UNIVERSITAT DE BARCELONA

Essays on Telecommunications, Trade, and the Credit Market

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PhD in Economics

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A Carolina, mi adorada hija, y Nancy, mi amada esposa,
a quienes pertenecía el tiempo que estas líneas tomaron.

A mi madre y a mi padre, en gratitud a sus enseñanzas.

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Chapter 1 – Introduction

This PhD thesis analyzes three relevant topics in an era of deep globalization and digital transformation: the impact of free trade agreements on telecommunications markets, the effects of deploying broadband telecommunications networks on firm's access to credit, and the effects of broadband deployment on firms' export activity. It contains three distinct yet interlinked essays aimed at contributing to the literature on development economics and to improve the public policies designed to reduce commercial barriers and to promote international trade.

Chapter two of the thesis is titled "The impact of free trade agreements in national markets: Evidence from the telecommunications sector in Latin America".[1] The objective of the chapter is to assess the causal impact of the signature of US-led Free Trade Agreements on the performance of the telecommunication markets in Latin America. The free trade agreements (FTAs) signed in the 2000s between the US and several Latin American countries included a chapter that established several obligations to liberalize and introduce pro-competition reforms in the telecommunications market.

The signature of the agreements can be considered as an exogenous shock to the telecommunications sector, since they did not respond to the interest of national authorities of Latin American countries. In fact, in most cases telecommunications authorities were forced to adopt these reforms and encountered many internal political difficulties to implement them. The liberalization of the market facilitated the entry in signatory countries of many foreign investors and operators, but they also promoted the development of competition. To test the impact of the reforms generated by the agreements, my analysis examines the causal impact of the FTAs on key indicators of the telecommunications market, such as the prices of the services, the level of penetration of the fixed and mobile services, and the investments.

Motivation: Since the early 2000s, the proliferation of Regional Trade Agreements (RTAs) and Free Trade Agreements (FTAs) in Latin America has been remarkable. The motivation of my study arises from the need to understand the multilayered impacts of these agreements, especially considering that recent free trade treaties go far beyond traditional trade restrictions, to cover aspects such as regulatory standards, health and safety rules, investment, banking and finance, telecommunications and intellectual property. This new generation of trade agreements has been shaped by special interests and influential firms, but it is unclear whether they have increased

[1] Published in Review of International Economics Volume 29, Issue 4, September 2021.

welfare and mutually beneficial trade, or if they have generated purely redistributive outcomes. (e.g., Blanga-Gubbay et.al., 2018; Rodrick, 2018; Woll and Artigas, 2007).

In this context, this chapter brings novel insights on the non-trade effects of trade agreements—specifically, on their effects in the telecommunication markets of Latin American countries. This is a very important topic given the frequency with which such regulations and obligations appear in the new generation of trade agreements. In addition, the analysis of the impact of FTAs on the telecommunications sector is an important objective, given the sector's multiplier effects on national economies. Telecommunications services are an input in the production of goods and the provision of other services, and the changes in their price and coverage have major consequences for the productivity, growth and welfare of each country (e.g., Antonelli, 1996; Cronin et. al., 1993; Madden and Savage, 1998).

Data: My analysis is based in an examination of FTAs signed between the United States and several Latin American countries in the 2000s, particularly focusing on the agreements containing a telecommunications chapter. The dataset used in this chapter comes mainly from the World Telecommunications/ICT Indicators Database of the International Telecommunication Union's (ITU) and it is complemented by institutional and regulatory data from the World Bank (WB) and the Organization of American States (OAS). The data covers 28 Latin American and Caribbean countries over the period 1996-2015, which includes ten FTAs with the US analyzed. The dataset includes information about average revenue per user (ARPU), fixed and mobile prices, penetration of services, and private investment in telecommunications. These variables were used to identify changes in the levels of competition in national markets after the signature of the FTAs.

In order to analyze the impact of the US-FTA telecommunications obligations on the national markets of Latin American countries I use several outcome variables. The ARPU is defined as the revenue generated by all telecommunication services in a specific country and year, divided by the total number of users. The ARPU is a measure widely used by telecommunications operators and regulators around the world to analyze market performance. The other outcome variables used in the empirical analysis to reflect market competition are fixed and mobile prices. In the case of fixed prices, I consider the price of a three-minute local call at peak time, while for the case of mobile prices, I use the price of a one-minute prepaid local call at peak time. The analysis also examines the effect of the US-FTAs on the penetration rate of fixed and mobile services, which are defined as the number of subscribers of these services per 100 inhabitants. Finally, the analysis considers the private investment in telecommunications reported by the World Bank.

Identification Strategy: To assess the causal impact of the FTAs on the national telecommunications markets, my study employs a difference-in-differences (DiD) econometric model that examines the impact of the adoption of FTAs on the prices and coverage of fixed and mobile telecommunications services, using as a control group the Latin American and Caribbean countries that did not enter into these agreements. Among the group of Latin American and Caribbean countries studied, eleven signed US-FTAs containing a telecommunications chapter. Mexico was the first to do so in 1993, but we do not consider this case because it lies beyond our period of analysis. The remaining countries signed US-FTAs between 2003 and 2007. These were Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Peru.

Results: The results of my empirical analysis reveal that the US-FTAs had an important effect on the telecommunications markets of Latin American and Caribbean countries. The most important result is that they generated a substantial reduction of 45.5% in the average revenue per user (ARPU) among signatory countries. Mobile service prices also experienced a significant decline of 34%, whereas fixed call prices, mobile and fixed penetration exhibited no statistically significant impact.

These findings suggest that changes in the regulatory framework introduced by the agreements had a quicker and deeper effect on mobile services than on fixed communications services, where it is more difficult to develop competition and national authorities continued to regulate the retail prices. During the 2000s, mobile services underwent significant growth in all Latin American countries, but the liberalization measures and pro-competition reforms introduced in the countries that signed the US-FTAs—such as facilitating the entry of new competitors, the introduction of number portability, and the interconnection of telecommunications networks at cost-oriented prices—could have helped to increase competition and reduce prices to a greater extent than in non-signatory countries.

I do not find a statistically significant impact of the agreements on the prices and the penetration level of fixed telecommunication services, which in part can be explained by the existence of price regulations for the incumbent telecommunications operators; and in part by the reduced profitability of expanding fixed telecommunications networks beyond urban areas. In addition, no significant impact is observed in the penetration of mobile services. This implies that the different evolution of mobile prices between signatories and non-signatories of US-FTAs has not led to changes in the adoption of this services, even though the reductions of prices may have increased the usage of mobile services by consumers.

Overall, the main contribution of this chapter is to show that the signature of the FTAs between the US and some Latin American countries, containing telecommunications chapters has benefited the consumers in national markets through price reductions. However, these agreements have not generated a significant impact on private investment and in the penetration of telecommunications services.

Policy Implications: The implications of this research extend beyond academic analysis, offering valuable guidance for policymakers. Developing countries considering the adoption of FTAs including a modern and far-reaching telecommunications chapter can anticipate that this can result in an increase in competition and a reduction in the prices, enhancing consumer welfare. Importantly, the results of my econometric analysis do not find that the adoption of these agreements has negatively affected the deployment of telecommunications networks by private operators, which could have been a consequence or their lower profitability.

The results that I have found for the mobile services are quite relevant for the design of public policies, because they imply that the inclusion of market reforms in the US-FTAs have produced a reduction in the telecommunications prices that has benefited the consumers. In addition, this reduction of prices generates positive externalities in other economic activities that use telecommunications services as an input.

The absence of a statistically significant impact of US-FTAs on the penetration of telecommunications services has also important policy implications. Stakeholders that have traditionally opposed the adoption of these agreements in Latin American countries have usually argued that they are only beneficial in mature markets that had reached a sufficiently high level of market penetration, which was not the case of Latin American countries during the years in which the US-FTAs were negotiated. Incumbent operators often argued that the adoption of the obligations contained in the telecommunications chapter of the agreements would negatively affect the development of the telecommunications market in the region, by reducing the incentives to expand and upgrade existing telecommunications networks. My analysis has not validated this argument.

Chapter three of the thesis is titled "Access to Credit and the Expansion of Broadband Internet in Peru"[2] and examines the impact of having access to the high-speed broadband technology on the performance of firms and banks in the credit market. Specifically, this chapter analyzes how the staggered arrival of broadband internet in Peru has modified the access to credit and the performance of firms. Grounded in the well-documented relationship between growth and financial development, the exploration of financial frictions is crucial to understand the productivity challenges and resource misallocation often observed in developing economies (Levine, 1997; Restuccia and Rogerson, 2017). In this sense, the main novelty of this chapter is to analyze how the irruption of the broadband internet in Peru implied a technology shock that affected both the supply and demand of bank intermediation.

[2] Co-authored with Antonio Cusato. An earlier version of this research was published as a working paper of the Inter-American Development Bank (IADB).

Motivation: The central motivation of this chapter is the recognition that financial frictions are a key explanatory factor for the limitations on firm productivity, resource misallocation and financial exclusion in developing countries. Access to credit is essential for the expansion and development of firms. Credit allows firms to expand their operations, invest in new technologies, or explore new markets. Without access to credit, firms may not be able to secure the necessary funds to purchase new equipment, acquire real estate, or expand their workforce. In addition, credit is crucial for firms to navigate cash flow fluctuations and manage operations effectively. Access to credit lines and working capital loans helps businesses bridge financial gaps, meet payroll, and cover operational costs during lean periods. Overall, access to credit allows firms to make strategic investments and develop their market potential. Considering this, the main goal of this research is to unravel the credit supply and demand dynamics generated by the staggered arrival of high-speed broadband internet in Peru.

Data: We use three different data sources to assess the impact of broadband deployment on the credit market. We use annual information on the deployment of fixed broadband networks in Peru for the period 2010-2019. These data come from the Peruvian regulator of the telecommunications market (OSIPTEL), who collects data from all telecommunications operators to elaborate its market reports and studies. Data on broadband coverage has been collected at the *Centro Poblado* (CP) level, which is the smallest administrative jurisdiction in the country.

Our data on firms' credit comes from the Taxpayers Registry and the Credit Bureau Registry. The Peruvian Taxpayers Registry collects information for the universe of formal firms in the country (defined as those that pay taxes). The information of the registry includes the fiscal address of each firm, which allow us to geolocate the firms and to identify if they are in a CP with broadband access. It also includes an indicator about the range of sales for each firm.

Finally, the Peruvian Credit Registry has information on the universe of loans and interest payments of all firms and persons. Our analysis focuses on the credit offered to formal firms that pay taxes, since we do not have access to the addresses of the population. Specifically, we focus on credit provided for working capital and investment purposes to big, medium, small and micro firms.

Identification Strategy: We consider the arrival of fiber broadband internet at the CP level as an exogenous technology shock, influencing both the supply and demand sides of bank intermediation. Taking advantage of the staggered deployment of fiber broadband networks in Peru, the study applies a staggered difference-in-differences (DiD) approach to causally link the deployment of broadband internet with changes in firm access to credit, performance, and market dynamics.

A key assumption of our identification strategy is that the timing of the deployment of the Fiber to the X (FTTX)[3] lines across CPs is not associated with the evolution of the credit market. In order to validate this assumption, we examine whether the pattern of the deployment of this technology was correlated with the characteristics of the CPs (population, housing, distance to Lima, distance to the nearest airport, previous existence of a DSL network, amount and number of credits, number of workers). Our analysis shows that the FTTX broadband roll-out is not related with most of previously described characteristics of the CPs, except in the case of the variables that indicate the distance of the firms to Lima and to the nearest airport, which validates our assumption that the roll-out of the FTTX broadband lines are exogenous.

Results: The results of this chapter sheds light on the impact of broadband availability on the performance of firms in Peru, as well as on the access to the credit market. Specifically, we show the sequential effects of the arrival of the broadband internet on the firms' economic activity and credit. When analyzing the extensive margin, we find that the probability of entry into the credit market increased and the probability of exit from the credit market decreased in the areas benefited with the broadband deployment. Moreover, we find that arrival of broadband increased the access of firms to credit. This effect occurred four and five years after the broadband deployment. At year five, total credit per firm increased by 38%, the number firm-banks relations increased by 20% (which implies that firms were served by more banks), and the number of loans per firm-bank relationship increased by 5.4%.

Our analysis also studies the intensive margin of broadband deployment, examining the causal effect of broadband deployment on the size of credit per firm-branch, as well as on the interest rates. We analyze firm-branch relationships when the two entities have the same or different locations. Notice that when the location is not the same, we can either examine the effect of broadband deployment at the location of the bank branch, or at the location of the firm, as they might benefit of the technological upgrade at different periods. We observe that broadband deployment has a positive effect for the average size of the loan for those firms that benefit from the arrival of the broadband before the bank branches, and in this case, we find that firms benefit from a reduction of interest rates.

The second contribution of this chapter is to empirically disentangle the effects of broadband deployment between the impact in the supply of credit (bank branches) and in the demand (firms). We show that in the case of Peru the demand channel has been more important that the supply channel for the access to the credit. When firms

[3] The application of Optical Technology for providing broadband connectivity is called Fiber to the X. This application is given the designation FTTX, where X is a letter indicating how close the fiber endpoint comes to the actual user: FTTN (Node), FTTC (Curb), FTTB (Building), FTTH (Home). Fiber-to-the-home (FTTH) refers to the deployment of optical fiber from a central office switch directly into a home (Keiser, 2006).

and banks receive the impact of the broadband simultaneously, and when the impact arrives first to the firms than to the bank branches, there is a reduction in the market interest rates of 4 percentage points. These results occur five years after the broadband technology deployment. By contrast, we do not find effects when the technology affects bank branches but not the firms (supply channel). Our results about the existence of a demand channel effect are consistent with the idea that the firms that benefit most from broadband are small firms and with "thin" credit files.

Policy Implications: Decisions on promoting the public and private investment in the expansion of the fiber broadband network to reach more micro and small firms can help enhance their performance in the market. Consequently, the risk perception of those micro and small firms by credit lenders improves, increasing the probability of obtaining credit or expanding current credit lines.

This chapter highlights that access to information and communications technologies is essential for the financial inclusion of micro and small firms, which are often classified as riskier, and have little opportunities to engage with multiple bank branches, thereby limiting their growth potential. These results are particularly relevant for policymakers aiming to promote the development of micro and small firms, fostering their financial inclusion and reducing their credit risk. Policies aligned with these goals include the promotion of public and private investment in fixed and mobile broadband infrastructure, as well as investments in digital education and promotion of mobile banking.

Chapter four is titled "Broadband deployment and firm exports' strategy"[4] and analyzes the effects of the deployment of broadband internet on firms' exporting activity. Specifically, our research analyzes the impact of access to fiber broadband on the value of exports, the number of destination countries at which firms export, and the level of concentration (HHI index) of the firms' exports.

Motivation: While existing literature has explored the positive effects of internet access on GDP growth, employment, and productive efficiency, so far little attention has been paid to study how high-speed broadband internet shapes firms' exports activity. This chapter tries to address this question by investigating the effects of the deployment of fiber broadband on the export strategies of Peruvian firms. Specifically, we exploit the quasi-exogenous variation in broadband access generated by a public program in 2014. The objective of this program was to connect with the FTTX broadband technology the 196 capitals of province of Peru. The staggered deployment of this new network allows us to investigate the impact of broadband on firms' internationalization strategies.

[4] Co-authored with Joan Calzada.

Data: Our research uses data from the Peruvian Customs Exports Registry, Taxpayers Registry, and data on broadband fiber deployment from the Peruvian regulator of the telecommunications market (OSIPTEL). We use a firm-level dataset obtained from the Peruvian Customs Exports Registry covering all firms with an export activity in the period 2000–2019. The Registry provides the value of each firm's exports, expressed in US dollars and information on the sector and destination of the exported products. Importantly, the dataset includes the address of the firms, which allow us to calculate their geographical location. We complement this information with data from the Taxpayers Registry on the number of employees of the firms and their sales volumes.

Data on the deployment of broadband lines in Peru has been obtained from the Peruvian regulator of the telecommunications market (OSIPTEL). The data is at the *Centro Poblado* (CP) level, which is the smallest administrative jurisdiction in the country. This information allows us to determine the exposition of firms to different types of broadband technologies (i.e. DSL, FTTX, HFC) and to calculate a proxy of the distance of the telephone local exchanges (local loop length) to which they are connected. This distance determines the quality of the DSL service firms can receive.

Identification Strategy: We examine the causal effect of broadband deployment on firms' export results. Our study employs a difference-in-differences (DiD) approach that exploits the fact that the quality of the DSL broadband service is attenuated with the distance of the firm to the telephone local exchange. Specifically, we consider that those firms located more than 2.5 kilometers away from the local exchange will benefit relatively more from the upgrading to the FTTX technology than those firms with a closer location, because they receive a poor DSL service. Considering this, we apply a difference-in-differences approach (DiD) that compares the difference in exports of firms exposed to the FTTX technology who were closer and further away from the 2.5 km to the local exchanges, relative to the difference between firms not exposed to the FTTX technology who were located closer and further away from the local exchanges.

Results: The findings of this research reveal significant positive effects of FTTX broadband deployment on firms' export activities. Peruvian firms with access to high-speed internet participate more in international markets, export more, and have more diversified exports in terms of the destination countries. Specifically, the access to the FTTX technology by those firms located more than 2.5 kilometers away from the local exchanges increased the value of exports by 35.5% and the number of destination markets by 8.5%, while it reduced the concentration of their export activity by 4.7%. Our study also reveals that the benefits of broadband adoption extend beyond large firms and have heterogeneous effects across sectors.

Policy Implications: This study highlights the importance of universalizing firms' access to broadband technologies to improve their performance in international markets, diversify the foreign markets to which they export and to reduce their dependence on large destination markers such as China, the United States and the European Union.

Our findings have important policy implications for governments, regulators, and industry associations that seek to promote the adoption and use of broadband Internet, and also for those that seek to promote exports and market diversification. First, policymakers should prioritize investments in high-speed broadband infrastructure and digital skills development, especially in regions and sectors that are lagging behind in terms of connectivity and digital literacy. Second, they should foster a supportive regulatory environment that encourages competition, innovation, and consumer protection in the digital sector. Third, they should promote international cooperation and standardization in areas such as data privacy, cybersecurity, and cross-border e-commerce, to facilitate firms' participation in global value chains.

Chapter 2 – The Impact of Free Trade Agreements in National Markets: Evidence from the Telecommunications Sector in Latin America[5]

2.1 Introduction

Since the early 2000s, there has been a large increase in the number of regional trade agreements (RTAs) and, to a greater extent, free trade agreements (FTAs) signed around the world. According to the World Trade Organization (WTO), from 1948 to 1994 the General Agreement on Tariffs and Trade (GATT) received 124 notifications of RTAs covering trade in goods and services and, from the creation of the WTO in 1995 to 2016, a further 400 agreements (World Trade Organization, 2017). The economic impact of the proliferation of bilateral agreements is difficult to assess, but there is a general concern that they can slow multilateral trade liberalization and prevent larger reductions in tariffs (Limao, 2016).

One important characteristic of recent treaties is that they go far beyond traditional trade restrictions to cover aspects such as regulatory standards, health and safety rules, investment, banking and finance, and intellectual property. With trade agreements increasingly focusing on domestic rules and regulations, their impact on consumers is less clear, and this impact is increasingly hard to evaluate by way of the received trade theory. This new generation of agreements are shaped by special interests and influential firms, and it is too early to tell whether they will give rise to freer, mutually beneficial trade, to welfare reductions, or to purely redistributive outcomes (e.g., Blanga-Gubbay et.al., 2018; Rodrick, 2018; Woll and Artigas, 2007). Some of the new clauses in these agreements have been proposed by the United States and the European Union as a means of exporting their regulatory models to other regions, and thus facilitate the entry or expansion of their firms in developing countries. However, governments in developing countries might also be able to take advantage of the obligations included in the treaties to reform protected national markets and to introduce efficiency measures that would otherwise be difficult to implement.[6]

This paper sheds light on these questions by analyzing the impact of the FTAs signed in the 2000s between the United States and several Latin American countries (US-

[5] Published in Review of International Economics Volume 29, Issue 4, September 2021.
[6] Some of these obligations can be considered as endogenous shocks, especially if treaties only bound current liberalization or national regulations, or when treaties reflect voluntary commitments. As explained later, this is not the case of the FTAs analyzed in this paper.

FTAs), and covering the national telecommunications markets of the signatories. The analysis focuses on the causal impact of those agreements that feature a telecommunications chapter, on key indicators of telecommunications sector performance in Latin American and Caribbean (LAC) countries. These indicators are: average revenue per user (ARPU); price of fixed and cellular calls; fixed and cellular service penetration measured by number of lines per 100 inhabitants; and private investment in the telecommunications sector.

Analysis of the impact of FTAs on the telecommunications sector is an important objective, given the sector's multiplier effects on national economies. Telecommunications services are an input in the production of goods and the provision of other services, and the changes in price and coverage have major consequences for the productivity, growth and welfare of each country (e.g., Antonelli, 1996; Cronin et. al., 1993; Madden and Savage, 1998). Telecommunications services are carefully regulated by national authorities. As a result, any pro-competition reform on its regulation can be expected to increase competition, with positive effects on prices, service penetration, and investment in the sector.

All US-FTAs signed in the 2000s with Latin American countries included an almost-identical telecommunications chapter, which was later replicated in most US-FTAs with other countries. These chapters present market-regulation measures, aiming to increase competition and prevent incumbent operators from implementing anti-competitive practices.[7] They contain obligations such as the interconnection of telecommunications networks, mandatory wholesale resale by large operators, number portability, co-location of equipment, and the creation and maintenance of an independent telecommunications regulator, among others.[8] The justification for these pro-competition harmonization measures is that eliminating differences across national regulations reduces transaction costs associated with entering or expanding existing operations into the telecommunications market of other countries. This paper examines the exogenous impact of US-FTAs on the regulation of telecommunications markets, in terms of the effects on competition and firms' investment decisions. The obligations set down by the US-FTAs, including those presented in the telecommunications chapters, can be considered an exogenous shock to sector regulation, since they did not reflect an interest by national authorities to reform the

[7] Janisch (1989), Globerman and Booth (1989) and Shefrin (1993) are some of the first academic studies to have analyzed the FTA telecommunications chapters. They describe the content of the agreements and provide an ex-ante evaluation of their impact.

[8] The Office of the United States Trade Representative (USTR) describes the main characteristics of the FTA telecommunications' chapters: https://ustr.gov/trade-agreements/free-trade-agreements

telecommunications market. In fact, in most cases telecommunications authorities were forced to adopt these reforms and encountered political difficulties in doing so.[9]

Countries participating in the US-FTAs are expected to implement a higher level of competition and lower prices for telecommunications services.[10] First, the obligations included in the treaties require national authorities to introduce internal reforms that are verified by their co-signatories before the treaty comes into force. Second, the trade liberalization measures established by treaties apply competitive pressure to all firms in the economy, requiring better and cheaper telecommunications services to face the new market conditions.[11]

This paper draws on an unbalanced panel dataset obtained mainly from the International Telecommunications Union (ITU), containing information for 28 Latin American and Caribbean countries over the period 1996–2015. This dataset includes information about average revenue per user (ARPU),[12] fixed and mobile prices, penetration of services, and private investment in telecommunications. These variables are used to identify changes to competition levels in national markets after the FTAs come into force. This information is complemented with institutional and regulatory data obtained from the World Bank.

Taking into account the exogenous effect of the US-FTAs on the regulation of national telecommunications markets, this paper applies a difference-in-differences (DiD) econometric model to assess their impact on the prices and coverage of fixed and mobile telecommunications services, using as a control group the Latin American and Caribbean countries that did not enter into these agreements. Among the group of Latin American and Caribbean countries studied, eleven signed US-FTAs containing a telecommunications chapter. Mexico was the first to do so in 1993, which lies beyond our period of analysis and so this country is not taken into account. The rest of the countries signed US-FTAs between 2003 and 2007.

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[9] News articles published during the negotiation periods show internal opposition to US-FTAs in several Latin American countries. For instance, see Mora (2004) on Costa Rican political opposition to the proposed opening up of the telecommunications and insurance sectors.

[10] The telecommunications chapters in US-FTAs contain a bundle of sectoral measures that must be introduced or locked into national laws and regulations, generating competitive pressures on each internal telecommunications market. For instance, mandatory infrastructure sharing for major suppliers means that small telecommunication companies can lease infrastructucture from a major supplier at reasonable rates, forcing the major supplier to compete by lowering prices for end users.

[11] For a review of the literature analyzing the effects of information and communication technologies on international trade and services exports, see Kneller and Timmis (2016).

[12] ARPU is defined as the total revenue of telecommunications companies divided by the total number of users. It is a measure widely used by telecommunication companies and regulators around the world.

The results reveal a 45.5% reduction in ARPU among the Latin American countries that entered into US-FTAs, but while the prices of cell-phone calls decreased by 34%, no significant effect was found for fixed call prices. These findings suggest that changes in the regulatory framework introduced by the agreements had a quicker and deeper effect on mobile services than on fixed communications services, where it is more difficult to develop competition and retail prices continue to be regulated. During the 2000s, mobile services underwent significant growth in all Latin American countries, but liberalization measures introduced in countries with US-FTAs—such as the entry of new competitors, the introduction of number portability, and the interconnection of facilities and equipment at cost-oriented rates—may have been instrumental in spurring competition and reducing prices to a greater extent than in non-signatory countries.

The present analysis does not find US-FTAs to have an effect on fixed or mobile penetration rates, or on private investment in telecommunications. One explanation for this could be the important expansion of mobile services—both for treated and non-treated countries—in the period of analysis. Although the reduction in prices of cell-phone calls has been considerable among US-FTA signatories, the network effects generated in the consumption of these services coupled with the long-time low coverage of landline telecommunications in Latin America explain the parallel growth in the penetration of telecommunications services in the two groups of countries.

In sum, this paper brings novel insights into the non-trade effects of trade agreements. It analyzes the impact of the trade policy initiated by the signing of US-FTAs on the non-trade performance of a specific, relevant sector: the telecommunications sector. This is highly topical given the increasing depth and breadth of coverage of the current generation of trade agreements; thus, the paper contributes to an important research agenda in an area where the literature is scant.

The rest of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 explains the main characteristics of the FTAs between the US and LAC countries. Section 4 outlines the privatization and liberalization process involving telecommunications services in Latin America. Section 5 presents a brief theoretical background to the analysis. Section 6 describes the data and explains the empirical strategy. Section 7 shows the estimated results under different estimation techniques, and as well as several robustness checks. Finally, Section 8 summarizes the main conclusions.

2.2 Literature Review

Despite the relevance of FTAs to the regulation of certain internal markets, very few papers have examined their consequences. The closest paper to this one, as far as is known, is Djiofack-Zebaze and Keck (2009), which analyzes the impacts of unilateral reform and telecommunications commitments under the WTO General Agreement on Trade in Services (GATS) for African countries. The study finds that the liberalization commitments of African WTO members did not affect the evolution of telecommunications services, although adherence to the WTO-GATS Reference Paper was associated with lower prices. It is important to note that the WTO-GATS Reference Paper contains only six basic regulatory commitments for the telecommunications sector. These commitments are much less extensive than the FTA commitments considered in the present paper, and WTO members are not required to comply with them; they may voluntarily decide to do so by including the Reference Paper within their respective international commitments.

A second paper related to the present one is Fiorini and Hoekman (2018), which studies the relationship between trade in services and indicators of access to several services of relevance to the achievement of the UN sustainable development goals. Using a cross-country analysis of 103 economies, the study shows that when the level of economic development or the quality of institutions is sufficiently high, openness to services, trade, and investment positively affects access to information and communication technologies and to financial and transport services. In turn, Lim and Chen (2012), explores the effects of trade liberalization on telecommunications in the Asia-Pacific Economic Cooperation (APEC) region. The study finds that in higher-risk countries, both investment in telecommunications and GDP could be reduced as a result of sectoral liberalization.[13] Two other papers with a research question similar to the present are Trefler (2004) and Bustos (2011), both of which analyze the impact of FTAs on productivity and firms' choices of technology upgrade.

