficiency
2014	23	23	100%
2015	168	168	100%
2016	369	361	98%
2017	891	864	97%
2018	2,113	1,723	82%
2019	3,207	2,311	72%
Total	6,771	5,450	80%

Table 2.8: Efficiency analysis - Cumulative number and proportion of municipalities where State aid was necessary

Year	Municipalities with State aid	Municipalities with entry threshold higher than market size	State aid efficiency
2014	23	23	100.0%
2015	191	190	99.5%
2016	560	544	97.1%
2017	1,451	1,366	94.1%
2018	3,564	2,936	82.4%
2019	6,771	4,348	64.2%

olds in the year when State aid took effect. The fact of having still some proportion of municipalities receive State aid when entry seemed plausible according to our *ex post* analysis (20% of aided municipalities) may be interpreted as a sign that State aid was "overdimensionned". This could be the consequence of the Government's will not to "under-dimension" the aid and risk to leave some areas in need out of support.

Moreover, although early entry or crowding out of private investments cannot be ruled out, they seem hard to avoid. In particular, at the early stages of fiber deployment, demand for ultra-fast broadband was highly uncertain and investment costs were substantial as deployment efficiency was not totally mastered. The existence of a replacement effect suggested by our results may have reinforced this effect and consequently decreased private operators' incentives to invest in fiber in places where it would have been financially viable. In addition, it is also important to recall that

State aid granting decisions intervene before the date when State aid takes effect, which increases the gap between the moment when State aid relevance is analyzed and the moment when deployment takes place.

2.6.3 Deployment of fiber

Table 2.9 reports the estimation results for our coverage model. We estimate four regressions. We first consider a specification where the effect of State aid is constant (columns (1) and (2)). Then, we consider a specification where the effect of State aid is interacted with year dummies (columns (3) and (4)). We do this to capture potential differences in trends between aided and non-aided municipalities. For each specification discussed above, we estimate two regressions: using OLS and using the correction term for the presence of fibre infrastructure operators (Heckman).

In columns (1) and (2) in Table 2.9, the presence of State aid has a significant and positive impact on fiber coverage. Its average magnitude over the period 2014-2019 in the OLS estimation (column (1)) is 6.1%. When the correction term from the fibre entry model is included in the estimation (column (2)), the magnitude of the impact of State aid slightly increases to 6.4%. The significant estimate of the Mills ratio indicates that the OLS estimates suffer from sample selection bias.

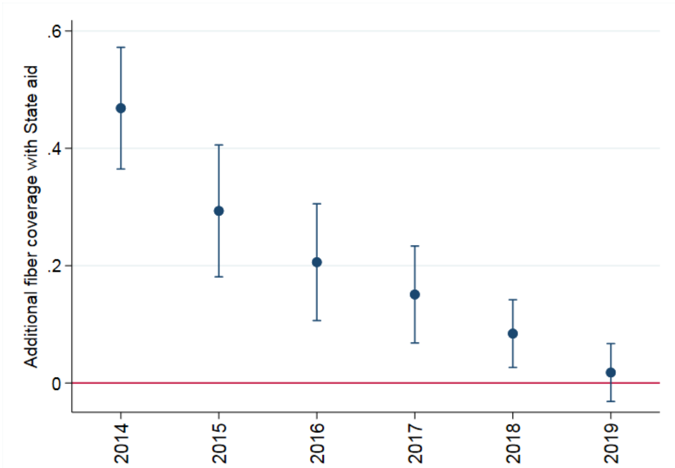
In columns (3) and (4) in Table 2.9, we see that the positive impact of State aid on fiber coverage is large at the beginning of the period, but decreases over time. The coefficient of the Mills ratio is again positive and statistically significant, suggesting that the OLS estimates suffer from sample selection bias. Based on the estimates from column (4) in Table 2.9, Figure 16 shows the evolution of the impact of State aid on fiber coverage over time. The additional coverage in aided municipalities was 47% in 2014, 29% in 2015, 21% in 2016, 15% in 2017, and 8% in 2018.[31] In 2019 there is no evidence that State aid allowed for significant higher coverage.

We include in the models a number of control variables to account for the heterogeneity of local markets, which we expect to have a significant impact on the deployment of fiber. The effects are qualitatively similar across specifications, except for differences with respect to the level of significance of certain variables. In specification (4), a higher level of fiber coverage in neighboring municipalities in the

[31] The impact of State aid on coverage in years 2015-2019 is computed by adding each interaction coefficient to the coefficient of the State aid dummy.

previous period is associated with higher levels of fiber coverage in the municipality. This tends to confirm the existence of geographic dependence in fiber deployment. The coefficient of income is negative and statistically significant at the 90% level. This suggests that income effects are dominated by the cost effects. Fiber coverage in private and mixed initiative zones is higher than in the public initiative zone. Moreover, coverage increases as the quality of the legacy copper network decreases. This result reinforces the evidence of a replacement effect that we also find when estimating the entry model. The coefficients of yearly dummies are positive, statistically significant and they increase over time. This is intuitive as deployment is an incremental process. Finally, we also include in the estimations department dummy variables to control for differences in attractiveness of municipalities which belong to them. The majority of them are highly significant.

Figure 16: Evolution of the impact of State aid on fiber coverage



Note: Estimates from column (4) in Table 2.9 where the dependent variable is the fiber coverage rate at the municipality level. Each point represents the additional coverage rate in aided municipalities. For example, in 2015 aided municipalities had additional 29% coverage with respect to non-aided municipalities. The vertical lines represent the confidence intervals at 95%.

Our results suggest that the presence of State aid in municipalities has allowed higher fiber coverage rates, particularly at the beginning of the period. As time passes, the gap seems to be closing in non-aided municipalities. This decrease on the effect of State aid on coverage over time suggests similar remarks as the ones made when analyzing the efficiency of the plan by means of the entry model. That is, that several issues influencing entry and deployment may be at play at the beginning of fiber diffusion. In particular, if the underlying justification for public intervention should the existence of positive externalities not internalized by private operators, demand for ultra-fast broadband was highly uncertain and investment costs were higher at the beginning of the period.These factors suggest the presence of information asymmetries. However, we do not believe that public intervention in the form of State aid would have been the adequate policy in such case. Most importantly, the existence of a replacement effect may have decreased private operators' incentives to deploy fiber for reasons outside the viability of a fiber business plan on its own. The consequences of such a replacement effect from the legacy copper network on entry decisions concerning other technologies requires special attention by regulators.

Table 2.9: Fiber coverage in municipalities

Dep. Var: Fiber coverage rate	(1) OLS	(2) Heckman	(3) OLS	(4) Heckman
State aid (dummy)	0.061**	0.064**	0.518***	0.468***
	(0.030)	(0.030)	(0.043)	(0.053)
State aid (dummy) * 2015			-0.196***	-0.175***
			(0.034)	(0.033)
State aid (dummy) * 2016			-0.299***	-0.262***
			(0.042)	(0.046)
State aid (dummy) * 2017			-0.359***	-0.318***
			(0.041)	(0.049)
State aid (dummy) * 2018			-0.434***	-0.384***
			(0.037)	(0.046)
State aid (dummy) * 2019			-0.506***	-0.451***
			(0.035)	(0.048)
Level of coverage in neigbor t-1	0.378***	0.489***	0.381***	0.451***
	(0.039)	(0.034)	(0.037)	(0.038)
Log(Income)	-0.070*	-0.066*	-0.075**	-0.072*
	(0.036)	(0.037)	(0.036)	(0.037)
Type of initiative zone (ref: public)				
Private initiative	0.063**	0.108***	0.065**	0.093***
	(0.030)	(0.033)	(0.031)	(0.032)
Mixed initiative	0.073	0.135**	0.076	0.115*
	(0.058)	(0.058)	(0.059)	(0.059)
Copper loss (ref: <=20dB)				
20dB-30dB excellent	0.019	0.030*	0.022	0.028*
	(0.015)	(0.015)	(0.015)	(0.015)
30dB-40dB very good	0.065***	0.072***	0.067***	0.071***
	(0.018)	(0.018)	(0.018)	(0.018)
40dB-50dB good	0.111***	0.117***	0.112***	0.116***
	(0.023)	(0.023)	(0.023)	(0.023)
50dB-60dB poor	0.147***	0.153***	0.147***	0.151***
	(0.026)	(0.026)	(0.026)	(0.026)
>=60dB bad	0.154***	0.156***	0.155***	0.156***
	(0.030)	(0.030)	(0.030)	(0.030)
Year dummies (ref 2014)				
y2015	0.052***	0.047***	0.031**	0.030**
	(0.016)	(0.013)	(0.012)	(0.012)
y2016	0.090***	0.085***	0.064***	0.064***
	(0.024)	(0.022)	(0.021)	(0.020)
y2017	0.112***	0.112***	0.093***	0.095***
	(0.027)	(0.024)	(0.026)	(0.025)
y2018	0.164***	0.163***	0.166***	0.165***
	(0.029)	(0.026)	(0.031)	(0.029)
y2019	0.195***	0.197***	0.234***	0.232***
	(0.030)	(0.028)	(0.032)	(0.030)
Mills ratio		0.050***		0.032**
		(0.017)		(0.016)
Department dummies	Yes	Yes	Yes	Yes
Constant	0.758**	0.603	0.769**	0.670*
	(0.364)	(0.385)	(0.364)	(0.382)
Observations	81,616	81,616	81,616	81,616
Adjusted R-squared	0.289	0.291	0.296	0.297

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

2.7 Conclusion

In this chapter we exploit a rich data set on fiber deployment, State aid and local market characteristics in France to analyze the efficiency and the impact on fiber coverage of State aid granted through the French Broadband Plan (*Plan France Très Haut Débit*). First, we study the determinants of entry into fiber and evaluate the efficiency of the plan using a model of fiber entry. Second, we assess the impact of State aid on fiber deployment, controlling for the endogeneity of fiber entry.

State aid is an important policy tool for the deployment of networks in rural and low-density areas, where private operators may have no incentives to provide ultra-fast broadband. However, State aid is subject to control as it may distort competition or crow-out private investments. In particular, it is important to corroborate that State aid was granted in areas where market operators would not normally choose to invest. Moreover, the underlying objectives of State aid for broadband set by the European Commission should be verified, that is, achieving a higher level or faster rate of coverage and penetration in areas where market failure exists. This chapter was written as part of the *ex post* evaluation of the French Broadband Plan required by the European Commission to comply with its State aid scheme.

Our results suggest that the French Broadband Plan was rather efficient in providing aid in places where fiber entry would not have occurred otherwise. In 80% of cases, State aid benefited municipalities where entry was not expected during the year when State aid became effective. When considering the possibility of entry after State aid took effect, its effectiveness is 64%. Although cases of early entry or crowding out of private investments cannot be ruled out, they seem hard to avoid given the uncertainties surrounding investment costs and demand at the early stages of fiber diffusion. Moreover, it could seem preferable for the Government to "overdimension" its policy instead of risking to leave some areas without fiber provision due to an "underdimensionned" State aid plan. Our analysis also suggests that the French Broadband Plan allowed higher fiber coverage rates in aided municipalities, especially at the beginning of the period of analysis. This effect decreases over time.

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

The decrease in the effectiveness of the plan and of its effect on coverage over time should call the attention of regulators. High uncertainty on the demand for ultra-fast broadband and investment costs at the beginning of the period could in part explain this. While information asymmetries can justify public interventions, economic theory suggests that public subsidies are not the best tools to address them. Most importantly, a replacement effect from the legacy copper network suggested by our results could - at least in part- be responsible for an under provision of fiber. The existence of such an effect and its consequences on innovation and entry decisions on other technologies should be analyzed by Regulatory Authorities.

Due to data limitations and the focus on infrastructure operators, in this chapter we are unable to study the impact of State aid on competition or the impact of fiber competition on deployment. Thus, the analysis of entry in the downstream market for fiber service provision to residential and/or business consumers seems an interesting avenue for future research. Moreover, in this chapter we assume that there is no bias of favoritism or corruption in the granting of aid in local markets. For instance, there might be political factors (e.g., differences in the engagement of constituents or local representatives across markets, political orientation at the regional, departmental and local levels) influencing the location and timing of State aid. This question has gained our interest and will be studied in a future research project.

Appendices

A1 Additional Tables

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

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

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

Year	Model I	Model II	Model III
2014	98.8%	98.7%	98.8%
2015	98.4%	98.2%	98.4%
2016	97.1%	96.7%	97.0%
2017	96.7%	96.3%	96.3%
2018	95.5%	95.1%	94.2%
2019	92.8%	91.7%	89.9%
All	97.0%	96.7%	96.4%

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

CHAPTER 3

Transport Policy in the Digital Age: Insights from the Entry of Ride-Hailing Platforms in Chile*

*This chapter was written with Vicente Lagos (Telecom Paris, Institut Polytechnique de Paris) and Christine Zulehner (University of Vienna). We are grateful to Maya Bacache, Olivier Sautel, Jasmin Fliegner, Xavier Lambin, Helena Perrone and Paul Belleflamme for comments and useful suggestions. We thank Alejandro Tirachini and Andrés Gómez-Lobo for providing us access to responses to their Uber use survey in Chile. This chapter has also benefited from discussions with participants at the 2018 Digital Economics Summer School organized by the *Association Francophone de Recherche en Economie Numérique* (AFREN), the 2018 Doctoral Workshop on the Economics of Digitization at Télécom Paris, the 2019 ADRES Doctoral Conference held in Marseille, MaCCI Annual Conference 2019, the 2019 Doctoral Workshop on the Economics of Digitization at Louvain-La-Neuve, the 2019 Conference of the International Transportation Economics Association held in Paris, the 68TH Annual Meeting of the French Economic Association, the 34th Annual Congress of the European Economic Association, and the 2019 Annual Conference of the Verein für Socialpolitik. All errors are our own.

Abstract

This chapter empirically assesses the impact of ride-hailing platforms on the incidence of drunk-driving fatal crashes and fatalities in Chile. Using a difference-in-differences approach, we study heterogeneous effects in fatalities by gender and role in the crash (driver or passenger). Our results suggest that the introduction of ride-hailing platforms has significantly reduced fatal crashes and fatalities, especially the number of female passengers' fatalities and the number of male drivers' fatalities at night. The former result may evidence that ride-hailing platforms like Uber can contribute to the mitigation of the mobility bias against women in the traditional transport sector.

Key words: Uber; ride-hailing; alcohol-related crashes; drunk-driving; traffic fatalities; mobility bias.

JEL classification: I12, I18, K42, R41.

3.1 Introduction

"Uber was banned partly because of passenger safety

— but women say they'll be less safe without it"

Shona Ghosh, Business Insider[1]

Since the advent of Uber, i.e., an app-based platform offering ride-hailing services, the mobility landscape has undergone considerable changes in many cities all over the world.[2] Transactional efficiencies increased the popularity of ride-hailing services and their likelihood of being adopted by customers. Nevertheless, their introduction has led to opposition from traditional transport sectors, especially taxis, and to a regulatory debate related to security and risky behavior concerns.[3],[4] Opponents argue that the lack of state regulation for this type of services – regarding both drivers and vehicles – put passengers and pedestrians at risk. They claim that less experienced drivers with few or no background checks are more prone to driving crashes.[5] Uber challengers further argue that the increased number of vehicles on the road increases congestion and that the use of applications while driving can increase driver distraction. These factors could potentially increase the likelihood of crashes.[6]

[1]Article published by http://uk.businessinsider.com/, written by Shona Ghosh on Sep. 22, 2017, 1:28 PM. Retrieved on June 10, 2018, from the following link: http://uk.businessinsider.com/women-less-safe-without-uber-london-2017-9

[2]The number of firms using the same type of technology and business model as Uber has increased in the last years, e.g., Lift, Cabify, Careem, DiDi, among others.

[3]As of September 2017, Uber had been banned in several locations (non-exhaustive list): Bulgaria, Denmark, Italy, Hungary, Vancouver (British Columbia) and Australia's Northern Territory. Uber has also faced suspensions in Finland, France, Spain and the Netherlands. See: http://www.independent.co.uk/travel/news-and-advice/uber-ban-countries-where-world-taxi-app-europe-taxi-us-states-china-asia-legal-a7707436.html

[4]For instance, Anil & Fisher Ellison (2017) study regulatory distortion using evidence from Uber's entry decisions in the US.

[5]Likewise, less scrutinized vehicles – compared to taxis or traditional vehicles for hire - while used more intensively can increase the risk of crashes related to vehicle parts' failures.

[6]Empirical evidence on this question is scant and dissimilar. For instance, Li et al. (2016) provide evidence suggesting that ride-sharing services such as Uber significantly decrease traffic congestion time, congestion costs, and excessive fuel consumption in urban areas of the United States. Tirachini & Gomez-Lobo (2018) find that the advent of ride-sourcing applications increases the number of vehicle kilometers traveled in Chile, unless ride-sourcing applications substantially

There are several reasons why ride-hailing platforms like Uber can represent relevant alternatives to traditional services like taxicabs. These apps allow the tracking and sharing of location in real time, use rating systems intended to ensure safety and high-quality service, provide the possibility to wait somewhere safe until the vehicle arrives and payments are automatic in most of the cases (see also Dills & Mulholland 2018, Greenwood & Wattal 2017). In the specific case of countries like Chile, these features are even more relevant as women express safety concerns in transportation, and they drive considerably less than men do. Moreover, in some cities Uber services are cheaper than traditional taxi-hires, making them also attractive from a budgetary point of view. In other cases, they can also create allocation efficiencies by adapting prices to demand and supply fluctuations.[7]

The availability of these services may have also created an opportunity to attenuate the magnitude of the existing mobility bias against women, especially in developing countries. These platforms use technological features that potentially make them safer (i.e., location track, reputation and rating systems). Thus, in the context of insecurity and sexual harassment in transportation, ride-hailing apps may represent an attractive alternative especially for women. According to surveys and the conclusions of transport policy roundtables, security issues affect in particular women in both public and private transportation.[8],[9] For instance, a recent study by the Development Bank of Latin America (CAF) and the FIA foundation on public transport in Chile, Peru and Argentina found that in Santiago 73% of women feel unsafe using public transport (compared to 59% of men), 48% have witnessed or known of a case of sexual harassment and 51% have experienced it themselves.[10] There is also evidence of widespread sexual harassment affecting women in public transport and public space in Bogotá (Quinones, 2020). The public opinion and policy makers

increase average occupancy rate of trips and become ridesharing.

[7]In the US, this is the case in 19 over 21 cities studied by Silverstein (2014) when tips to taxi drivers are not considered and in all 21 cities when the latter are considered., According to a consumers and users' organization study, it seems that Uber is also less expensive than traditional taxis in Chile. See: http://www.cooperativa.cl/noticias/pais/transportes/estudio-determino-que-cabify-es-el-transporte-mas-barato-y-los-taxis/2017-11-15/161112.html.

[8]See for instance: European Parliament (2006), Uteng (2012), European Institute for Gender Equality (2016).

[9]Women exclusive cars in metro and train systems in different countries around the world are examples of policies introduced for fighting sexual harassment in public transportation.

[10]See: Allen, H., Pereyra, L., Sagaris, L., & Cárdenas, G. (2017). Ella se mueve segura. She moves safely. A study on women's personal security and public transport in three latin american cities. fia Foundation Research Series, Paper, 10.

increasingly recognize that due to different socio-economic roles and responsibilities, women have different patterns of use, access and needs that transport planning does not address systematically (Granada et al., 2016). There is also evidence of statistical discrimination of women when investigating bargaining outcomes in the taxi market (Castillo et al., 2013). Furthermore, there exists empirical evidence that commuting has an important detrimental effect on the psychological health of women, but not men (Roberts et al. 2011).

This chapter investigates the impact of Uber's ride-hailing service on the incidence of alcohol-related fatal traffic crashes and alcohol-related traffic fatalities in the Metropolitan Region of Chile (i.e., the Province of Santiago and its suburbs). We focus on crashes caused by people driving under the influence of alcohol (hereinafter "drunk-driving crashes"), following recent empirical literature in the US, which has used these indicators to measure the impact of Uber's entry on road safety. Moreover, we study heterogeneous effects of crashes by daytime and in fatalities by gender and role of people involved in the crashes. The idea that ride-hailing platforms like Uber may create an opportunity for reducing instances of drunk-driving and related fatalities comes from the fact that its availability may encourage some potential drowsy or alcohol intoxicated drivers to ride instead of driving themselves (Badger 2014, Rayle et al. 2016). Moreover, it can provide passengers in potential drunk-driving situations with an easy way to avoid unwanted risks.[11],[12] The rationale behind, based on rational choice theory, is that ride-hailing platforms constitute a new relevant alternative to cabs or public transportation, especially for trips whose purpose is alcohol consumption or whose timeframe is late at night (Peck 2017). Thus, ride-hailing platforms' availability would add to the choice set of potential drinkers or already inebriated individuals (Greenwood & Wattal 2017), and to the trade-off between public transportation, alcohol consumption, and intoxicated driving (Jackson & Owens 2011). Beyond the monetary costs of the ride, accounting for security concerns and comfort considerations can position ride-hailing platforms like Uber as an overall "cheaper" alternative to drunk-driving compared to traditional

[11] See: https://www.washingtonpost.com/news/wonk/wp/2014/07/10/are-uber-and-lyft-responsible-for-reducing-duis/?utm_term=.f7c7c6e72e3f

[12] This type of effect seems plausible in a context of regulatory structure for traditional taxis services designed to limit the number of licensed vehicles, thus probably resulting in more citizens operating motor vehicles under the influence of alcohol (Greenwood & Wattal, 2017).

transport services.[13] This could be especially the case for women.

Using detailed crash-level data from Chile for the period 2008-2016, of every car accident registered by the police, we estimate the impact of ride-hailing platforms on the number of drunk-driving fatal crashes and drunk-driving fatalities. We focus on the case of Uber as it has been by far the most popular and used ride-hailing platform in Chile.[14] The identification strategy relies on the assumption that the entry of Uber, that occurred first in the Metropolitan Region of Chile (Uber Black entered in January-2014, and UberX entered in June-2015) was motivated by profitability reasons unrelated to the expected evolution of the number of drunk-driving crashes. Hence, this event would represent a form of natural experiment, which allows us to estimate the impact of Uber's entry on the variables of interest through a simple reduced-form difference-in-differences estimator. We use some of the remaining 294 Chilean "untreated" municipalities as control group.

Our results suggest that the entry of UberX generated a significant reduction in the number of drunk-driving fatal crashes and fatalities in Chile's Metropolitan Region, by approximately 33% and 42% respectively. Our results also suggest that for these types of crashes, the entry of UberX significantly reduced the number of female passengers' fatalities by 71% (with no statistically significant effect for male passengers) and the number of male drivers' fatalities during the nighttime by 43% (with no statistically significant effect for female drivers). These results are robust to the inclusion of different sets of controls, exposure measures and regression methods. While potential identification issues may bias our results, we believe they most likely go in the direction of an underestimation of the true effect of UberX's entry.[15]

Since we observe a reduction in the number of passenger fatalities associated with

[13] Nonetheless, there are alternative positions to this view. Brazil & Kirk (2016) mention three. First, depending on the degree of law enforcement in the respective country, ride-sharing may still be costlier than drunk-driving as drunk-drivers might not be caught. Second, if individuals inclined to drink and drive are not rational in the first place, the entry of Uber may not have any impact on their behavior. Third, Uber's unprecedented growth may not be sufficient to influence an important part of drunk-driving incidences occurring each year.

[14] According to a study by the National Productivity Commission and Chile Foundation, Uber is the platform that dominates the market in both knowledge and use in 2018, followed far behind by Cabify. See: Comisión Nacional de Productividad y Fundación Chile (2018), Conocimiento y uso de las plataformas digitales de transporte, p. 4. Figure 18 confirms this has been the case over time.

[15] See Sections 3.5.2, 3.6.1 and 3.6.3 for detailed discussions about identification and for the robustness checks.

the entry of UberX for women, this result may evidence that Uber has contributed to a mitigation of the mobility issues women face in the traditional transport sector. Indeed, if safety concerns in public transportation mainly affect women, and they drive less than men do, then the introduction of a safer transportation option like Uber should represent a new relevant choice, especially for female passengers. Women could change their behavior when facing the risk of traveling with an intoxicated driver (i.e., by having Uber as a new safer alternative compared to using traditional public or private transportation).

We contribute to the existent literature by providing evidence of the effects of ride-hailing platforms like Uber in other geographical regions, more precisely in Chile, where around 3,650 drunk-driving crashes occur every year (of which around 500 are fatal and leave an average of 670 people dead or severely injured per year).[16] Specificities related to the availability of transport alternatives, as well as reputation and security issues of traditional vehicle for hire services in developing countries make the question of the potential societal effects of ride-hailing platforms even more relevant for policy makers in these regions.[17] Moreover, we contribute to the literature by providing evidence on the benefits ride-hailing apps may bring to women, which suffer from a mobility bias in the traditional transport sector.

The reminder of the chapter is organized as follows. Section 3.2 reviews the related literature. Section 3.3 discusses the gender bias in mobility. Section 3.4 describes the case of Chile and the data used in the chapter. Section 3.5 presents the empirical strategy and results. Section 3.6 discusses identification and robustness checks.

[16] Statistics based on CONASET data, for drunk-driving crashes defined as crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. A private driver is defined as an individual driving a vehicle that is unrelated to the provision of any public or private service (e.g., taxis, ambulances, firemen, police, intra-city buses, inter-city buses, school buses, etc.).

[17] Some of the typical concerns about taxis in Chile include the functioning of taximeters, the possibility that bargaining may be necessary for long distances and the suggestion of using radio taxi services especially at night and for security reasons. See for example: http://www.contactchile.cl/es/descubrir/seguridad/bus-metro-taxi.html. For women in particular, several claims and complaints about violence or harassment in taxis are received each year as testified by Cristóbal Llugany, manager of SaferTaxi Chile in 2015 (See: https://www.publimetro.cl/cl/nacional/2015/03/08/implementan-mas-seguridad-mujeres-taxis-urbanos-santiago.html). SaferTaxi is an app-based service to request, travel, and pay for taxi rides with mobile phone in Chile and other Latin American countries (See: http://www.safertaxi.com/en)

Section 3.7 concludes.

3.2 Literature Review

This chapter directly relates to three streams of the economics literature studying transportation options and drunk-driving. First, it relates to the theoretical literature on rational choice theory and drunk-driving, which sheds light on the way intoxicated or potentially intoxicated individuals make decisions. In particular, this literature studies deterrence and how individuals trade off benefits and costs of specific behaviors or courses of action (Jackson & Owens 2011, Turrisi & Jaccard 1992, Ross 1984 and Thurman et al. 1993). Second, this chapter relates to empirical work on transportation options and crime rates, specifically DUI, which focuses on accessibility to existing transportation options or availability of new alternatives (Philips & Sandler 2015 and Martin-Buck 2017).[18] Third, this chapter is closely associated to the empirical literature studying the impact of ride-hailing on overall and drunk-driving traffic crashes and fatalities.

In particular, this latter stream of literature focuses on the effects of ride-hailing apps on specific US cities (Greenwood & Wattal 2017, Morrison et al. 2018 and Peck 2017) or across metropolitan counties in the US (Brazil & Kirk 2016, Dills & Mulholland 2018 and Barrios et al. 2020). For instance, Greenwood & Wattal (2017) study the impact of the introduction of Uber in the rate of vehicle homicides in California. Using a difference-in-differences approach, with different regression methods, the authors find evidence of a significant drop in the rate of homicides after the introduction of Uber.[19] Their results also suggest that not all services offered by Uber have the same effect, as the effect of Uber Black is intermittent and manifests only in selective locations (i.e. large cities). Likewise, Brazil & Kirk (2016) test the association between the availability of Uber's rideshare services and total, drunk driving-related, and weekend and holiday-specific traffic fatalities in the 100 most populated metropolitan areas in the United States. Using Negative Binomial and Poisson regression models, the authors find that the deployment of Uber services in a given metropolitan county had no association with the number of subsequent traffic fatalities, whether measured in aggregate or specific to drunk-

[18] DUI stands for "driving under the influence". Usually, it refers to alcohol or any other drug or intoxicant.

[19] Different regression specifications, including: OLS, Poisson and Negative Binomial.

driving fatalities or fatalities during weekends and holidays.[20] This literature points thus in different directions, calling for more empirical evidence on the potential impact of rides-haring services in drunk-driving crashes and fatalities.

This chapter contributes to the previous three streams of literature by providing evidence of the effects of alternatives brought by the digital economy on drunk-driving fatal outcomes in another geographical region with specificities in the quality and availability of traditional transport alternatives. More importantly, it contributes to the literature by enlightening on the potential differences in decision making and outcomes according to individual's gender and roles (drivers and passengers).

Thus, this chapter also relates to the literature studying the relationship between gender and mobility (Duchene 2011, Peters 2013, Castillo et al. 2013, Ng & Acker 2018, Quinones 2020). In particular, this literature studies differences by gender in the use and needs regarding mobility. Moreover, it recognizes safety as a gender-specific issue restricting women's mobility.

This work seeks to inform the ongoing policy debate regarding ride-hailing and ride-sharing services and their societal impacts. Recent studies also look at the relationship between ride-hailing and traffic congestion (Li et al. 2016, Henao & Marshall, 2018, Tirachini & Gomez-Lobo 2018), safety regulations (Anil & Fisher Ellison 2017), search frictions and matching (Shapiro 2018, Bian 2020, and Vergara-Cobos 2018), public transit ridership (Hall et al. 2018), taxi drivers' earnings (Berger et al. 2018) and moral hazard (Liu et al. 2021).

3.3 A Gender Bias in Mobility

The study of the interrelation between gender and mobility has gained increasing importance in recent years. Multilateral organizations and governments now recognize the existence of a mobility bias against women in the traditional transport sector. As discussed in the Transforming Transportation 2018 conference cohosted by the World Bank and the World Resources Institute, "transportation is not gender neutral". Men and women have different socio-economic roles, which are associated with

[20]In Brazil & Kirk (2020), using a more recent period of study, the authors find that "Uber availability is not associated with changes in total, alcohol-involved, and weekend and holiday-specific traffic fatalities in aggregate, yet it is associated with increased traffic fatalities in urban, densely populated counties".

different patterns of use, access and needs with respect to transportation. Unfortunately, there is still little evidence about these differences in needs and transport planning does not systematically address them.[21]

Among the various barriers limiting their mobility, women face security issues and sexual harassment in public and private transportation.[22] Women-exclusive carriages in metro lines are an example of policies intended to protect women from sexual harassment in public transportation. In Latin America, authorities in Rio de Janeiro and Mexico City implement them, but they also exist in cities like Tokyo, Osaka, Cairo, Delhi, Bombay, Calcutta, Chennai and Tehran. Decision makers in London and Santiago have also considered introducing this kind of policy for the same reasons. However, they have dismissed because they consider it does not address the main underlying problems. Regarding other transportation modes, Thailand introduced this policy in the country's main train routes and Iran proposes gender-segregated bus services.[23],[24]

Several studies and surveys provide evidence on the differentiated feelings and experiences in transportation by gender. For instance, a study carried out in France in 2018 by the ONDRP[25] shows that about 51% percent of women (compared to 38% of men), declared to feel unsafe in the public transportation system. Another recent study by the Development Bank of Latin America (CAF) and the FIA foundation revealed the sexual harassment suffered by thousands of women on public transport in Chile, Peru and Argentina. According to the results, in Santiago 73% of women feel unsafe using public transport (compared to 59% of men), 48% have witnessed or known of a case of sexual harassment and 51% have experienced it themselves.[26]

Beyond public transportation, taxi and ride-hailing drivers are also accused of sex-

[21] See: http://blogs.worldbank.org/transport/transport-not-gender-neutral

[22] See for instance: European Parliament (2006), Uteng (2012), European Institute for Gender Equality (2016).

[23] For London, see: http://madame.lefigaro.fr/societe/en-angleterre-lidee-des-wagons-reserves-aux-femmes-refait-surface-240817-133706. For Santiago, see: https://www.emol.com/noticias/Nacional/2018/10/15/923836/Si-no-son-vagones-segregados-entonces-que-Experta-propone-estrategias-para-combatir-acoso-sexual-en-el-transporte-publico.html.

[24] See: https://www.telegraph.co.uk/women/womens-life/11824962/Women-only-trains-and-transport-How-they-work-around-the-world.html

[25] Observatoire national de la délinquence et des réponses pénales.