Other related studies include empirical evaluations of the impact of FTAs on trade flows and welfare. Frequently used methodologies to analyze the agreements are gravity equations, as well as ex-ante simulations using computable general equilibrium (CGE) models. The gravity equation has been widely used since it was first proposed by Tinbergen (1962) to explain patterns and determinants of trade. Carrère (2006) finds that regional agreements have generated a significant increase in trade among members, often at the expense of the rest of the world. Baier and Bergstrand (2007) points out that, on average, a FTA will approximately double the two signatories' bilateral trade after 10 years. Magee (2008) observes that regional agreements have significant anticipatory effects on trade flows and continue to affect trade for up to 11

[13] A related paper by Andonova and Díaz-Serrano (2009) examines the effects of political institutions on the development of the telecommunications industry.

years after their signature; and Heid and Larch (2016) argues that the welfare effects of trade agreements are typically magnified when employment changes are accounted for.

The gravity equation has also been used in a number of studies on trade in services, such as Kimura and Lee (2006), Walsh (2008) and Karam and Zaki (2013). Most of these papers find positive impacts of trade agreements on trade in services flows. Furthermore, Hoekman and Shepherd (2017) uses the gravity equation to establish links between services and trade productivity at the firm level, showing that services trade restrictions play an additional role to merchandise trade barriers to export performance.

A number of papers have studied the effect of trade liberalization on productivity (e.g., Amiti and Konings, 2007; Bresnahan et al., 2016; Lileeva and Trefler, 2010; Melitz, 2003). Moreover, a recent empirical paper by Linarello (2018) uses a DiD identification strategy to examine the effects of three Chilean FTAs on firms' productivity performance. The study finds that the decrease in foreign tariffs faced by downstream industries accounts for 22.5% of aggregate productivity growth.

Several ex-ante general equilibrium studies examine the effect of trade agreements on growth, prices, welfare and trade flows. Most of these models show that aggregate trade creation is much greater than trade diversion in the case of RTAs, and that these agreements increase welfare (Robinson and Thierfelder, 2002).[14]

Another relevant section of the literature is that which analyzes the effects of the liberalization and privatization of telecommunications, especially in Latin America. One notable paper in this field is Wallsten (2001), which studies the effects of privatization, competition, and regulation on the performance of the telecommunications sector in 30 Latin American and African countries in the period 1984–1997. The paper shows that competition in these countries was correlated with an increase in telephony penetration, payphones, and connection capacity, and with a decrease in the price of local calls; while privatization, combined with an independent regulator, has a positive impact on the evolution of the industry. Fink et al. (2003) analyzes the impact of policy reform in basic telecommunications for 86 developing countries, finding that countries that liberalized the telecommunications sector entirely have greater telephone density and higher labor productivity than those that only partially reformed the sector. Li and Xu (2004) note that both full privatization and the increase in competitive pressures positively impacted the evolution of the sector. Zheng and Ward (2011) observe that increased competition in mobile telecommunications is associated with lower prices, while privatization is associated with lower prices and increased use of the service.

[14] Among some recent works in the literature, we find Krishna (2003), Baier and Bergstrand (2004), Romalis (2007), Sébastien et al., (2014), and Krebs and Pflüger (2017).

Finally, there is a relatively new but growing literature in political science dealing with the effects that non-trade provisions in trade agreements have on non-trade outcomes (e.g., Bastiaens and Postnikov, 2017; Brandi et al., 2020; Hafner-Burton, 2009; Hicks and Kim, 2012; Lechner, 2016; Postnikov and Bastiaens, 2014; Raess et al., 2018; Spilker and Böhmelt, 2013). Hafner-Burton (2009) analyzes the political process behind the inclusion of human rights clauses in US and EU preferential trade agreements, and the relationship between these clauses and real change in signatory governments' protection of human rights. The paper argues that although there is no guarantee of real change—because many of the governments that sign free trade regulations oppose human rights protections and do not intend to enforce their implementation—trade agreements that encompass human rights provisions have had a positive impact for the people they are intended to protect. These results are challenged by Spilker and Böhmelt (2013) which, using the genetic matching technique, does not find that preferential trade agreements (PTAs) have a significant impact on human rights protection. Other recent studies have examined the labor and environmental provisions of PTAs. Postnikov and Bastiaens (2014) conclude that EU-PTAs that include labor obligations show a positive ex-post effect on worker's rights. With regard to environmental provisions, the study finds a relationship between the signing of PTAs and a reduction in pollution (Bastiaens and Postnikov, 2017). According to another study, environmental provisions in PTAs can help reduce dirty exports and increase green exports from developing countries (Brandi et al., 2020).

2.3 The Free Trade Agreements between the United States and Latin American Countries

Trade relations between the United States and Latin American and Caribbean countries have been close for a long time. The United States is by far the largest export market for the region and the primary investor, most notably for Mexico and the Caribbean Basin region (Hornbeck, 2011). Although the US remains the most important external actor in Latin America in terms of investment, trade experts have argued that the country's influence has diminished in recent years, largely in favor of China (e.g., Azpuru, 2017; Urdinez et al., 2016).

According to World Bank data, in 2018 the United States was the first market for Latin American exports, accounting for US$ 423,311 million, which represents the 43% of the region's overall exports. Latin America's second-largest partner that year was China, accounting for US$ 122,069 million, which represents 12% of the total. This pattern is similar when analyzing the LAC region imports in 2018: the US represents 32% and China 19% of total imports.

The trade relationship between the US and the LAC countries has been formalized through a series of FTAs. The recent wave of negotiations was initiated after the failure of negotiations aimed at establishing the Free Trade Agreement of the Americas (FTAA) in the early 2000s. This was an ambitious negotiation process that intended to unify North America, Central America and South America through a unique mega-regional trade agreement. The negotiations did not succeed for several political and economic reasons, but a few years later the US and some Latin American countries initiated bilateral negotiations that culminated in the signature of several US-FTAs between 2003 and 2007. The obligations under these agreements are based, with some modifications and additions, on the text of the North American Free Trade Agreement (NAFTA) between Canada, Mexico, and the United States that had been in force since 1994. The agreements cover all trade in goods and services, and their ultimate objective is full tariff elimination with virtually no exceptions.

The US-FTAs examined in this paper were usually negotiated by working groups made up of officials from the signatory governments, who met routinely until each specific chapter was finalized. At the beginning of each negotiation process, one negotiating party proposed a draft chapter based on previous talks with stakeholders. In the case of the US-FTA telecommunications chapters, the stakeholders included regulatory authorities, telecommunication companies, associations, and equipment producers from the respective countries involved. During the negotiations, each country handled each chapter according to their specific interests.

On their successful conclusion, the negotiations gave rise to the signature of a bilateral agreement between the United States and the other country, and then to a process of internal approval, usually by the national parliaments. After completing these procedures, both countries mutually agreed on the date on which the agreements had to enter into force—even though they were not actually applied until a checklist of obligations was approved. This checklist procedure is very helpful for the identification strategy employed in the present empirical analysis, because it serves to verify that all FTA obligations were in fact implemented during the period between the date of signature and the date of entry into force of each US-FTA. The checklist procedure is a specific characteristic of the US's trade agreements, and is not a requirement of other trade agreements such as those promoted or pursued by the EU.

Most Latin American countries have participated in negotiations with the US for a US-FTA, although not all attempts have been successful. For instance, US–Colombia and US–Peru agreements were negotiated jointly, and during the process Ecuador participated actively, while Bolivia was involved as an observer with the option of joining the negotiations later. At the end of the negotiations only Peru and Colombia reached an agreement with the US, but the fact that Ecuador and Bolivia also participated, and that their government officials sat at the same table, means that these countries serve as good controls for the present econometric analysis. Uruguay also sought a bilateral agreement with the US and held preliminary meetings in Washington D.C., but the negotiation process was not initiated due to Uruguay's membership of MERCOSUR. Finally, it is important to stress that almost all Latin American and Caribbean countries took part in the FTAA negotiations, and, as mentioned, some of the countries involved in the failed negotiations ended up signing a bilateral US-FTA. The FTAA negotiations are also important for the present DiD identification strategy, as they confirm that the aspirant-FTAA countries in the control group were actively seeking an agreement with the US.

As noted earlier, each of the US-FTA agreements included in the present analysis includes a near-identical telecommunications chapter aimed at facilitating the entry or expansion of telecommunications service providers into the signatory countries, and at promoting competition in their markets. These chapters contains obligations such as ensuring the interconnection of facilities and equipment at cost-oriented rates; unbundling of network elements at cost-oriented rates; mandatory wholesale resale of telecommunication services by major suppliers at reasonable rates; number portability; competitive safeguards to discourage anti-competitive conduct; physical or virtual co-location of equipment at cost-oriented rates; and the implementation or maintenance of an independent regulator, among others. The objective of these measures is to increase competition among telecommunications companies and prevent incumbent operators from engaging in anti-competitive practices. The obligations flowing from the telecommunications chapters are almost the same for all countries that reached an agreement with the United States, except in the case of the agreement with Mexico (NAFTA), which was negotiated earlier and contains fewer obligations. See Appendix A for a detailed explanation of how each provision included in US-FTA telecommunications chapters impacts on competition in the telecommunications sector.

2.4 Telecommunication Services in Latin America

State-owned companies controlled the provision of public services in most Latin American countries for decades (Gutierrez and Berg, 2000). This changed in the 1990s when several countries in the region initiated a market liberalization process, motivated by the inefficiency of public firms, the need to attract resources to finance network expansion, and the pressure of international organizations such as the World Bank and the International Monetary Fund (Razo and Rojas Mejía, 2007). In most countries, this process was accompanied by the privatization of state monopolies, under the assumption that private operators would offer better service. However, privatization was often accompanied by an exclusivity period in which operators were expected to obtain resources to expand their networks and serve a larger proportion of the population. Wallsten (2004) shows that in countries that implemented these periods of exclusive monopoly, firms doubled their sale price but at the cost of substantially reduced investment. On the other hand, Gutierrez and Berg (2000) finds that regulatory framework and freedom factors have significant positive impacts on fixed telephone lines per capita.

Mobile services were also initially exploited through state or private monopolies. However, technological progress, the need to upgrade networks, and the model preferred by developed countries very soon pushed most Latin American governments to liberalize this service.

In Central America, mobile telecommunications progressed from concessions to private operators, but the service was rapidly opened up to competition in the 1990s. In Brazil, privatization took place in 1996, and entailed the division of the state monopoly into three regional companies, one long-distance company, and eight mobile operators. Some years later, additional licenses were offered to new private competitors (Rozas, 2005). In Mexico, mobile telephony began in 1987 when the country was split into nine regions, and two licenses were delivered in each of them (Mariscal and Rivera, 2005).

Chile, Colombia, Panama, and Ecuador began to provide mobile services under a liberalized market. Panama and Ecuador simultaneously tendered two national licenses. Chile and Colombia both divided their territory into regions and licensed operators in each of them. In Chile, the government divided the country into three regions, and two licenses were tendered per region (Fischer and Serra, 2002). Similarly, in Colombia the country was divided into three regions and a duopoly was established in each (Lapuerta et al., 2003).

A key factor in the universalization of mobile communications in the region has been technological progress, which has allowed an increase in service coverage at a reduced cost while also releasing additional licenses and improving the quality of the service. The second generation of mobile telephony (2G) was adopted by Latin America countries at the end of the 1990s. Three 2G standards were adopted in the region. Mexico deployed the second-generation time-division multiple access (TDMA) standard in 1989, and was followed thereafter by the other countries in the region. The American code-division multiple access (CDMA) standard gained a strong presence throughout the region some time later, due to the extensive presence of Bellsouth. Finally, Telefónica and América Móvil implemented the European Global System for Mobile Communications (GSM) standard in the countries in which they had concessions, and in 2004 Bellsouth was purchased by Telefónica. Although for some years the TDMA, the American CDMA and the European GSM digital standards coexisted in some countries, the GSM quickly prevailed over the other technologies. The transition from analogue to digital technology allowed a reduction in the size and cost of mobile devices, and promoted a dramatic increase in the number of subscribers.

The third generation of mobile network technology (3G) was introduced between 2006 and 2008, and was characterized by its ability to transmit data at high speeds. The European Universal Mobile Telecommunications System (UMTS) standard was widely adopted in the region, as were some of its advanced protocols such as High Speed Downlink Packet Access (HSDPA). Finally, the 4G Long-term Evolution (LTE) standard was adopted as of 2010. These technologies facilitated significant deployment of mobile networks and allowed most of the population in the region to access the service. Thus, in 2003—the year in which Chile entered into the first US-FTA agreement in the sample—the average mobile-telephony penetration in Latin America was 20% of population, by 2010 penetration had reached more than 100% (ITU-WT/ICT, 2016). Furthermore, voice traffic in Latin American countries also increased over a similar period. The minutes of use (MOU) indicator, measured as the total traffic in minutes divided by the number of subscribers, almost doubled between 2003 and 2014.[15]

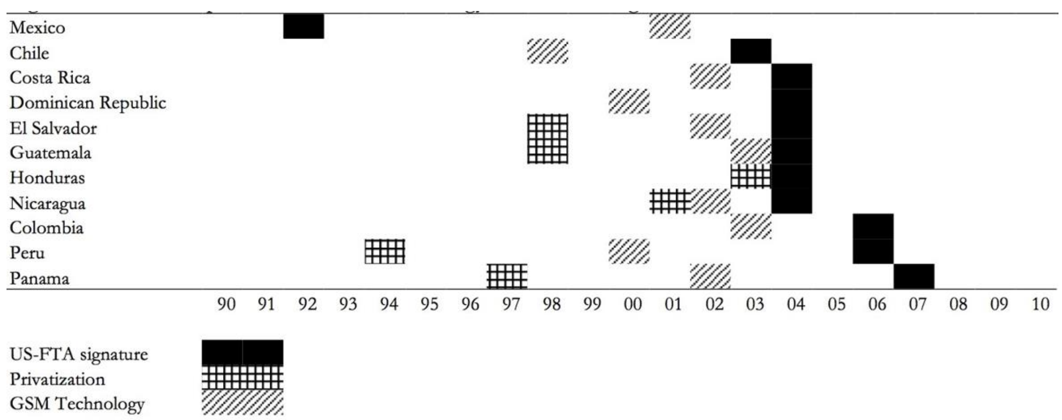
Figure 2.1 shows the dates on which GSM technology was introduced, incumbent operators were privatized, and US-FTAs were signed. For the purposes of the present DiD it is important to clarify that the dates of privatization and the introduction of GSM technology are not correlated with the signature of US-FTAs.[16]

In addition to technological progress, other factors that explain the rapid expansion of mobile communications over the period are: (1) the introduction of the prepaid system, which allowed low-income consumers to access the service; (2) the generalization of the calling party pays (CPP) pricing scheme, where calls are charged to the caller and not to the recipient; (3) the reduction in the price of mobile devices; and (4) the regulation of termination fees, which favored a progressive convergence between the prices of on-net and off-net calls (Galperin, 2012).

[15] Author's own calculations based on the ITU database. The average MOU for Latin America was 708 in 2003 and 1,350 in 2014.

[16] The GSM technology allowed to accommodate more operators in the same spectrum band. In this sense it is important to clarify that the timing of the US-FTAs is not correlated with the timing of the GSM technology adoption

Figure 2.1 – Timeline of Privatization, GSM Technology, and US-FTA Signatures for Treated Countries (1990-2010)



Note: The horizontal axis shows the years between 1990 and 2010
Source: Own elaboration

2.5 Theoretical Section on Mechanisms

This section analyzes the determinants of prices in telecommunications markets and the mechanisms by which the US-FTAs can affect them. Following the model of Shew (1994), this paper considers that competing telecom companies offer a minimum price P^*_{it} for their services Q_{it}. Since consumers usually subscribe to service packages (covering local, national and international telephone calls; mobile services; broadband services; among others), operators can consider both the price of each individual service and the price for a package of services, which in the present case is approximated by way of average revenue per user (ARPU). This price P^*_{it} is a function of a group of variables, according to the following equation: $P^* = f(S, M, R, Q)_{it}$, where S_{it} is service quality (reputation, network coverage, broadband access), M_{it} is the market environment (population density, personal incomes, education), R_{it} represents market characteristics and regulations (number of operators, entry barriers, infrastructure sharing, number portability), and Q_{it} is the quantity of services offered by the operator (type of services, number of subscribers, number of minutes). For the purposes of the empirical analysis, ARPU and the prices of telephone calls are considered to depend on these groups of variables.

When a change in a country's regulation of the sector comes as a consequence of implementation of a US-FTA, this change is expected to impact telecom price via the aforementioned variables.[17] First, the measures established in the telecommunications chapter—such as the reduction of entry barriers or the establishment of number portability to facilitate the change from one operator to another—are expected to directly affect the market through an increase of competition and a reduction of prices. In addition to these effects, the price reduction might also generate an increase in consumption by favoring the attainment of economies of scale and the expansion of services to high-cost areas of the countries. Thus, it is important to recall that during the period of analysis, the coverage of fixed and mobile telecommunications services was very low in Latin America and the Caribbean, and a reduction of prices might have had a major effect on coverage. In fact, according to ITU-WT/ICT (2016) data, in 2002 the average number of subscriptions per hundred inhabitants for Latin America and the Caribbean was only 29.7 and 25.7 for fixed and mobile lines, respectively.

Second, it is expected that the implementation of the market-access chapters in the FTAs will also have entailed a reduction in the costs of importing equipment for national telecommunications operators, such as switchers and telephone exchanges. Most Latin American and Caribbean countries do not manufacture this equipment, so the reduction in operating costs should amplify the previous effects.

Third, and finally, the market-access provisions contained in the agreements also prompted an increase in the level of openness in the affected countries and exposed domestic firms to stiffer competition from foreign rivals.[18] Taking this into account, there is expected to be increased interest among the productive sectors of these economies in pressurizing governments into taking additional measures to bolster competition in the telecommunications sector and to reduce costs.

From to the abovementioned mechanisms, it is possible to derive the following testable implications about the effects of the US-FTAs on the telecommunications prices. First, the prices of telephone calls and the overall expenses of telecommunications services should decrease as a direct consequence of the stronger competition. Second, the reduction in telecommunications prices and operating costs should lead to an increase in the penetration of fixed and mobile telephony. And third, the impact on the telecommunications market is expected to be stronger in those countries more affected by the market-access chapters. The next subsections present the data and the methodology used to test the predictions.

[17] The transmission mechanism analyzed in this paper are similar to those used to examine the effects of the privatization and liberalization of telecommunications in Latin America. See Wallsten (2001) and Fink et al. (2003).

[18] Linarello (2018) shows that after signing bilateral agreements with the United States, South Korea, and the European Union, Chilean exports almost tripled and aggregate imports almost doubled between 2002 and 2006.

2.6 Materials and Methods

2.6.1 Data

The data used in this study comes mainly from the December 2016 edition of the International Telecommunication Union's (ITU) World Telecommunications/ICT Indicators Database. The sample covers 28 LAC countries over the period from 1996 to 2015, which comprises the ten US-FTA treaties analyzed. As noted, Mexico's treaty, NAFTA, was signed in 1992 and therefore falls beyond the period of analysis. All the other agreements were signed between 2003 and 2007 (Table 2.1).

To analyze the impact of the US-FTA telecommunications obligations on the national markets of Latin American countries, several outcome variables are employed. The first is ARPU,[19] which is defined as the revenue generated by all telecommunication services in a specific country and year, divided by the total number of users. ARPU is a measurement widely used by telecommunications companies and regulators around the world to analyze market performance.[20] According to McCloughan and Lyons (2006), ARPU is a good proxy of price when subscribers do not focus on the per-minute price, but instead compare the total cost of service offering. The other outcome variables utilized in the empirical analysis to reflect market competition are fixed and mobile prices. In the case of fixed prices, the price of a three-minute local call at peak rate is taken into consideration; while in the case of mobile prices, the price of a one-minute prepaid local call at peak rate is factored in. The analysis also examines the effect of the US-FTAs on the penetration rate of fixed and mobile services, which are defined as the number of subscribers of these services per 100 inhabitants. Finally, the analysis considers the private investment in telecommunications reported by the World Bank, which denotes commitments to infrastructure projects in telecommunications that have reached financial closure and directly or indirectly serve the public, excluding small projects. Table 2.2 describes the main variables used for the analysis.

The dummy variable "FTA" is used to reflect the years in which a trade agreement has been adopted in a country. Specifically, this variable captures whether country i has applied in year t an FTA containing a telecommunications chapter. This variable has

[19] Prices of telecommunication services are difficult to approximate, since each operator usually offers various service—such as voice, SMS and data—as well as a wide range of offers that can hardly be collapsed into a single indicator. Empirical studies use different approaches to address this problem, such as a representative basket of services, or measures based on average income.

[20] The ARPU has been used by Shy (2002) to empirically test that paper's theory on switching costs for Israel; McCloughan and Lyons (2006) estimate the determinants of ARPU for the OECD, based on the model proposed by Shew (1994). Maicas et al. (2009) use the ARPU to approximate the prices of mobile telephony, in a study on the effects of number portability on switching costs; Usero and Asimakopoulos (2012) take the ARPU as a proxy for prices when studying mobile number portability in Europe.

been constructed using information from the Organization of American States' Foreign Trade Information System (SICE) (2017) and the website of the United States Trade Representative's Office (USTR) (2017).

Latin American countries have signed FTAs with several countries over the years, but in the present DiD model the treatment is the signing of the first FTAs to have included a mandatory telecommunications chapter, subject to a dispute settlement mechanism and a checklist procedure for each country. In each of the countries considered, these conditions and obligations were assumed for the first time in their US-FTAs. Therefore, the empirical analysis essentially takes into account the impact of US-FTAs that contain telecommunications chapters.

Table 2.1 shows the countries included in our analysis, as well as the date that each agreement was signed and came into force. It should be noted that no other agreements signed by Latin American countries during this period are relevant for our analysis. For instance, Peru entered into agreements with Canada and the EU—both of which included telecommunications chapters—after its US agreement, but these agreements did not entail any additional changes to the Peruvian regulations beyond those already implemented in the US-Peru FTA. Although there are a few isolated examples of previous international agreements that affected the telecommunications sector in Latin American countries, they are very limited and did not modify the sectoral regulations. For instance, commitments under the WTO Reference Paper on telecommunications are narrow in scope and voluntary for each WTO member, and so they are not included in the present analysis.

Data on per capita GDP, population, population density, urban population and trade openness were obtained from the World Bank's database, WB World Development Indicators. The dummy variables that reflect the existence of independent regulatory agencies and privatization of state telecommunications operators were obtained from ITU World Telecommunications/Regulatory Database (2017), as well as from articles published by Levi-Faur (2003), the Economic Commission for Latin America and the Caribbean–ECLAC (2009), and Jordana and Ramio (2010).

2.6.2 Identification Strategy

An essential assumption for the adoption of the DiD model is that the US-FTA treatment is as good as randomly assigned conditional on country-specific and year-specific shocks. The main argument to support this assumption rests on the fact that almost all countries in the region participated in negotiations to sign an agreement with the US before and/or during the 2003–2007 period, and that the unobservable country–time contingent reasons that led some countries to sign the agreements and others to abandon the negotiations are exogenous to the outcome variables.

Dealing with endogeneity and the environment context are among the major challenges faced by empirical studies on the effects of services trade liberalization and policy reform (Francois and Hoekman, 2010). The endogeneity problem arises because most service liberalization has been carried out unilaterally, and most preferential trade agreements (PTAs) lock in the current services liberalization status, which means that there is no additional liberalization after these agreements are signed. As a consequence, in many agreements the timing of the effective liberalization or policy reform depends on the unilateral decision of national authorities, and is not linked with the signing of trade agreements. In other words, the timing of the policy reform is endogenous.

Another relevant aspect to recall is that the commitments are voluntary in the case of the World Trade Organization (WTO) General Agreement on Trade in Services (GATS), and indeed that of all PTAs based on the GATS architecture, which shows the willingness of members to open or lock in certain services sectors and causes endogeneity to arise. This may be the case when regulators push for preferential liberalization in services-specific trade agreements.

The purpose of this section is to explain that no such limitations occur in the case of the US-FTAs with Latin American countries. US-FTAs are standardized and very ambitious in scope, which means that effective policy reforms do take place after these agreements are signed, and that the group of reforms are the same for all countries that sign an agreement with the United States. Most importantly, the United States applies an institutionalized mechanism to ensure the effective implementation of each FTA commitment: the so-called implementation checklist, which is a matrix that specifies each commitment to be implemented by an FTA partner, and the law or decree that implements it. This mechanism ensures that no US-FTA enters into force until all its commitments are fully implemented.

Having clarified that the commitments in US-FTAs are the same for all Latin American co-signatories, and that there is effective policy reform after the US-FTAs are signed, it is important to discuss the timing of their adoption. A crucial aspect of the identification strategy is that the adoption of the agreements constitutes an exogenous shock to the telecommunications authorities, as they do not participate in the decision to open negotiations with the United States over the more-than twenty different chapters ranging from trade in goods to e-commerce. Indeed, the negotiations are part of a broader policy decision driven mainly by the possibility to access the massive US market on a tariff-free basis; and in this context Latin American telecommunications regulators are forced to accept standardized telecommunications reforms regardless of whether or not they consider them worthwhile for their interests.

It is important also to take into account that the negotiating interest to liberalize and introduce more competition in the Latin American telecommunication markets, through FTA provisions, comes from the country that exports capital in the telecom sector: The United States. The Latin American countries are not capital exporters in the telecommunications sector.

Another aspect of relevance to the analysis is whether there are earlier regional examples of agreements with telecommunications chapters, and which may have signaled or influenced the US choice of FTA partners. On this, it is important to explain that very few previous FTAs involving the US and Latin American countries included a telecommunications chapter. Those that do exist were negotiated by the partners of the US in the NAFTA: Canada and Mexico. Specifically, these agreements were: 1) The G-3 Agreement (Colombia, Mexico and Venezuela, 1994); 2) Canada-Chile (1996); 3) Mexico-Chile (1998), and 4) Mexico-Uruguay (2003). It is hard to establish a link between these earlier agreements and the US's later selection of "telecoms partners". In fact, some non-treated countries (that never signed an FTA with the United States), such as Uruguay and Venezuela, were signatories of these previous agreements with telecommunications' chapters. In addition, the abovementioned earlier agreements covered only a few telecommunications obligations, which were of a very low standard compared to those included in the US-FTAs analyzed here. For instance, in the Mexico-Chile agreement of 1998 there are no commitments related to interconnection at cost-oriented rates, infrastructure sharing, number portability, independent regulator, dialing parity, or unbundling of networks, among other areas that featured in the later agreements.

2.6.3 Empirical Model

A DiD model is used to investigate the impact of signing a US-FTA on telecommunications markets. The ARPU and the price equations are based on the empirical model developed by Shew (1994) and adapted by McCloughan and Lyons (2006). The model for the ARPU is a function of service quality, market environment, regulatory framework and quantity of services provided by operators. For prices, service penetration, and investment outcomes, the model includes a group of control variables proposed by Wallsten (2001). The resulting DiD model is as follows:

$$LY_{it} = \beta_0 + \beta_1 FTA_{it} + \beta_2 OPN_{it} + \beta_3 OPN_{it}^2 + \beta_4 IR_{it} + \beta_5 PRV_{it} + \beta_6 FS_{i(t-1)} + \beta_7 MS_{i(t-1)} + \beta_8 BS_{i(t-1)} + \beta_9 PGDP_{it} + \beta_{10} PGDP_{it}^2 + \beta_{11} PD_{it} + \beta_{12} PD_{it}^2 + \beta_{13} URP_{it} + \beta_{14} URP_{it}^2 + \alpha_t + u_i + \varepsilon_{it} \quad (1)$$

where LY_{it} is the logarithm of the outcome variable (i.e ARPU, prices, penetration, investments) in country i and period t. FTA_{it} is a dummy variable that takes the value of 1 when country i has signed a US-FTA containing a telecommunications chapter in period t. The model also includes a group of control variables: OPN_{it} is the quotient $Trade/GDP$, and reflects the degree of international trade openness of country i in period t; IR_{it} is a dummy variable that takes the value of 1 when country i has an independent telecommunications regulator; PRV_{it} is a dummy variable that takes the value of 1 when country i has privatized its state telecommunications operator; $FS_{i(t-1)}$ is the number of fixed telephony subscribers of country i in period $t-1$; $MS_{i(t-1)}$ is the number of mobile subscribers of country i in period $t-1$; $BS_{i(t-1)}$ is the number of broadband subscribers in country i in period $t-1$; $PGDP_{it}$ is the GDP per capita of country i in period t; PD_{it} is the population density of country i in period t; and URP_{it} is the urban population of country i in period t. As suggested by McCloughan and Lyons (2006), in the case of the $LARPU$ estimation, the squared values of OPN_{it}, $PGDP_{it}$, PD_{it} and URP_{it} are included in the equation to account for a possible nonlinear relationship with the outcome variable. The u_i term represents unobservable time-invariant country effects, α_t are the year fixed effects, and ε_{it} is the error term.