[26] For details about France, see: Vanier & D'arbois de Jubainville (2018). For more details about Chile, Peru and Argentina, see: Allen, et al. (2017).

ually assaulting or raping customers. According to Freedom of Information data obtained by the Sun, in the UK, in 2015, there were 154 allegations against taxi and car-hire drivers of which 32 against Uber drivers.[27] While Uber was banned in London in 2017 partially because of passenger safety, according to Shona Ghosh, senior tech reporter at Business Insider, women say they will feel less safe taking taxis or cabs instead.[28]

In the specific case of Chile, several other facts reveal the gender bias in mobility beyond the statistics about sexual harassment in private and public transport. First, women do not have the same access or, at least, not the same exposure to driving than men. In 2016, women represented 17% of all drivers in traffic crashes in Chile, while they represented 61% of passengers. In the same year, only 24% of driving licenses processed corresponded to applications made by women.[29],[30] Moreover, in 2018 a new app-based ride-hailing platform called "She Drives Us" was launched in the Chilean market. The main differentiating feature of this app is the fact that both drivers and passengers are exclusively women. One of the main motivations claimed for its introduction was avoiding the threat of gender violence.[31]

3.4 The Case of Chile and Data

3.4.1 Uber in Chile

When entering in the Chilean market, Uber first deployed its services in the Metropolitan Region. This region is one of Chile's 16 first-order administrative divisions. It counts 52 municipalities, including the country's capital city Santiago (or Province of Santiago), and it accounts for 41% of Chile's population. Uber initially entered in the Metropolitan Region in January-2014 only with its Uber Black service, which consists in an offer of high-end cars and a price per-ride that is in general more expensive than the one offered by traditional taxi services. In June 2015, Uber introduced the UberX service (along with Uber SUV), which offers cheaper rides

[27] See: https://www.independent.co.uk/news/uk/uber-drivers-accused-of-32-rapes-and-sex-attacks-on-london-passengers-a7037926.htmlr3z-addoor

[28] See: http://uk.businessinsider.com/women-less-safe-without-uber-london-2017-9/

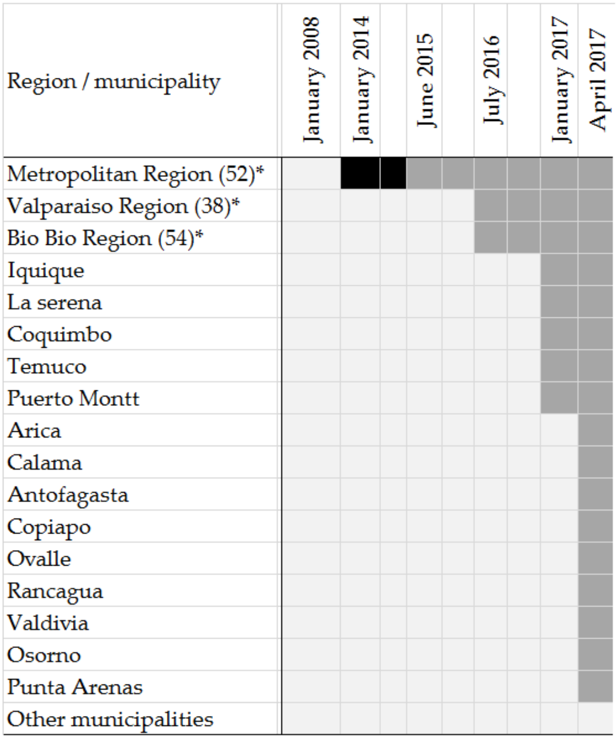
[29] Calculations based on the information provided by the data observatory of CONASET.

[30] Calculations based on INE's statistics about processed driving licenses per year.

[31] See: https://www.latercera.com/tendencias/noticia/shedrivesus-la-aplicacion-transporte-mujeres-ahora-permite-pagar-debito/177294/

with prices that can be 25% lower than the ones offered by Uber Black.[32] Figure 17 illustrates Uber's entry dates in different regions and municipalities across Chile.

Figure 17: Uber's entry dates and availability in different Chilean municipalities



*Number of municipalities in the region in parenthesis.
Note 1: Our database includes information only until December 2016. We truncated it to the third quarter of 2016 to avoid confounding treatment and control groups. In total, there are 346 municipalities in Chile.
Note 2: Black boxes represent Uber Black's entry and presence alone in the Metropolitan Region; gray boxes represent the entry and availability of UberX and other types of Uber services such as SUV or Uber Black at the same time. In practice, other ride-hailing platforms entered the Metropolitan region during the analysis period, but they remained far less used than Uber. The light gray area illustrates the absence of Uber's services in different municipalities across time.

In terms of market penetration, Uber services became popular by the second half of 2016 and have remained the dominant ride-hailing platform in Chile in both knowledge and use, followed far behind by Cabify.[33] Figure 18 displays the popularity of the search "Uber" in the Metropolitan Region of Chile measured by its Google Trends index.[34] The relative popularity of the search words "Cabify", "Easy taxi"

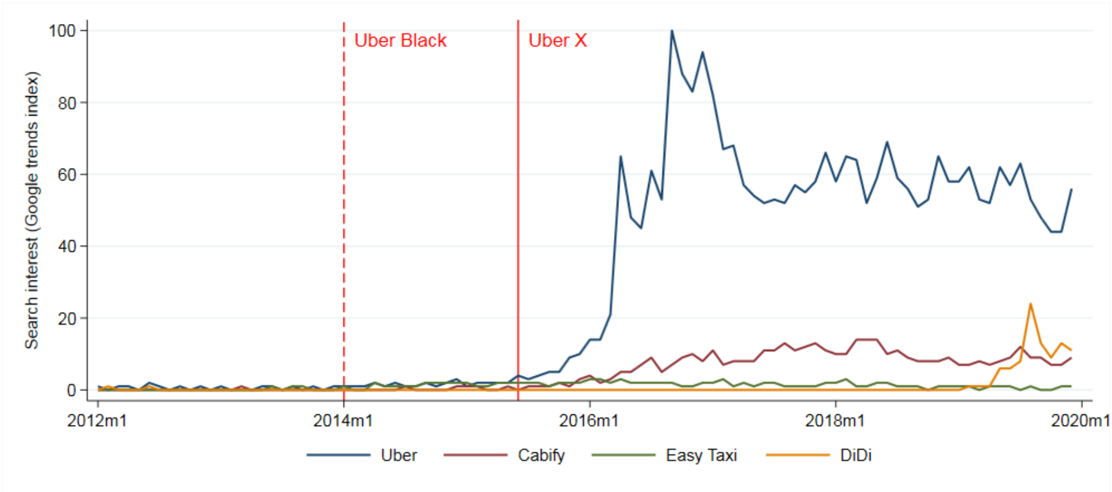
[32] A printed version of Ubers' website in Chile with information about its functioning and tariffs in 2015 if available upon request.

[33] See: Comisión Nacional de Productividad y Fundación Chile (2018), Conocimiento y uso de las plataformas digitales de transporte, p. 4.

[34] The data on interest over time provided by Google trends represent search interest relative to the highest point on the chart for the given region and time. A value 100 is the peak popularity

and "DiDi" is also displayed for comparison. The vertical lines indicate Uber Black and UberX's entry dates.

Figure 18: Search interest over time for the terms "Uber", "Cabify", "Easy Taxi" and "DiDi" in the Metropolitan Region of Chile



Source: Google Trends

The entry of Uber and other ride-hailing platforms generated an intense debate among authorities, taxi drivers and users in Chile. In October 2016, the Chilean congress proposed a legislation that would regulate the operation of this type of services. The legislation, approved by the lower house of congress in April 2019, and under ongoing debate on the Senate as of November 2021, aims at introducing a maximum quota of cars that can operate with these platforms, the requirement of professional license for drives, and the requirement of certain quality standards for cars, among others.[35],[36] Thus, Uber was considered as a non-regulated service (or even illegal) during the period of our study.

In turn, users have expressed concerns regarding the possibility that these new regulations may limit the availability of ride-hailing services. The reason is that these new services have been perceived by users as of higher quality in comparison to traditional taxi rides, mainly due to the existence of transparent pricing, better

for the term. A value of 50 means that the term is half as popular. Likewise, a score of 0 means the term was less than 1% as popular as the peak.

[35] For more information about the state and progress of the bill, see: https://www.camara.cl/pley/pley_detalle.aspx?prmID=11449&prmBoletin=10937-15

[36] For more information, see: http://www.t13.cl/noticia/nacional/comision-transportes-aprueba-nuevo-proyecto-ley-regula-sistemas-como-uber-y-cabify

quality cars, shorter waiting times, and the possibility to pay with credit card, among others.[37] The appearance in 2016 of the movement *"Ubersequeda"* (which translates as "Uber stays") is an example of users' initiatives to demand the right of users to freely access ride services of higher quality.[38]

Researchers from the University of Chile conducted a survey to depict the habits of Uber users in Santiago, in particular the purposes and reasons of use.[39] According to the survey's respondents, the most popular purpose for Uber rides in Chile is going to restaurants, bars and parties (more than 30% of female and male respondents). On the reasons of use, ease of payment, trip cost, fare transparency, the possibility of identifying the driver and waiting time are cited among the most popular motives to use Uber's services. Moreover, an important proportion of respondents also indicate that they use Uber to avoid driving after consuming alcohol. Thus, the survey's results suggest that we can be confident about the mechanism behind the casual relationship we want to test between ride-hailing services' availability and drunk-driving crashes and related fatalities in Chile.

The survey also allows to compare purposes and reasons of use by gender.[40] The ranking of different purposes for Uber trips is almost the same for men and women (see Figure 19). However, the relative importance of reasons of use differs by gender (see Figure 20). The possibility of identifying the driver, evaluating the service and the perception of safety against crime are relatively more cited as reasons for using Uber by female than male (3rd and 6th places vs. 4th and 8th places, respectively). We consider that having similar trip purposes, but different reasons for using Uber by gender is may be an indication of the gender mobility bias discussed in the previous section.

3.4.2 Data

The data used in this chapter comes from several sources. The information about crashes comes from the data observatory of CONASET, the national body in charge

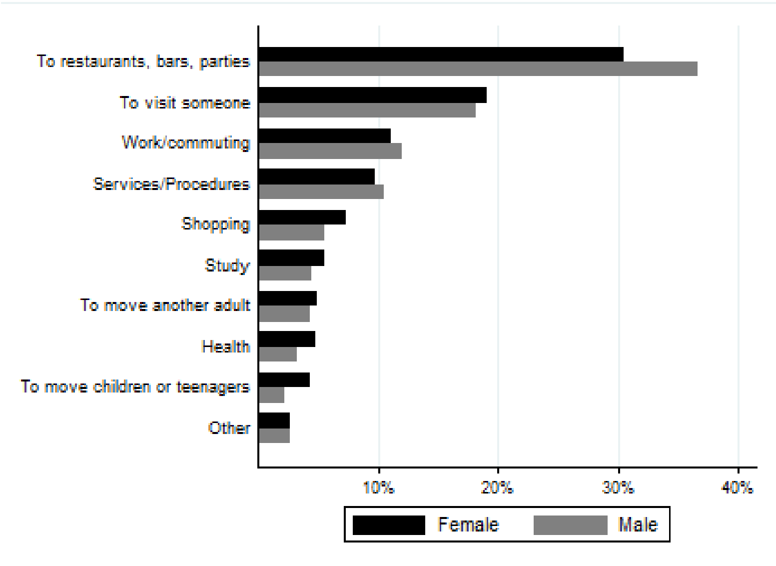
[37] See: http://www.emol.com/noticias/Nacional/2016/04/07/796905/Confianza-y-buen-servicio-Por-que-nos-los-usuarios-defienden-Uber.html

[38] The printed version of the petition is available upon request.

[39] See: Tirachini & Gómez-Lobo (2018).

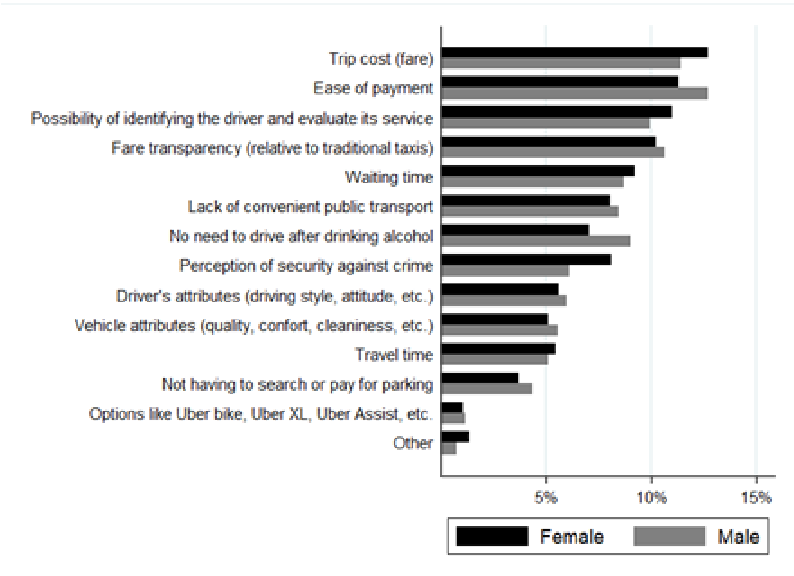
[40] We are grateful to Alejandro Tirachini and Andrés Gómez-Lobo for providing us access to responses to the Uber use survey distinguished by gender. For a detailed description of this survey, see: Tirachini & Gómez-Lobo (2018).

Figure 19: Trip purposes when using Uber by gender



Note: Question asked in the survey: *"For which type of trips do you use Uber? You can choose more than one"*. As each person could indicate several options, we rescaled the results to reflect proportions with respect to total responses instead of total respondents per group.

Figure 20: Reasons to use Uber by gender



Note: Question asked in the survey: *"When you travel using Uber, what are the reasons for using it? You can choose more than one"*. As each person could indicate several options, we rescaled the results to reflect proportions with respect to total responses instead of total respondents per group.

of traffic safety in Chile.[41] The database provides an inventory of all road crashes registered by the police, with related characteristics such as the date and time, the municipality where it took place, the type of accident (collision, run-over, crash, fire and rollover), the cause (alcohol in the driver, road deficiencies, speeding, distraction in the driver, etc.) and the number of dead and injured people. For each individual involved, the observatory provides information about age, gender, role (driver, passenger, pedestrian), the type of car (automobile, station wagon, jeep, motorcycle) and the type of service (private, bus, taxi). It covers the period 2008-2016.

To supplement the information about crashes, we use data from INE (*Instituto Nacional de Estadísticas*).[42] INE reports information per municipality about the number of registered vehicles, detailed by type (motorized, automobiles, taxis, trucks, etc.), as well as information about the population, by age and gender. Moreover, we recover information about the surface area of each municipality on the statistical reports of the BCN (Biblioteca del Congreso Nacional de Chile[43]) to calculate population and vehicle densities by municipality.

To identify the presence of Uber in a particular municipality, we retrieved Uber entry dates from Uber's website and online newspapers articles (see Table A.1.1). For each launch, we code a dummy variable identifying the municipalities receiving the service and the period through which the service is active. In practice, this means we are able to exploit differences in availability of the service across municipalities. In other words, the entry of Uber in the Metropolitan Region first provides a natural experiment that allows us to measure the impact of its entry on different outcomes of interest.

Based on all this information we construct a panel dataset of 335 municipalities during 34 quarters, going from the first quarter of 2008 to the second quarter of 2016. The data was initially available until the fourth quarter of 2016. However, Uber also launched services in two other regions of Chile (*Valparaiso* and *Bio Bio*) in July 2016. Thus, to avoid confounding treatment and control groups, we truncate the dataset to the third quarter of 2016.

[41] Comisión Nacional de Seguridad de Tránsito in Spanish. For detailed information, see: https://www.conaset.cl/

[42] See: http://www.ine.cl/

[43] See: https://www.bcn.cl/siit/reportescomunales/index.html

The panel is unbalanced. In practice, when aggregating information from the accident level to the municipality-quarter level, several observations are missing. While it is almost sure that missing points represent a scenario where the outcome variables are equal to zero, it cannot be ruled out that it may be the case of missing information caused by misreporting. For this reason, we truncate the information of each municipality, considering the first time in which an accident, of any type, was reported as the first quarter to be considered in the panel. Moreover, we dropped from the sample municipalities reporting more than 50% of the quarters with zero crashes (any type of accident).[44]

In our empirical analysis, we focus first in four variables: the number of drunk-driving crashes, the number of drunk-driving fatal crashes, the number of fatalities in drunk-driving crashes and the number of fatalities and injured people in drunk-driving crashes. Table 3.1 presents the list of variables considered and their definition.[45]

Occurrences for each of the definitions described in Table 3.1 are also considered specifically for the nighttime, i.e., between 22:00 and 6:00. Table 3.2 presents the summary statistics for the four outcome variables studied. Table A.1.2 in Appendix A1 presents summary statistics for these variables restricted to the nighttime. Each observation corresponds to one municipality in a specific quarter. Figure A.1.1 in Appendix A1 presents the distribution of each variable.

Table 3.3 provides an overview of drunk-driving crashes, as defined in Table 3.1, by time frame, severity, and per year.

On average, there were 3,646 drunk-driving crashes per year in Chile between 2008 and 2016. Among them, 1,599 of those crashes occurred during the day (43.6%) and 2,048 during the night (56.4%). With respect to their severity, on average 3,148 of

[44] In such cases, the uncertainty regarding the possibility of whether having under-reporting or observation points with effective zero crashes within a specific municipality seems very high. In practice, we dropped 9 municipalities, whose observations represent 2.6% of the sample and other extra observations representing 0.6% of the sample. Note that in our subsequent analysis, this truncation is not likely to affect our results because only one out of 403 observations dropped would have made part of the control groups considered.

[45] In Table 3.1, a private driver is defined as an individual driving a vehicle that is unrelated to the provision of any public or private service (e.g., taxis, ambulances, firemen, police, intra-city buses, inter-city buses, school buses, etc.).

Table 3.1: Variables considered and definition

Variable name	Definition
Number of drunk-driving crashes	Number of crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep.
Number of drunk-driving fatal crashes	Number of crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old), the type of at least one of the vehicles was an automobile, a van or a jeep, and the accident resulted in at least one fatality or severely injured person.
Number of fatalities in drunk-driving crashes	Number of dead and severely injured people in crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep.
Number of fatalities and injured people in drunk-driving crashes	Number of dead, slightly injured, less seriously injured and severely injured people in crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep.