Coefficient β_1 in Equation (1) is the parameter of interest and reflects the DiD impact on the telecommunications market generated by the US-FTA. The implementation of the US-FTA telecommunications chapters by national regulatory agencies is regarded in the present analysis as an exogenous shock, since governments negotiate the treaties based on factors unrelated to the present situation in the telecommunications market.[21] Note that the effect of the US-FTAs in the telecommunications market will be estimated correctly provided that the modeling assumptions for the DiD estimator are met, as will be discussed in section 2.7.

Equation (1) includes fixed, mobile and broadband subscriber variables in period $t-1$, to control for changes in the quantity of consumed services. The first lag is used to avoid endogeneity problems. However, because the first lag may not completely avoid these problems, the results of a reduced version of Equation (1) that omits the variables for fixed, mobile, and broadband subscribers are also reported. On the other hand, when the dependent variables are the prices of fixed and mobile telecommunications services, the control variables are the same as described before, except that a linear structure is employed and that the equation for fixed telecommunications services considers the number of fixed telecommunication subscriptions in period $t-1$, $FS_{i(t-1)}$, while the equation on mobile services considers the number of mobile telecommunication subscriptions in period $t-1$, $MS_{i(t-1)}$. The results of the reduced versions of price equations are also reported, not considering the lag of subscribers.

[21] A related discussion can be found in Borrell, et al. (2014), which uses bilateral and regional trade agreements as instruments for estimating the impact of antitrust-related leniency programs and avoids self-selection bias.

Finally, equations for the penetration of fixed and mobile telecommunications and for private investment in telecommunications do not consider as controls the number of subscribers of fixed, mobile and broadband services.

The estimation of the model in Equation (1) may present heteroscedasticity problems and temporal autocorrelation in the error term. The Breusch-Pagan/Cook-Weisberg heteroscedasticity test reveals that the data do not present the heteroscedasticity problem in the case of the ARPU and fixed penetration equations, but they do present this problem for the equations on prices, mobile service penetration and private investment in telecommunications. Likewise, the Wooldridge test for detecting autocorrelation indicates the presence of first-order autocorrelation in the data for all specifications. To account for these problems the models are estimated using cluster robust standard errors. Finally, with regard to potential multicollinearity problems, a high correlation might be expected between the explanatory variables and their squared values. However, since these variables are used as controls, a high correlation poses no problem on the values estimated for the FTA's impact. Note that only the ARPU equation contains squared values of explanatory variables, as suggested by previous literature on the determinants of ARPU. Appendix B shows the correlation matrix of the variables used in the model.

2.7 Results and Discussion

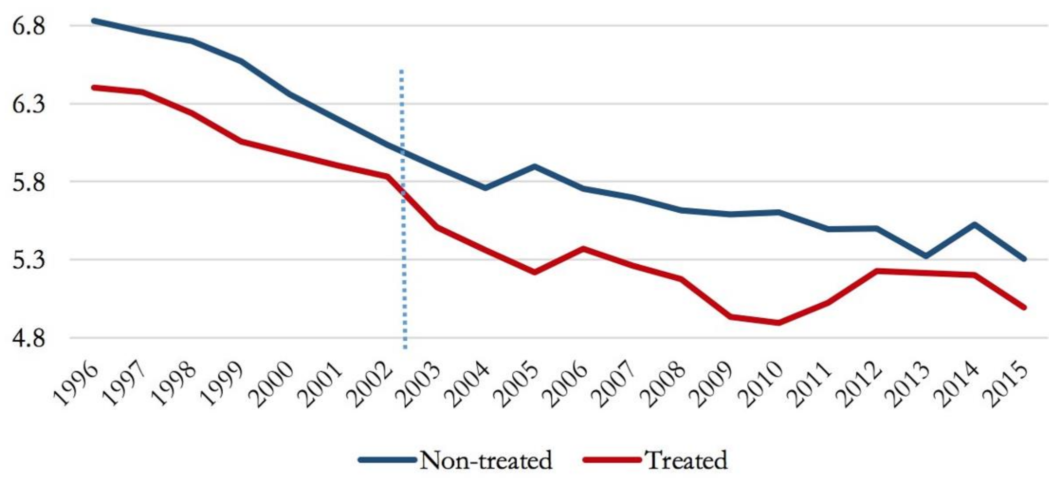
2.7.1 Evolution and Pretreatment Conditions

Before presenting the econometric results, it is necessary to show that the signing of US-FTAs did not occur in a period in which there were pre-existing differences in the evolution of the telecommunications markets between the groups of treated and non-treated countries. This section shows that the pre-treatment trends for the outcome variables were similar before the adoption of the agreements, and that the conditions of the DiD model are met.

An essential requirement for the application of the DiD model is that there be parallel trends between treated and control groups in the pre-treatment period (see Angrist and Pischke, 2009; Meyer, 1995). In the present case, the parallel trends must have been met before 2003, the year in which the first modern FTA of the sample was signed (US-FTA with Chile). Figures 2.2–2.7 show the evolution of the outcome variables for the two groups of countries. In the case of ARPU, it is clear that both series present a downward trend, with specific periods in which they move away from each other, especially in the 2000s. A similar behavior occurs in the case of the logarithm of the price of a one-minute call for mobile services. In the rest of variables of interest, only positive monotonic trends are observed.

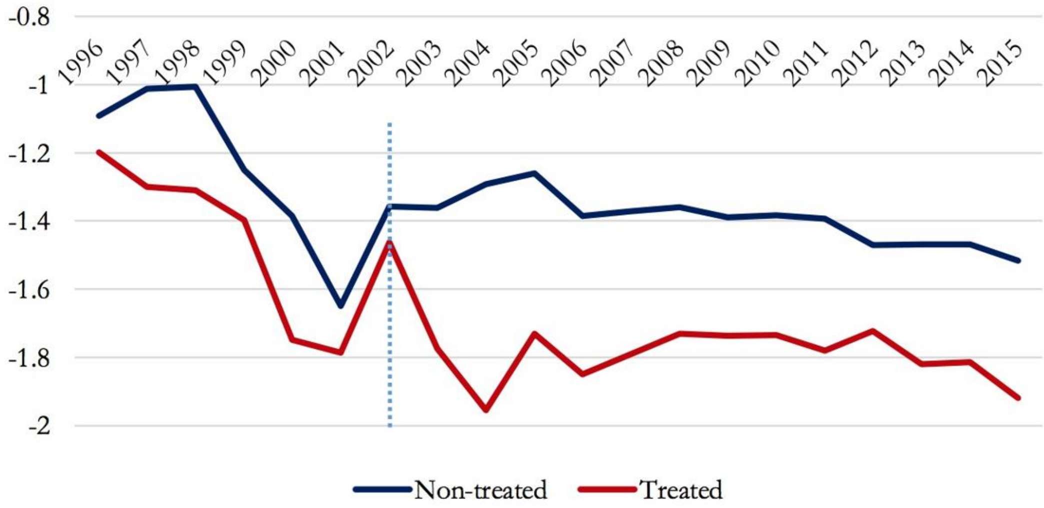
Figure 2.2 shows that the in the case of the log of ARPU, the treated and control groups were converging before 2003. However, a slight downward shift in the red line representing the treated group can be identified after 2003, which coincidently marks the start of the US-FTA signature period. In the case of the log of mobile prices (Figure 2.3) the sudden shift downwards of the treated group during the same period is very clear and pronounced, suggesting that the adoption of the US-FTAs led the countries in the treated group to reduce their mobile prices, diverging from the control group after 2003.

Figure 2.2 – Log ARPU by Treated and Non-Treated countries.



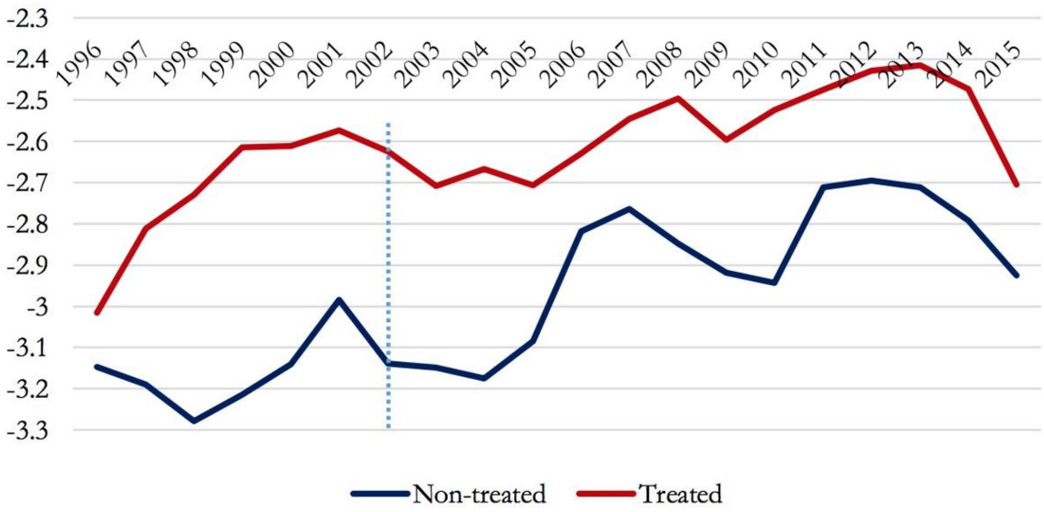
Source: Own elaboration

Figure 2.3 – Log mobile prices by treated and non-treated countries.



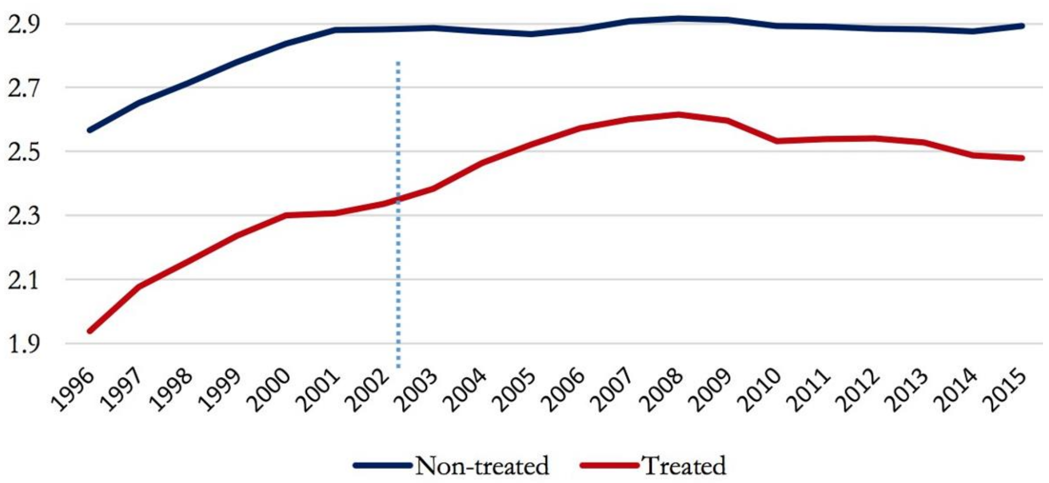
Source: Own elaboration

Figure 2.4 – Log Fixed Prices by Treated and Non-Treated Countries.



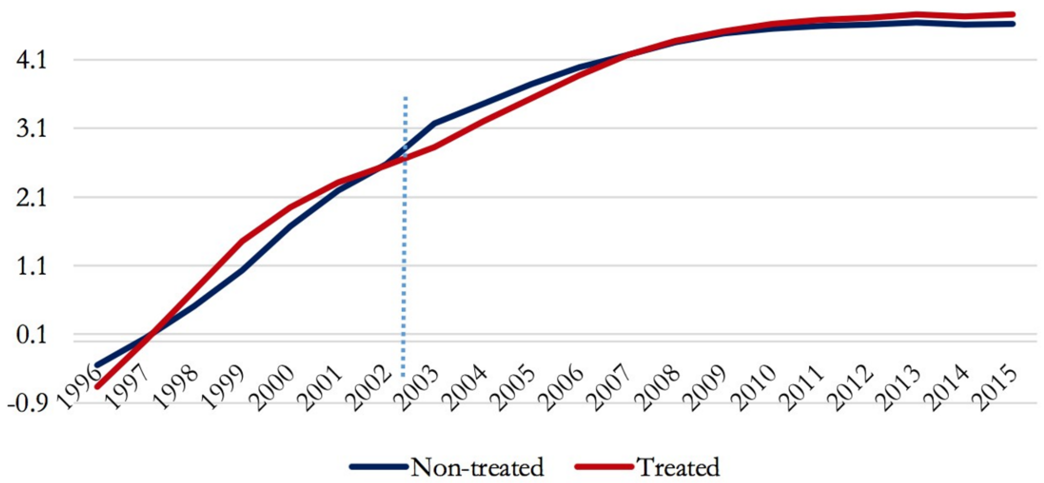
Source: Own elaboration

Figure 2.5 – Log Fixed Penetration by Treated and Non-Treated Countries.



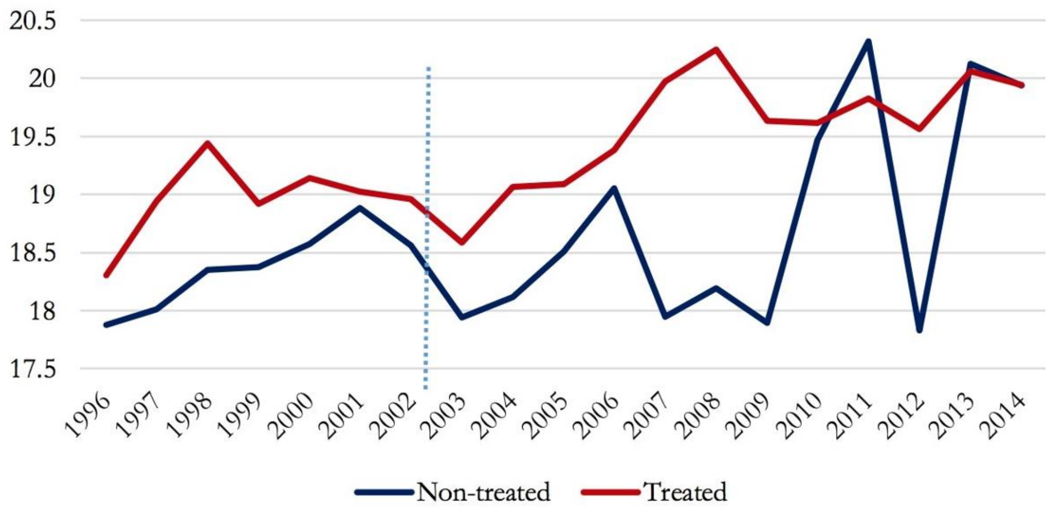
Source: Own elaboration

Figure 2.6 – Log Mobile Penetration by Treated and Non-Treated Countries.



Source: Own elaboration

Figure 2.7– Log Investment in Telecommunications by Treated and Non-Treated Countries



Source: Own elaboration

Observation of the evolution of the variables of interest during the pretreatment period (before 2003) suggests that the parallel trends assumption is met—not necessarily by a linear trend—between the treated and control countries. This result is confirmed by computing a difference-in-means t-test for each variable and year during the pre-treatment period (see Appendix C). There is no statistically significant difference in means between the treated and control groups during the pre-treatment period, except for the dependent variables log of ARPU ($LARPU$) and fixed penetration ($LFXPNT$). Since the requirement for the application of the DiD model is not the statistical equivalent of the variables during the pre-treatment period but the existence of parallel trends, the 'common pre-dynamics test' proposed by Mora and Reggio (2012, 2015) is also calculated. The results of this test confirm that the parallel trends null hypothesis cannot be rejected for all dependent variables during the pre-treatment period (Appendix D).

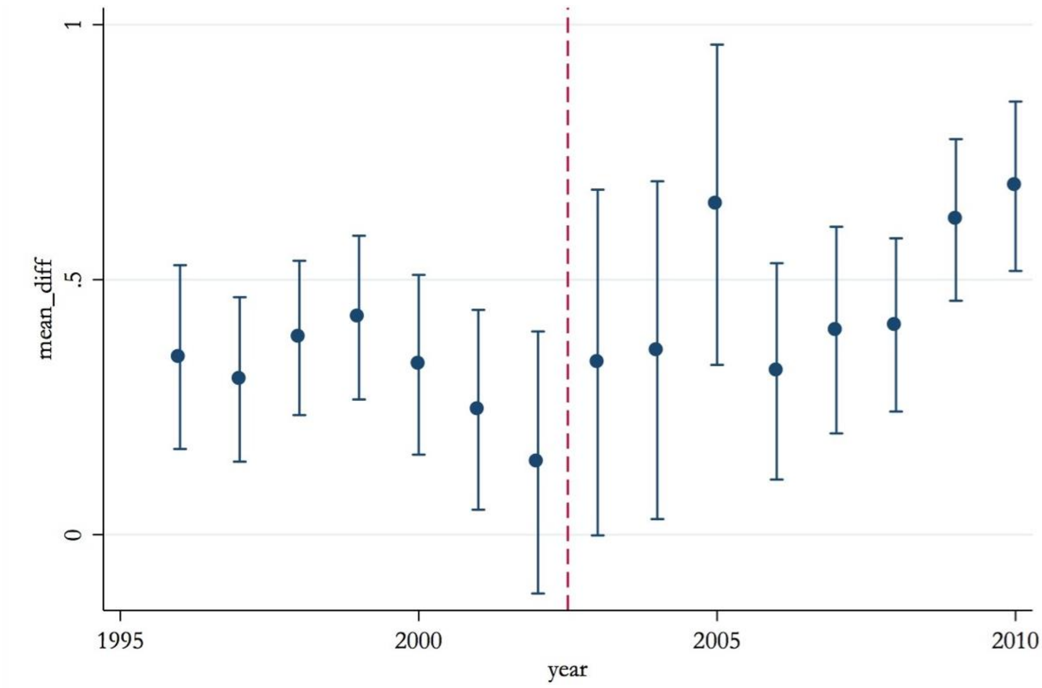
Figures 2.2 and 2.3 show lower values for ARPU and the prices for countries in the treatment group, which a priori suggests that telecommunications provisions in the FTAs were established in countries that had already been engaged in pro-competitive reforms. However, the results of the t-test of difference in means reported for each variable and year show that for mobile services, the difference in means between treated and control group prices is not statistically significant (i.e., the null hypothesis that the difference in means of mobile prices between the treated and control group is zero cannot be rejected). This is also true for ARPU two years before the treatment.

The null hypothesis that the difference in ARPU means between the treated and control groups is zero for 2001 and 2002 likewise cannot be rejected. Bearing this in mind, it must be concluded that the red and the blue lines in Figure 2.2 statistically overlap for ARPU in 2001 and 2002 (two years before treatment starts), and that the red and blue lines in Figure 2.3 statistically overlap for mobile prices each year before the treatment. This statistical results clarify that the agreements were not directed to countries that were already adopting competitive reforms in the sector.

Figures 2.8 and 2.9 graphically present the results of the *t*-test of difference in means, where it can be seen that the price variables for treated and control countries behave differently before and after the treatment period. In the case of ARPU (Figure 2.8) the difference in means was reducing during the pre-treatment period, converging to zero in 2002, which means that in this year the countries in the treatment and control groups were statistically equal. Then, after 2003, when countries in the treated group started to sign US-FTAs, the difference in means between the treated and control group increased. This pattern is clearer when the t-test of difference in means for the mobile prices variable is analyzed graphically (Figure 2.9). In this case, in 2001 and 2002, it can be seen that mobile prices in the treated and control group were statistically equal. However, after 2003 and during the period in which the US-FTAs were signed, the difference in means increased, which means that both groups were following different paths.

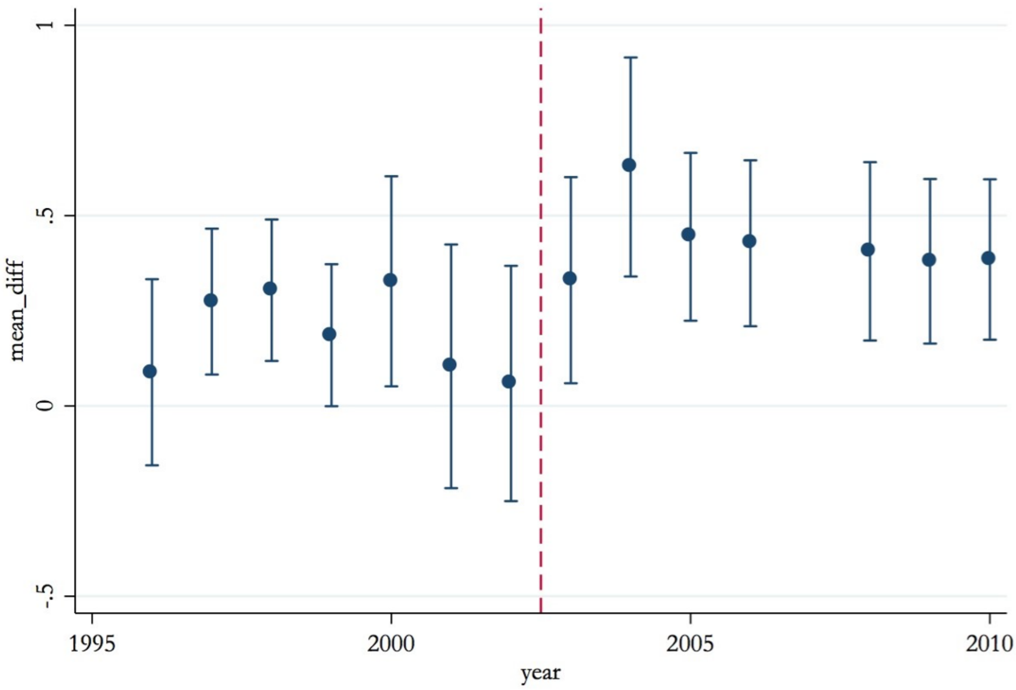
Furthermore, to check if there is a pattern of countries that were already pro-telecoms sector reforms in the treated group, compared to the control group, the ITU-ICT Regulatory Tracker is analyzed (unfortunately only available from year 2007 onwards). This tracker records the existence and features of regulatory frameworks, including indicators for regulatory authorities, mandates, regimes and competition frameworks. A higher score reflects a better and more advanced regulation in the ICT sector. Focusing on the first available year (2007) it can be seen for instance that a number of important control countries in the analysis (with no US-FTAs), like Argentina (86), Brazil (88.5), Ecuador (85.5) and Venezuela (82.5) scored better than treated countries (with US-FTAs), like Chile (79), Colombia (79), Guatemala (53.17) or Honduras (82). After an assessment of the ITU-ICT Regulatory Tracker, it cannot be concluded that the treated countries were those already pro-telecoms sector reforms. There is no clear pattern that allows to classify the treated or control countries as more or less advanced in telecom regulation.

Figure 2.8 – Log Average Revenue per User (ARPU) Mean Difference



Source: Own elaboration

Figure 2.9 – Log Mobile Prices Mean Difference



Source: Own elaboration

All in all, these results suggest that the use of the DiD methodology is appropriate because all the conditions for its application are met. The impact of a policy reform in the telecommunications sector of a group of countries is assessed, arriving at a time that is exogenous (US-FTA signature date). The countries analyzed belong to a single region (Latin America and Caribbean) and can be clearly separated in two groups: those that have signed a US-FTA that includes a telecommunications chapter (treated group), and those that have not (control group). Finally, the parallel trends assumption for the treated and control groups is satisfied for the pre-treatment period.

2.7.2 Estimation Results and Discussion

This section describes the effect of the US-FTAs on the set of outcome variables. Table 2.3 shows the results for the $LARPU$ variable. While Panel A reports the estimates for Equation (1), Panel B presents its reduced form, in which the lagged variables of the number of subscribers for each service is eliminated. For reference purposes, the first specification in each panel shows the results of the pooled model, but these are clearly biased due to the omission of non-observable time invariant factors, such as the national institutions and the regulatory framework.

The first-order autocorrelation fixed effects model $AR(1)$ in panels A and B of Table 2.3 corroborate the statistical significance of the DiD impact of FTAs on ARPU.[22] However, it is possible that the data entails a different type of autocorrelation, or serial and transversal autocorrelation, which cannot be controlled by the $AR(1)$ model. Bertrand et. al. (2004) indicates that the use of an $AR(1)$ autocorrelation process may not be enough to solve the problem. Taking this into account, the present study estimates the ARPU equations using a fixed effects model that controls for heteroscedasticity and autocorrelation problems through the application of cluster-robust standard errors.

Since the number of clusters (28) is too low to trust in the cluster-robust standard errors, Table 2.3 includes a column showing the p-values obtained by applying the wild cluster bootstrap Wald test, as suggested by Cameron et. al. (2008).[23] An additional column showing the p-values resulting from this test is also included in the estimation

[22] The results of AR(1) estimations for ARPU equations along are shown, because first-order autocorrelation but not heteroscedasticity was previously found in the data.

[23] Bertrand et al. (2004) shows that the cluster-robust technique when the number of clusters is low (less than fifty) produces an over rejection of the null hypothesis of significance of the parameter estimates. This over-rejection is especially severe when the number of clusters is less than 20. To deal with this problem, Cameron et al. (2008) proposes the use of the wild-cluster bootstrap method, which, according to their simulations, produces empirical rejection rates extremely close to the theoretical values, even with as few as six clusters

output for all the other dependent variables. Furthermore, the Hausman test revealed the superiority of the fixed effects model over the random effects model in all cases.

To sum up, the preferred estimation approach is the fixed effects model, using the wild-cluster bootstrap standard errors. This method shows that the US-FTAs have a negative impact on ARPU of 45.5% (Panel B), statistically significant at 5%. As explained in the mechanisms section, there are two factors that help to interpret these results. First, the obligations contained in the FTA telecommunication chapters should have generated an exogenous pressure for national regulatory authorities to implement a number of important pro-competition reforms that otherwise would have been difficult to adopt. The reduction in ARPU should therefore be interpreted as a consequence of the increase in competition.[24] Second, the implementation of the market-access chapters in the FTAs also meant a reduction in the costs of importing equipment for national telecommunication operators, such as switchers and telephone exchanges. And third, the implementation of the market-access chapters might have led national firms directly affected by the agreements to lobby in favor of the reform of inefficient markets. In this sense, the market-access chapter could be an indirect mechanism to increase economic efficiency in internal markers and to reduce firms' production costs. In all likelihood, the combination of these external and internal factors explains the important reduction in the ARPU we observe.

Another interesting result in Table 2.3 is that the trade openness variable has a negative sign, and its squared value has a positive sign, both of which are statistically significant under all specifications. This result indicates that for lower levels of openness to trade, the signing of FTAs generates a reduction in ARPU; but there is an inflection point and for high levels of openness to trade more trade liberalization increases ARPU. The economic intuition behind this behavior may be that trade liberalization in relatively closed countries introduces efficiency by reducing customs tariffs, allowing imports—including imports of telecommunications equipment—at lower prices. This effect may be greater than the effect produced by the increase in the number of calls for relatively closed countries. However, in the case of countries that already have high levels of openness to trade, more trade liberalization hardly introduces more efficiency in an already efficient country, and the effect of greater number of calls weights more than the efficiency effect, increasing ARPU.

Panel A in Table 2.4 provides the empirical estimates for mobile telecommunications prices, $LMPR$ and Panel B for fixed telecommunications prices, $LFXPR$. Four different specifications are employed for these variables: (i) the heteroscedasticity and autocorrelation-robust pooled model, (ii) cluster-robust fixed effects, (iii) wild-cluster

[24] As explained in Section 3, the implementation of the treaties requires a verification process (checklist) to guarantees that all obligations had been adopted in each country.

bootstrap fixed effects, and (iv) the reduced version of the model—without the lag in the number of subscriptions—estimated using the wild-cluster bootstrap fixed effects.