Table 3.2: Summary statistics of the first four dependent variables studied

	Obs.	Mean	St. Dev.	Min	Max
Number of drunk-driving crashes	12017	2.73	5.67	0	67
Number of drunk-driving fatal crashes	12017	0.37	0.85	0	14
Number of fatalities in drunk-driving crashes	12017	0.50	1.26	0	24
Number of dead and injured people in drunk-driving crashes	12017	2.95	5.95	0	73

Table 3.3: Number of drunk-driving crashes in Chile

Year	Total	Daytime	Nighttime	Fatal	Non-fatal	Proportion of nighttime crashes (%)	Proportion of fatal crashes (%)
2008	3032	1272	1760	536	2496	58.0	17.7
2009	3020	1269	1751	513	2507	58.0	17.0
2010	3391	1362	2029	532	2859	59.8	15.7
2011	3855	1623	2232	550	3305	57.9	14.3
2012	2719	1218	1501	379	2340	55.2	13.9
2013	3592	1570	2022	468	3124	56.3	13.0
2014	3950	1770	2180	471	3479	55.2	11.9
2015	3946	1794	2152	447	3499	54.5	11.3
2016	5310	2509	2801	587	4723	52.7	11.1
Average	3646	1599	2048	498	3148	56.4	14.0

drunk-driving crashes were non-fatal (86%) and 498 were fatal (14%).

Table 3.4 details the number of fatalities in drunk-driving crashes, according to the definitions in Table 3.1, by time frame and per year. On average, each year there are 3,933 people affected to some degree due to drunk-driving crashes in Chile. Among them, on average 668 (17%) die or have a severe injury that could end in death. Injuries and deaths in drunk-driving crashes occur on a greater proportion at night (56%). The proportion of drunk-driving fatalities per year to the total population in Chile is similar to the one observed in the US.[46]

Table 3.4: Number of fatalities in drunk-driving crashes in Chile

	Dead and injured people			Fatalities		
Year	Total	Daytime	Nighttime	Total	Daytime	Nighttime
2008	4166	1618	2548	745	263	482
2009	3942	1690	2252	734	303	431
2010	4151	1638	2513	718	273	445
2011	4132	1760	2372	723	275	448
2012	2975	1436	1539	515	239	276
2013	3670	1668	2002	621	251	370
2014	3699	1707	1992	624	260	364
2015	3807	1800	2007	578	233	345
2016	4856	2306	2550	758	345	413
Average	3933	1736	2197	668	271	397

Figure A.1.2 in Appendix A1 compares the evolution of the total number of fatalities in drunk-driving crashes and the number of drunk-driving fatal crashes (both at all time frames and at night), in the Metropolitan Region and in other regions of Chile. This Figure illustrates an increase in the outcomes of interest after the entry of UberX which occurs in other regions, but not in the Metropolitan Region where Uber was available.

We further study gender-specific outcomes in drunk-driving crashes through a set of variables accounting for fatalities by gender and according to whether the individual was a passenger or a driver in the crash. In the same way as for the previous set

[46] According to Brazil and Kirk (2016), 121 million episodes of drunk driving, resulting in 10,000 traffic fatalities occur annually in the United States. Those figures correspond to episodes occurring in 2014 based on data from the Data from the National Highway Traffic Safety Administration. When we report the number of fatalities to the population in 2014 in the US (319.7 million people according to "US clock", See: https://www.census.gov/popclock/), the proportion of drunk-driving fatalities in the total population is 0.0031%. In the case of Chile, for the year 2014, the proportion is 0.0035%.

of variables, we also observe occurrences uniquely during the nighttime. Table 3.5 presents the summary statistics of the four gender-specific variables considered. Table A.1.3 in Appendix A1 presents summary statistics for these variables considering nighttime outcomes. Each observation corresponds to one municipality in a specific quarter. Figure A.1.3 in Appendix A1 presents the distribution of each variable.

Table 3.5: Summary statistics of the four gender-specific variables studied

	Obs.	Mean	St. Dev.	Min	Max
Number of female driver fatalities	12017	0.02	0.13	0	2
Number of male driver fatalities	12017	0.23	0.61	0	10
Number of female passenger fatalities	12017	0.09	0.40	0	6
Number of male passenger fatalities	12017	0.12	0.45	0	10

Figure A.1.4 in Appendix A1 illustrates, for each year, the proportion of fatalities in drunk-driving crashes by role, gender and time framework. In 2013, before Uber's entry in the Metropolitan Region, there were 572 fatalities of drivers and passengers in drunk-driving crashes. Among these fatalities, 13 corresponded to female drivers at night (2.3%), 10 to female drivers during the day (1.7%), 177 to male drivers at night (30.9%), 113 to male drivers during the day (19.8%), 62 to female passengers at night (10.8%), 50 to female passengers during the day (8.7%), 85 to male passengers at night (14.9%) and 62 to male passengers during the day (10.8%). Figure A.1.5 in Appendix A1 compares the overall evolution of the number of female and male passenger and driver fatalities in drunk-driving crashes in the Metropolitan Region and in other regions of Chile.

The study of fatalities by gender and role (passenger and driver) is relevant for two main reasons. First, in the presence of a gender bias in mobility, women's choice set is different than men's choice set, at least its quality. Then, we could expect women to be more responsive than men to a change in the transportation offer, especially given the features of ride-hailing platforms. Second, in our data we observe differences in the proportion of crash-related fatalities by role. This could also be explained by differences between drivers and passengers' choice sets and trade-offs. Appendix A2 details the mechanisms helping explain potential differences in the effect of ride-hailing platforms' availability on the outcomes studied.

Figure 21 compares the proportion of men and women in the total number of drivers and passengers involved in all types of crashes, drunk-driving crashes and drunk-driving crashes at night between 2008 and 2016. From this Figure, two elements catch our attention. The first element concerns drivers. The proportion of female drivers involved in all types of crashes and drunk-driving crashes in Chile is strikingly low. It has always been lower than 20% and 10%, respectively since 2008. This may be an indication of two possible situations. To begin, for diverse possible reasons, including income or specific cultural attitudes towards activities that have been traditionally carried out by men, women may not drive as much as them. Between 2011 and 2019, the proportion of driving licenses processed in Chile corresponding to female applications has been below 24%. In addition, women may indeed be less likely to be involved in crashes under the role of driver due to differences in the way of driving. It has been argued that women drive more safely because of differences in risk aversion.[47]

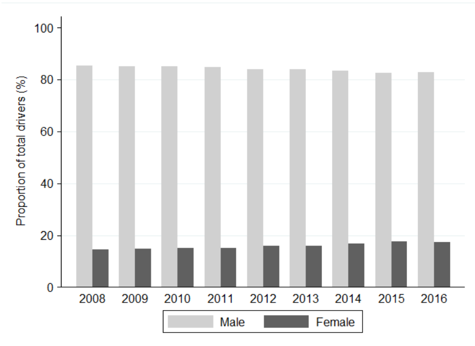
The second element concerns passengers. Women represent a greater proportion compared to men in all types of crashes (around 60%) and approximately the same or a bit less than men in drunk-driving crashes (around 45% and 50% of total passengers). The difference in proportions among passengers between the case of all types of crashes and drunk-driving crashes at night could be an indication that women go out less than men during the night precisely due to a mobility bias against them.

These statistics suggest that women do not have the same choice set as men when deciding how to go back home, especially during the night. Moreover, they suggest that the distinction by gender and role (driver or passenger) is relevant for our analysis. In particular, the choice of being a driver seems to be endogenous for men, but not necessarily for women.

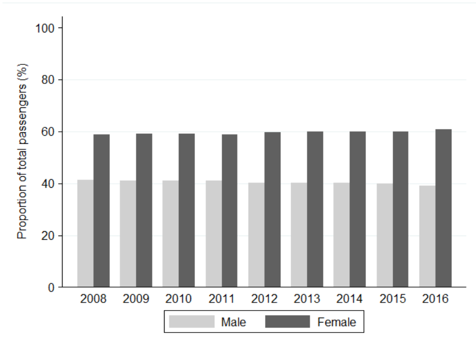
[47]For instance, Harris et al. (2006) study gender differences in reported perceptions about probability of negative outcomes, severity of potential negative outcomes and enjoyment expected from risky activities in different domains. They find that different perceptions partially mediate female lower propensity toward risky choices in gambling, recreation, and health domains.

Figure 21: Proportion of male and female in the total number of drivers and passengers involved in traffic crashes in Chile (2008 – 2016)

All crashes

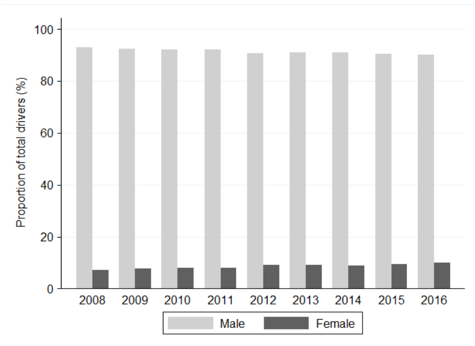


(a) Divers

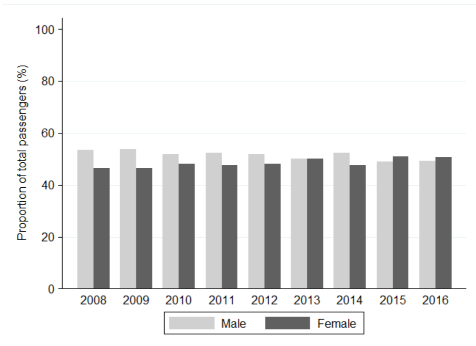


(b) Passengers

Drunk-driving crashes

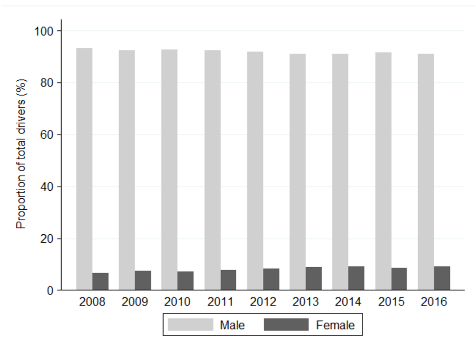


(c) Drivers

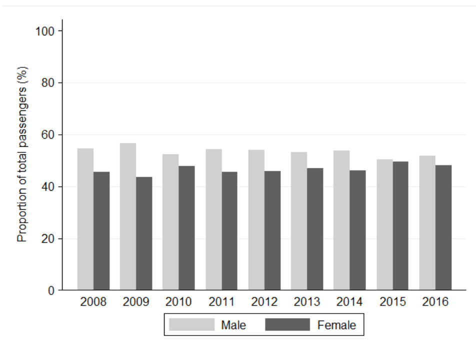


(d) Passengers

Drunk-driving crashes at night



(e) Drivers



(f) Passengers

3.5 Empirical Strategy and Results

3.5.1 Difference-in-differences Approach

To establish the effect of Uber's entry on the different outcomes we use a difference-in-differences approach. The main benefit of such an approach lays in the use of observational data to mimic an experimental design, as UberX and Uber Black appear in different locations at different points in time, i.e. are dispersed geographically and temporally. We estimate the effect of Uber's entry using the following equation:

$$y_{it} = \alpha X_{it} +_1 UberBlack_{it} +_2 UberX_{it} + \delta_t + \mu_i + \varepsilon_{it}, \tag{3.1}$$

where y_{it} is the outcome of interest[48] at municipality i and quarter-year t, X is a vector of control variables, μ is a vector of municipality fixed effects that control for time invariant differences between municipalities and δ is a vector of quarter-year fixed effects that control for common variation over time across municipalities. The variables of interest are $UberBlack$, which is the product of a treated municipality indicator and a time indicator equal to one after the entry of Uber Black (and before the entry of UberX), and $UberX$, which is the product of a treated municipality indicator and a time indicator equal to one after the entry of UberX.

From Figures A.1.1 and A.1.3 in Appendix A1 and Tables 3.2 and 3.5 presenting summary statistics, we notice that the distribution of our variables of interest is non-normal and is highly skewed towards zero. Moreover, our variables of interest are of count nature (since we are counting the number of times an event occurs in an interval of time and space). This suggests that the traditional OLS model is not well suited for our data. First, the normality assumption is violated. Second, if a log-transformation is applied for OLS regression analysis, issues arise, namely the loss of data due to undefined values by taking the log of zero and the lack of capacity to model dispersion.[49] Hence, our empirical approach consists in estimating

[48] See different variables defined in Table 3.1.

[49] The literature tries to work around the former issue by adding a constant value (usually one) to the variable of interest before applying the log-transformation. See for example, Greenwood & Wattal (2017) or Barrios et al. (2020).

a Poisson regression model. This approach is consistent with what has been done by other similar empirical studies.[50] As a robustness check we also consider some specifications estimated using an OLS regression (see Section 3.6.1).

Table A.1.4 in Appendix A1 presents a comparison of average characteristics of municipalities in the treatment and the control groups for different samples (all municipalities and municipalities with more than 100,000, 75,000 and 50,000 inhabitants in 2015). The treatment and control groups based on municipalities with more than 75,000 inhabitants in 2015 present the most similar average characteristics. The reason is that in our observation period Uber had only entered in the Metropolitan Region, which is the most highly populated area of Chile. Thus, by excluding very small municipalities, with population less than the 25% percentile of the population of municipalities of the Metropolitan Region in 2015, we ensure comparability of municipalities between treatment and control groups.

We build our preferred specification by restricting the sample to municipalities with more than 75,000 inhabitants in 2015. In addition to time and municipality fixed effects, we control for population density as this characteristic is the only that remains considerably different on average between the treatment and control groups. As robustness checks, we test for different specifications including different control groups and control variables (see Section 3.6.1).

3.5.2 Identification

The key identifying assumption of the difference-in-differences method is that in the absence of entry by Uber, the number of drunk-driving crashes and fatalities in municipalities belonging to the treatment and control groups would have followed similar trends over time. This is the well-known parallel trends assumption. We verify that this assumption is satisfied by running placebo tests, as suggested by Autor (2003). Further threats to identification are discussed in Sections 3.6.2 and 3.6.3.

This test consists of introducing placebo treatments in the estimation equation at all

[50] For instance, see: Brazil & Kirk (2016) and Greenwood & Wattal (2017). As demonstrated by Wooldridge (1999), the Fixed Effects Poisson estimator is completely robust. Relative to this estimator, the Fixed Effects Negative Binomial makes stronger assumptions difficult to meet in practice.

periods except one. The following equation is estimated using a Poisson regression model and our preferred specification:

$$y_{it} = \alpha X_{it} + \sum_{j \neq 2012q3-2013q2} \gamma_j (UberM \cdot I(t=j)) + \delta_t + \mu_i + \varepsilon_{it}, \tag{3.2}$$

where y_{it} is the outcome of interest[51] at municipality i and quarter-year t, X is a vector of control variables, μ is a vector of municipality fixed effects that control for time invariant differences between municipalities and δ is a vector of quarter-year fixed effects that control for common variation over time across municipalities. $UberM_i$ is an indicator variable identifying the municipalities where Uber entered first (Metropolitan Region). The sum includes time dummies I for all periods except the period going from the third quarter of 2012 and the second quarter of 2013. We choose this reference period because it is the period right before the entry of both Uber Black and Uber X, and because it is equivalent to the period where Uber X is active in municipalities of the Metropolitan Region only (i.e., the period 2015q3-2016q2). In equation (3.2), all coefficients γ_j with j preceding the period 2012q3-2013q2 are placebo tests for whether there is a significant difference in the relevant outcome variables, between the group of municipalities in which Uber entered afterwards and municipalities with no entry. If the parallel trends assumption is satisfied, all γ_j coefficients preceding the reference period should not be significantly different from zero.

The estimated coefficients γ_j of our preferred specification are plotted in Figure 22 for each of the following outcome variables of interest: number of drunk-driving fatal crashes, number of fatalities in drunk-driving crashes, number of female passenger fatalities in drunk-driving crashes and number of male passenger fatalities in drunk-driving crashes.[52]

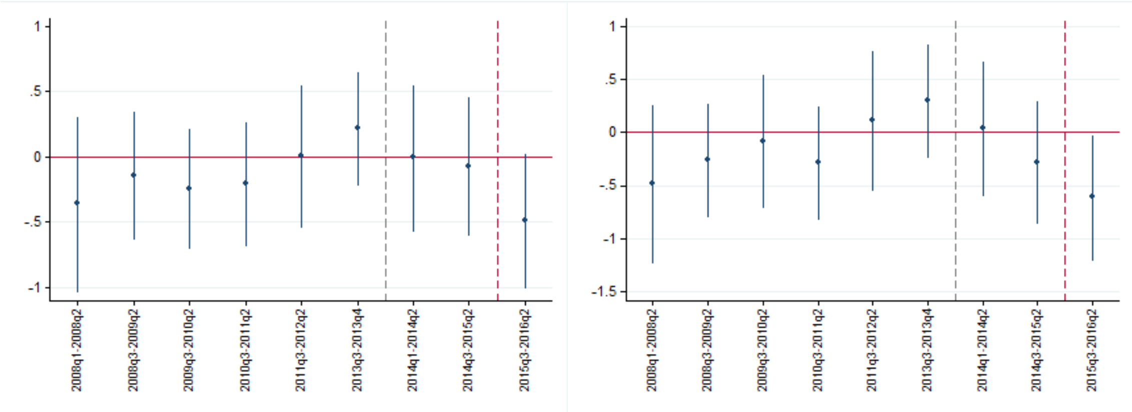
The figures suggest that, for each of the outcome variables, there is no difference between the group of municipalities of the Metropolitan Region (where Uber entered) and the rest of the municipalities before the entry of Uber. None of the coefficients

[51] See different variables defined in Table 3.1

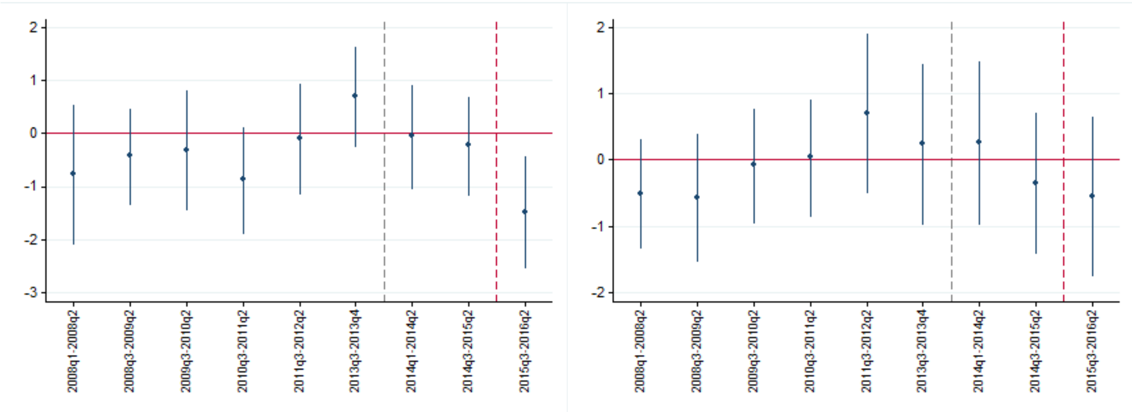
[52] In this specification, we include only municipalities in which the population in 2015 was above or equal to 75,000 inhabitants and we consider as a control variables time and municipality fixed effects, as well as the population density.

for periods preceding the entry of Uber (marked by the first vertical dashed line) are significant at the 95% significance level, which confirms that the parallel trends assumption is satisfied.

Figure 22: Parallel trends assumption – Placebo tests – Time relative to the entry of Uber X



(a) Number of drunk-driving fatal crashes (b) Number of drunk-driving fatal crashes



(c) Number of female passenger fatalities (d) Number of male passenger fatalities

Note: Confidence intervals at the 95% significance level. The first vertical dashed line represents the entry of Uber Black; the second vertical dashed line represents the entry of Uber X.

3.5.3 Estimation Results

Table 3.6 presents the results of the Poisson model estimates on the number of fatalities in drunk-driving crashes and the number of drunk-driving fatal crashes for our preferred specification. As stated above, in this specification we include only municipalities in which the population in 2015 was above or equal to 75,000 inhabitants and we consider as control variables time and municipality fixed effects, as well as the population density.

Table 3.6: Poisson model estimates of Uber's entry on the number of drunk-driving fatal crashes and fatalities

	(1) Number of fatalities in drunk-driving crashes	(2) Number of drunk-driving fatal crashes	(3) Number of fatalities in drunk-driving crashes at night	(4) Number of drunk-driving fatal crashes at night
Uber Black	-0.086	0.047	-0.35	-0.23
	(0.22)	(0.20)	(0.28)	(0.25)
UberX	-0.54**	-0.40*	-0.74**	-0.57**
	(0.24)	(0.20)	(0.31)	(0.26)
N	2447	2447	2447	2447
Chi-squared	244.4	322.4	126.6	182.6

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries of drivers, passengers and pedestrians. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as control variables. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Incidence rate ratios for UberX's estimates in columns 1, 2, 3 and 4 are 0.58, 0.67, 0.48 and 0.57, respectively.

The effect of Uber Black on the different outcomes is not statistically significant in any specification. This result is in line with findings by Greenwood & Wattal (2017). One possible explanation is that the adoption of the service by consumers was not high enough to have an effect. Figure 18 suggests this may be the case, as the interest in searches of the word "Uber" remained very low between July 2014 and May 2015 (when only Uber Black operated). Building a user base is a gradual process after entry, but in the case of Uber Black, relative prices could also explain low adoption. Uber Black is a high-end service that can be substantially more expensive than traditional hailing services like taxicabs (over 20% to 30% price premiums).[53]

Regarding UberX, our results suggest that its introduction significantly reduced the number of fatalities and fatal crashes related to drunk-driving in the Metropolitan Region. The incidence rate ratio associated to the UberX coefficient on fatalities is equal to 0.58.[54]

This means that the availability of UberX in the Metropolitan Region reduced overall fatalities (drivers, passengers and pedestrians) by 42% (= 1 − 0.58) on average with respect to other regions. Considering that the total number of drunk-driving

[53]See Greenwood & Wattal (2017).

[54]See column (1) in Table 3.6. The incidence rate ratio is calculated by taking the exponential of the coefficient.

fatalities in the Metropolitan Region was 621 in 2013, before Uber's entry, this means that the expected number of lives saved in a year in the Metropolitan Region would be approximately 261 after the entry of UberX.[55]

From columns (3) and (4) in Table 3.6 we observe that these reductions are driven by nighttime outcomes. This seems in line with the survey evidence suggesting that going to bars, restaurants and parties is the main purpose for using Uber in Chile. These places and activities are most related to alcohol consumption and are mainly visited and executed at night. Moreover, it is consistent with the reduction of alternatives to drunk-driving at night (public transportation is less or not available) and with the perception of insecurity that globally surrounds mobility during the night, making Uber's availability a more relevant alternative.

Table A.1.5 in Appendix A1 presents the estimates for our preferred specification also including non-fatal crashes and less severe injuries. We observe that the estimates of Uber Black and UberX on overall drunk-driving outcomes are not statistically significant. From Table A.1.6 in Appendix A1 we observe that these estimates are also not statistically significant for non-fatal outcomes alone. Non-fatal crashes represent 86% of overall drunk-driving crashes on average. Thus, having a negative and statistically significant impact of UberX on fatal outcomes and a non-statistically significant estimate on overall drunk-driving outcomes does not necessarily imply a positive and statistically significant impact on non-fatal ones.

Moreover, we consider a mechanism that may explain this result. Non-fatal drunk-driving crashes could in principle be associated with lower levels of alcohol consumption. That is, individuals having consumed low amounts of alcohol may not perceive drunk-driving in their current state as a real danger. Thus, these individuals may not consider alternatives to drunk-driving like ride-hailing platforms, at least not as much compared to individuals in actual or expected higher levels of drunkenness.

3.5.4 Estimation Results by Gender and Role

Table 3.7 presents the estimates of the Poisson model of our preferred specification on four outcome variables of interest: the number of passenger fatalities, both of male and female, and the number of driver fatalities, again distinguished by gender.

[55] The estimated reduction of drunk-driving fatal crashes is 33% (= 1 - exp(-0.40)). See column (2) in Table 3.6.

Table 3.7: Poisson model estimates of Uber entry on gender and role-specific number of fatalities

	Passenger		Driver	
	Female (1)	Male (2)	Female (3)	Male (4)
Uber Black	0.095	-0.18	-0.13	-0.17
	(0.38)	(0.39)	(0.71)	(0.19)
UberX	-1.25***	-0.63	-0.77	-0.30
	(0.48)	(0.52)	(0.65)	(0.24)
N	2175	2345	1462	2447
Chi-squared	201.7	180.0	12938.0	220.0

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as control variables. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Incidence rate ratios for UberX's estimates in columns 1, 2, 3 and 4 are 0.29, 0.53, 0.46 and 0.74, respectively.

As in the case of global outcomes, we do not find evidence of a statistically significant effect of Uber Black's entry. Regarding UberX, we observe a negative and statistically significant effect only on the number of female passenger fatalities (reduction of these outcomes), with no statistically significant effect on male passengers' fatalities or on drivers' fatalities (independently of their gender).[56]

The incidence rate ratio associated to the UberX coefficient on female passenger fatalities is equal to 0.29. This means that the availability of UberX in the Metropolitan Region reduced female passenger fatalities by 71% ($= 1 - 0.29$) on average with respect to the control regions. If we consider that the total number of female passenger fatalities in the Metropolitan Region was 28 in 2013, this means that the expected number of female passengers' lives saved in a year in the Metropolitan Region would be approximately 20 after the entry of UberX.

Several factors could explain why the availability of ride-hailing platforms like Uber may reduce female passenger fatalities. First, if women are less likely to drive and

[56] We undertake a t-test for the difference between the coefficient corresponding to effect of UberX on the number of female passenger fatalities and the coefficient corresponding to effect of UberX on the number of male passenger fatalities. In this t-test we adjust for the sample size. The result is that we cannot reject the null hypothesis that the difference between the two coefficients is equal to zero. However, even if we cannot reject this hypothesis, nor the null hypothesis that the coefficient for the number of male passenger fatalities is equal to zero, the coefficient for the number of female passenger fatalities remains positive and statistically significant and this is robust across specifications. Thus, we may lack enough statistical power with our data to rule out a large effect on male passenger fatalities.

find themselves most of the cases as passengers in drunk-driving situations, then Uber may provide an alternative that is especially relevant for this segment of the population.[57] Second, if women suffer particularly from sexual harassment and security issues in transportation, then Uber may represent an attractive alternative for them due to the reputation and rating systems that seek to restore trust in drivers. Third, it may be the case that women have specific risk attitudes, which could influence their inclination to avoid being the passenger of an intoxicated driver when a new relevant alternative is available.

Table 3.8 presents the estimates for the same four variables restricted to the night-time. As in the case of global outcomes, we observe that the reduction in female passenger fatalities is driven by nighttime effects (81% reduction). This result is in line with a reduction of transportation alternatives at night and with the perception of danger especially encountered by women and documented in different studies and surveys.[58] From column (4) in Table 3.8, we also observe that the estimate for male driver fatalities, which was not significant in Table 3.7, appears to be statistically significant when restricted to nighttime outcomes (reduction of 43%).[59]

The absence of a significant effect of UberX's entry on female drivers' fatalities must be interpreted cautiously. These occurrences are extremely rare in Chile, which reduces considerably the number of observations available for estimation. Thus, our model may not have enough power to identify an effect for this segment (see Figure A.1.4 in Appendix A1 and the reduced number of observations in column (3) of Tables 3.7 and 3.8).

[57] As shown in Section 3.4.2, between 2011 and 2019 less than 24% of driving licenses processed in Chile corresponded to applications made by women.

[58] See Section 3.3 for detailed examples.

[59] We undertake again a t-test for the difference between the coefficients of female and male passengers' fatalities. In the case of nighttime outcomes, we can reject the null hypothesis that the difference between the two coefficients is equal to zero with 95% confidence level. However, the rejection of this null hypothesis is not robust across all specifications. Thus, we may lack enough statistical power with our data to completely rule out a large effect on male passenger fatalities at night. In the case of female and male drivers' fatalities, we cannot reject the null hypothesis that the difference between the two coefficients is equal to zero.

Table 3.8: Poisson model estimates of Uber entry on gender and role-specific number of fatalities (nighttime)

	Passenger		Driver	
	Female	Male	Female	Male
	(1)	(2)	(3)	(4)
Uber Black	-0.053	-0.55	0.080	-0.37
	(0.51)	(0.42)	(0.70)	(0.25)
UberX	-1.67**	-0.35	-1.01	-0.57*
	(0.68)	(0.65)	(0.98)	(0.31)
N	2039	2108	1224	2379
Chi-squared	188.9	150.3	55895.8	216.4

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as control variables. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively. Incidence rate ratios for UberX's estimates in columns 1, 2, 3 and 4 are 0.19, 0.70, 0.37 and 0.57, respectively.

3.6 Discussion and Robustness Checks

This Section discusses in detail our main results and presents robustness checks. Section 3.6.1 reports the results of additional specifications to assess the robustness of our main specification, Section 3.6.2 provides evidence for other types of crashes and Section 3.6.3 discusses other potential threats to identification.

3.6.1 Additional Specifications

We assume that Uber's entry is driven by profitability considerations unrelated to the expected evolution of crashes. However, if Uber's entry is endogenous our identification strategy might be invalid. Uber's profitability might be correlated with the size of municipalities (demand for rides) and thus with their level of congestion, which could ultimately be correlated with the observed number of crashes and their evolution.

To address this threat to identification, we conduct several checks. First, we test alternative specifications using different control variables, namely: population, number of vehicles (or the previous two variables at the same time) and population or vehicle density (as proxies for congestion).

Second, to ensure comparability of municipalities between treatment and control groups, we restrict the number of municipalities in both groups. Precisely, we consider a main specification, where we include only municipalities in which the population in 2015 was above or equal to 75,000 inhabitants. The reason is that in our observation period Uber had only entered in the Metropolitan Region, which is the most highly populated area of Chile. Thus, we exclude very small municipalities, with population less than the 25% percentile of the population of municipalities of the Metropolitan Region in 2015. We consider different robustness checks by modifying the threshold size of municipalities.[60]

Third, we estimate our main specification for counts using OLS regression and relative counts using the Poisson model. The fixed-effects Poisson estimator is completely robust (Wooldridge 1999), but the use of OLS and the use of relative counts are also common in the literature (see Greenwood & Wattal 2017, Dills & Mulholland 2018 or Barrios et al. 2020). Our aim is to check whether our main results depend on the estimation method or a particular dependent variable. Moreover, these checks facilitate the comparison of our results with the results of other empirical studies.

We present the results of these robustness checks in Appendix A3. We find that our results are robust across different specifications, to different control variables and control groups (see Tables A.3.1 and A.3.2) and to the use of OLS as a regression method (see Table A.3.3). They are also robust to the inclusion of different exposure measures, such as population density (total and working age only), number of vehicles per capita and number of taxis per capita.[61]

Tables A.3.4 and A.3.5 in Appendix A3 present the estimates of UberX's entry on gender-role specific outcomes, according to different specifications. The estimates of UberX's entry on female passenger fatalities (overall and at night – see columns (1) and (2) in Table A.3.5) and male driver fatalities at night (see column (4) in Table A.3.4) are negative and statistically significant across specifications. The former

[60] Table A.1.4 in Appendix A1 presents the number of treatment and control municipalities considered in different specifications according to the size of municipalities and summary statistics of some of their observable characteristics. The information on Table A.1.4 allows identifying two sets of relevant groups for our analysis. That is, municipalities with 75,000 inhabitants or more in 2015 and municipalities with 100,000 inhabitants or more in 2015, as both thresholds depict the most similar characteristics between treatment and control groups.

[61] The result tables of estimations using different exposure measures are not included in this draft but are available upon request. Ideally, we would like to test our model using Vehicle Kilometers Travelled (VKT) as exposure measure. Nonetheless, to our knowledge, this information is not available in Chile at the municipality level.

are larger in magnitude than the latter. In terms of incidence rate ratios, reductions of female passenger fatalities at night are comprised between 70% and 85%.[62] The reduction of male driver fatalities at night is comprised between 35% and 58%, with the level of significance varying across specifications.[63] These results are also robust to the inclusion of different exposure measures (c.f. Tables A.3.6 to A.3.9 in Appendix A3) and to the use of OLS as an alternative regression method (c.f. Table A.3.10 in Appendix A3).

3.6.2 Other Types of Crashes

We run additional robustness checks using placebo treatments for fatal outcomes. We do this for two reasons. First, if the mechanisms in place in the case of drunk-driving situations play a role only on this type of crash, then we should not observe an effect of Uber's entry in other types of crashes or specific effects by gender and role. Second, if increased congestion or insecurity conditions alleged by opponents of ride hailing platforms are present or strong enough, then we could observe an increase in the number of traffic crashes and related fatalities for other kinds of crashes.

To conduct this check, we consider the four most popular causes of crashes in Chile other than alcohol in the driver, namely, "driver is distracted", "driving without a reasonable distance (from the car ahead)", "loss of control of the vehicle" and "undetermined causes".[64] In addition, we also study the case of all crashes and all crashes excluding those caused by alcohol in the driver. Table A.3.11 in Appendix A3 summarizes the Poisson model estimates of UberX's effect on the number of crashes and fatalities originated by theses causes. We observe no statistically significant effect of UberX's entry on other types of crashes, except for the ones related to losing control of the vehicle. These crashes appear to have been reduced during the nighttime (c.f. column (1) on Table A.3.11 in Appendix A3). We also observe a negative and statistically significant effect on fatalities of all causes at night. Furthermore, we observe that, as in the case of drunk-driving crashes, UberX reduced the number of

[62]For incidence rate ratios (IRR) of 0.15 and 0.30, corresponding to the lowest and highest estimates in column (2) of Table A.3.5 in Appendix A3, respectively.