The cluster-robust fixed-effects estimation reveals that mobile prices are 34% lower in the group of countries that signed the US-FTAs. This result is statistically significant at the 5% level (*p*-value: 0.037). Using the wild-cluster bootstrap Wald test to correct for an undesired over-rejection of the significance hypothesis, it is confirmed that this parameter estimate is significant at the 7% level at least (*p*-value 0.064).[25]

The estimated impact of US-FTAs on mobile prices (-34%) goes in the same direction as the previous findings on ARPU (-45.5%). This suggests that the reduction in ARPU after signing a US-FTA comes mainly from an adjustment in the prices of mobile services, which were affected by a number of pro-competitive regulations such as number portability and infrastructure sharing. The economic explanations for the impact of US-FTAs on mobile telecommunications prices are the same as those already stated for the ARPU: adoption of the agreement leads to an increase of the competition in the sector and to a reduction of the production costs. These findings are very relevant in terms of public policy, because they imply that implementing profound market access and telecommunications provisions in US-FTAs produces an efficiency effect in national telecommunications markets, benefitting consumers in terms of lower prices. In addition, these agreements also have positive impacts on productive activities given the importance of the telecommunications sector to them.

Unlike the case of mobile telecommunication prices, the signing of the FTAs did not have an effect on fixed telecommunication prices. The results in Panel B of Table 2.4 show that there is no statistically significant association for the FTA variable. One explanation for this result is that while mobile prices were freely set by telecommunications companies during the period, fixed telecommunications prices were regulated by national authorities, usually with a price cap. Thus, while mobile prices could easily adjust to the new market conditions, fixed telecommunication prices were more rigid and possibly set based on the operators' investment objectives. An additional explanation is that the operators' entry into the fixed communications has been very modest in Latin America and pro-competitive reforms could never have the relevance they acquired for mobile services.

With regard to the estimation results for mobile and fixed penetration, panels A and B of Table 2.5 show that the US-FTAs did not have a statistically significant impact on the growth of these services. In other words, the statistical evidence does not verify that these treaties have been a factor in driving or delaying the expansion of fixed or

[25] Since the simulations of Cameron et al. (2008) show that the wild-cluster bootstrap methodology with 25 to 30 clusters could slightly under-reject the null hypothesis of significance of the parameter estimates, it can be stated with near-certainty that the *p*-value for the FTA parameter estimate in the mobile price equation is between 3.7% and 6.4%.

mobile telecommunications networks in Latin America. The expected impact of the treaties on the penetration of fixed or mobile services was ambiguous, due to the presence of two conflicting effects. On the one hand, increased competition and lower prices can create a disincentive for operators to expand their networks. On the other hand, the competitive pressures generated by US-FTAs on other sectors of the economy can increase demand for telecommunications services as well as their usage. The data, however, do not support either of these two hypotheses.

The absence of a statistically significant impact of US-FTAs on the penetration of telecommunications services has important policy implications, since stakeholders that opposed the agreements, and especially incumbent operators, have often argued that the pro-competitive telecommunications obligations in the agreements are only beneficial in mature markets in which a sufficiently high level of service universalization has been attained, which was not the case of Latin American countries during the US-FTA negotiation period. Incumbent operators often argued that the adoption of the provisions contained in the telecommunications chapter would negatively affect the development of the telecommunications market in the region, by reducing the incentives for network expansion and for the upgrading of existing infrastructures. Considering that the LAC countries were not mature telecommunications markets before the period of signing, the estimation results of the present study do not support the incumbents' argument.[26]

Another interesting result presented in this table is that privatization has been important for the expansion of telecommunication services. Specifically, we obtain an estimated impact of more than 100% of increase in mobile penetration.

Finally, the results in Table 2.6 reveal that the US-FTAs with telecommunications chapters are positively correlated with private investment in telecommunications. However, this impact is not statistically significant. Therefore, it cannot be asserted that FTAs have influenced private investment in telecommunications in Latin America. This result also entails an important policy message, in a similar way as before. According to the non-significant parameter estimate for private investment, the data do not back the arguments that pro-competitive obligations in the telecommunications chapters disincentive private investment. Again, only the privatization parameter estimate is significant under all estimation techniques. Privatization of state-owned operators more than doubled private investment in telecommunications services.

[26] Recall that in 2002 the average mobile and penetration for Latin American and Caribbean countries was only 29.7% and 25.7%, respectively.

Decomposition effects of the agreements

Goodman-Bacon (2018) proposes a new methodology to clarify the causal interpretation of the DiD coefficient when the empirical framework presents multiple treatment times. The Goodman-Bacon DiD decomposition theorem demonstrates that a two-way fixed-effects DiD coefficient equals a weighted average of all possible simple two-group/two-period (2x2) DiD estimators, which compare one group that changes treatment status to another group that does not. This finding is useful for decomposing the DiD estimate and identifying the source of variation.

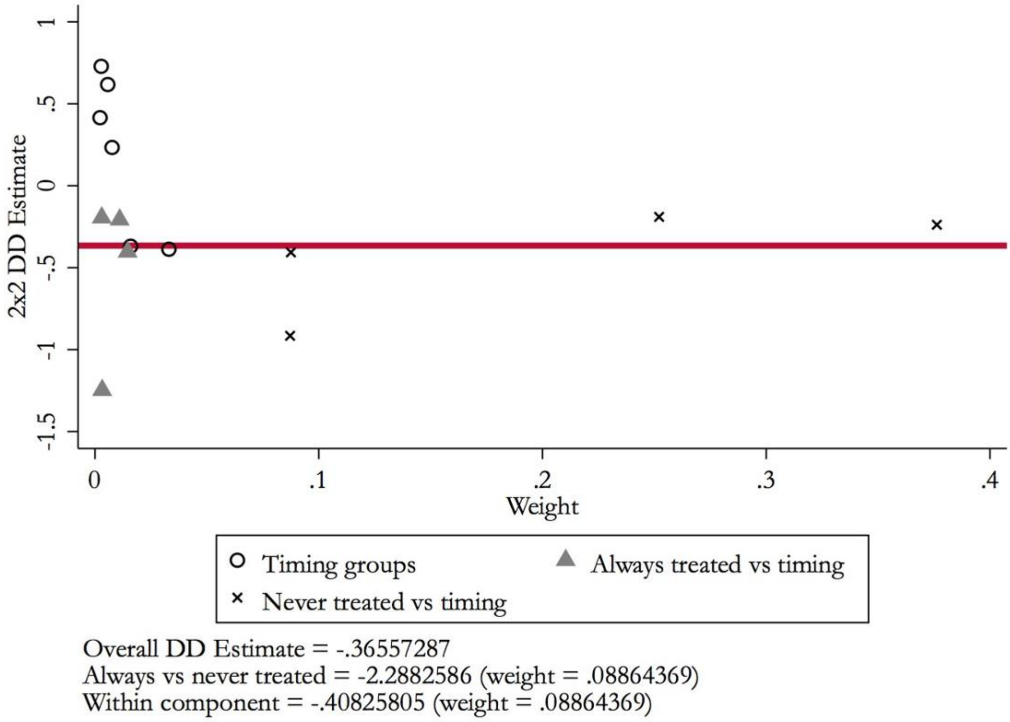
In the present analysis, the Goodman-Bacon decomposition is applied to the price equation (Goodman-Bacon et al., 2019). Since the panel is unbalanced, it is necessary to linearly interpolate the database to allow application of this methodology. For this reason, the estimated impact of US-FTAs on mobile prices is slightly different (-36%) from that previously obtained (-34%).

The results of the Goodman-Bacon decomposition are summarized in Table 2.7. As expected, all 2x2-estimated values resulting from this decomposition present a negative sign. The results show that the main source of variation of the DiD estimator, accounting for 80% of the variation, is the never-treated group (i.e. the group of countries that never signed a US-FTA), compared with the timing treatment groups, or the groups that signed US-FTAs at different times.[27]

Figure 2.10 contains a scatterplot of 2x2 DiD estimates and their associated weights. The graph shows three types of 2x2 comparisons, which differ by control group: (1) timing groups (countries that signed the agreements at different times) serve as the control groups of one other: those that signed US-FTAs later serve as the control group for the group that signed its US-FTAs earlier, and those that signed US-FTAs earlier serve as the control group for the latter group; (2) always treated (in the sample, Mexico was treated before the start of the analysis), which serves as the control group; and (3) never treated (countries that never signed an FTA with the US), which serves as the control group. The bottom of the graph also shows the component that arises from variation in controls across the always-treated (Mexico) and never-treated groups (non-US-FTA group), and the "within" residual component.

[27] If no control variable is included in the analysis, it is possible to obtain a detailed Goodman-Bacon decomposition of four types of 2x2 comparisons, which differ by control group. The results are similar to those previously obtained, but in this case the treated group versus the never-treated group account for 88% of the variation, and the treated group versus the always-treated group (Mexico) account for 8% of the variation.

Figure 2.10 – Bacon Decomposition of the Price Equation



There are some positive 2x2-estimated timing groups (see the open circles in Figure 2.10), but they are outweighed by the negative 2x2-estimated timing groups resulting in a negative estimated value (-15%) for the timing-groups factor. In addition, the weight of the timing-groups factor in the overall DiD estimation is very low: only 6.7%. As a result, the potential bias of the DiD estimation in Table 2.7 is very low. It can also be seen that there are few influential DiD estimates within the never-treated group (no US-FTAs) versus the timing groups or groups that contain FTAs signed at different times. These influential DiD estimates add a lot of weight to the overall DiD estimate (see the two Xs on the right side and over the red line in Figure 10). However, note that other DiD estimates within this group are also negative and around the horizontal red line that represents the overall DiD estimate.

Robustness checks

This section presents several robustness checks to verify the validity of the conclusions for the ARPU and mobile-prices equations. For each of these two equations, three placebo tests are presented: Placebo I, which assigns treatment in randomly selected years for treated countries; Placebo II, which assigns treatment randomly to control countries, maintaining the original proportion between treated and control countries; and Placebo III, which assigns the treatment four years before each US-FTA is signed. The time-frame of four years before the treatment date is chosen to avoid overlaps with the start of each FTA negotiation period. Indeed, the negotiation of the agreements took two or three years, but there was no change to the telecommunications legislation until the FTAs were actually signed.

Panels A, B, C, and D in Table 2.8 show the results for the complete and reduced versions of the ARPU and mobile-price equations. Panel A shows, for the complete version of the ARPU equation in (1), that Placebo I and Placebo II yield positive estimates for the US-FTA parameter, which is counterintuitive. This also occurs in the case of Panel B (reduced version), where both Placebo I and Placebo II yield positive estimates for the US-FTA treatment variable. In Panel C (complete version) and Panel D (reduced version) for the mobile price equation, only Placebo II presents the counterintuitive positive impact. Note that all placebo tests yield not statistically significant estimates, confirming the validity of the results obtained in the previous section.

Finally, an additional robustness check of the main results is performed by replicating the preferred specification for ARPU and mobile prices and excluding each country one by one. For the ARPU equation, the results of the US-FTA-estimated coefficient fluctuate between -30% and -58%; and for the mobile price equation the results fluctuate between -29% and -43% when eliminating the countries one by one. In the case of ARPU, the statistical significance at 5% persists throughout the exercise of eliminating the countries one by one. In the case of the mobile-price equation, in some few cases statistical significance at 5% is not reached but statistical significance at 10% is always reached.

2.8 Conclusions

The number of new-generation FTAs worldwide has grown substantially since the early 2000s. An important characteristic of these treaties is that they go far beyond traditional trade restrictions to include several obligations to modify national legislations, and to implement pro-market reforms before the agreements enter into force. Some recent papers have studied the political economy of this new generation of trade agreements (Blanga-Gubbay et al., 2018) and their impact on trade flows and tariffs (Limao, 2016). However, little evidence has been published about their impact on protected internal markets, or about the efficiency effects of their non-tariff obligations. In this context, this paper brings novel insights on the non-trade effects of trade agreements—specifically, on the effects in national telecommunication markets. This is a very important topic given the frequency with which such regulations appear in this new generation of trade agreements.

The objective of this paper has been to measure the economic impact on national telecommunication markets of the FTAs signed between the US and several Latin American countries from 2003 to 2007. Using a DiD econometric model, it has been shown that participation in US-FTAs reduced ARPU by 45.5%, and prices of mobile services by 34%. No statistically significant impacts were found on prices and the penetration level of fixed telecommunication services, which can be explained in part by the retention of price regulations for incumbent operators; and in part by the reduced profitability of expanding fixed telecommunications networks beyond urban areas. In addition, no significant impact was observed in the penetration of mobile services. This implies that the different evolution of mobile prices between signatories and non-signatories of US-FTAs has not translated into a different level of access to mobile services, even though price reductions may have increased the usage of mobile services by consumers.

This study's main contribution has been to show that the signing of US-FTAs containing telecommunications chapters has benefited users by reducing prices, and has not generated negative impacts on private investment nor on service penetration. The findings suggest that US-FTAs were an exogenous force that promoted or accelerated the implementation of sectoral reforms, which otherwise would not have been enacted or which would have been conditioned by internal stakeholders. They also suggest that the increase of competition in productive sectors more directly affected by US-FTA-induced tariff elimination may have intensified demand for more efficient and competitive telecommunication services. A combination of these external and internal effects explains the sizeable reduction in ARPU and the prices of mobile services identified here.

This Paper has important public-policy implications. First, developing countries considering the potential benefits of negotiating an FTA that includes a modern and far-reaching telecommunications chapter, like those in the US-FTAs analyzed here, can expect to see an increase in competition and a reduction in prices. Second, negotiating and signing such FTAs does not disincentive network expansion or private investment in the telecommunications sector.

The focus here has been on the relevance of the non-tariff regulations included in modern FTAs—specifically, on telecommunications national markets. Future research should continue examining the impact of this new generation of FTAs on regulated internal markets. In particular, further economic research is required on the impact of provisions on trade agreements related to customs procedures, intellectual property rights, government procurement, financial services, investment, and electronic commerce, among other areas.

Tables of results

Table 2.1 – Free Trade Agreements Containing a Telecommunications Chapter

		FTA	Signature date	Entry into force
1	Argentina	No	-	-
2	Belize	No	-	-
3	Bolivia	No	-	-
4	Brazil	No	-	-
5	Chile	Yes	06/06/2003	01/01/2004
6	Colombia	Yes	11/22/2006	01/07/2011
7	Costa Rica	Yes	08/05/2004	23/12/2009
8	Cuba	No	-	-
9	Dominica	No	-	-
10	Dominican Republic	Yes	08/05/2004	01/03/2007
11	Ecuador	No	-	-
12	El Salvador	Yes	08/05/2004	01/03/2006
13	Grenada	No	-	-
14	Guatemala	Yes	08/05/2004	30/06/2006
15	Guyana	No	-	-
16	Honduras	Yes	08/05/2004	01/04/2006
17	Jamaica	No	-	-
18	Mexico	Yes*	12/17/1992	01/01/1994
19	Nicaragua	Yes	08/05/2004	01/04/2006
20	Panama	Yes	06/28/2007	31/10/2012
21	Paraguay	No	-	-
22	Peru	Yes	04/12/2006	01/02/2009
23	St. Lucia	No	-	-
24	St. Vincent and the Grenadines	No	-	-
25	Suriname	No	-	-
26	Trinidad and Tobago	No	-	-
27	Uruguay	No	-	-
28	Venezuela	No	-	-

Note: All bilateral FTAs are between a Latin American or Caribbean country and the United States.
* In the case of Mexico, since the NAFTA was signed in 1992, it falls outside the period of analysis and is part of an "always-treated group". For the purposes of the econometric estimations, it does not contain any shock.
Source: SICE-OAS, USTR and ministries responsible for foreign trade.

Table 2.2 – Descriptive Statistics

	Variable	Obs.	Mean	Std. Dev.	Min	Max	Description – Data Source
1	LARPU	423	5.76	0.72	3.17	7.97	Log of ARPU (Revenue from all telecommunication services/number of subscribers) - ITU
2	LMPR	450	-1.49	0.56	-3.79	-0.25	Log of price of a one-minute prepaid local call (peak rate) - ITU
3	LFXPR	504	-2.83	0.89	-6.38	-1.36	Log of price of a three-minute local call (peak rate) - ITU
4	LMPNT	560	3.11	1.86	-3.81	5.19	Log of mobile lines per 100 inhabitants - ITU
5	LFXPNT	560	2.60	0.57	0.85	3.52	Log of fixed lines per 100 inhabitants - ITU
6	LINV	381	18.90	2.02	13.99	24.07	Log of private investment in telecommunications – World Bank-WDI.
7	FTA	560	0.24	0.43	0	1	1 if country has signed an FTA containing a telecommunications chapter with the US – Organization of American States
8	IR	560	0.56	0.49	0	1	1 if country has an independent regulator – different sources
9	PRV	560	0.74	0.44	0	1	1 if country has privatized its state operator – different sources
10	OPN	555	76.87	35.28	9.05	120.75	Trade openness (Trade/GDP) – World Bank-WDI
11	FS	560	3,216,855	7,549,570	14,992	45,000,000	Number of fixed subscriptions - ITU
12	MS	560	11,500,000	31,700,000	280	281,000,000	Number of mobile subscriptions - ITU
13	BS	556	768,828.3	2,718,591	0	24,900,000	Number of broadband subscriptions - ITU
14	PGDP	559	6,180.16	3,470.52	1,165.53	17,052.26	GDP per capita, PPP current international US$ - World Bank-WDI
15	PD	560	97.56	101.88	2.88	314.18	Inhabitants per square kilometer / World Bank-WDI
16	URP	560	15,200,000	32,100,000	31,841	176,000,000	Urban population - World Bank-WDI

Note: Unbalanced panel dataset for 28 countries and 20 years.

Table 2.3 – ARPU Equations Results

	Panel A				Panel B			
	Pooled	Fixed effects (AR(1))	Fixed effects (Cluster robust)	Fixed effects (Wild cluster bootstrap)	Pooled	Fixed effects AR(1)	Fixed effects (Cluster robust)	Fixed effects (Wild cluster bootstrap)
FTA	-0.229***	-0.186**	-0.492**	-0.492**	-0.234***	-0.185**	-0.455**	-0.455*
	(0.067)	(0.072)	(0.185)	[0.040]	(0.069)	(0.072)	(0.19)	[0.055]
Openness (trade/GDP)	-0.010***	-0.007*	-0.017**	-0.017**	-0.012***	-0.007*	-0.0179**	-0.0179**
	(0.003)	(0.003)	(0.006)	[0.017]	(0.003)	(0.004)	(0.006)	[0.023]
Openness sq.	0.00005***	0.00001	0.000079***	0.000079**	0.00006***	0.00001	0.000082***	0.000082**
	(0.0000)	(0.00001)	(0.000025)	[0.013]	(0.000)	(0.00001)	(0.00002)	[0.018]
Independent Regulator	0.007	-0.045	-0.045	-0.045	-0.025	-0.050	0.015	0.015
	(0.045)	(0.064)	(0.122)	[0.771]	(0.043)	(0.063)	(0.113)	[0.913]
Privatization	0.046	0.051	-0.052	-0.052	0.049	0.052	-0.048	-0.048
	(0.057)	(0.074)	(0.125)	[0.712]	(0.057)	(0.074)	(0.125)	[0.734]
Fixed Subscribers (t-1)	-1.21e-08	-1.73e-08	-4.26e-08	-4.26e-08	-	-	-	-
	(1.43e-08)	(2.24e-08)	(3.67e-08)	[0.461]				
Mobile Subscribers (t-1)	9.97e-10	2.64e-09	4.67e-09	4.67e-09	-	-	-	-
	(2.81e-09)	(4.53e-09)	(6.62e-09)	[0.576]				
Broadband Subscribers (t-1)	-1.29e-08	-6.13e-09	-9.64e-08	-9.64e-08	-	-	-	-
	(2.60e-08)	(3.69e-08)	(5.79e-08)	[0.214]				
Per-capita GDP	0.000077***	0.00014	0.00044*	0.00044	0.0000752***	0.0001874	0.00045*	0.00045*
	(0.00002)	(0.000095)	(0.00023)	[0.157]	(0.00002)	(0.000095)	(0.00023)	[0.137]
Per-capita GDP sq.	-3.15e-09***	-4.75e-09	-1.55e-08*	-1.55e-08	-2.98e-09***	-6.46e-09	-1.64e-08*	-1.64e-08*
	(1.14e-09)	(4.21e-09)	(8.70e-09)	[0.202]	(1.14e-09)	(4.19e-09)	(8.88e-09)	[0.180]
Population Density	-0.002	0.004	0.01769	0.01769	-0.0023	0.01007	0.0000176	0.0000176
	(0.002)	(0.010)	(0.2003)	[0.472]	(0.0020)	(0.0101)	(0.00004)	[0.487]
Population Density sq.	0.000012	-6.61e-06	0.000017	0.000017	0.000012	0.000023	0.0000362	0.0000362
	(6.89e-06)	(0.00003)	(0.000041)	[0.746]	(7.08e-06)	(0.000033)	(0.83)	[0.732]
Urban Population	-2.89e-09	2.24e-09	1.12e-07*	1.12e-07	-4.23e-09	-1.61e-08	6.69e-08	6.69e-08
	(4.29e-09)	(3.62e-08)	(5.76e-08)	[0.172]	(4.06e-09)	(2.88e-08)	(4.30e-08)	[0.139
Urban Population sq.	1.45e-17	-9.45e-17	-1.90e-16	-1.90e-16	4.70e-18	1.18e-18	-2.01e-16	-2.01e-16
	(2.77e-17)	(1.96e-16)	(1.62e-16)	[0.363]	(2.27e-17)	(1.36e-16)	(1.39e-16)	[0.242]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
R^2	0.98	0.45	0.02	0.02	0.98	0.44	0.04	0.04
R^2 (within)	-	0.60	0.79	0.79	-	0.59	0.78	0.78
Joint sig. test	46366.66***	14.98***	-	-	650.32***	15.97***	-	-
Observations	416	388	416	416	418	390	418	418
Id.	28	28	28	28	28	28	28	28

Note: Standard errors in parentheses. p-values in square brackets. Statistical significance at ***1%, **5% and *10%. Standard errors of the cluster-robust fixed-effects model are cluster-robust by country. Standard errors in the pooled model assume first-order autocorrelation and are heteroscedasticity robust. The Hausman test verified the superiority of the fixed-effects model over the random-effects model.

Table 2.4 – Mobile and Fixed Price Equation Results

Panel A: Mobile Price Equation

	Pooled (Het. and AR(1) robust)	Fixed effects (Cluster robust)	Fixed effects (Wild cluster bootstrap)	Fixed effects [reduced version] (Wild cluster bootstrap)
FTA	-0.307***	-0.341**	-0.341*	-0.318*
	(0.089)	(0.156)	[0.064]	[0.076]
Openness (trade/GDP)	-0.002*	0.0008	-0.0008	0.0006
	(0.001)	(0.0024)	[0.792]	[0.864]
Independent Regulator	-0.028	-0.134	-0.134	-0.186
	(0.074)	(0.187)	[0.637]	[0.620]
Privatization	0.171*	0.002	0.002	-0.038
	(0.103)	(0.168)	[0.990]	[0.833]
Mobile Subscribers lag.	3.53e-09**	9.34e-09	9.34e-09*	-
	(1.70e-09)	(5.65e-09)	[0.058]	
Per-capita GDP	0.000012	0.00002	0.00002	0.00003
	(0.000013)	(0.00002)	[0.568]	[0.454]
Population Density	-0.0004	0.0189*	0.0189	0.0164
	(0.0004)	(0.0098)	[0.227]	[0.283]
Urban Population	-1.01e-10	-3.01e-08	-3.01e-08	2.01e-08
	(1.60e-09)	(4.43e-08)	[0.610]	[0.622]
Year dummies	Yes	Yes	Yes	Yes
Country fixed effects	No	Yes	Yes	Yes
R^2	0.68	0.02	0.02	0.02
R^2 (within)	-	0.18	0.18	0.18
Joint sig. test	1567.45***	-	-	-
Observations	446	446	416	416
Id.	28	28	28	28

Panel B: Fixed Price Equation

	Pooled (Het, and AR(1) robust)	Fixed effects (Cluster robust)	Fixed effects (Wild cluster bootstrap)	Fixed effects [reduced version] (Wild cluster bootstrap)
FTA	-0.255**	-0.016	-0.016	-0.008
	(0.105)	(0.214)	[0.933]	[0.969]
Openness (trade/GDP)	-0.004**	-0.0103***	-0.0103	-0.010
	(0.001)	(0.003)	[0.105]	[0.104]
Independent Regulator	0.095	0.007	0.007	0.014
	(0.103)	(0.162)	[0.968]	[0.934]
Privatization	0.343**	0.529	0.529	0.516
	(0.135)	(0.324)	[0.132]	[0.156]
Fixed Subscribers lag.	-2.32e-08	-1.19e-08	-1.19e-08	-
	(2.71e-08)	(2.27e-08)	[0.634]	
Per-capita GDP	4.70e-06	0.00006*	0.00006	0.00006
	(0.000016)	(0.00023)	[0.136]	[0.141]
Population Density	0.00007	0.000047	0.00047	0.00044
	(0.00066)	(0.0102)	[0.969]	[0.975]
Urban Population	-8.61e-09	2.05e-08	2.05e-08	1.34e-08
	(6.59e-09)	(2.20e-08)	[0.497]	[0.598]
Year dummies	Yes	Yes	Yes	Yes
Country fixed effects	No	Yes	Yes	Yes
R^2	0.86	0.09	0.09	0.04
R^2 (within)	-	0.19	0.19	0.78
Joint sig. test	83.16***	-	-	-
Observations	499	499	499	499
Id	28	28	28	28

Note: Standard Errors in parentheses. p-value in square brackets. Statistical significance at ***1%, **5% and *10%. Standard errors of the cluster-robust fixed-effects model are cluster-robust by country. Standard errors in the pooled model assume first-order autocorrelation and are heteroscedasticity robust. The Hausman test verified the superiority of the fixed-effects model over the random-effects model.

Table 2.5 – Mobile and Fixed Penetration Equation Results

	Panel A: Mobile Penetration Equation				Panel B: Fixed Penetration Equation		
	Pooled (Het. and AR(1) robust)	Fixed effects (Cluster robust)	Fixed effects (Wild cluster bootstrap)		Pooled (Het, and AR(1) robust)	Fixed effects (Cluster robust)	Fixed effects (Wild cluster bootstrap)
FTA	0.098 (0.075)	-0.045 (0.195)	-0.045 [0.802]	FTA	0.013 (0.025)	-0.102 (0.109)	-0.102 [0.377]
Openness (trade/GDP)	-0.003** (0.001)	-0.004 (0.0027)	-0.004 [0.294]	Openness (trade/GDP)	-0.0007* (0.0004)	-0.00006 (0.0024)	-0.00006 [1.000]
Independent Regulator	0.00045 (0.072)	0.003 (0.208)	0.003 [0.987]	Independent Regulator	-0.031 (0.021)	-0.269*** (0.796)	-0.269*** [0.004]
Privatization	0.371*** (0.091)	1.052*** (0.133)	1.052*** [0.000]	Privatization	0.05 (0.032)	0.185** (0.080)	0.185** [0.045]
Per-capita GDP	0.0001*** (0.000015)	0.00004 (0.00005)	0.00004 [0.438]	Per-capita GDP	0.000083*** (9.06e-06)	0.00001 (0.00002)	0.00001 [0.717]
Population Density	-0.0007 (0.0004)	0.00003* (0.00004)	0.00003 [0.999]	Population Density	0.0023*** (0.00066)	-0.00061 (0.0064)	-0.00061 [0.932]
Urban Population	-2.39e-09* (1.22e-09)	-4.14e-08*** (1.03e-08)	-4.14e-08 [0.106]	Urban Population	1.64e-09 (5.56e-10)	1.03e-08* (5.20e-09)	1.03e-08 [0.158]
Year dummies	Yes	Yes	Yes	Year dummies	Yes	Yes	Yes
Country fixed effects	No	Yes	Yes	Country fixed effects	No	Yes	Yes
R^2	0.84	0.51	0.51	R^2	0.87	0.03	0.03
R^2 (within)	-	0.93	0.93	R^2 (within)	-	0.45	0.45
Joint sig. test	2722.44***	-	-	Joint sig. test	414.46***	-	-
Observations	555	555	555	Observations	555	555	555
Id.	28	28	28	Id	28	28	28

Note: Standard Errors in parentheses. p-value in square brackets. Statistical significance at ***1%, **5% and *10%. Standard errors of the cluster-robust fixed-effects model are cluster-robust by country. Standard errors in the pooled model assume first-order autocorrelation and are heteroscedasticity robust. The Hausman test verified the superiority of the fixed-effects model over the random-effects model.

Table 2.6 – Private Investment in Telecommunications

	Pooled (Het. and AR(1) robust)	Fixed effects (Cluster robust)	Fixed effects (Wild cluster bootstrap)
FTA	1.078***	0.527	0.527
	(0.149)	(0.387)	[0.267]
Openness	-0.016***	0.008	0.008
	(0.002)	(0.008)	[0.335]
Independent Regulator	-0.174	0.283	0.283
	(0.178)	(0.311)	[0.383]
Privatization	1.316***	1.395***	1.395**
	(0.176)	(0.412)	[0.037]
Per-capita GDP	0.000069**	0.00005	0.00005
	(0.000029)	(0.0001)	[0.620]
Population Density	-0.004***	-0.0062	-0.0062
	(0.01)	(0.0178)	[0.756]
Urban Population	2.11e-8***	-4.48e-09	-4.48e-09
	(1.7e-09)	(1.57e-08)	[0.803]
Year Dummies	Yes	Yes	Yes
Country fixed effects	No	Yes	Yes
R^2	0.98	0.05	0.05
R^2 (within)	-	0.31	0.31
Joint sig. test	1076.50***	-	-
Observations	378	378	378
Id.	27	27	27

Note: Standard Errors in parentheses. p-values in square brackets. Statistical significance at ***1%, **5% and *10%. Standard errors of the cluster-robust fixed-effects model are cluster-robust by country. Standard errors in the pooled model assume first-order autocorrelation and are heteroscedasticity robust. The Hausman test verified the superiority of the fixed-effects model over the random-effects model.

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Table 2.7 – Bacon Decomposition of the Price Equation

Log Mobile Prices	Coefficient	Weight
FTA	-0.365*** (0.154)	1.000
Timing groups	-0.155	0.067
Always vs. timing	-0.400	0.031
Never vs. timing	-0.315	0.803
Always vs. never	-2.288	0.009
Within	-0.408	0.088

Note: Standard Errors in brackets. Statistical significance at ***1%, **5% and *10%.

Table 2.8– Robustness Checks for ARPU and Mobile Price Equations

	Panel A			Panel B		
Log ARPU	Placebo I	Placebo II	Placebo III	Placebo I	Placebo II	Placebo III
FTA	0.028 [0.894]	0.181 [0.403]	-0.153 [0.414]	0.04 [0.840]	0.127 [0.565]	-0.149 [0.434]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.03	0.02	0.03	0.06	0.05	0.06
R^2 (within)	0.76	0.76	0.76	0.76	0.76	0.76
Observations	416	416	416	418	418	418
Id.	28	28	28	28	28	28
	Panel C			Panel D		
Log Mobile Prices	Placebo I	Placebo II	Placebo III	Placebo I	Placebo II	Placebo III
FTA	-0.138 [0.475]	0.156 [0.943]	-0.157 [0.401]	-0.176 [0.369]	0.075 [0.716]	-0.129 [0.457]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.02	0.02	0.02	0.00	0.00	0.00
R^2 (within)	0.16	0.14	0.16	0.14	0.14	0.14
Observations	446	446	446	446	446	446
Id.	28	28	28	28	28	28

Note: p-values in square brackets (1000 repetitions wild-cluster bootstrap). Statistical significance at ***1%, **5% and *10%.

Appendix A – Mechanism of Transmission of US-FTA Telecommunication Chapters

Obligation	Description	Transmission Mechanism	Expected Impact	Obligation present in FTA
Access and Use of Public Telecommunication Services	Ensuring that enterprises have access to and use of any public telecommunications services, including leased circuits, under non-discriminatory conditions.	Preventing anti-competitive behavior against companies that provide services over the telecommunications network. Reducing or preventing entry barriers, ensuring competition among suppliers.	Promotes competition. Prevents anti-competitive conduct that could result in rising telecom prices.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Interconnection	Ensuring interconnection in a timely fashion, at cost-oriented rates, with the same quality offered to subsidiaries or affiliates. Interconnection agreements must be public.	Preventing anti-competitive behavior by forcing the major supplier to cooperate. Reducing or preventing entry barriers, ensuring competition among suppliers.	Promotes competition among telecommunication companies. Interconnection at cost-oriented rates pushes telecommunication prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Resale	Ensuring that major suppliers offer for resale, at reasonable rates, the telecommunication services that they provide at retail to end users.	Reducing entry barriers by allowing companies that do not have a physical network to supply telecommunications services and compete.	Promotes competition among telecommunications services providers. Pushes telecommunication prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Number Portability	Ensuring that suppliers of telecommunications services provide number portability.	Reducing user's costs of switching from one telecommunications company to another.	Introduces competitive pressures to increase quality and reduces prices to attract users.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Dialing Parity	Ensuring that suppliers of telecommunications services provide dialing parity, which means that the number of digits must be the same for the same telecommunications service.	Preventing anti-competitive behavior by precluding the allocation of numbers in a discriminatory fashion.	Levels the playing field to compete under the same conditions. Prevents anti-competitive conduct that could result in rising telecoms prices.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia

				Peru Panama
Treatment by Major Suppliers	Ensuring that major suppliers accord suppliers of telecommunications services treatment no less favorable than such major suppliers accord to their subsidiaries, their affiliates, or non-affiliated service suppliers.	Preventing discriminatory anti-competitive behavior. Reducing or preventing entry barriers, ensuring competition among suppliers.	Levels the playing field to compete under the same conditions in the telecommunications market. Prevents anti-competitive conduct that could end in rising telecom prices.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Competitive Safeguards	Countries must have laws or regulations to prevent suppliers from engaging on or continuing anti-competitive practices, such as anti-competitive cross-subsidization, using information obtained from competitors with anti-competitive results, or failing to disclose information about technical facilities.	Preventing anti-competitive conduct and predatory prices.	Discourages inefficient pricing practices. Ensures prices reflect the cost of providing services.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Unbundling of Network Elements	Giving regulatory bodies the authority to require major suppliers to offer access to network elements on an unbundled basis under terms and conditions, and at cost-oriented rates, that are reasonable, non-discriminatory and transparent.	Reducing entry barriers and entry costs by allowing companies to connect to any part of the major suppliers' network at reasonable conditions.	Promotes competition among telecommunications services providers. Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Provisioning and Pricing of Leased Circuits	Ensuring that major suppliers provide leased circuit services, at capacity-based, cost-oriented prices.	Reducing entry barriers, entry costs, and production costs by allowing companies to lease circuits form major suppliers.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Co-location	Ensuring that major suppliers provide physical co-location necessary for interconnection, at cost-oriented rates. Where physical co-location is not practical for technical reasons, provides an	Reducing entry barriers, entry costs, and production costs by allowing companies to physically attach equipment using the major suppliers' infrastructure.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru

	alternative, such as virtual co-location at cost-oriented rates.			Panama
Access to Poles, Ducts, and Rights of Way	Ensuring that major suppliers afford access to poles, ducts, conduits, and rights-of-way owned or controlled by major suppliers under terms and conditions, and at rates, that are reasonable and non-discriminatory.	Sharing infrastructure reduces entry barriers, entry costs and production costs.	Pushes prices down.	CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Submarine Cable Systems	Ensuring that any enterprise authorized to operate a submarine cable system accords reasonable and non-discriminatory treatment with respect to access to that system (including landing facilities).	Preventing vertically integrated companies from engaging in anticompetitive practices that involve denying access to submarine cables.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Conditions for the Supply of Information Systems	Not requiring private suppliers of information services to supply services to the public generally, cost-justify rates, file a tariff for those services, or connect with a particular customer for the supply of these services, among others. In sum, not regulating these services.	Allowing suppliers of information services to compete without intervention by the telecommunications regulator.	Prices of information services reflect the competitive market.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Independent Regulatory Bodies and Government-Owned Telecommunications Suppliers	Ensuring that the regulator is separate from, and not accountable to, any supplier of telecommunications services. Ensuring that its decisions are impartial win comparison with other stakeholders. Ensuring that there is no favorable treatment for government-owned suppliers.	Institutional efficiency reduces production costs for telecommunications companies.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Universal Service	Each country defines its own universal service obligations, but these must be administered in a transparent, non-discriminatory, and competitive neutral manner. Ensuring that the kind of universal service defined is no more burdensome than is necessary.	Preventing the imposition of unreasonable conditions that increase production costs.	Prevents price rises.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama

Licenses and Other Authorizations	Ensuring a transparent licensing procedure. Providing the reasons for the denial of an application on request.	Institutional efficiency reduces production costs for telecommunication companies.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Allocation of Scare Resources	Administering the allocation and use of scare telecommunications resources, including frequencies, numbers, and rights of way, in an objective, timely, transparent, and non-discriminatory manner. Endeavoring to rely generally on market-based approaches in assigning spectrum.	Transparent procedures reduce transaction and production costs for telecommunication companies.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Enforcement	Providing the regulator with the authority to enforce the obligations of the FTA telecommunications chapter, including the ability to impose effective sanctions, such as financial penalties and suspension and revocation of licenses.	A credible sanction mechanism modifies the conduct of telecommunications suppliers with market power. They avoid anti-competitive practices.	Prevents price rises. Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Resolution of Disputes	Providing recourse before the regulatory body to settle supplier disputes, including disputes over interconnection terms, conditions and rates. Providing reconsideration procedures and judicial review.	An efficient dispute settlement procedure reduces transaction costs.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Transparency	Ensuring prompt publication of rulemaking. Ensuring stakeholders are provided, to the extent possible, with adequate advance public notice of, and the opportunity to comment on, any rulemaking that its telecommunications regulatory body proposes.	Transparency reduces searching costs and produces better regulations.	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama

Flexibility in Technology Choices	Allowing suppliers to choose the technologies that they will use to supply their services, including commercial mobile wireless services, subject to requirements necessary to satisfy legitimate public policy interests.	Promoting efficiency by allowing the selection of the best technology	Pushes prices down.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama
Forbearance	Recognizing the importance of market forces, a country may forbear from regulating certain telecommunications services if it is not necessary to prevent discriminatory practices or protect consumers or the public interest.	The market rules all services not subject to market failures.	Prevents unnecessary price rises.	Chile CAFTA-DR (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua) Colombia Peru Panama

Appendix B – Correlations Matrix

	Variable	Log ARPU	Log Fxd. Penet.	Log Mob. Penet.	Log Inv. in telecom.	FTA	Indep. Regl.	Privatiz.	Openness	Fx. Subs.	Mob. Subs.	Bband. Subs.	Per-capita GDP	Pop. Density	Urb.Pop.
1	Log ARPU	1.00													
2	Log Fixed Penetration	-0.12	1.00												
3	Log Mobile Penetration	**-0.72**	0.37	1.00											
4	Log Investment in telecom.	-0.21	0.14	0.26	1.00										
4	FTA	-0.43	-0.07	0.33	0.31	1.00									
5	Independent Regulator	-0.26	0.05	0.28	-0.16	-0.05	1.00								
6	Privatization	-0.04	0.17	0.30	0.19	0.12	0.22	1.00							
7	Openness	0.06	-0.01	0.03	**-0.54**	-0.04	-0.04	0.24	1.00						
8	Fixed Subscribers	-0.08	0.19	0.14	**0.65**	0.07	-0.01	0.10	-0.43	1.00					
9	Mobile Subscribers	-0.21	0.17	0.25	**0.55**	0.14	-0.03	0.11	-0.32	**0.85**	1.00				
10	Broadband Subscribers	-0.18	0.17	0.22	0.48	0.12	0.01	0.10	-0.27	**0.76**	**0.96**	1.00			
11	Per-capita GDP	-0.06	**0.66**	0.35	0.44	-0.01	-0.10	0.12	-0.22	0.34	0.31	0.31	1.00		
12	Population Density	0.02	0.26	0.04	-0.34	-0.02	0.33	0.24	0.13	-0.24	-0.19	-0.16	0.04	1.00	
13	Urban Population	-0.04	0.13	0.09	**0.69**	0.10	-0.03	0.09	-0.46	**0.97**	**0.80**	**0.65**	0.32	0.22	1.00

Source: authors' database.

Appendix C – Difference in Means Test

t-test of difference in means for variable-log ARPU, 1996-2002

Year	Treated	Control	Difference
1996	6.40 (0.11)	6.75 (0.13)	0.35** (0.18)
1997	6.37 (0.10)	6.67 (0.11)	0.30** (0.16)
1998	6.23 (0.10)	6.62 (0.11)	0.38*** (0.15)
1999	6.06 (0.10)	6.48 (0.11)	0.43 **(0.16)
2000	5.98 (0.10)	6.31 (0.13)	0.33** (0.18)
2001	5.90 (0.10)	6.01 (0.23)	0.11 (0.23)
2002	5.83 (0.12)	5.97 (0.21)	0.14 (0.26)

t-test of difference in means for variable-log mobile prices, 1996–2002

Year	Treated	Control	Difference
1996	-1.20 (0.17)	-1.11 (0.15)	0.09 (0.24)
1997	-1.30 (0.18)	-1.03 (0.10)	0.27 (0.19)
1998	-1.31 (0.18)	-1.00 (0.09)	0.30 (0.18)
1999	-1.40 (0.13)	-1.21 (0.13)	0.18 (0.18)
2000	-1.75 (0.18)	-1.42 (0.14)	0.33 (0.28)
2001	-1.79 (0.14)	-1.68 (0.22)	0.10 (0.32)
2002	-1.46 (0.24)	-1.40 (0.20)	0.05 (0.31)

t-test of difference in means for variable-log fixed prices, 1996–2002

Year	Treated	Control	Difference
1996	-3.01 (0.23)	-3.09 (0.43)	-0.08 (0.54)
1997	-2.81 (0.25)	-3.19 (0.34)	-0.38 (0.47)
1998	-2.73 (0.19)	-3.28 (0.34)	-0.55 (0.43)
1999	-2.61 (0.14)	-3.21 (0.34)	-0.60 (0.42)
2000	-2.61 (0.16)	-3.14 (0.31)	-0.53 (0.38)
2001	-2.57 (0.17)	-2.99 (0.31)	-0.41 (0.39)
2002	-2.52 (0.17)	-3.13 (0.27)	-0.51 (0.36)

t-test of difference in means for variable-log mobile penetration, 1996–2002

Year	Treated	Control	Difference
1996	0.67 (0.37)	0.42 (0.28)	0.25 (0.46)
1997	0.01 (0.29)	0.02 (0.31)	0.02 (0.46)
1998	0.74 (0.26)	0.48 (0.33)	-0.25 (0.46)
1999	1.45 (0.25)	1.01 (0.35)	-0.45 (0.48)
2000	1.95 (0.23)	1.68 (0.34)	-0.27 (0.47)
2001	2.31 (0.21)	2.18 (0.34)	-0.13 (0.45)
2002	2.56 (0.19)	2.53 (0.30)	-0.03 (0.40)

t-test of difference in means for variable-log fixed penetration, 1996–2002

Year	Treated	Control	Difference
1996	1.93 (0.19)	2.45 (0.16)	0.51** (0.25)
1997	2.08 (0.20)	2.53 (0.16)	0.45** (0.25)
1998	2.15 (0.20)	2.59 (0.16)	0.44** (0.25)
1999	2.24 (0.19)	2.66 (0.16)	0.42** (0.25)
2000	2.30 (0.19)	2.72 (0.16)	0.41** (0.25)
2001	2.31 (0.20)	2.76 (0.15)	0.45** (0.25)
2002	2.34 (0.19)	2.76 (0.15)	0.42** (0.24)

t-test of difference in means for variable-log invest. in telecoms., 1996–2002

Year	Treated	Control	Difference
1996	18.30 (0.75)	17.88 (0.66)	-0.42 (0.99)
1997	18.94 (0.58)	18.01 (0.66)	-0.93 (0.91)
1998	19.44 (0.62)	18.35 (0.76)	-1.09 (1.03)
1999	18.91 (0.64)	18.37 (0.80)	-0.54 (1.03)
2000	19.14 (0.72)	18.57 (0.83)	-0.57 (1.13)
2001	19.03 (0.66)	18.88 (0.82)	-0.14 (1.05)
2002	18.96 (0.39)	18.56 (0.58)	-0.40 (0.80)

Note: Standard errors in parentheses. Statistical significance at ***1%, **5% and *10%

Chapter 3 – Access to Credit and the Expansion of Broadband Internet in Peru[28]

3.1 Introduction

The well documented relationship between growth and financial development makes financial frictions one of the better studied explanation for low levels of firm's productivity and misallocation of resources in developing countries (Levine, 1997; Restuccia and Rogerson, 2017). This paper contributes to this literature by identifying the causal effect of the access to information technologies on credit market frictions and firms' performance. To achieve this objective, we analyze how the staggered arrival of broadband internet in Peru has modified the access to credit and the performance of firms.

Access to credit is essential for the expansion and development of firms. First, credit allows firms to expand their operations, invest in new technologies, or explore new markets. Without access to credit, firms may not be able to secure the necessary funds to purchase new equipment, acquire real estate, or expand their workforce. Second, credit is crucial for firms to navigate cash flow fluctuations and manage operations effectively. Access to credit lines and working capital loans helps businesses bridge financial gaps, meet payroll, and cover operational costs during lean periods. Overall, access to credit allows firms to make strategic investments and develop their market potential.

The literature that studies the relevance of credit constraint for firms' performance has usually exploited quasi-exogenous shocks in the supply of credit that affect borrowing. For example, Khwaja and Mian (2008) study the impact of bank liquidity shocks in Pakistan associated with the collapse of sources of bank's funding in dollars due to an anticipated nuclear test. Banerjee and Duflo (2014) characterize financially constrained firms by examining a public lending program in India that modified the eligibility conditions for firms. Banerjee et al. (2019) exploit the implementation of a large credit-expansion government program in Thailand to study the effects of credit access on business profits, conditioning for pre-intervention productivity. They find evidence that credit constraints are binding for high productivity households. Paravisini et al. (2014) study the effects of financial constraints in the export performance of Peruvian firms, as a result of a credit contraction associated with the reduction of banking foreign funding. More recently, Breza and Kinnan (2021) takes advantage of media scandal about microfinance practices in India that lead the government to a drastic reduction

[28] Co-authored with Antonio Cusato. An earlier version of this research was published as a working paper of the Inter-American Development Bank (IADB).

in the supply of credit. They study the aggregate consequences of this shock, showing that district-level reductions in credit supply are associated with significant decreases in casual daily wages, household wage earnings and consumption.

The novelty of our paper regarding this literature is that instead of focusing uniquely on the changes in the credit supply, we analyze how the irruption of the broadband internet in Peru implied a technology shock that affected the supply and demand of bank intermediation. Specifically, we exploit the staggered arrival of broadband internet in Peruvian localities (*Centros Poblados*) to examine the causal effect of information technologies in the access to credit and the performance of Peruvian firms. Our first hypothesis is that the access to broadband internet has boosted firms' performance (sales and cash flows) and has led the benefitted firms to increase the demand of credit to their bank branches. This has also led the bank branches to provide more credit and to reduce the interest rates. Our second hypothesis is that the availability of broadband internet in local areas has incentivized the entry of firms into the credit market and has reduced the probability of exiting from the credit market. We test our hypothesis by estimating the impact of broadband availability on the total credit per firm, the number of firm-bank relations, the number of loans per firm-bank relation, the probability of entering and exiting from the credit market (i.e. extensive margin), as well as on the size of credit per firm-bank relation and the interest rates (i.e. intensive margin).

Peru is a good case to analyze the effects of credit access on firm's development, especially for small and medium firms (SMEs). According to a 2018 survey, more than 60% entrepreneurs in Peru mention access to finance as the leading obstacle for their business, as well as high interest rates (OEAP, 2018). While the development of digital banking could help to moderate this problem, the percentage of the population that does not have access to the internet is still important (38.92% in 2020). Taking this into account, the objective of our analysis is to examine the impact of the deployment of fiber broadband networks on the credit market and the firms' performance during the period 2010-2019.

The roll-out of the fiber network of Peru was initiated with a concession in 2014. The new broadband network used the *fiber-to-the-x* (FTTX) technology, the fastest technology available worldwide[29], and in the following years it connected 180 of the 196 capitals of provinces of the country. Importantly, the staggered deployment of this networks provides exogenous variation in terms of the access of firms and banks to the broadband technology.

[29] The application of Optical Technology for providing broadband connectivity is called *fiber-to-the-x*. This application is given the designation FTTX, where X is a letter indicating how close the fiber endpoint comes to the actual user: FTTN (Node), FTTC (Curb), FTTB (Building), FTTH (Home). *Fiber-to-the-home* (FTTH) refers to the deployment of optical fiber from a central office switch directly into a home (Keiser, 2006).

Using a rich dataset combining the information from the Peruvian credit registry and the Peruvian taxpayers' registry, we adopt a staggered difference-in-differences (DiD) approach that examines the causal effect of the deployment of broadband internet on the performance of the universe of Peruvian firms, the credit offered to firms and interest rates (Sun and Abraham, 2021). Our identification strategy relies on the assumption that the timing of the deployment of FTTX broadband lines at the local level is not associated to the determinants of the credit market outcomes. In this sense, we verify that the expansion of the network is not correlated with baseline characteristics of each location, including credit market outcomes (total credit, number of firms borrowing, number of loans, the size of the firm measured by the number of workers) or the population. By contrast, we do find that in some periods of the deployment of the broadband, the expansion of the network was explained by the distance to the capital of the country, Lima, or the nearest airport. Our baseline model accounts for this situation.

The results of our analysis shows that total credit outstanding per firm increased four years after the arrival of the broadband network in the location of the firm. The increase in credit at the fifth year after the deployment of the fiber is of around 40%, when we use the never treated firms as counterfactual. In addition, we find that in the fifth year after the deployment of the broadband the number of banks that serve the firm increased by 20%, and the number of loans per firm-bank increased by 5%.

We also analyze how broadband availability changed the access of firms to the credit market (i.e. extensive margin). For this objective, we aggregate the number of firms with credit at each location and we calculate the share of local firms that entered and that exited the credit market in each year, and the share of firms of the previous period that did not register credit in the current period. Our results show that broadband access had a positive effect in the entry of firms in the credit market, but only after three and four years of the broadband deployment. Moreover, we find a reduction in the exit rate after the second year.

Our analysis also considers the causal effect of broadband on the size of credit per firm-branch, as well as on the interest rates (i.e. intensive margin). We analyze firm-branch relationships when the two entities have the same or different locations. Notice that when the location of the firm and the branch is not the same, we can either examine the effect of broadband deployment at the location of the bank branch, or at the location of the firm, as they might benefit of the technological upgrade at different periods. We observe that broadband deployment has a positive effect for the average size of the loan for those firms that benefit from the arrival of the broadband before the bank branches. In addition, in this case we find that firms benefit from a reduction of interest rates. For firms and branches that share the same location and benefited simultaneously from the arrival of the broadband technology, we find no significant impact on the average size of the loan, but a reduction of interest rates of 4 percentage points. Moreover, we do not find any effect for those cases in which the bank branches, but not the firms, benefit from the broadband technology. These finding suggest that firms benefit from the adoption of the information and communication technologies mainly through the demand side channel.

We also examine the heterogeneous effects of broadband access on different types of firms. First, we use an indicator of the Peruvian tax authority to classify firms as micro, small, medium and large. Second, we consider the firms' credit file "thickness", which accounts for the number of loans that firms have.[30] Interesting enough, we find that the impact of broadband deployment on average credit for a firm is driven by micro and small firms, as well as firms with thin credit files (just one or two credit relationships in the system). This results supports the idea that broadband internet helps firms to relax borrowing constraints (Stiglitz and Weiss, 1981). This result is also in line with the literature that has found that small firms are more "opaque" than larger ones, simply because they have less "soft information" that can be collected by bank officials (Abraham and Schmukler, 2017; Liberti and Petersen, 2018).

We complement our credit market analysis with an analysis of the firms' performance. Using data from the tax authority's registry and an indicator of the firms' sales range (with fifteen categories), we find that broadband access generates a short-term positive shock to our proxy of firm's sales. This effect starts one year after the arrival of broadband, peak at year three, and start shrinking at year four. We also analyze the entry and exit of firms in the locations benefited by the arrival of the broadband (extensive margin). We find a reduction in the probability of firms exiting the market in the first two years after the deployment of broadband. Moreover, we find an increase in the probability of entry in the third and fourth years after the arrival of the new technology. As we have explained above, the effect of broadband on the credit market takes place in the fourth year after its arrival. This suggest that after the broadband arrival firms' performance improves, but firms need more time to access credit. This might occur because banks are willing to provide more funds to firms only after verifying that these have improved their balance sheets.

Finally, the paper examines the robustness of our results using a dataset from the Survey of National Firms (*Encuesta Nacional de Empresas*), although due to data availability we can only examine the effects of broadband on large firms. Our results show that broadband deployment had a positive and short-term effect in the firms' value added, number of workers, and labor productivity.

[30] We use the information for 2013. Following Blattner and Nelson (2021), we define a thin credit file if the firm has one or two loans (45% of the firms), medium credit files if the firm has three or four loans (29% of the firms), and thick credit files if the firm has five or more loans (26% of the firms).

The results of our research are important for understanding the mechanisms by which the deployment of broadband technologies impacts firm performance and access to credit for firms in developing countries, thereby contributing to financial inclusion and reducing the cost of credit, especially for micro and small firms. This is especially important for policymakers who must decide how to allocate resources to promote the expansion of broadband networks in areas beyond economic hubs or large cities, which are usually attended by private firms with their own infrastructure without the government intervention.

The rest of the paper is organized as follows. Section 2 provides a literature review. Section 3 describes the deployment of fixed broadband networks in Peru as well as characteristics of the data. Section 4 presents the model and the identification strategy; Section 5 shows and discusses our findings. Section 6 introduces robustness checks. Section 7 presents effects beyond the credit market. Section 8 discusses threads to the identification strategy. Finally, Section 9 concludes.

3.2 Related Literature

Our paper contributes to several streams of the economic literature. First, our work is related to the literature analyzing the impact of information technology on banking competition. Hauswald and Marquez (2003) develop a theoretical model that examines the effects of information technology over competition and interest rates. They find that an improvement in technology increases the informational advantage of those banks that invest in gathering information against those that do not invest, reducing competition and increasing interest rates for borrowers. Only when information is disseminated to other market participants (information externalities) the adoption of a new technology can boost competition and reduce interest rates. Vives and Ye (2022) consider a theoretical model in which banks face a cost of monitoring/screening that is increasing in the wedge (for example, physical distance) between the bank expertise and the entrepreneurs project characteristics. Investments in information technology can reduce the cost of monitoring/screening without affecting the distance, as for example when the bank buys information management software (the investment is not specific to the relationship). The investments can also reduce the distance between the bank and its clients, as for example when it facilitates the transmission of information between them (e.g. the investment allows the exchange of information within the bank branching network, or between the local borrower and the banks headquarter). Their results are like in Hauswald and Marquez (2003) when investments only affect one bank (i.e. competition is reduced, and banks can charge higher interest rates). By contrast, when investments affect two banks and monitoring costs are less affected by distance, competition increases, and interest rates are lower. On the contrary, if investments affect two banks and distance is not affected, the interest rates do not vary. Our paper provides empirical support to this research. We find that when broadband arrives only at the branch bank location, it probably does not affect the distance between banks and firms (since the later are not affected by the technology), and therefore there are no effects over interest rates. By contrast, when the broadband technology reaches both firms and banks, or at least firms, the distance between lender-borrower is reduced and consequently we find effects over interest rates. In our paper, these effects are relevant for small and micro firms with "thin" credit files, which are those more affected by information constraints.