[63]Incidence rate ratios (IRR) of 0.42 and 0.65, corresponding to the lowest and highest estimates in column (4) of Table A.3.4 in Appendix A3, respectively.

[64]Respectively from the Spanish "conducción no atento condiciones transito momento", "conducción sin mantener distancia razonable ni prudente", "pérdida control vehículo" and "causas no determinadas".

female passenger fatalities in “lost control of vehicle” crashes, overall and especially at night (c.f. column (4) on Table A.3.11 in Appendix A3). The coefficient corresponding to the effect of UberX’s entry on female passenger fatalities at night and male driver fatalities at night in “all causes” crashes is also negative and statistically significant.

The impact of UberX on crashes caused by lost control of the vehicle may appear unexpected. However, we believe this this in fact in line with the mechanisms we have discussed before. Going to bars, restaurants and parties is stated as the main purpose for using Uber in Chile. Other than the state of drunkenness caused by the eventual consumption of alcohol, these activities may also cause drowsiness. Thus, when a new relevant alternative is available, drivers and/or passengers may prefer to avoid the risks of a situation where the driver is likely to be less alert and effective. This is even more relevant during the nighttime as transportation alternatives are scarcer and a perception of insecurity surrounds mobility. The same mechanisms explaining a reduction of female passengers’ fatalities in drunk-driving crashes could explain the reduction of these occurrences.

Most importantly, we find no evidence of any increase in the number of crashes of different kinds after Uber’s entry in Chile. On the contrary, it seems that overall fatalities at night, in particular female passenger and male driver fatalities at night decreased after UberX’s entry.

3.6.3 Other Potential Threats to Identification

Beyond the potential sources of endogeneity mentioned in the previous Section, other factors could bias our estimates. One example are possible changes in the patterns of alcohol consumption affecting in a particular way the Metropolitan Region and/or one gender. We are not aware of such differentiated evolution in preferences for alcohol consumption. Unfortunately, so far it has not been possible to collect data on the evolution of alcohol consumption by municipality in Chile.

Likewise, it is possible that high crash rates in specific areas entail an increase in road control only on those specific areas. In this hypothetical case, we would observe a decrease in crashes in some areas, but partially as a response to road control, not only to Uber use, thus introducing a bias in our estimates. We are not aware of systematic evidence in this sense. On the contrary, policies designed in Chile for reducing crashes, and drunk-driving crashes in particular, have had nationwide coverage and there is no reason to suspect that enforcement is applied differently in the Metropolitan Region with respect to the rest of the country. The most prominent laws are "Zero Tolerance" introduced in March 2012, which changed the accepted thresholds for alcohol consumption when driving, and "Emilia Law", introduced in September 2014 to impose more stringent penalties for drunk-driving violations.

Another consideration is that the availability of ride-hailing platforms could change the number of people in cars when there is a crash. This would affect crash rates and bias our estimates. We verify whether this could be the case by implementing two checks. First, we look at the evolution of the number of cars per-capita for the treatment (Metropolitan Region) and control (other regions) groups. Figure A.3.1 in Appendix A3 shows that the number of cars per capita follows a similar upwards trend overtime for both the treatment and control groups. After 2014, the number of cars per capita seems to grow at a slower rate in the Metropolitan region compared to other regions. In this case, and if the number of cars per capita in a given municipality is a good predictor of the actual number of people per car in a drunk driving crash, one could expect to observe on average a larger number of people involved in a given crash in the Metropolitan Region (treatment group) compared to other regions (control group). In such a case, we would underestimate the impact of the entry of Uber on the number of fatal crashes (as more people should be on average expected to be involved in a given crash). Second, we analyze the correlation between the average number of people per car in drunk-driving crashes and Uber's availability using our difference-in-differences approach.[65] We find no evidence of a statistically significant correlation (c.f. Table A.3.12 in Appendix A3). Moreover, in principle, it should never be the case that an Uber driver involved in a crash is drunk. Thus, Uber should not be increasing (at least not directly) the number of passengers in drunk-driving crashes.

[65]The CONASET dataset only contains the total number of drivers and passengers involved in a given crash, and it does not provide the exact composition of drivers and passengers riding each car. However, we can compute the average number of people per car per crash by dividing the total number of drivers and passengers involved in a given event by the number of drivers (knowing that there should be only one driver per car).

Another potential source of bias is the possibility that Uber did not effectively enter the whole Metropolitan Region at once. Before July 2016, Uber only accepted payment by credit card, and this likely limited the use of Uber only to the richer municipalities of the Metropolitan Region (as the access to credit cards by households in Chile is on average low).[66],[67] In July 2016, Uber introduced the payment in cash. This should have increased the use of Uber to practically all the municipalities in the Metropolitan Region.[68] Therefore, as our sample period ends in June 2016, our estimates might be biased towards zero.

It is important to point out that there are no informal taxis in Chile as is the case in many other countries in the region. Thus, we believe that the reduction we observe in the number of drunk-driving fatal crashes and fatalities is not a displacement effect of informal taxi drivers but rather a substitution effect between drunk-driving situations and the new transportation alternative. Riding with informal taxi drivers is perceived to be dangerous.

Finally, the entry of Uber can have at least two effects on the number of fatal crashes, and these effects may act in opposite directions. On the one hand, the entry of Uber may induce people to drunk-drive less (in the case of drivers) or rely less on drunk drivers (in the case of passengers) as a mean of transportation and choose Uber as a safer option instead. On the other hand, as Uber represents a new option of transportation, some of the people avoiding going out prior to Uber's entry could change their behavior and demand more nights out. If this is the case, congestion and crowding could likely increase the number of traffic crashes and fatalities on the roads (a similar exposition regarding these two effects is made in Dills & Mullholland [2018]).[69] Our estimates suggest that the net effect is a decrease

[66] See: https://www.publimetro.cl/cl/diario-pyme/2016/07/19/uber-ahora-anade-efectivo-forma-pago.html

[67] A report published by the sectoral regulator of financial markets in Chile, shows that by December-2017 less than 30% of the population has a credit card from a bank. See Table 5 of the report available at: http://www.cmfchile.cl/portal/publicaciones/610/articles-38692_doc_pdf.pdf

[68] In the review of the acquisition of Cornershop by Uber carried-out by the Chilean Competition Authority, it is mentioned that the introduction of cash as a payment method contributed to the expansion of ride sharing apps in Latin America. Indeed, Uber claims that 50% of the trips in Latin America are paid in cash. See Paragraph 71 and Footnote 117 of the decision, available at: https://www.fne.gob.cl/wp-content/uploads/2020/06/inap2_F217_2020.pdf.

[69] According to the survey conducted by researchers at the University of Chile, mentioned previously, 28.8% of people state to make in general more trips after Uber's entry than before, 68.8% claim to make the same number of trips and 2.4% to make less.

in the number of fatal crashes and fatalities associated to drunk-driving.

3.7 Conclusion

The presence of ride-hailing platforms like Uber may create an opportunity for reducing instances of drunk-driving by encouraging a fraction of intoxicated – or potentially intoxicated – drivers to ride instead of driving themselves. Likewise, it may provide passengers with a relevant alternative to avoid the dangers of drunk-driving situations. Moreover, the availability of these platforms may provide a relevant transportation alternative especially for women who suffer from a mobility bias.

Using a difference-in-differences approach and a Poisson regression model, this chapter tests the effect of Uber's entry in the Metropolitan region of Chile on the number of drunk-driving crashes and fatalities. The results suggest that the presence of the UberX service significantly reduced the number of occurrences of the most severe outcomes: drunk-driving fatal crashes and fatalities in this type of crashes.

Moreover, our results suggest that UberX's entry significantly reduced the number of female passengers' fatalities and the number of male drivers' fatalities at night. In the presence of a mobility bias against women in the traditional transport sector, we believe that this novel evidence is particularly relevant for the design of policies regulating ride-hailing platforms and overall transportation and urban policies, both in developed and in developing countries.

Appendices

A1 Additional Tables and Figures

Table A.1.1: Uber entry dates in Chile

Municipality / Region	Date	Source
Santiago (Region Metropolitana)	January 2014 (Black) and June 2015 (X and SUV)	http://www.economiaynegocios.cl/noticias/ noticias.asp?id=176161 and printed version of Uber's website in Chile available upon request
Valparaiso and Bio Bio (Concepcion)	July 2016	https://www.fayerwayer.com/2016/06/uber-oficializa-servicio-para-regiones-de-valparaiso-y-biobio/
Iquique, La Serena/Coquimbo, Temuco and Puerto Montt	January 2017	http://www.elobservatodo.cl/noticia/sociedad/lo-esperabas-uber-anuncia-llegada-la-serena
Arica, Calama, Antofagasta, Copiapò, Ovalle, Rancagua, Valdivia, Osorno, Punta Arenas	April 2017	http://www.latercera.com/noticia/arica-punta-arenas-uber-llega-10-nuevas-ciudades-chile/

Table A.1.2: Summary statistics of the first four dependent variables studied (nighttime)

	Obs.	Mean	St. Dev.	Min	Max
Number of drunk-driving crashes	12017	1.53	3.50	0	52
Number of drunk-driving fatal crashes	12017	0.22	0.60	0	9
Number of fatalities in drunk-driving crashes	12017	0.30	0.93	0	23
Number of fatalities and injured people in drunk-driving crashes	12017	1.65	3.80	0	53

Figure A.1.1: Distribution of the global outcomes studied

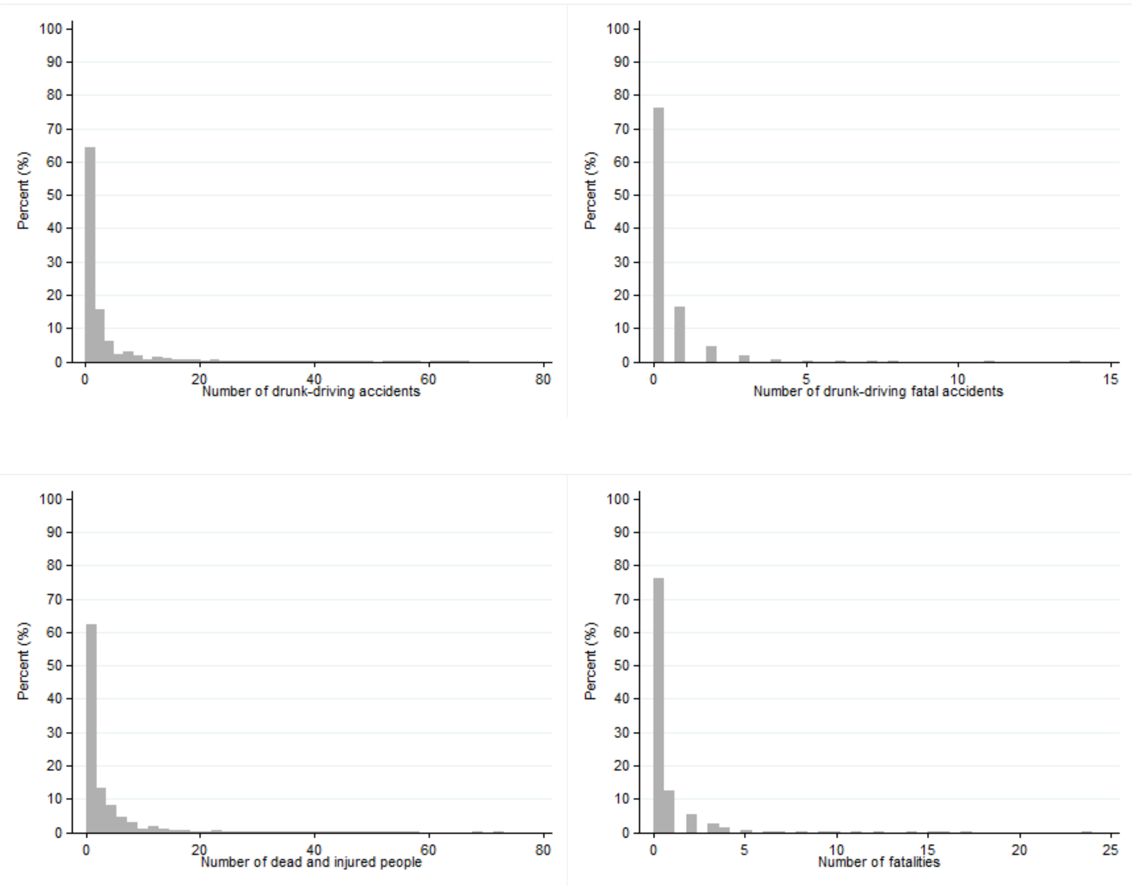
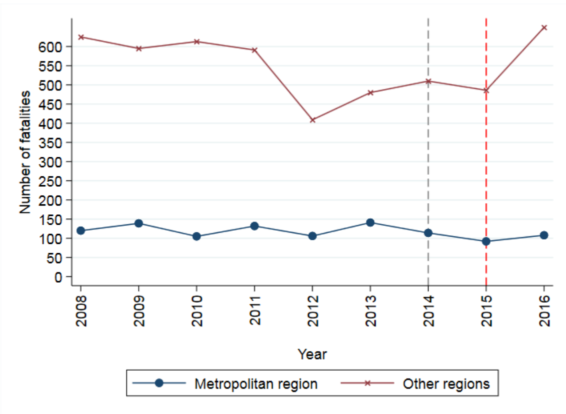


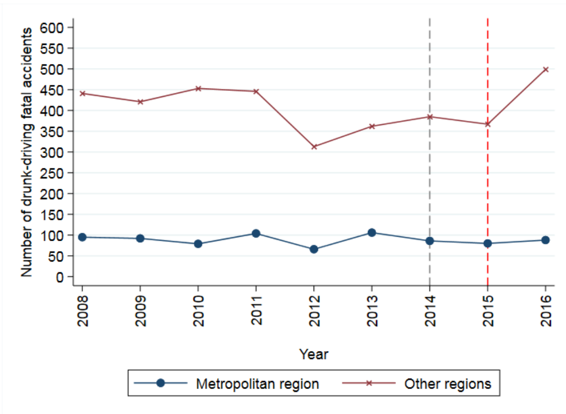
Table A.1.3: Summary statistics of the four gender-specific variables studied (nighttime)

	Obs.	Mean	St. Dev.	Min	Max
Number of female driver fatalities	12017	0.01	0.09	0	2
Number of male driver fatalities	12017	0.13	0.44	0	6
Number of female passenger fatalities	12017	0.06	0.31	0	6
Number of male passenger fatalities	12017	0.07	0.34	0	6

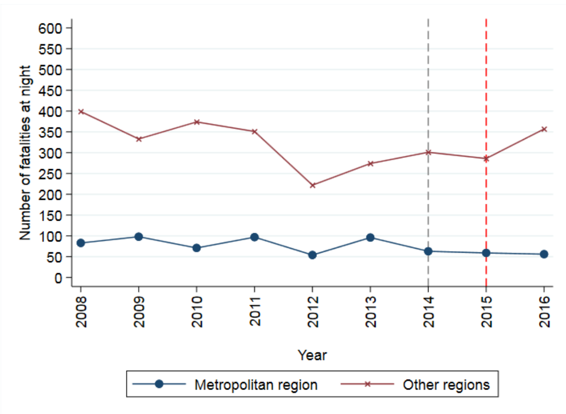
Figure A.1.2: Evolution of drunk-driving fatalities and crashes (Metropolitan Region vs. Other regions - 2008-2016)



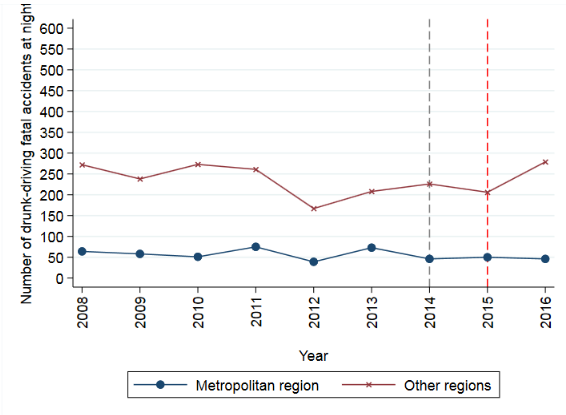
(a) Number of fatalities



(b) Number of fatal crashes



(c) Number of fatalities at night



(d) Number of fatal crashes at night

Figure A.1.3: Distribution of the main gender-specific dependent variables studied