Mazet-Sonilhac (2022) looks at one step before the beginning of the firm-bank relationship, modeling a costly search process that firms perform to locate and match a bank, in addition to the subsequent bank process of screening projects. His model provides a gravity equation for credit flows between cities, where a reduction in search costs (for example via the expansion of broadband internet) allow firms to meet with more banks and obtaining a lower interest rate. Using data on the expansion of broadband internet in France, he finds that banks that benefited by broadband deployment had a 10% increase the share of credit from firms located outside the bank's city. Then, he uses his estimated structural model to show that the expansion of broadband and the consequent reduction in search frictions can reduce interest rates for small business by 4.9%. In the context of his model, the reduction of rates is more important in rural areas and medium-sized cities, which are more affected by search frictions.

Our paper is very close to D'Andrea et al. (2021), who empirically estimates the effects of broadband over credit in Italy, for loans above 30 thousand euros. The authors find that broadband deployment generates positive effects over credit, showing, as we do, that there are no effects during the first years of the roll-out. Their analysis focus on the supply channel of credit, showing that broadband increases the productivity of banks (expanding their geographical scope), increase competition and reduce interest rates. While this paper only exploits information on the location of branches, our paper considers the cases with a non-simultaneous arrival of broadband to banks and firms, which allows us to emphasize the importance of the demand channel in the bank-firm relationship. Another related paper is D'Andrea and Limodio (2019), who study the effects of high-speed internet at the bank-level for African banks. They examine the staggered arrival to Africa of fiber-optic submarine cables, exploiting the variability in the geographic and temporal roll-out of this infrastructure. Their results show an expansion of real time transfers in the interbank market (due to a decrease in 98% in the cost of operating this system), increasing bank liquidity (or reducing liquidity hoarding), and promoting lending to the private sector.

This paper is also related to the growing literature studying the economic impact of broadband internet. Thus, for example, Hjort and Poulsen (2019) exploits the staggered arrival of submarine cables in Africa to examine the impact of broadband in the labor market. Akerman et al. (2015) using Norwegian data and Bergeaud et al. (2021) using French data show that broadband internet generates a skilled-biased increase in the productivity of firms, with gains for skilled workers. Also, with data from Norway, Hvide et al. (2022) studies how broadband internet increases people's participation in the stock market and that lead households to make financial decisions that are more in line with the advice from portfolio theory. Bhuller et al. (2022) study how broadband affects search and hiring in the labor market in Norway, showing positive effects over job finding rates and starting wages. Akerman et al. (2022) documents that broadband expansion lowers information frictions, making the trade patterns of exporters and importers more sensitive to distance and economic size.

Finally, our paper is also related to the growing literature examining financial exclusion. Branches can alleviate information frictions by collecting soft information about consumers and their neighborhoods. Celerier and Matray (2018) exploit the staggered interstate branching deregulation in the US after the Riegle-Neal Act as an exogenous shock on bank competition and show that the competition resulting from these regulations reduced the share of unbanked households, benefiting those with lower income and living in rural areas. This result is in line with the literature showing that the distance between lenders and borrowers determines the availability and terms of credit, especially in low-income neighborhoods (Degryse and Ongena, 2005; Agarwal and Houswald, 2010; Ergungor, 2010; Brown, 2016; Allen et al., 2014; Beck et al., 2006). Nguyen (2019) analyzes the level of lending to small firms in US neighborhoods exposed to the merge of large banks in the period 1999-2012. She shows that branch closings that follow mergers between large banks lead to prolonged declines in local small business lending. Jagtiani and Maingi (2019) investigate the impact of mergers affecting community banks on local small business lending in the period 2002-2014. They obtain that relative to counties where the acquirer bank had operations before the merger, local small business lending declined significantly more in counties where only the target bank had operations before the merger. Thus, the absence in the county of community banks can lead local business to a credit gap that is not filled by the rest of bank entities.

3.3 Data and Context

This paper utilizes three different data sources to assess the impact of broadband deployment on the credit market. The first data source comprises detailed information on broadband deployment in Peru by locality and year, obtained from the Peruvian telecommunications regulator. The second source of data is the taxpayers' registry, which identifies the addresses of all firms that pay taxes. Finally, the third data source is the Credit Bureau Registry, which records all types of credit obtained by firms from bank branches. The following sections provide detailed information on each data source.

3.3.1 Broadband Deployment

We use annual information on the deployment of fixed broadband networks in Peru for the period 2010-2019. These data come from the Peruvian regulator of the telecommunications market (OSIPTEL), who collects data from all telecommunications operators to elaborate its market reports and studies. Data on broadband coverage has been collected at the *Centro Poblado* (CP) level, which is the smallest administrative jurisdiction in the country. Peru has 24 regions, including 196 provinces, 1,874 districts and 99 thousand CPs. However, most of the Peruvian population and economic activity is concentrated in a reduced number of CPs in the Coastal Region.

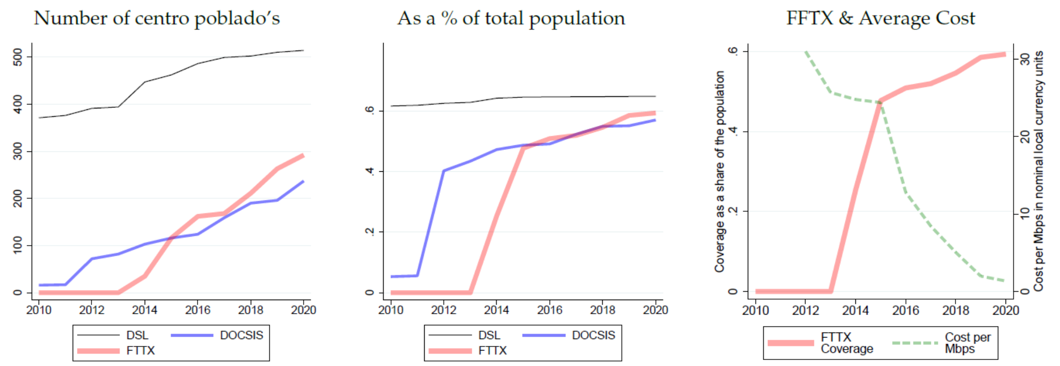
Our analysis focuses on the effects of the deployment of fixed broadband internet on the firm-branch relationship. Figure 3.1 shows the expansion of three broadband technologies at the CP level in the period examined. DSL lines (Asymmetric Digital Subscriber Lines) were installed at the beginning of the 2000s to bring internet to households and small businesses. This technology uses the existing copper wires of incumbent telecommunication operators and for this reason the speed they can adopt is relatively low. In spite of this, this technology revolutionized the way to access the internet, driving the creation of new services and promoting electronic commerce. HFC and FTTX networks are currently considered as high-speed broadband technologies. HFC (Hybrid Fiber Coaxial) networks operate based on the DOCSIS standard. They are hybrid fiber optic and coaxial cable telecommunications network that allows the transmission of video, voice and data in broadband. These networks use coaxial cable in the last mile, because it is cheaper and easier to install. FTTX networks uses optic fiber network to the home of the users (FTTH) or to other levels of the network (FTTX). Initially these networks could reach a speed of 50 Mbps, not much higher than the fastest DSL networks, but at the end of the period examined they could offer speeds higher than 600 Mbps.

The left panel of Figure 3.1 shows the number of CPs with access to each broadband technology, DSL, HFC (DOCSIS), and FTTX. The middle panel present the availability of these technologies as a percentage of total population of Peru. The right panel of the figure shows the percentage of the Peruvian population with access to the FTTX technology and the average cost of internet access per Mbps.[31] As it can be seen,

[31] See Muente Schwarz, R. (2017) for prices up to 2017, and the Peruvian regulator's web page https://punku.osiptel.gob.pe/ for more recent prices.

the biggest drop in prices of the FTTX technology occurred one year after its arrival, but it continued afterwards (the prices drop by 65% between 2015 and 2017).

Figure 3.1 – Expansion of Internet by *Centro Poblado* and Cost per Mbps.



Note: The panels show the evolution of broadband coverage in Peru by access technology in the period 2010-2020. The left panel shows the number of CPs covered by the DSL, HFC and FTTX technologies. HFC networks operate based on the DOCSIS standard. The middle panel shows the percentage of the Peruvian population with access to these technologies. The right panel shows the percentage of the Peruvian population with access to FTTX lines and the cost per Mbps of this technology.

In our intention to treat estimations we use the FTTX technology as a proxy of broadband expansion. This has several advantages. First, according to Figure 3.1, the irruption of FTTX boosted competition and lowered prices, proving higher chances of affecting firms and the credit market. Second, the use of the FTTX technology gave firms access to fast broadband internet. Indeed, notice that DSL and HFC (DOCSIS) technologies might face problems of attenuation of the speed for distances higher than two miles from the local exchange (Analysys Mason, 2020; Ahlfeldt, et al. 2017), which implies that firms located at larger distance from the local exchanges could receive a low quality internet connection.[32] Finally, the expansion of the FTTX technology started in Peru in 2014, which gives us four years of data before the introduction of this technology.

The deployment of fixed broadband network (HFC and FTTX technologies) in Peru is the result of the interaction of private and public agents (Argandoña and More, 2020). In the early years of the expansion of the fixed telephony in the country, telecommunications operators invested in the regions with higher potential demand, considering their population density and income. In the 2000s, operators upgraded existing cooper lines with the DSL technology to offer Internet in the high demand

[32] Other papers have examined the impact of broadband networks on different outcome variables considering the expansion of DSL networks and using different identification strategies (Akerman et al., 2015; Ahlfeldt, et al. 2017; Gavazza et al. 2019; Bhuller et al., 2022).

areas (Pacheco, 2012). Then, at the beginning of the 2010s the government launched a national plan to universalize the access to the broadband services in all the regions of the country, regardless of their commercial interest. The Government defined the areas to cover and opened a tendering procedure in which the concessionaire had to build and operate the new fiber infrastructure (MTC, 2022). Based on our discussions with government officials, we identify two periods in the roll-out of broadband lines during the period 2010-2020. First, the deployment of the HFC (DOCSIS) technology was mainly driven by the private sector. This initial phase mainly affected the *centros poblados* (CPs) located in the coastal region of the country, which concentrates most of the population and the economic activity and that due to its geographical conditions requires less investments for the deployment of the lines. The construction of the new FTTX lines was approved in 2012 and considered the expansion of the infrastructure to other regions of the country (highlands and the jungle areas).[33] In 2014 the Government offered the concession of the network to *Azteca Comunicaciones* (MTC, 2022), who had to connect 180 of the 196 capital of provinces of the country. The deployment of this infrastructure incentivized private operators to develop their own infrastructures, generating overlaps in most parts of the network. This situation increased market competition and reduced prices.[34]

3.3.2 Data on Firms' Credit

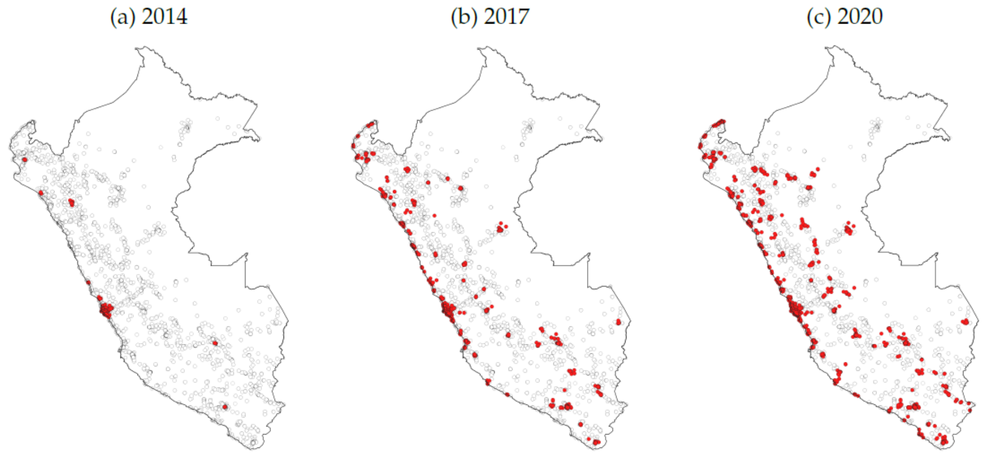
Our data on firms' credit comes from the Taxpayers Registry[35] and the Credit Bureau Registry.[36] The Peruvian Taxpayers Registry collects information for the universe of formal firms in the country (defined as those that pay taxes), with the exception of branches of foreign companies located in Peru. The information of the registry includes the fiscal address of each firm, which allow us to geolocate the firms and to identify if they are in a CP with broadband access. It also includes an indicator about the range of sales for each firm.

The Peruvian Credit Registry has information on the universe of loans and interest payments of all firms and persons. Our analysis focuses on the credit offered to formal firms that pay taxes, since we do not have access to the addresses of the population. Specifically, we focus on credit provided for working capital and investment purposes

[33] Ley N° 29904 – Ley de Promoción de la Banda Ancha y Construcción de la Red Dorsal Nacional de Fibra Óptica.
[34] In 2016, when the national network started its operations, it covered 180 capital of provinces. By contrast, the second and third (private operators) only covered 98 and 71 provinces, respectively (Pacheco et al. 2017; OSPITEL, 2018).
[35] Obtained from Superintendencia Nacional de Administración Tributaria (SUNAT). www.sunat.gob.pe
[36] Obtained from Asociación de Bancos del Perú (ASBANC). www.asbanc.com.pe

to big, medium, small and micro firms.[37] We exclude credit extended to public firms and financial institutions from our analysis. In the case of interest rates, the proxy is constructed as the annualized interest payments over the loan size.[38]

Figure 3.2 – Firms' Access to Broadband and Credit



Note: Grey and red circles represent the location of all the firms that had access to credit in at least one year between 2014 and 2020, which amount to 187.7 thousand firms. The firms with a red circle are those located in a CPs with access to broadband internet (for the three different years). Firms with access to credit and broadband totaled 35.9 thousand, 82.2 thousand and 132.5 thousand, in 2014, 2017 and 2020, respectively.
Source: Author's elaboration.

After combining the information of the two registries, we have 235 thousand firms with positive outstanding credit for the period 2014-2020, which is the period of the roll-out of the FTTX broadband lines. We have been able to georeference 187 thousand firms, which represent 80% of all firms with positive outstanding credit. Notice that many firms could not be geolocated because they do not have a correct address. Table A.1 in Appendix A reports two relevant features about the matching process. First, when we aggregate the data at the Bank Branch-Firm-Centro Poblado-Year level, we find that the proportion of firms that we could not georeference is almost

[37] Ivashina et al. (2022) use the Peruvian Credit Registry's data between 2001 and 2018, accounting for the heterogeneity on the types of loans (asset-based loans, cash-flow loans, trade finance agreements, and leases). Their analysis of the banking lending channel excludes microfinance institutions and loans approximately below 6 million dollars.

[38] This is the approach used by banks to report the interest rate to the Peruvian regulatory body. The interest is calculated as the yearly sum of bank's financial income divided over the twelve month moving average of outstanding credit (Huayta et al., 2017). Since we use the end of the year's data on credit (as on December), we multiply the bank's financial income by twelve and divide it by the outstanding level of credit.

the same for micro, small, medium and large firms (between 18% and 19% of the observations). Second, we reject that there are relevant differences in the size of the loans for micro, small, and medium firms between those geolocated and those that could not be geolocated. For these reasons, we conclude that we do not face a major concern associated with our inability of georeferencing the universe of firms.

Figure 3.2 combines information of credit and broadband access for the 187 thousand firms that we could georeference. The left panel of the figure shows that in 2014 the FTTX technology was only available for the firms in Lima and in other large cities (red circles). The grey circles correspond to firms that received a credit in the period considered, but that did not have access to this technology. In 2020, the figure reveals that there was an important increase of the availability of broadband, but still there were large parts of the country where firms accessing credit did not have access to the FTTX technology. In sum, the figures show a substantial variation in the number of firms with access to the broadband technology and with positive credit outstanding over time. For illustrative purposes, Figure A.0 in Appendix A shows the map of the city of Cusco in 2014 and 2019, showing the CPs with access to broadband and firms with access to credit.

We impose two restrictions in the final sample used for the empirical analysis. First, we limit the sample period between 2010 and 2019, to avoid including in the analysis the period of the COVID pandemic of 2020 and the corresponding response of the Peruvian government.[39] After this adjustment we are left with 155 thousand firms. Second, to construct the counterfactual we only select firms in CPs that had access to the DSL technology in 2010 (i.e. we exclude firms in CPs without access to internet). This leaves us with 149 thousand firms in our sample.

Finally, it is important to clarify that we do not know the CPs of each bank branch used by the firms, we only know the district, which is a more aggregate administrative division. Data on loans are classified in 92 accounting categories, and for each category we know the district of the bank branch in charge of each Bank Branch-Firm-Category relationship. In addition, notice that when we aggregate the data at the Bank Branch-Firm-District-Year level, a firm can have relations with one, two or more branches of the same bank, since it can have more than one category of credit. Hence, our data allow us to examine firms working with several banks and bank branches, which might have different locations.

39 During the Covid crisis Peruvian Central Bank and the Ministry of Economics implemented extraordinary measures to provide liquidity to the firms.

3.4 Empirical Approach

3.4.1 Baseline Specification

My We use the roll-out of broadband telecommunications lines as a plausible source of exogenous variation to examine the impact of the information technologies in the access to the credit by Peruvian firms. Specifically, we carry out two exercises that examine the extensive and the intensive margin effects of the access to the broadband technology.

Extensive margin. In order to examine the extensive margin effect of the broadband access, we aggregate the data at the Firm-Centro Poblado-Year level, using the address of firms. We run the following regression:

$$y_{ict} = \sum_{k=-min}^{max} \delta_k \, D_{ct}^k + \boldsymbol{X}_\gamma + \eta_d + \tau_t + \varepsilon_{ict} \tag{1}$$

where y_{ict} refers to the outcome of interest (total credit per firm, number of firm-bank relationships, number of loans for firm-bank relationships, and entry and exit ratio) for firm i located at the centro poblado c during the year t. In this expression, D^k is a dummy variable that takes value of one when the FTTX broadband lines arrives before/after k periods to centro poblado c, and δ_k are our parameters of interest. Our estimations cover a time window that goes from minus three years up to a maximum of five years from the date of deployment of the FTTX technology.

The model includes a vector with controls about the firms' characteristics $\boldsymbol{X}$ and their interactions with a time trend, where these characteristics are correlated with the roll-out of the broadband network during certain years. Specifically, we control by distance to Lima and distance to the nearest airport (see the following section 4.2 for a discussion of these variables). The model also includes fixed effects at the district level, η_d, to account for differences between very small jurisdictions, and time fixed effects, τ_t. Standard errors has been clustered at the district level.

The estimation of equation (1) uses as a control group (i) those firms that were never treated with the arrival of FTTX broadband lines but that were exposed to the DSL technology, or (ii) those firms that were treated with the FTTX lines at the end of the period of analysis, the years 2019-2020.[40]

[40] We implement our estimations following Sun and Abraham (2021), since in the presence of heterogeneous treatment effects across different treatment cohorts, the estimated coefficients

To analyze the exit ratio, we define a dummy variable for exit D^{exit} ($x_{it} = 0 \mid x_{it-1} > 0$), which takes the value of 1 if the firm reports no credit this period, conditioned on having positive credit on the previous period, and zero otherwise. This indicator is useful to assess the effects of broadband over the share of firms in a particular CP that ends all its performing credit relationships with banks.

Intensive margin. The objective of the analysis of the intensive margin is to disentangle the effects produced by broadband access on the banks supply shocks and firms demand shocks. Specifically, we can analyze (a) firms and branches located in the same district, (b) firms and branches with different locations where broadband arrived first to the branch's district, and (c) firms and branches with different locations where broadband arrived first to the firms' district.

We consider three different specifications for the intensive margin analysis, where we aggregate the information at the Bank Branch-Firm-District-Year level, and we account for the case in which firms can have multiple-bank relations and multiple-branch relations.

For case (a), where firms and branches share the same location (district) and the FTTX broadband technology arrives simultaneously to both firms and branches, we use the following specification:

$$y_{ibdt} = \sum_{k=-min}^{max} \delta_k \, D_{ibdt}^{k} + \boldsymbol{X}_{\gamma} + \eta_p + \lambda_i + \lambda_b + \phi_{it} + \phi_{bt} + \varepsilon_{ibdt} \qquad (2)$$

where y_{ibdt} refers to the outcome of interest (size of credit per firm-branch relationship and interest rate) for firm *i* borrowing form bank branch *b* located at the district *d* and during the year *t*. The arrival of technology is denoted by the dummy variable D^k that takes the value of one when the FTTX broadband lines arrives before/after *k* periods to district *d*, benefitting the firm *i* and the branch *b*; and δ_k is our parameter of interest measuring the impact of broadband access. As in the previous case, our estimations cover a time window that goes from minus three years up to a maximum of five years from the date of deployment of the FTTX technology. Note that differently from the extensive margin analysis, equation (2) includes the bank branch *b* and spatial variation is at the district level *d*. In addition, the dummy D^k is not only district specific, but firm-branch (*ib*) specific, since in this case the technology arrived simultaneously to the firm and branch that are located in the same district.

The vector $\boldsymbol{X}$ controls for firms' characteristics (distance to Lima and distance to the nearest airport) and their interactions with a time trend. The model also includes province fixed effects (η_p), since the provinces are a higher administrative level than

may not represent correctly the parameter of interest. There can be cross-lag contamination or contamination from other periods, and the evaluation of pre-trends based on estimated pre-period coefficients can be misleading. For a discussion, see Baker et al. (2022) or Roth et al. (2022).

the districts, and firm fixed effects (λ_i) and branch fixed effects (λ_b). We include in equation (2) two time-varying fixed effects $\boldsymbol{\phi}$, one for the firm, and another for the bank branch. Standard errors have been clustered at the province level.

For case (b), where firms and branches are located in different districts and broadband arrived first to the branch's district, we use the following specification:

$$y_{ibdt} = \sum_{k=-min}^{max} \delta_k \, D_{bdt}^{k} + \boldsymbol{X}_{\gamma} + \eta_p + \lambda_b + \phi_{it} + \varepsilon_{ibdt} \tag{3}$$

where y_{ibdt} refers to the outcome of interest (size of credit per firm-branch relationship and interest rate) for firm *i* borrowing form bank branch *b* located at the district *d* and in year *t*. As in the previous case, the arrival of the broadband technology is denoted by the dummy variable D^k that takes the value of one when the FTTX broadband lines arrives before/after *k* periods to district *d*, benefitting the branch *b*; and δ_k is our parameter of interest measuring the impact of broadband access by bank branches. Our estimations cover a time window that goes from minus three years up to a maximum of five years from the date of deployment of the FTTX technology. Note that differently from the extensive margin analysis, equation (3) includes the bank branch *b* and spatial variation is at the district level *d*. In addition, the dummy D^k is not only district specific, but branch (*b*) specific, since the technology arrived early only to the to the branch's district.

The vector $\boldsymbol{X}$ controls for firms' characteristics (distance to Lima and distance to the nearest airport) and their interactions with a time trend. The model also includes province fixed effects (η_p), since the provinces are a higher administrative level than the districts, and branch fixed effects (λ_b). In equations (3) we control for time varying effects for the firm ($\boldsymbol{\phi_{it}}$) since the technology arrives first to the branch (b), following the previous discussion about the identification of credit supply shocks. Standard errors have been clustered at the province level.

For case (c), where firms and branches are located in different districts and broadband arrived first to the firm's district, we use the following specification:

$$y_{ibdt} = \sum_{k=-min}^{max} \delta_k \, D_{idt}^{k} + \boldsymbol{X}_{\gamma} + \eta_p + \lambda_i + \phi_{bt} + \varepsilon_{ibdt} \tag{4}$$

where y_{ibdt} refers to the outcome of interest (size of credit per firm-branch relationship and interest rate) for firm *i* borrowing form bank branch *b* located at the district *d* and in year *t*. The arrival of technology is denoted by the dummy variable D^k that takes the value of one when the FTTX broadband lines arrives before/after *k* periods to district *d*, benefitting the firm *i*; and δ_k is our parameter of interest measuring the impact of broadband access by firms. As in the previous case, our estimations cover a time window that goes from minus three years up to a maximum of five years from the date of deployment of the FTTX technology. Note that differently from the extensive margin analysis, equation (4) include the bank branch b and spatial variation is at the district level d. In addition, the dummy D^k is not only district specific, but firm (i) specific, since the technology arrived early only to the firm's district.

The vector $\boldsymbol{X}$ controls for firms' characteristics (distance to Lima and distance to the nearest airport) and their interactions with a time trend. The model also includes province fixed effects (η_p), since the provinces are a higher administrative level than the districts, and firm fixed effects (λ_i). In equation (4) we control for time varying effects for the branch (ϕ_{bt}) since the technology arrives first to the firm (i). Standard errors have been clustered at the province level.

Our analysis of cases (b) and (c) follows Khwaja and Mian (2008), in the sense that we identify the effects of a credit supply shock (produced by the arrival of the fiber technology) controlling for firm-specific demand shocks, under the assumption that these demand shocks are constant across banks. These authors compare loans of the same firm from two different banks (via the inclusion of a firm fixed effect), which are differently exposed to a supply shock (bank liquidity shock in their paper). The key identification strategy of their paper is that credit demand is firm-specific (and not bank-specific) and within firm comparison fully absorbs changes in demand. In our case, the same logic applies to the analysis of those districts where broadband arrives first to the branch [firm] district. We can control for firm-specific [branch-specific] demand shocks [supply shocks] via the inclusion of time-varying firm [branch] fixed effects.[41]

3.4.2 Discussion about the Identification Strategy

A key assumption of our identification strategy is that the timing of the deployment of the FTTX lines across CPs is not associated with the evolution of the credit market. In order to validate this assumption, we examine whether the pattern of the deployment of this technology was correlated with the characteristics of the CPs (population, housing, distance to Lima, distance to the nearest airport, previous existence of a DSL network, amount and number of credits, number of workers). Specifically, we estimate the following model that examines whether the expansion of broadband is related to baseline CP characteristics:[42]

$$\Delta z_{ct} = \sum_j \gamma_{j,1} 1(j = t) x_{1,c}^{baseline} + \ldots + \sum_j \gamma_{j,q} 1(j = t) x_{q,c}^{baseline} + \lambda_c + \mu_{c,t}$$

41 Our approach is different than D'Andrea et al. (2021), who use the branch location (they do not have information on the firm location) to identify a supply shock, and control for firm demand time varying fixed effects.

42 For a similar analysis, see Akerman et al. (2015), Bhuller et al. (2022), or Hvide et al. (2022).

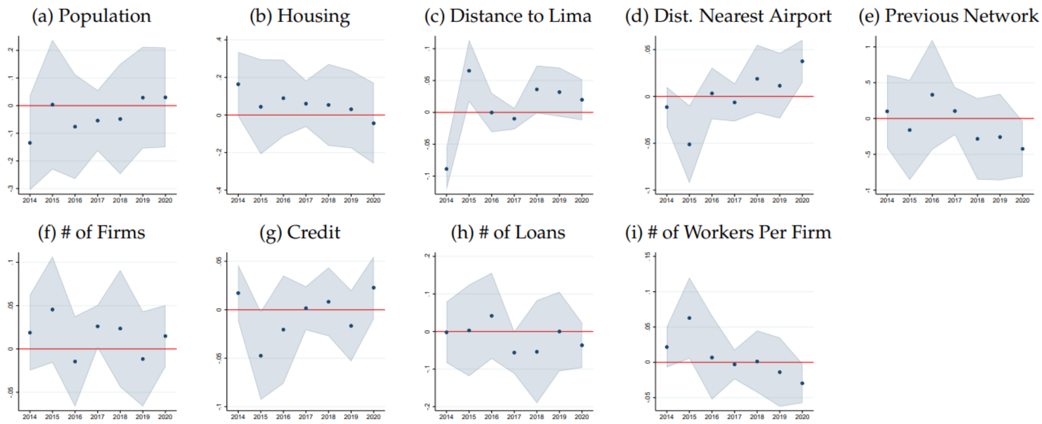
where Δz_{ct} is a dummy variable that takes the value of 1 for the year of the arrival of the FTTX technology to the CP c and zero otherwise. Moreover, $x_{j,c}$ is the baseline characteristic j of CP c. If the timing of the roll-out is completely unrelated to baseline characteristics, then $\gamma_{j,q}$ should not be different from zero, where j is a period after the expansion and q is the studied characteristic.