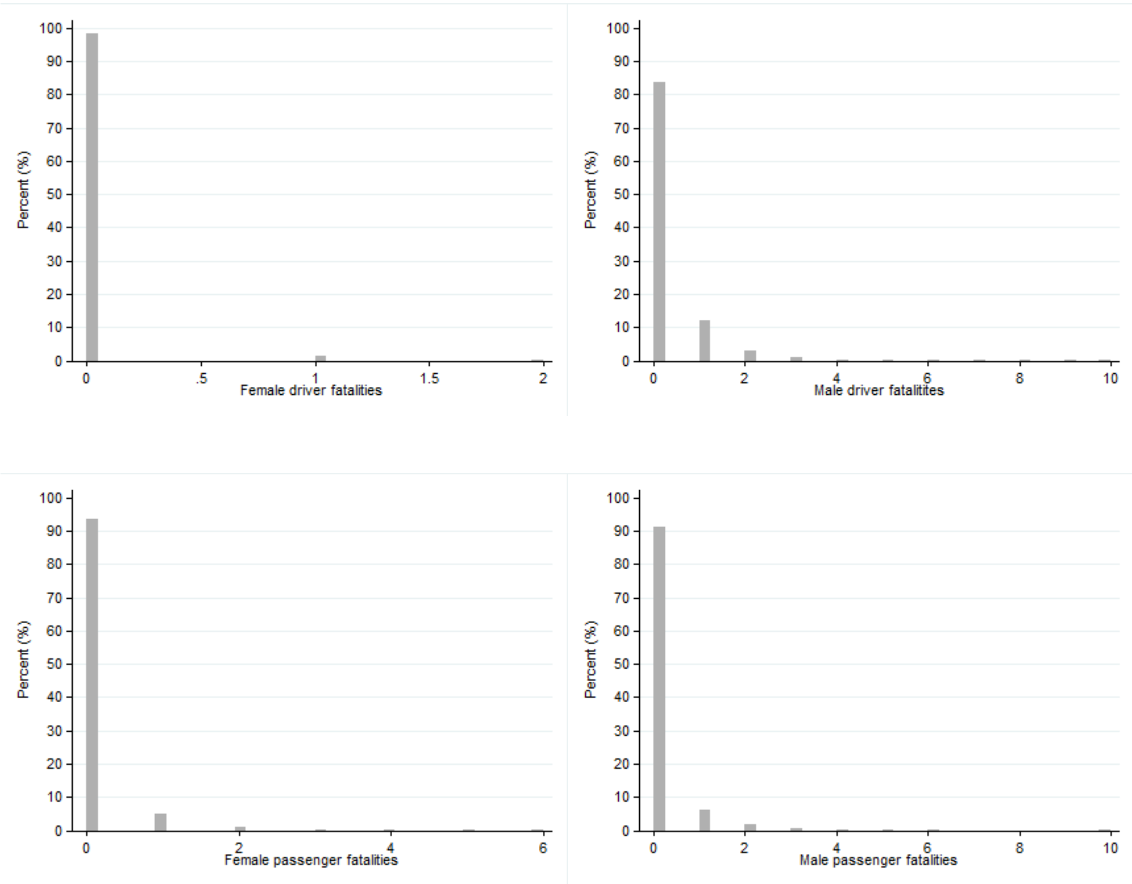
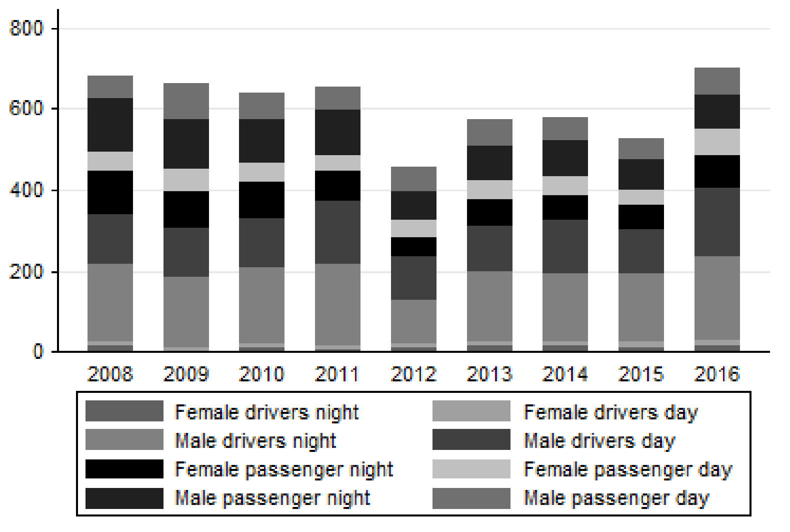
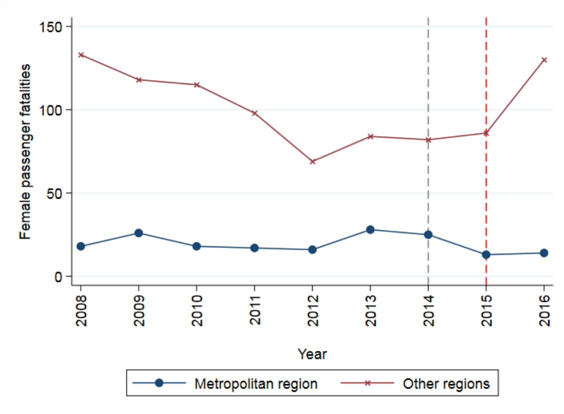


Figure A.1.4: Fatalities in drunk-driving crashes by role, gender and time framework

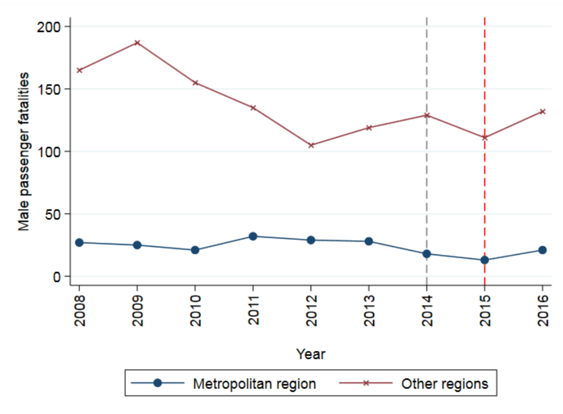


Note: Total number of fatalities in Chile based on the panel data constructed as described in Section 3.4.2. Drunk-driving crashes and fatalities as defined in Table 3.1.

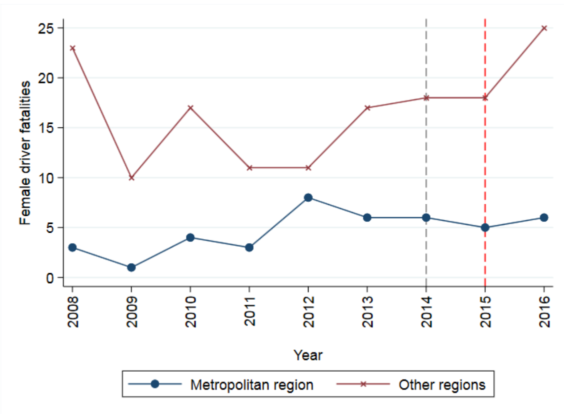
Figure A.1.5: Evolution of gender-specific variables (Metropolitan Region vs. Other regions - 2008-2016)



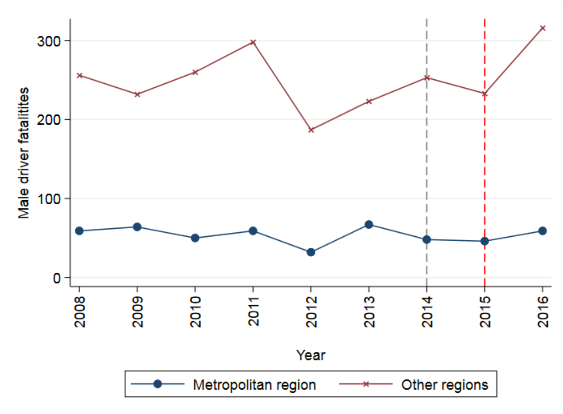
(a) Female Passenger



(b) Male Passenger



(c) Female Driver



(d) Male Driver

Table A.1.4: Characteristics of control and treatment municipalities according to the specification considered

Characteristic	Group	Municipalities considered by population size			
		All	≥100,000	≥75,000	≥50,000
# of municipalities	Control	283	28	33	47
	Treatment	52	30	39	42
Pop. in 2015	Control	37666.9	196384.7	180792.4	144352.5
	Treatment	140657.2	203586.8	177247.5	169193.7
Female pop. in 2015	Control	18883.3	99636.9	91800.2	73277.5
	Treatment	71835.5	104181.7	90732.2	86530.6
Male pop. in 2015	Control	18783.6	96747.8	88992.1	71075
	Treatment	68821.7	99405.1	86515.3	82663.1
# of vehicles in 2015	Control	10026.8	51287.3	46779.4	37065.5
	Treatment	36657.9	49004.2	45073.0	43140.6
# of automobiles in 2015	Control	5764.8	33042.3	29935.7	23410.6
	Treatment	24678.6	33568.1	30864.4	29407.8
# of taxis and “collectivos” in 2015	Control	305.7	1334.0	1238.6	977.3
	Treatment	748.0	1031.1	907.4	867.3
Population density in 2015	Control	447.9	569.2	549.7	447.9
	Treatment	7012.8	8220.7	7518.0	7012.8
# of drunk-driving fatal crashes in 2014q4	Control	0.3	1.7	1.7	1.3
	Treatment	0.5	0.5	0.5	0.5
# of fatalities in drunk-driving crashes in 2014q4	Control	0.4	2.2	2.2	1.6
	Treatment	0.6	0.6	0.6	0.5
Vehicles per person in 2015	Control	0.17	0.17	0.16	0.16
	Treatment	0.20	0.17	0.19	0.19
Taxis per person in 2015	Control	0.00	0.01	0.01	0.01
	Treatment	0.01	0.01	0.01	0.01

Table A.1.5: Poisson model estimates of Uber's entry on the number of drunk-driving crashes and the number of dead and injured people

	(1) Number of dead and injured people	(2) Number of drunk-driving crashes	(3) Number of dead and injured people at night	(4) Number of drunk-driving crashes at night
Uber Black	0.25	0.17	0.045	0.16
	(0.21)	(0.22)	(0.21)	(0.25)
UberX	0.11	0.22	0.060	0.19
	(0.18)	(0.18)	(0.19)	(0.19)
N	2447	2447	2447	2447
Chi-squared	222.5	408.8	287.6	442.6

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Deaths and all types of injuries of drivers, passengers and pedestrians are considered. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as control variables. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.1.6: Poisson model estimates of Uber's entry on the number of drunk-driving non-fatal crashes

	(1) Number of drunk-driving non-fatal crashes	(2) Number of drunk-driving non-fatal crashes at night
Uber Black	0.18	0.21
	(0.23)	(0.27)
UberX	0.28	0.27
	(0.19)	(0.20)
N	2447	2447
Chi-squared	422.0	437.9

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries of drivers, passengers and pedestrians. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as control variables. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

A2 Mechanisms

It is argued that new transportation alternatives or interventions could help decreasing the instances of drunk-driving. For instance, Jackson & Owens (2011), consider the extension of opening hours of the metro service in Washington. In this chapter, as in Greenwood & Wattal (2017), Peck (2017) and other studies, we consider the entry and availability of ride-hailing platforms like Uber. These platforms are popular in particular at night, for rides usually related to situations involving alcohol consumption.

Rational choice theory provides an interesting analytical framework for understanding which mechanisms operate and how. In practice, ride-hailing platforms represent a new alternative within individuals' choice set regarding transportation options. This new alternative can change the balance of trade-offs considered by an individual when facing a potential drunk-driving situation. These trade-offs include the probability of being caught by the police, having to pay a fine or even go to prison, having an accident and killing or hurting someone (including oneself). The costs related to each of these potential situations are compared to the costs of finding and using different alternatives in monetary terms, but also in terms of waiting time, ease of use and safety matters.

While the general costs and benefits related to Uber apply to every potential user indistinctively from its background, the gender bias in mobility could alter the balance of tradeoffs by making benefits greater for women. In particular, as avoiding danger is a concern especially for women, the extra-utility that can be derived from the availability of a new and safer transport alternative could be greater for them compared to men.

The utility derived from ride-hailing platforms in drunk-driving situations might also differ according to the role (driver or passenger) due to differences in their respective choice sets. This would come in addition to gender-related issues.

In Chile, the proportion of female drivers involved in crashes in is strikingly low (see Figure 21). Either women do not drive as much as men (due to income or cultural reasons), either their driving behavior is different (differences in risk aversion?). It seems that the cultural reason might largely explain why women do not have the same access or, at least, not the same exposure to driving than men. In 2016, only 24% of driving licenses processed in Chile corresponded to applications made by women. This proportion was 18% in 2011 and remained stable at 24% in 2019.

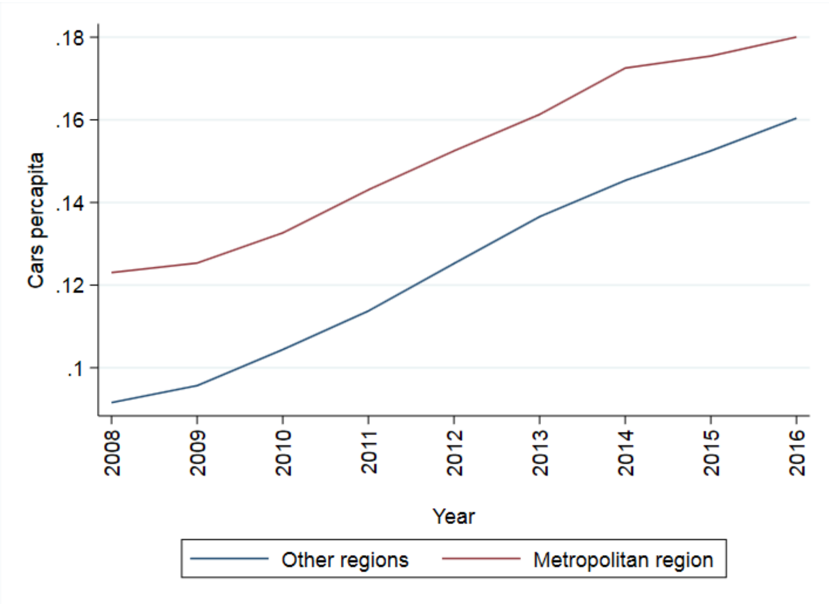
Thus, in countries like Chile the choice of being a driver might be endogenous for men, but not necessarily for women. For example, before Uber's entry, in principle a male passenger faces four choices when his driver partner gets intoxicated: going into the car with the intoxicated driver, taking a taxi, taking public transportation (less or no available at night), becoming a driver himself. A female passenger should in principle have the same four choices. However, not only taking a taxi or public transportation appear as less appealing due to the gender bias in mobility, but becoming a driver is not really an alternative for many of them as a significantly lower number of them possess a driving license. Table A.2.1 summarizes the differences in the choice sets by role and gender to help understand the mechanisms behind the results presented in Section 3.5.4.