Figure 3.3 presents the results of this exercise.[43] The figures indicate that the roll-out is not related with most of the variables, except in the case of the variables that indicate the distance of the firms to Lima and to the nearest airport. For 2014, the first year of the roll-out, there is a clear negative correlation between the access to the FTTX and the distance to Lima, which indicates that the CP's near the capital of Peru were among the first that benefit from the availability of the FTTX technology. It seems natural that the firsts capitals of provinces (and the CPs between them) that benefited from the new fiber backbone networks where those close to Lima. The capital of the country was one of the first areas to receive the service and several telecommunications operators provided the fiber service. In 2015, the second year of the expansion, the CPs that benefited more from the broadband expansion were those far from the capital (positive correlation), but close to an airport (negative correlation). Hence, the technology first reached those areas outside the capital that were political or economically most relevant (proxy by the proximity to an airport). For the rest of the years, results are not statistically relevant.

Despite we did not find significant results for other variables, in the case of housing, previous presence of the DSL technology and number of workers per firm, there seems to be a trend in the yearly evolution of coefficients from positive to negative, which gives a sense that the roll-out continued to less populated, more remote areas or places that where not previously attended by the DSL technology. Previous research has also found that urbanization is a variable correlated to the deployment of broadband technologies (Akerman et al., 2015; Calzada et al. 2018). Importantly, credit market indicators (number of firms, performing outstanding credit, or number of loans) are not only not statistically associated with the roll-out, but in addition the coefficients do not show a consistent trend. Note that our baseline estimations control for housing and distance to Lima aggregated at the province level. While we cannot rule out the possibility that time varying unobservables might bias our estimations, the inclusion of these controls and the fact that we use two alternative counterfactuals, give us confidence about the validity of our research design.

43 The estimations of the figure refer to the universe of firms and loans, but results do not change when we use the estimation sample.

Figure 3.3. The Relation Between FTTX roll-out (2014-2020) and Log of Baseline Centro Poblado Characteristics (2013)



Note: The shadowed areas represent the 95% confidence bands. Population and number of houses are in logs. Distances have been calculated as the average distance in km of the firms to Lima or to the nearest airport. Previous network is a dummy variable that reflects the availability of the DSL technology in the CP. The number of firms is the log of the number of firms geolocated in the CPs. Credit is the log of credits offered to the firms in the CP (2019 local currency units). The number of loans and the number of workers are in logs. The number of workers is a categorical variable showing different ranges.

Finally, note that in section 5.4 we discuss and discard two additional potential threats to our identification strategy: the economic impact for local firms of the construction of the broadband network and the expansion of other of infrastructures (electricity, water distribution and sewerage) that could coincide with the deployment of broadband.

3.4.3 Estimation Sample

The sample used in the empirical analysis includes all the firms with positive credit outstanding in the pre-deployment period 2010-2014. Other studies examining supply shocks in the banking system have used a similar approach. For example, this is the case of Khwaja and Mian (2008), who uses granular data on loans in Pakistan to study the impact of liquidity shocks. Paravisini et al. (2014) combine loan and export information at the firm-bank level in Peru to examine the effects of capital flow reversals over credit and export performance around the Great Recession of 2008. This work was later on complemented by Ivashina et al. (2022), who analyze the impact of the same shock on different types of loans. Bottero et al. (2020) use data from the credit registry in Italy to analyze credit market dynamics after the 2010 Greek bailout.

Our analysis of the extensive margin (data aggregated at the Firm-Centro Poblado-Year level) consider a sample of 207.6 thousand observations and 21.6 thousand firms, which represents 30% of all observations for the window 2010-2019 and 78.0% of the total credit in this period. The reduction in the final number of firms in our sample is due to the fact that more than half of the firms that appear in the Credit Registry show positive credit only for three years of the period examined or less.

Table 3.1 – Descriptive Statistics, Extensive Margin Analysis on Credit

Data aggregated at the *Firm - Centro Poblado - Year* Level					
	Observations	Mean	sd	p10	p90
Total credit (LCU 000s) per firm from the FS [21,594 firms]	207,647	3,528	31,883	0.5	3,096
Without broadband	102,723	2,620	21,073	17.6	2,501
With broadband	104,924	4,417	39,691	0.0	3,838
Micro-Small [16,943 firms]	162,107	444	1,777	0.0	946
Without broadband	81,907	408	1,316	15.3	857
With broadband	80,200	480	2,148	0.0	1,045
Medium-Large [4,375 firms]	42,954	14,860	63,111	12.2	27,459
Without broadband	19,532	11,803	46,288	79.6	22,770
With broadband	23,422	17,409	74,186	1.5	31,758
Thin-Medium Credit File [16,003 firms]	164,693	573	14,164	0.0	967
Without broadband	83,191	464	4,569	14.8	875
With broadband	81,502	683	19,597	0.0	1,066
Thick Credit File [5,591 firms]	55,028	10,089	56,329	22.5	15,148
Without broadband	25,488	7,896	39,288	134.5	12,011
With broadband	29,540	11,981	67,611	0.0	17,988
Number of bank-firm relations	207,647	2.3	1.3	1.0	4.0
Without broadband	102,723	2.2	1.3	1.0	4.0
With broadband	104,924	2.3	1.3	1.0	4.0
Number of loans per firm-bank r.	207,647	1.7	1.5	0.5	3.0
Without broadband	102,723	1.8	1.4	1.0	3.0
With broadband	104,924	1.6	1.5	0.0	3.0
Exit (%)	207,647	0.08	0.27	0.00	0.00
Without broadband	102,723	0.01	0.12	0.00	0.00
With broadband	104,924	0.14	0.35	0.00	1.00

Note: LCU denotes Local Currency Unit, sd denotes standard deviation, p10 denotes the 10th percentile, and p90 denotes the 90th percentile. LCU are expressed in real terms (in soles of 2019). Each firm can have relations with one or more banks. On average firms have 2.3 bank relationships, and those with the largest number of relationships (at the 90th percentile), are served by 4 banks. On average, firms in the sample have 1.7 loans per bank.

Table 3.1 presents the descriptive statistics of the sample of firms used to examine the extensive margin. We classify the 21,594 firms of the sample according to their size, using as indicator their sales range. We also classify them according to their credit file "thickness", using the number of loans they hold. In both cases, we classify firms considering their situation in 2013, that is, the year before the start of the fiber deployment. Note that all of these classifications (triplets for Firm-Centro Poblado-Year) have a similar number of firms with and without access to broadband internet. In the case of the outstanding credit (expressed in constant local currency units), differences in terms of access to the broadband technology are not big, in favor of those firms with access. In the case of the firm size or credit file "thickness" the differences are relatively important. Also, notice that in our sample firms have on average credit (relationships) with 2 banks, and on average each firm has 1.7 credits with each bank. Finally, our measure of exits shows that those observations with access to broadband internet has on average a higher mean of exists than those without broadband, 0.14 versus 0.01.

Table 3.2 – Descriptive Statistics, Intensive Margin Analysis for Credit

Data aggregated at the *Bank Branch - Firm - District - Year* Level					
	Observations	Mean	sd	p10	p90
Total credit (LCU 000s) per bank-firm [6,950 firms]	42,507	3,212	23,666	1.6	3,881
Without broadband	21,335	2,436	19,264	12.0	3,076
With broadband in banks & firms	17,698	4,138	27,315	0.0	5,516
With broadband only for banks (3 years window)	2,727	3,090	29,824	0.1	1,945
With broadband only for firms (3 years window)	747	3,858	17,620	0.0	8,376
Interest payments / outstanding loan per bank-firm	42,480	0.10	0.10	0.02	0.20
Without broadband	21,332	0.09	0.08	0.01	0.17
With broadband in banks & firms	17,680	0.11	0.11	0.03	0.22
With broadband only for banks (3 years window)	2,721	0.13	0.11	0.03	0.26
With broadband only for firms (3 years window)	747	0.10	0.11	0.03	0.19

Note: LCU denotes Local Currency Unit, sd denotes standard deviation, p10 denotes the 10^{th} percentile, and p90 denotes the 90^{th} percentile. LCU are expressed in real terms (in soles of 2019).

Our analysis of the intensive margin (data aggregated at the Bank Branch-Firm–District- Year level) considers a sample of 42,507 observations, for 6,950 firms. Since the information of the location of the bank branches is at the district level, we construct a measure of broadband availability at the district level z_{dt}, using as weights the availability of broadband by the population of the CPs in the district. Then, we define the arrival of technology FTTX at the district level if it is available for at least 90% of the district population.

As explained before, we consider three cases: (a) firms and branches located in the same district, which are simultaneously exposed to the arrival of the FTTX technology; (b) firms and branches with different locations, where broadband arrived first to the bank branch's district; and (c) firms and branches with different locations, where broadband arrived first to the firms' district. For cases (b) and (c), we assume that if broadband is deployed in year t at the firm's (branch) district, then the technology should be absent in the branch's (firm) district in periods t, t + 1 and t + 2, or we look for cases in which broadband is available for a 3-year window on one side (firm or branch). Finally, following Khwaja and Mian (2008), we restrict the sample for the intensive analysis to cases with multiple-bank relations and multiple-branch relations in order to analyze only firms that were already in the credit market before the broadband shock.

Table 3.2 shows the basic statistics of the sample for these three cases. For each Firm-Branch duplet, we examine the credit offered to the firms as well as a proxy of the interest rate charged to the firm.

Note that this sample has 6.9 thousand firms, as we require for analyzing the intensive margin a Firm-Branch relationship with a positive credit for the whole pre roll-out period 2010-2014 and where firms show multiple-bank relations and multiple-branch relations. This is required to capture results for firms that were already in the credit market before the broadband deployment. For the total credit number of observations with access to broadband (21,172), 83% correspond to case (a) where the technology arrives simultaneously to both the bank branch and the firm, 12.8% to case (b) where the technology arrives first to the branch, and 3.5% to case (c) where the technology arrives first to the firm. Finally, notice that the differences between groups in terms of the size of credit and the average interest rate are not large.

3.5 Results

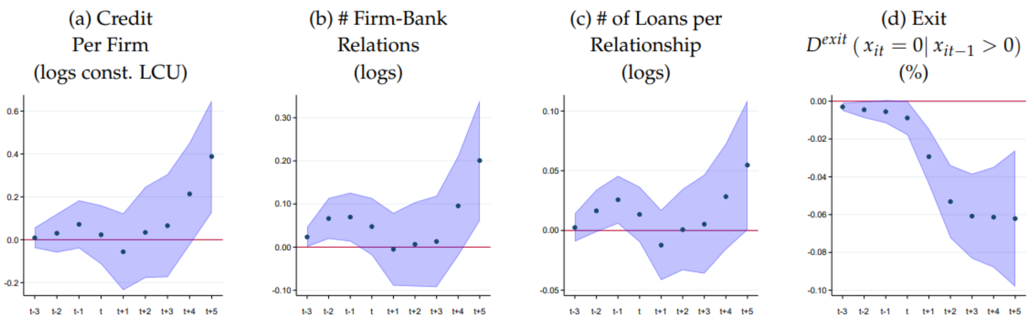
3.5.1 Baseline Results for the Credit Market

Extensive Margin Results. We have information on the exact location of each firm with positive credit outstanding and the year of the arrival of the FTTX technology to the CP were the firm is located. Hence, we are able to analyze the effects of broadband internet on the evolution of several variables that characterize the relationship of the firms with their banks. First, we consider the average total credit per firm in each particular CP. Second, we analyze the effect on the number of relationships that firms have with banks. Third, we examine the impact of broadband access on the number of loans that has each firm-bank relationship. Finally, we examine the effect of the broadband deployment on the exit ratio.

Figure 3.4 shows the effects of the broadband deployment in the four outcome variables. Interesting enough, we do not find evidence of pre-trends for these variables, except in the case of the number of firm-bank relations. Recall that the control group of our analysis are those firms with access to the DSL technology or to the traditional telecommunications technology (copper cables), but that never had access to the FTTX technology. Also, the sample is balanced only for the pre-treatment period, in order to analyze results on exit.

Figure 3.4. Total Credit Per Firm, Number of Bank-Firm Relations, Number of Loans per Bank-Firm Relationship and Exit.

Data aggregated at the Firm-Centro Poblado-Year Level



Note: Period *t* refers to the year of the arrival of broadband internet to the CP where the firm is located. The shaded area corresponds to the 95% confidence interval, and the vertical line corresponds to the 99% confidence interval. Clustered standard errors at the district level. The estimation includes fixed effects per year and fixed effects by district. The covariates at baseline are housing, distance to Lima, and these variables interacted with time trends.

In the case of the total credit per firm and the number of firm-bank relationships, panels (a) and (b), we start observing results in years t + 4 and t + 5, which indicates that there is a lag between the local availability of broadband and the effects over aggregate borrowing at the firm level. Specifically, we find that at the end of the fifth year total credit per firm increased 38% and number of firm-bank relationships increased by 20%. Panel (c) also shows that the number of loans per firm-bank relationship increases by 5.4%. This result suggest that it takes time for firms to adopt the new technology and to adjust its financial behavior. Finally, the indicator of exit shows that the probability of losing credit decreases in 6 percentage points between periods t and t + 3, and then shows no changes for subsequent periods, where the expansion of credit is concentrated.

At this point, it is interesting to compare our results with those of D'Andrea et al. (2021), which constitutes our main reference. Their analysis with survey data on household coverage for Italy shows that an increase in the coverage of ADSL from zero to 95% in a municipality increase the amount of credit (provided by a bank in a particular municipality) in 47%.[44] This result is relatively similar to our fifth year point estimate, acknowledging that that our dummy for the FTTX technology indicates full

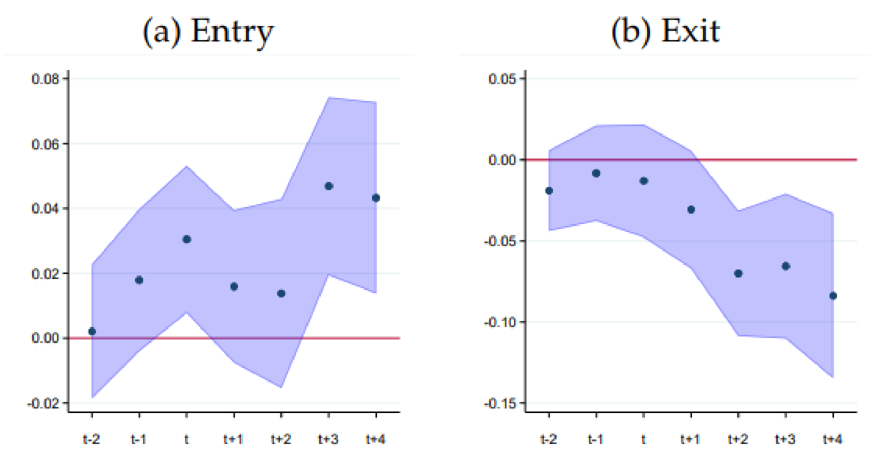
[44] The authors report an increase from zero to a high level of internet (75% coverage) of 28%, where this value for coverage corresponds to category number three in their asymmetric six-point scale of coverage (their regression coefficient is 0.081). To calculate the 47%, we use the value of five in their six-point scale (between 85% and 95% of coverage) and their regression coefficient.

coverage in a CP.[45] In addition, they find an increase of 21% in the number of loans extended by a particular bank as a result of a 95% increase in ADSL coverage in a municipality. Differently, our estimate for the fifth year is much smaller than theirs, a 5%.

Entry and Exit from the Credit Market. Our previous extensive margin analysis has considered a balanced panel of firms for the pre-treatment period. By construction, the balanced sample cannot be used to analyze the entry of firms. In order to assess the chances of entry and exit using all the information available, we next aggregate the data at the Centro Poblado-Year level. In addition to our exit dummy indicator, we define an entry dummy variable D^{entry} $(x_{it} > 0 \mid x_{it-1} = 0)$, which takes the value of 1 if firm i has positive outstanding credit this period ($x_{it} > 0$), conditioned on having zero outstanding credit in the previous year ($x_{it-1} = 0$), and zero otherwise. We define the probability of entry as the share of new firms with credit over the total number of firms with credit in the CP level in each period, while the probability of exit is the share of the firms that exit the credit market over the number of firms of the previous period. For this analysis, instead of analyzing the results between t − 3 and t + 5 as before, we focus on the periods t − 2 to t + 4.

Figure 3.5. Probability of Entry and Exit from the Credit Market

Data aggregated at the Centro Poblado - Year Level



[45] D'Andrea et al. (2021) use data from the Italian credit registry (1998-2008) and broadband expansion since 2004. They report that in terms of the population, coverage was 85% in 2005. Since they do not have information for the years of the expansion of broadband, they cannot test the parallel trends assumption nor study the correlation between the expansion of the network and baseline characteristics. To overcome this issue, they instrument their coverage indicator with a measure of the distance between the municipality in which the bank operates and the broadband infrastructure. The assumption behind is that the shortest the distance, the earliest the municipality had access to broadband internet.

Note: Period t refers to the year of the arrival of broadband internet at the Centro Poblado (CP). The shaded area corresponds to the 95% confidence interval. Clustered standard errors at the CP level. The estimation includes year and CP fixed effects. The counterfactual includes the CPs without access to the FTTX technology.

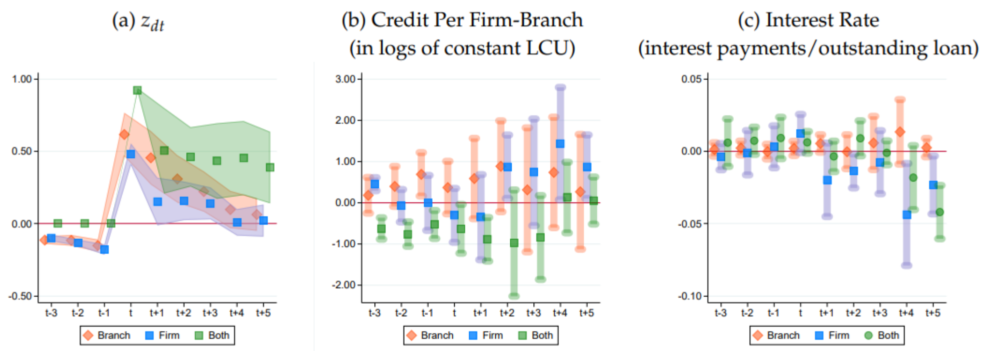
Figure 3.5 shows a contraction in the probability of exit in periods t + 1 and t + 2, and in the balanced sample of Figure 3.4. Moreover, the arrival of the FTTX technology increases the probability of entry in an order of magnitude of four percentage points. These results are significant only for periods t + 3 and t + 4, a timing that is consistent with the increase in the average total credit per firm documented in Figure 3.4.

Intensive Margin and Disentangling Between Supply and Demand Shocks: This section examines the effect of the broadband technology in the duplets firms-branches relationships that are in the same CP, and also in the duplets in which the firms and the branches are in different CPs, when the arrival of the broadband occurred only for the firms or only for the bank branches, in a three-year window. This analysis is useful to identify separately the effects of the shocks on the supply of credit (when the arrival of the broadband only affects the bank branches) and shocks on the demand of credit (when the broadband shock only affects the location of the firm).

As we have explained in section 4.3, we can identify the location of the bank branches at the district level, but not at CP level. For this reason, we aggregate the data at the Bank Branch- Firm-District-Year level and the number of firms in our estimating sample is reduced from 21.6 thousand firms of the extensive margin case to 6.9 thousand firms. Table 2 has shown that we have a little more of 21.3 thousand observations without treatment; 17.6 thousand observations were the FTTX technology arrived at the same time at the locations of firms and branches (at the district level), 2.7 thousand observations where broadband arrived only to the branches (at the district level), and 0.7 thousand observations where broadband arrived only to the firm's location (at the district level). Next, we report the results of our analysis on two outcome variables, total credit for the firm-branch relationship and a proxy of the average interest rate. As in the case of the extensive margin analysis, our sample has been balanced for the pre-treatment period and as discussed previously, we restrict the sample to firms with multiple lenders and with multiple branches.

Figure 3.6. Loans and Interest Rates for Firm-Branch Duplets

(Data aggregated at the Bank Branch - Firm - District - Year Level)



Note: Loans and interest rates for Firm-Branch duplets: (i) Located in the Same District, (ii) Located in Districts Where Broadband Arrived Only to the Firm Location in a 3-Years Window, or (iii) Only to the Branch District in a 3-Years Window Period *t* refers to the year where broadband internet coverage reaches at least 90% in the district were the firm or the bank branch is located. The shaded area corresponds to the 95% confidence interval. Clustered standard errors at the province level.

Panel (a) of Figure 3.6 reports the effect of the arrival of the broadband technology at the district level, z_{dt}.[46] Results in panels (b) and (c) of Figure 3.6 confirm the existence of a shock in the demand of credit as a consequence of the arrival of the broadband technology. In the case in which the arrival of the broadband technology only affects the district of the firms, we obtain an increase in the demand of credit and a reduction in the interest rate that are statistically significant for periods t + 4 and t + 5. In the case of firm-branch relationships that are in the same location we do not find parallel trends before the arrival of the technology, nor significant results in the last two periods. Differently, the reduction in interest rates is clear during the last period for those duplets with the same location, and for those exposed only to demand shocks (only affecting firms' locations). The reduction in rates is of the order of magnitude of 4 percentage points.

Finally, notice that we obtain the expected results when we use a less precise definition of what is a firm (or a branch) that is affected by the arrival to the FTTX technology. In particular, Figure A1 in Appendix A shows the case in which the time window between the arrival of the broadband technology in the two types of entities is restricted from three to one year. That is, we consider a sample of firms [branches] that are located in districts in which the technology shock occurred one year before

[46] By construction, there is a jump in the indicator at period t, but this wedge is reduced in the following periods, as the non-treated locations, are defined as those that did not reach a coverage of 90% (but can report coverage below this threshold).

the corresponding branch [firm]. Clearly, when we use these definitions, it is difficult to argue that our results are purely due to a supply or a demand shock.[47]

Effects Over New Branches: Beyond the intensive margin analysis, another channel that can explain the growth in total credit per firm is the entrance of new bank branches due to the arrival of broadband. D'Andrea et al. (2021) document that in Italy banks have opened branches in locations benefited by the arrival of the broadband technology, conditional on these locations not being small. In order to assess if this situation also occurs in Peru, we aggregate the data at the District-Year level, and we calculate the probability of entry, as the ratio between the sum of the new branches in each district, over the total number of branches in 2014, the first year of the roll-out of the FTTX technology in the country. Figure A2 in Appendix A shows the z_{dt} coverage indicator and the chances of entry. In our case, we do not observe any differences regarding entry between treated and the never treated districts after the arrival of the technology. This outcome can be attributed to the growing global trend of reducing the number of bank branches. Mergers and acquisitions in the banking sector, as well as the consolidation of bank branches are responses to the declining profitability of the banking business due to the surge in online banking services.

The observed outcome is likely to be attributed to the escalating global trend aimed at diminishing the quantity of bank branches. This trend is exemplified by the proliferation of bank mergers and acquisitions, alongside the consolidation of bank branch networks, which can be construed as strategic responses to the diminishment in the profitability of the banking sector, a diminishment largely precipitated by the advent of online banking services.

3.5.2 Heterogeneous Effects: Firm Size and Credit file "Thickness"

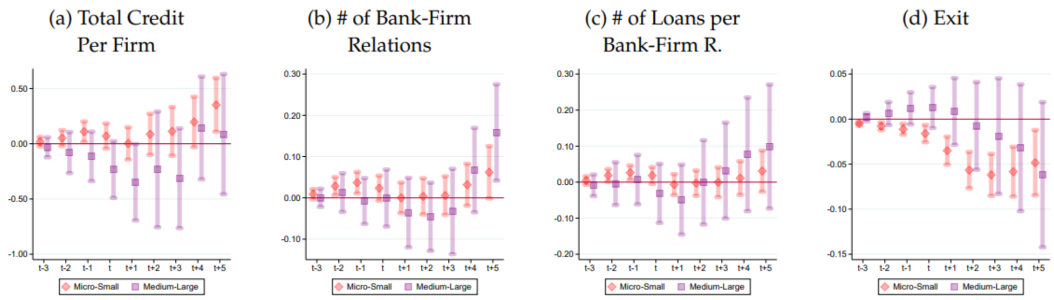
This section repeats the previous analysis in order to examine the heterogeneous impact of broadband deployment on firms of different size and different credit file "thickness". The richness of our dataset (we are working with the universe of firms) allows us to run independent regressions for micro and small firms and for medium and large firms. We classify firms considering the volume of their sales one year before the start of the broadband deployment, in 2014. Following a categorization of sales range elaborated by the Peruvian tax authority, we consider that micro and small firms

[47] This can be clearly seen in the evolution of z_{dt}, that jumps at period t but immediately contracts almost to the original level in period t + 1 (i.e. there is a large number of firm-branches with different locations where the technology arrives to these locations in consecutive years).

are those with annual sales in 2013 lower or equal to 2.3 million dollars, and medium and large firms are those with a higher volume of annual sales.[48]

Extensive margin. Figure 3.7 reports the analysis of the extensive margin exercise in Equation (1) when we classify firms as micro-small or medium-large. Panel (a) shows that the effects of broadband deployment on the total credit were significant only for micro-small firms. By contrast, panel (b) shows a significant effect on the number of firm-bank relations for both types of firms. We interpret this result as a consequence of the increase in competition. When broadband internet arrives to a CP, it allows all types of firms to attract more suppliers of funds, regardless of their size. Panel (c) reveals that broadband deployment had a non-significant effect in the number of loans per firm-bank relationship. Finally, panel (d) shows that broadband had a negative and significant effect in the exit rate of micro-small firms.

Figure 3.7. Extensive Margin Results by Firm Size (pre roll-out size)



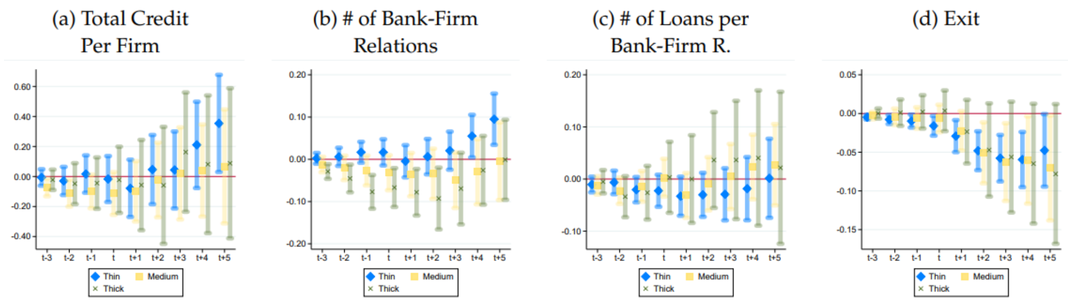
Note: Micro and small firms are those with annual sales in 2013 lower or equal to 2.3 million dollars. Period t refers to the year of the arrival of broadband internet at the CP where the firm is located. The vertical lines corresponds to the 95% confidence interval. Clustered standard errors at the district level.

We also classify firms according to their credit file "thickness" one year before the deployment of the FTTX broadband, in 2014. Following Blattner and Nelson (2021), we use information of 2013 to define firms with a thin credit file if they have one or two loans (45% of the firms), with a medium credit file if they have three or four loans (29% of the firms), and with a thick credit file if they have five or more loans (26% of the firms). Notice that since our credit bureau data starts in 2010, we cannot measure

[48] The Peruvian tax authority classifies firms according to the Peruvian Tax Unit (UIT), which changes value every year. In 2013 a UIT was worth 1,370 thousand dollars. According to this, micro firms are those with annual sales up to 150 UITs (205.5 thousand dollars), small firms are those with sales between 150 UITs and 1,700 UITs (up to 2.3 million dollars), medium size firms are those with sales between 1,700 UITs and 2,300 UITs (up to 3.2 million dollars), and large firms have annual sales higher than 2,300 UITs.

the number of years the firm has been interacting with banks. Figure 3.8 presents the results of our analysis once we use the previous classification.

Figure 3.8. Extensive Margin Results by Credit File “Thickness” (pre roll-out file)



Note: A thin credit file has one or two loans (45% of the firms), medium size credit files are those between three and four loans (29% of the firms) and thick credit files are those between five and 74 loans (26% of the firms). Period *t* refers to the year of the arrival of broadband internet at the CP where the firm is located. The vertical lines corresponds to the 95% confidence interval. Clustered standard errors at the district level.