Table A.2.1: Choice sets by role and gender before Uber's entry

Role	**Gender/Role proportions in drunk-driving crashes (2013)**	**Choice set (before Uber)**	**Choice set (female specificities)**
Drivers	Male: 51% Female: 4%	1. Drunk-driving	None
		2. Taking a taxi	Less appealing, particularly at night, due to the gender mobility bias
		3. Taking public transportation (less or no available at night)	Less appealing, particularly at night, due to the gender mobility bias
Passengers	Male: 25% Female: 20%	1. Going into the car with the inebriated driver	None
		2. Taking a taxi	Less appealing, particularly at night, due to the gender mobility bias
		3. Taking public transportation (less or no available at night)	Less appealing, particularly at night, due to the gender mobility bias
		4. Becoming drivers themselves	Not really an alternative for many of them as fewer possess a driving license

A3 Robustness Checks

Figure A.3.1: Evolution of the number of cars per-capita



Note: The number of cars does not consider off-road vehicles, commercial vans, minibuses, pick-ups, motorcycles, and other motorized and non-motorized vehicles. In addition, it does not consider public transportation vehicles and trucks.
Source: INE

Table A.3.1: Poisson model estimates of UberX's entry on the number of drunk-driving crashes (total and only fatal) according to different specifications

Control groups	Control variables	(1) Number of drunk-driving fatal crashes	(2) Number of drunk-driving fatal crashes at night	(3) Number of drunk-driving crashes	(4) Number of drunk-driving crashes at night
Municipalities with 100,000 or more inhabitants	No controls	-0.49**	-0.61***	0.24	0.25
	Population and Population2	-0.45**	-0.62**	0.22	0.21
	Vehicle and Vehicle2	-0.36*	-0.46**	0.28	0.30
	Population and Population2 + Vehicle and Vehicle2	-0.41*	-0.57**	0.23	0.24
	Population density	-0.50**	-0.74***	0.27	0.26
	Vehicle density	-0.64***	-0.84***	0.35*	0.35*
Municipalities with 75,000 or more inhabitants	No controls	-0.41**	-0.51**	0.18	0.17
	Population and Population2	-0.37*	-0.50**	0.17	0.14
	Vehicle and Vehicle2	-0.34*	-0.43**	0.19	0.17
	Population and Population2 + Vehicle and Vehicle2	-0.35*	-0.47**	0.16	0.14
	Population density	-0.40*	-0.57**	0.22	0.19
	Vehicle density	-0.60***	-0.74***	0.17	0.15

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatal crashes consider deaths and severe injuries of drivers, passengers and pedestrians. All specifications consider Time Fixed Effects and Municipality Fixed Effects as controls. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.2: Poisson model estimates of UberX's entry on the number of dead and injured people according to different specifications

Control groups	Control variables	(1) Number of fatalities	(2) Number of fatalities at night	(3) Number of dead and injured people	(4) Number of dead and injured people at night
Municipalities with 100,000 or more inhabitants	No controls	-0.67***	-0.90***	0.070	0.023
	Population and Population2	-0.63***	-0.91***	0.089	0.051
	Vehicle and Vehicle2	-0.53**	-0.72***	0.14	0.11
	Population and Population2 + Vehicle and Vehicle2	-0.59**	-0.84***	0.061	0.034
	Population density	-0.71***	-1.07***	0.093	0.025
	Vehicle density	-0.81***	-1.13***	0.11	0.057
Municipalities with 75,000 or more inhabitants	No controls	-0.54**	-0.67**	0.076	0.035
	Population and Population2	-0.51**	-0.66**	0.10	0.070
	Vehicle and Vehicle2	-0.46**	-0.55**	0.11	0.087
	Population and Population2 + Vehicle and Vehicle2	-0.47**	-0.59**	0.068	0.043
	Population density	-0.54**	-0.74**	0.11	0.060
	Vehicle density	-0.74***	-0.95***	0.055	0.020

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries of drivers, passengers and pedestrians. All specifications consider Time Fixed Effects and Municipality Fixed Effects as controls. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.3: Estimates of UberX's entry on the number of drunk-driving fatal crashes and fatalities

Estimation method	Dependent variable	(1) Number of fatalities in drunk-driving crashes	(2) Number of drunk-driving fatal crashes	(3) Number of fatalities in drunk-driving crashes at night	(4) Number of drunk-driving fatal crashes at night
OLS	Counts	-0.63**	-0.45***	-0.39*	-0.28**
	Log(1 + counts)	-0.17**	-0.15**	-0.15**	-0.13**
Poisson	Counts	-0.54**	-0.40*	-0.74**	-0.57**
	Counts per 100,000 inhabitants	-0.48*	-0.40*	-0.56	-0.45

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of car of at least one of the vehicles was an automobile, a van or a jeep. Fatal crashes consider deaths and severe injuries of drivers, passengers and pedestrians. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects and Municipality Fixed Effects. Population Density is included as control variable except for specifications with count rates as dependent variable. The results of our main specification (count data) estimated with Poisson are included here for comparison. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.4: Poisson model estimates of UberX's entry on gender-specific outcome variables according to different specifications (drivers)

Control groups	Control variables	(1) Female driver fatalities	(2) Female driver fatalities night	(3) Male driver fatalities	(4) Male driver fatalities night
Municipalities with 100,000 or more inhabitants	No controls	-0.51	-0.62	-0.50**	-0.72**
	Population and Population2	-0.36	-0.58	-0.45*	-0.69**
	Vehicle and Vehicle2	-0.19	-0.30	-0.38	-0.57*
	Population and Population2 + Vehicle and Vehicle2	-0.18	-0.50	-0.43*	-0.65**
	Population density	-0.72	-0.93	-0.50**	-0.86***
	Vehicle density	-1.26*	-1.12	-0.55**	-0.84***
Municipalities with 75,000 or more inhabitants	No controls	-0.65	-0.89	-0.33	-0.52*
	Population and Population2	-0.57	-0.90	-0.29	-0.48*
	Vehicle and Vehicle2	-0.42	-0.74	-0.26	-0.43*
	Population and Population2 + Vehicle and Vehicle2	-0.52	-1.01	-0.28	-0.48*
	Population density	-0.77	-1.01	-0.30	-0.57*
	Vehicle density	-1.32**	-1.43	-0.45**	-0.66**

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries. All specifications consider Time Fixed Effects and Municipality Fixed Effects as controls. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.5: Poisson model estimates of UberX's entry on gender-specific outcome variables according to different specifications (passengers)

Control groups	Control variables	(1) Female passenger fatalities	(2) Female passenger fatalities night	(3) Male passenger fatalities	(4) Male passenger fatalities night
Municipalities with 100,000 or more inhabitants	No controls	-0.97**	-1.28**	-1.13**	-1.15*
	Population and Population2	-0.94**	-1.49**	-1.21**	-1.16*
	Vehicle and Vehicle2	-0.87*	-1.21**	-1.09**	-0.94
	Population and Population2 + Vehicle and Vehicle2	-1.08**	-1.67***	-1.18**	-0.98
	Population density	-1.21**	-1.80**	-1.10**	-1.25*
	Vehicle density	-1.23**	-1.71**	-1.09**	-1.33*
Municipalities with 75,000 or more inhabitants	No controls	-1.12***	-1.37**	-0.71	-0.36
	Population and Population2	-1.09**	-1.47**	-0.73	-0.32
	Vehicle and Vehicle2	-1.03**	-1.35**	-0.74	-0.22
	Population and Population2 + Vehicle and Vehicle2	-1.11**	-1.53***	-0.74	-0.21
	Population density	-1.25***	-1.67**	-0.63	-0.35
	Vehicle density	-1.50***	-1.93***	-0.72	-0.56

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries. All specifications consider Time Fixed Effects and Municipality Fixed as controls. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.6: Poisson model estimates of Uber's entry on gender and role-specific outcome variables (nighttime) – Population density as exposure measure

	Number of fatalities at night			
	Passenger		Driver	
	(1)	(2)	(3)	(4)
Uber Black	0.14	-0.56	0.15	-0.34
	(0.44)	(0.40)	(.)	(0.22)
UberX	-1.39**	-0.37	-0.91	-0.54*
	(0.61)	(0.60)	(.)	(0.27)
N	2039	2108	1224	2379
Chi-squared	189.8	149.6	8755.3	199.5

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects and Municipality Fixed Effects as control variables. The exposure measure is Population Density. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.7: Poisson model estimates of Uber's entry on gender and role-specific outcome variables (nighttime) – Population density as control variable and vehicles per capita as exposure measure

	Number of fatalities at night			
	Passenger		Driver	
	(1)	(2)	(3)	(4)
Uber Black	-0.040	-0.55	0.14	-0.37
	(0.51)	(0.42)	(0.70)	(0.24)
UberX	-1.66**	-0.36	-0.94	-0.57*
	(0.67)	(0.66)	(0.98)	(0.31)
N	2039	2108	1224	2379
Chi-squared	349.5	265.9	10476.7	180.1

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatalities include deaths and severe injuries. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as control variable. The exposure measure is the number of vehicles per capita. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.8: Poisson model estimates of UberX's entry on gender specific outcomes according to different specifications (no control variables other than time and municipality fixed effects – different exposure measures)

		Fatalities				Fatalities at night			
Control groups	Exposure measure	Passenger		Driver		Passenger		Driver	
		Female	Male	Female	Male	Female	Male	Female	Male
Municipalities with 100,000 or more inhabitants	Population density	-0.98**	-1.14**	-0.50	-0.51**	-1.30**	-1.16*	-0.63	-0.73**
	Population between 15 and 59 density	-0.98**	-1.13**	-0.50	-0.51**	-1.29**	-1.16*	-0.62	-0.72**
	Vehicles per capita	-0.96**	-1.09**	-0.45	-0.48**	-1.26**	-1.12*	-0.50	-0.69**
	Taxis per capita	-1.07**	-1.27**	-0.58	-0.63***	-1.39**	-1.29**	-0.68	-0.85***
Municipalities with 75,000 or more inhabitants	Population density	-1.14***	-0.72	-0.66	-0.35	-1.39**	-0.37	-0.91	-0.54*
	Population between 15 and 59 density	-1.14***	-0.72	-0.65	-0.35	-1.38**	-0.37	-0.90	-0.53*
	Vehicles per capita	-1.09**	-0.66	-0.59	-0.30	-1.33**	-0.31	-0.79	-0.48*
	Taxis per capita	-1.21***	-0.84*	-0.74	-0.43**	-1.48**	-0.49	-0.98	-0.63**

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatal crashes consider deaths and severe injuries of drivers, passengers and pedestrians. All specifications consider Time Fixed Effects and Municipality Fixed Effects as controls. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.9: Poisson model estimates of UberX's entry on gender specific outcomes according to different specifications (population density, time and municipality fixed effects as control variables – different exposure measures)

		Fatalities				Fatalities at night			
Control groups	Exposure measure	Passenger		Driver		Passenger		Driver	
		Female	Male	Female	Male	Female	Male	Female	Male
Municipalities with 100,000 or more inhabitants	Population between 15 and 59 density	-1.20**	-1.08**	-0.69	-0.48**	-1.79**	-1.23*	-0.91	-0.84***
	Vehicles per capita	-1.23**	-1.11**	-0.72	-0.52**	-1.81**	-1.27*	-0.87	-0.87***
	Taxis per capita	-1.30**	-1.24**	-0.77	-0.63***	-1.88**	-1.39**	-0.98	-0.98***
Municipalities with 75,000 or more inhabitants	Population between 15 and 59 density	-1.26***	-0.62	-0.76	-0.30	-1.67**	-0.34	-1.00	-0.57*
	Vehicles per capita	-1.26***	-0.63	-0.75	-0.31	-1.66**	-0.36	-0.94	-0.57*
	Taxis per capita	-1.34***	-0.77	-0.86	-0.41*	-1.76**	-0.49	-1.11	-0.68**

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of at least one of the vehicles was an automobile, a van or a jeep. Fatal crashes consider deaths and severe injuries of drivers, passengers and pedestrians. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as controls. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.10: Estimates of UberX's entry on gender and role-specific fatalities

Estimation method	Dependent variable	(1) Female passenger	(2) Male passenger	(3) Female driver	(4) Male driver
OLS	Counts	-0.18*	-0.073	-0.036	-0.27**
	Log(1 + counts)	-0.081*	-0.031	-0.023	-0.12*
Poisson	Counts	-1.25***	-0.63	-0.77	-0.30
	Counts per 100,000 inhabitants	-0.92*	-0.42	-0.63	-0.29

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of car of at least one of the vehicles was an automobile, a van or a jeep. Fatal crashes consider deaths and severe injuries of drivers, passengers and pedestrians. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects and Municipality Fixed Effects. Population Density is included as control variable except for specifications with count rates as dependent variable. The results of our main specification (count data) estimated with Poisson are included here for comparison. Robust standard errors are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.11: Poisson model estimates of UberX's entry on the number of crashes and fatalities originated by different causes

Time frame	Cause of crash	Fatal crashes	Fatalities	Female Driver	Female Passen-ger	Male Driver	Male Passen-ger
		(1)	(2)	(3)	(4)	(5)	(6)
All	Driver distraction	-0.086	-0.11	0.28	-0.12	-0.30	0.36
	Driving without reasonable distance	0.27	0.28	1.00	0.46	0.40	-0.17
	Lost control of vehicle	-0.13	-0.087	-0.58	-0.77**	0.078	0.17
	Undetermined causes	0.091	0.10	0.23	-0.26	0.21	-0.055
	All causes except drunk-driving	-0.0100	-0.017	-0.026	-0.048	-0.022	0.11
	All causes	-0.027	-0.047	-0.052	-0.14	-0.034	0.015
At night	Driver distraction	-0.049	0.037	0.058	-0.025	-0.41	-0.058
	Driving without reasonable distance	0.30	0.23	17.2	0.45	0.11	-0.26
	Lost control of vehicle	-0.46*	-0.35	-0.10	-1.81**	-0.32	-0.039
	Undetermined causes	0.15	0.15	-0.17	-1.02	0.0058	0.47
	All causes except drunk-driving	-0.095	-0.11	0.24	-0.38	-0.23	0.15
	All causes	-0.15	-0.21*	0.10	-0.57**	-0.28*	0.054

Note: Total fatalities include deaths and severe injuries of drivers, passengers and pedestrians. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications consider Time Fixed Effects, Municipality Fixed Effects and Population Density as control variables. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A.3.12: Poisson model estimates of Uber's entry on the number of people per car in drunk-driving crashes

	(1) Average number of people per car in drunk-driving crashes	(2) Average number of people per car in drunk-driving fatal crashes
Uber Black	0.059	0.084
	(0.081)	(0.21)
Uber X	0.098	-0.16
	(0.10)	(0.20)
N	2447	2447
Chi-squared	91.8	88.2

Note: The model only considers crashes where the cause was "alcohol in the driver", there was at least one private driver (at least 18 years old) and the type of car of at least one of the vehicles was an automobile, a van or a jeep. Treatment and control municipalities considered are those with 75,000 inhabitants or more in 2015. All specifications include Time Fixed Effects, Municipality Fixed Effects and Population Density as control variables. Robust standard errors, shown in parentheses, are clustered by municipality. Symbols *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

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ECOLE
DOCTORALE

Titre : Politiques publiques à l'ère du numérique : constats dans les secteurs des télécommunications et des plateformes numériques

Mots clés : Politiques publiques ; Télécommunications ; Plateformes numériques ; Entrée sur le marché ; Mobilité; Evaluation d'impact.

Résumé : Cette thèse de doctorat étudie des questions de politique publique dans le contexte de la transformation numérique de l'économie mondiale. Elle examine des situations nouvelles et des interventions publiques dans les secteurs des télécommunications et du numérique affectant la mobilité des personnes et leur intégration dans l'économie numérique. Elle est divisée en trois chapitres.

Le premier chapitre évalue l'impact de la régulation de l'itinérance internationale mise en œuvre dans l'Union européenne sur les revenus et les prix de détail des opérateurs de téléphonie mobile. Les résultats suggèrent que la régulation, mise en œuvre par phases, a diminué les revenus des opérateurs mobiles et n'a eu aucun impact sur les prix pendant la dernière phase de la régulation. Ainsi, nous ne trouvons aucune preuve d'une réaction stratégique des opérateurs mobiles à la régulation.

Le deuxième chapitre étudie les déterminants de l'entrée en fibre optique par les opérateurs de télécommunications et évalue l'efficacité d'un programme d'aide d'État pour le déploiement de réseaux à très haut débit en France. Nos résultats permettent d'identifier la taille du marché et le revenu des ménages comme deux facteurs importants qui augmentent l'attractivité des marchés locaux et favorisent l'entrée. De plus, nous constatons une forte dépendance géographique du processus d'entrée, un effet de remplacement du réseau cuivre existant et une augmentation de la facilité d'entrée dans le temps. Par ailleurs, nous constatons que le programme d'aides d'Etat a été globalement efficace et a permis d'augmenter la couverture en fibre optique dans les communes aidées, notamment dans les premières phases de la diffusion de la fibre.

Le troisième chapitre étudie les défis de la politique de transport en présence de plateformes de location de véhicule avec chauffeur. Plus précisément, il évalue l'impact des plateformes sur l'incidence des accidents mortels et des décès dus à l'alcool au volant, en utilisant le Chili comme étude de cas. Il étudie également les effets hétérogènes en fonction du genre. Les résultats suggèrent que ces plateformes ont permis de réduire les accidents mortels et les décès dus à l'alcool au volant à Santiago, notamment le nombre de décès de femmes passagères et d'hommes conducteurs durant la nuit.

Title : Public Policy in the Digital Age: Evidence from Telecommunications and Digital Platforms

Keywords : Public Policies; Telecommunications; Digital Platforms; Market Entry; Mobility; Impact Assessment.

Abstract : This doctoral thesis studies questions relevant for public policies in the context of the digital transformation of the world economy. It examines new situations and public interventions on the telecommunications and digital sectors affecting people's mobility and their integration in the digital economy. It is divided into three chapters.

The first chapter assesses the impact of the roaming regulation implemented in the European Union on mobile operators' revenues and retail prices. The results suggest that the regulation decreased mobile operator's revenues per user, while having no impact on prices during the latest phase of the regulation. Thus, we find no evidence of a strategic reaction to the regulation by mobile operators.

The second chapter studies the determinants of fiber entry by telecommunications' operators and evaluates the efficiency and the impact of a State aid plan for the deployment of ultra-fast broadband networks in France. On the determinants of fiber entry, we identify market size and income as important characteristics that increase the attractiveness of local markets. Moreover, we find evidence of a strong geographic dependence in the fiber entry process, the presence of a replacement effect from the legacy copper network and an increase in the ease of entry over time. On the evaluation of the plan, we find that it was overall efficient and helped increase fiber coverage in aided municipalities at the early stages of fiber diffusion.

The third chapter studies challenges of transport policy in the presence of ride-hailing platforms. Specifically, it assesses the impact of these platforms on the incidence of drunk-driving fatal crashes and fatalities, using Chile as a case study. Moreover, it studies heterogeneous effects in fatalities by gender. The results suggest that, ride-hailing platforms significantly reduced drunk-driving fatal crashes and fatalities in Santiago. In particular, it helped decrease the number of female passengers' fatalities and the number of male drivers' fatalities at night.

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