Panel (a) in Figure 3.8 shows that all the growth in credit is explained by firms with thin credit files. Panel (b) shows that the same is true when we look at the number of banks serving a firm, a result that we interpret as a result of the n increase in competition. In terms of the number of loans per firm-bank relationship, panel (c) does not reveal statistically significant results. Finally, panel (d) shows that in the case of the exit indicator, there is a short-lived improvement in the indicator for firms with thin and medium size credit lines.

At this point it is relevant to note that the credit market literature has explored the relation between information disparities and access to credit. Blattner and Nelson (2021) using data of a US consumer credit bureau show that information disparity (e.g. thin versus thick credit files) lead to inefficient and unequal access to credit markets, since the traditional credit scores are not good predictors of default risk for individuals with thin credit files. In the same vein, Di Maggio et al. (2022) show that the use of alternative data by fintech platforms allows the identification of the “invisible prime” borrowers, which are consumers with low credit scores, thin credit files, but also a low propensity to default. In this context, since our results on the effects of the broadband technology are mainly driven by firms with thin credit files, we can argue that the deployment of the new broadband technology has helped this type of firms (with thin credit files) to reduce information disparities and improve its access to the credit market, making them more visible for the lending banks. In that sense, our results suggest that the arrival of broadband internet access contributes to the reduction of information frictions, contributing to financial inclusion in developing markets.

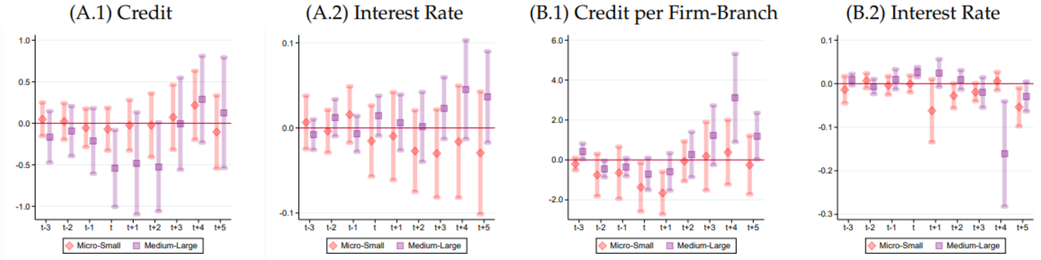
Intensive margin. Figure 3.9 reports the analysis of the intensive margin exercise in Equation (2) when we consider the firms' size categories defined before. Panel A of Figure 3.9 considers the case in which the broadband arrives only at the bank branch district. As in the general case of Figure 3.6, the results show that the arrival of the broadband did not generate a significant effect on the supply of credit. Panel B focusses in the case in which the broadband arrives only at the firm district, therefore examining the effects of the broadband on the demand of credit. Interestingly, for micro-small firms we do not find significant effects in terms of the size of credit per firm-branch relationship. Recall that the small firms are those that explain the credit expansion associated to broadband deployment, which explain that this effect is mainly driven by the extensive margin. By contrast, the effects of broadband for medium-large firms at the individual level (firm-branch) shows an increase in credit for periods t + 4 and t + 5. Finally, panel B.2 shows that in the case of interest rates, the aggregate drop-in rates in period t + 5 are driven by micro-small and medium-large firms.

Figure 3.9. Intensive Margin Results by Firm Size (pre-roll-out size)

PANEL [A]: BROADBAND ARRIVES ONLY AT THE BRANCH DISTRICT

PANEL [B] BROADBAND ARRIVES ONLY AT THE FIRM DISTRICT

(A.1) Credit | (A.2) Interest Rate | (B.1) Credit per Firm-Branch | (B.2) Interest Rate



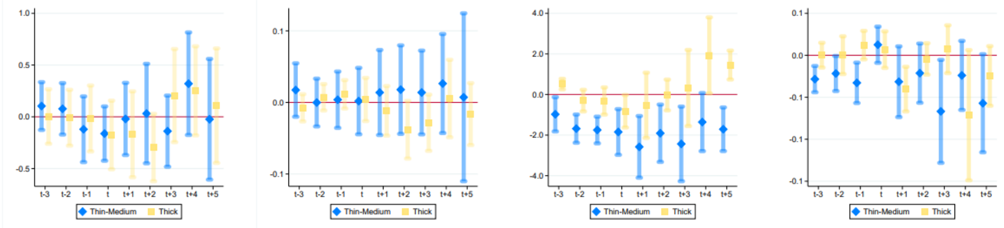
Note: Micro and small firms are those with annual sales in 2013 lower or equal to 2.3 million dollars (following a categorization of sales range elaborated by the Peruvian tax authority). Period t refers to the year of the arrival of broadband internet to the district of the firm [branch], imposing that the technology does not arrive to the branch [firm] district in a 3 year-window. The shaded lines correspond to the 95% confidence interval. Clustered standard errors at the district level.

Figure 3.10. Intensive Margin Results by Credit File "Thickness" (pre-roll-out file)

PANEL [A]:
BROADBAND ARRIVES ONLY AT THE BRANCH DISTRICT

PANEL [B]
BROADBAND ARRIVES ONLY AT THE FIRM DISTRICT

(A.1) Credit | (A.2) Interest Rate | (B.1) Credit per Firm-Branch | (B.2) Interest Rate



Note: A thin credit file has one or two loans (45% of the firms), medium size credit files are those between three and four loans (29% of the firms) and thick credit files are those between five and 74 loans (26% of the firms). Period t refers to the year of the arrival of broadband internet to the district of the firm [branch], imposing that the technology does not arrive to the branch [firm] district in a 3 year-window. The shaded lines correspond to the 95% confidence interval. Clustered standard errors at the district level.

The analysis of the intensive margin when we account for the firms' credit file "thickness" are similar to those described above. For this exercise, we put together the firms with thin files (one or two loans) and medium size files (between three and four loans) in 2013. This is because, since we are balancing the sample for the pre roll-out period, it is difficult to find firms with thin files that were present during the whole period 2010-2014 (otherwise we do not have enough observations to implement the estimation). Panel A of Figure 3.10 focus on the supply shocks, and shows no effects for any type of firm. Panel B of Figure 3.10 shows the results for the demand shocks. In terms of credit for thin or medium size firms, Panel B.1 of Figure 10.4 reveal that the parallel trends assumption does not hold, but we observe a relatively constant difference in relation to the control group, which might point out at no major changes in the size of credit at this level. Finally, in terms of the interest rate in Panel B.2 of Figure 3.10, we find reductions in the rates for thin and medium firms in period t + 3, although there are significant differences with the control group for the pre roll-out period.[49]

3.6 Robustness Checks

The objective of this section is to analyze the robustness of our results to different specifications of the estimated equations (1) to (4), as well as using a different counterfactual. Our first robustness check for equation (1) considers the analysis of

49 We take our estimates of Figure 3.10 with caution, given the initial problems with the estimation and the fact that equation (2) involves a highly saturated specification.

the extensive margin results of Figure 3.4. First, we drop the covariates used in our estimation, and their interaction with time trends to verify if the estimated effects differ substantially from those obtained from Equation (1). Second, we change the counterfactual and instead of using the never treated firms, we pick the firms treated in the last two years, 2019 and 2020 (including the covariates and their trends) to analyze if the results substantially differ from those obtained using the original counterfactual. The results of these exercises are reported in Figure A.5 of Appendix A. We find that when we exclude the covariates we obtain a similar pattern for the effects for the access to the broadband, but with higher values of the coefficients. When we focus on the estimations for the last-treated firms, our results also show the same profile than for the general model of Figure 3.4, but with higher point estimates. The only exception is the exit indicator, which shows a contraction like in the baseline estimation, but it is not statistically significant. In consequence, we conclude that our extensive margin results are robust to different specifications and different counterfactuals.

When we carry out the same exercise for the intensive margin analysis, we are left with very few observations for the only treated firms and banks, and our parallel trends assumption does not hold in this case. However, we are able to estimate the effects over interest rates for Equation (2), using as counterfactual those firms and banks that share the same district and that were treated in 2019 and 2020. Figure A.6 of Appendix A shows the results of this exercise. In our baseline estimates, interest rates fell by 1.81 per cent in $t + 4$, and using the last treated, rates fell by 2.32% for the same period (we cannot estimate $t + 5$).

As an additional robustness check, instead of assigning placebo shocks to different locations and periods, we exploit the heterogeneous deployment of the HFC technology (DOCSIS). As shown in Figure 3.1, the deployment of this technology in Peru started in 2011, and during the first four years of their roll-out the cost per Mbps fell only 20%. Hence, differently from the FTTX network, which involved the construction of the main network of fiber optic in the country and almost immediately generated a decline in prices of 65%, we do not expect to see large effects in a window of five periods after treatment. The results for the extensive margin analysis are shown in Figure A.7 of Appendix A. As expected, we do not observe effects associated to the expansion of the HFC technology, concluding that our estimations for FTTX broadband deployment are robust.

3.7 Effects beyond the Credit Market

In order to obtain a complete picture on how the deployment of the broadband technology modified the firms' access to credit, this section examines the effects of the arrival of this technology over a group of indicators related to the firms' performance, like the entry/exit of firms and the firms' productivity. For this exercise, we use the universe of Peruvian firms.

3.7.1 Universe of Firms: Sales, Entry and Exit

This section examines the effects of broadband deployment on sales for the universe of Peruvian firms. While our analysis of the credit market has used a relative low number of firms, this section considers the universe of Peruvian firms (between 331 thousand and 524 thousand firms per year). The analysis excludes financial firms and public enterprises, according to the information available in the taxpayer's registry. Once we balanced the pre-treatment period (2010-2014), as we did for the credit market, we are left with 222 thousand firms. The counterfactual of this exercise includes those firms never treated that belong to districts were the coverage of FTTX technology is less than 90% and the coverage of the DSL technology at some point in the sample represent more than 0% of the population.

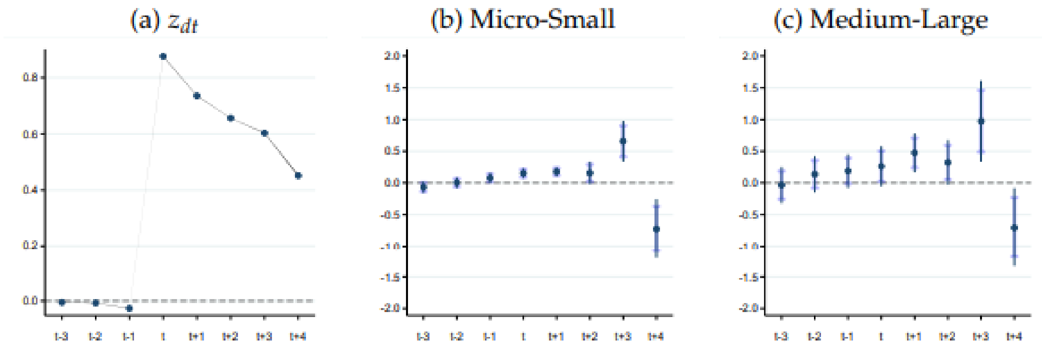
Our proxy of sales is an asymmetric fifteen-point indicator that provides ranges for the firms' yearly value of sales. The range is expressed in terms of a reference value (UIT), which is adjusted annually by the Peruvian tax authority. As explained above, in 2013 the value of a UIT was 1,370 thousand dollars, and in 2019 it was 1,272 thousand dollars. Figure A.3 in Appendix A shows the cumulative distribution of firms in 2013 and 2019 according to the fifteen-point indicator and the corresponding ranges in dollars. In order to assess the impact of broadband deployment, we work with the changes in this indicator of sales, whose distribution is shown in Figure A.4. To account for firm heterogeneity, our estimations include a group of firm's characteristics at the baseline year 2013: sector, number of workers range, firms' year creation cohort, and type of tax administration system. We also control for trends associated with these variables, the distance to the capital Lima, population and housing. Finally, the model include district and time fixed effects and we cluster standard errors at the district level.

Figure 3.11 presents the results of the analysis by firm size, grouping micro and small firms and medium and large firms. Specifically, there are 212 thousand micro-small firms in the pre-treatment period and 9 thousand medium-large firms). Panel (a) presents the evolution of our district coverage indicator. Panels (b) and (c) show that after the arrival of broadband, the indicator of sales range starts increasing in t + 1 and t + 2, peaks at t + 3, and exhibits an important drop at t + 4. Similar results are found when we analyze separately the four categories of firms.[50] These results are interesting

[50] To check the strength of our estimations, we repeat the robustness check exercise presented in the previous section by estimating the impact of the deployment of the HFC (DOCSIS)

for different reasons. First, they are consistent with a narrative that broadband improves firms' performance in the first three years after the arrival of the FTTX technology, and that after this period it might affect firms credit conditions. Second, the short-term nature of the impact of broadband differs from previous results in the literature. Malgouyres et al. (2021) examines importing firms in France and shows that broadband increases the value of imports and the value of sales. Differently from us, they document a persistent increase in sales up to five years after the roll-out.

Figure 3.11. Change in the Yearly Sales Range [Asymmetric Fifteen Point Indicator], by Firm Size (pre roll-out size) (Data aggregated at the Firm - District - Year Level)



Note: Period t refers to the year of the arrival of broadband internet to the district where the firm is located. The lines correspond to the 95% and 99% confidence intervals.

Next, we explore the dynamics of the probability of entry and exit around the arrival of the FTTX technology. We define an entry and exit dummies for firms in the same way we did for the credit market analysis. Then we aggregate the data at the District - Year level.

Figure 3.12 shows the results of entry and exit of firms. Panel (a) presents the evolution of our district coverage indicator. Panels (b) and (c) report the evolution of the probability of entry and exit at the district level, around the time of the arrival of the FTTX technology. The evolution of the impact on the probabilities is consistent with the timing of our previous results. Chances of entry start picking up one period after the arrival of the technology and show an average increase in 4 percentage points in t + 2 and t + 3. Overall, we find similar patterns for the entry of firms that we found for the entry to the credit market. That is, broadband affects first the results on real activity, and then affects the credit market. The reduction in the exit probability is of the same order of magnitude and materializes in periods t + 1 and t + 2.

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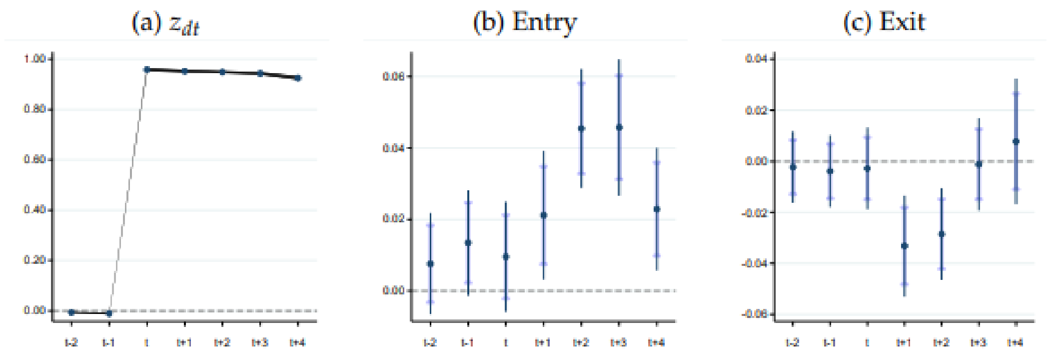
networks in our indicator of ranges for firm's sales, and we report no effects over the universe of firm's sales in Peru in Figure A.8 of Appendix A.

Figure 3.12. Probability of Firm's Entry and Exit (Data aggregated at the District - Year Level)

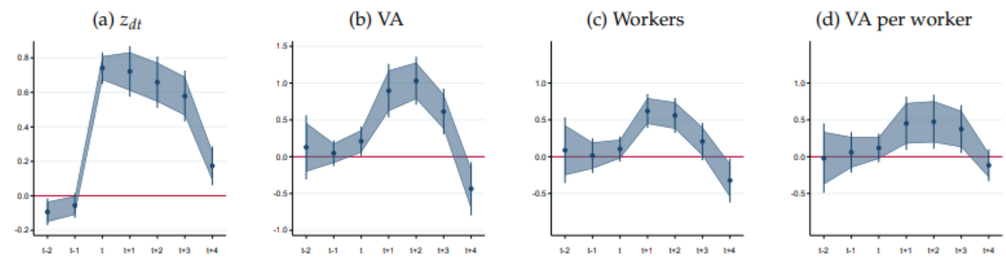


Note: Period t refers to the year of the arrival of broadband internet to the district were the firm is located. The lines correspond to the 95% and 99% confidence intervals.

3.7.2 Large Firms: Labor Productivity

Next, we examine whether the increase in sales documented in the previous section is associated with higher levels of labor productivity of firms.

Figure 3.13. Large Firms: Value Added (VA), Number of Workers, VA per Worker (Data at the Firm - District - Year Level)



Note: VA is defined as the sum of Commercial Margin (Sales of Merchandise minus Costs of Selling Merchandise), Net Sales of Products, and Services Sales). VA, Workers and VA per worker are expressed in logs. Period t refers to the year of the arrival of broadband internet to the district were the firm is located (if the district has more than 90% of coverage, where is indicator is constructed using the information at the *Centro Poblado* level and population size). The shaded area corresponds to the 95% confidence interval. Clustered standard errors at the district level. The estimation includes year fixed effects. The counterfactual includes those firms never treated that belong to districts were the coverage of DSL technology at some point represent more than 0% of the population.

For this analysis, we have detailed information about value added and number of workers for large firms. Using data from the National Survey of Firms for 2014-2017 and 2019, we analyze the effects of broadband on labor productivity on large firms.[51] Panel (a) in Figure 3.13 shows the results of the analysis for our indicator of district broadband coverage z_{dt}, panel (b) for the value added (VA) of the firm, panel (c) for the number of workers, and panel (d) for our measure of labor productivity, which is the ratio between VA and the number of workers. The reported results of this analysis shows that broadband deployment in Peru improved firms productivity by increasing workers productivity.

Other recent papers have documented how broadband internet affects firms' productivity. Akerman et al. (2015) using Norwegian data shows that broadband is a skill-biased technological change for firms, increasing (decreasing) the productivity of skilled (unskilled) workers. Bergeaud et al. (2021) finds similar results using French data. They show that the arrival of broadband increases firm productivity and the demand of high skilled workers. In addition, they show that broadband help firms to outsource some non-core firm jobs, showing gains (losses) in terms of salary of skilled (unskilled) workers that leaves the firms. Note that our analysis cannot contribute to this discussion, since we do not have detailed information on firms' workers.

3.7.3 Threads to Identification

We can identify two potential threats for the identification strategy used in our analysis of the previous sections.

Construction of the broadband network: One potential limitation of our identification strategy is the effect that the construction of the broadband network could have generated over the firms in each location. In this sense, notice that the cost of the construction of the 13.5 thousand km of the main network of fiber optic was 400 million dollars, which implies an approximate investment of 30 thousand dollars per kilometer. As a reference, the construction of a highway in Peru exceeds one million dollars per km (Ministry of Transportation, 2022). Hence, we consider that these investments should not be considered as a concern.

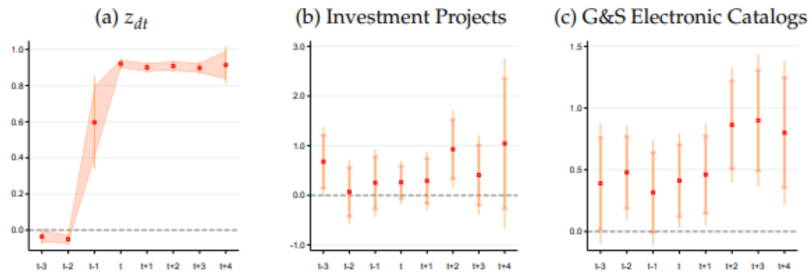
Parallel roll-out of other infrastructures: Another threat for our identification is that the deployment of the broadband technology could coincide with the roll-out of other types of infrastructures. In order to examine this possibility, we have analyzed data on public procurement, which includes public investment projects.

We use information from the *Organismo Supervisor de las Contrataciones del Estado* (OSCE), the public institution in charge of supervising public procurement in Peru. The

51 As explained in the data section, the survey includes a balanced sample for large firms, and a yearly cross-sectional survey for medium, small and micro firms. Considering this data restriction, we narrow the analysis to large firms.

information is at the contract level, and we aggregate the data on acquisitions at the Public Institution- District-Year level. The sample between 2013-2019 corresponds to all contracts regulated by the Law of Public Procurement.[52]

Figure 3.14. Public Procurement Contracts for Investment Projects and the Purchase of Goods and Services (GandS) Using Electronic Catalogues



Note: Period t refers to the year of the arrival of broadband internet to the district were the public institution is located (if the district has more than 90% of coverage, where this indicator is constructed using the information at the Centro Poblado level and population size). The lines correspond to the 95% and 99% confidence intervals. Clustered standard errors at the province level. The estimation includes year, province and type of government level (national, regional, municipal) fixed effects. The counterfactual includes those public institutions never treated that belong to districts were the coverage of DSL technology at some point represent more than 0% of the population.

The results of the impact of deployment of FTTX broadband on public procurement contracts for investment projects are reported in Figure 3.14. Panel (a) presents or measure of broadband availability at the district level z_{dt}, using as weights the availability of broadband by the population of the CPs in the district. Panel (b) shows significant results for broadband deployment on public procurement contracts for investment projects in period t + 2, but no effects in the first two years of the arrival of the network, nor in the last two years of our analysis. We are not concerned about this finding since it is hard to argue that this one-point result does constitute a parallel and persistent shock that overlaps with the broadband roll-out. Moreover, recall that we document effects over firms in t and t +1, and our main concern was the simultaneous increase in other types of investments in these two periods (also note

[52] We balance the sample of firms for the pre-treatment period. Since we only have data since 2013, we include those firms that had investment projects (or acquisitions via electronic catalogues) during 2013 and 2014. We control for baseline characteristics, as the distance to the capital Lima, population, housing and the total value of procurement by public institution, to have a proxy of the size of the public institution. We also include trends associated with these characteristics. Fixed effects for year, province and public sector level (national, regional, municipal) are also part of the specification.

that our point estimates in these two periods are very similar to those in $t - 2$ and $t - 1$).

As a robustness check for the results on investment projects presented in this section, we also considered the impact of the deployment of broadband internet on other variable of the same database obtained from OSCE: the public procurement purchases of goods using electronic catalogues. Differently from other types of procurement contracts, the electronic catalogues have been designed for the acquisition of standardized goods (such as pencils, staples or office paper) by public entities, through an online platform, whose prices have been pre-determined. In summary, it is a type of public procurement that actively uses the internet.

Panel (c) reports the effects of broadband FTTX deployment over purchases using electronic catalogues. In this case, we do observe a clear and expected impact of broadband deployment on public procurement purchases using electronic catalogs since period $t + 2$. This result act as a robustness check, creating confidence on our previously presented non-statistically significant result on investment projects.

3.8 Conclusions

This paper has studied the effects of broadband internet in the access to credit of the firms in Peru in the period 2010-2019. We have shown that the roll-out of the fiber network all over the country after 2014 improved the firms' access to credit and their economic performance. In addition, the probability of entry increased and the probability of exit decreased in the areas benefited with the broadband deployment. Our first contribution is to document the sequential timing of the effects over the firms' economic activity and the credit market outcomes. More specifically, we report that for those firms-banks with an ongoing relationship the effect in the credit occurred four and five years after the broadband deployment. At year five, total credit per firm increased by 38%, the number firm-banks relations increased by 20%, indicating that firms are served by more banks, and the number of loans per firm-bank relationship increased by 5.4%.

The second contribution of our paper is to empirically disentangle the effects of broadband deployment between the impact in the supply of credit (bank branches) and in the demand (firms). We show that for Peru the demand channel has been more important that the supply channel. In the case in which firms and banks receive the impact of the broadband simultaneously, and for the case in which the impact arrives first to the firm location than to the bank branch location, we observe a reduction in market interest rates of 4 percentage points. These results occur five years after the broadband technology deployment. We do not find effects when the technology affects bank branches but not the firms (supply channel). The results supporting the demand effect channel are consistent with the idea that the firms that benefit most from broadband are those that are small firms and with “thin” credit files.

The findings of this research are important for understanding how the deployment of broadband technologies impacts firm performance and access to credit for firms in developing countries. These findings have important policy implications for developing countries. Our results suggest that promoting the expansion of broadband networks can be an effective way to stimulate economic growth, improve firm performance, increase access to credit, and reduce its cost (interest rates) to firms. Policymakers should therefore prioritize investments in broadband infrastructure, particularly in areas that are currently underserved by private companies.

We also show that access to information and communications technologies is essential for the financial inclusion of micro and small firms, which are often classified as riskier, and have little opportunities to contact with several bank branches, limiting their growing potential. These results are particularly relevant for policymakers that want to promote the development of micro and small firms, fostering their financial inclusion and reducing their credit risk.

Finally, our study highlights the need for further research on the impact of broadband internet on firm performance and financial inclusion in developing countries. Future studies could explore the potential spillover effects of broadband deployment on the internationalization of firms, innovation, the use of electronic payment methods, among others.

Chapter 4 – Broadband Deployment and Firms' Export Strategies[53]

4.1 Introduction

Broadband Internet is an essential mechanism for the participation of firms in international markets. High-speed Internet access allows firms to advertise their products, communicate with potential clients and providers, track the progress of the transactions and to gather information about the developments of their competitors.[54] In the last decade, the improvement of the information and communications technologies (ICT) have lowered firms' logistics costs and increased trade efficiency (Freund and Weinhold, 2002 and 2004; Kneller and Timmis, 2016; Fernandes et al. 2019). In addition, new technologies have helped firms to develop new business activities such as digital trade and cross-border e-commerce. There is important research in economics examining the role of broadband Internet on GDP growth, employment and efficiency of production activities (Röller and Waverman, 2001, Holt and Jamison, 2009; Czernich et al. 2011; DeStefano et al., 2018). Some papers have analyzed the effects of internet access on the trade activity (World Bank, 2016, Fernandes et al. 2019; Hjort and Tian, 2023). However, a relevant question that has not yet been studied is how communication technologies shape the organization of the export activity of firms. The Internet allows to strengthen the relationship of firms with their traditional commercial partners, but it can also help them to open new markets to reduce their dependency on some countries or regions. In this paper we examine the effects of broadband technologies on firms' internationalization strategies. For this objective, we take advantage of the quasi-exogenous variation in access to the broadband technology that generated a public program launched in Peru in 2014 that connected most of the country's province capitals with fiber.

Several empirical papers have shown the existence of a positive impact of Internet access on the exports of firms. Some papers have used data aggregated at the country and industry level (Freund and Weinhold, 2002 and 2004, Clarke and Wallsten, 2006). Other papers have used firm-level data and exploited spatial differences in broadband

[53] Co-authored with Joan Calzada.

[54] Information and communication technologies (ICTs) influence firms' decision to trade directly and indirectly through efficiency gains. They can induce firms to trade by reducing information and trade costs (Hagsten and Kotnik, 2017). Moreover, they can indirectly affect trade due to its effect on productivity (Cardona et al., 2013; Añón Higón and Bonvin, 2002; Fernandes et al., 2019).

availability and broadband speeds (Kneller and Timmis, 2016, Akerman et al. 2022, Zhou et al., 2022; and Fernandes et al., 2019). Our paper contributes to this literature in several ways. First, while most of the previous studies consider the effects of the deployment of the Digital Subscriber Line (DSL) technology,[55] we analyze the impact produced by a public program in Peru that promoted the deployment of the fiber (FTTX) technology in regions previously covered by the DSL technology.[56] Second, our identification strategy is based on the idea that the deployment of the FTTX broadband lines benefited relatively more those firms using DSL that where more distant from the telephone local exchanges. Indeed, a well-known characteristic of the DSL technology is that its quality decreases with the distance between the consumer's premises and the telephone local exchanges (i.e. with the length of the local loop). Specifically, it is considered that the quality of the service is mostly attenuated for distances superior of 2.5 kilometers. By contrast, the quality of the FTTX technology is maintained for large distances. Given this, we expect that the deployment of the fiber technology in Peru has increased the export activity of firms located more than 2.5 kilometers from the DSL local exchanges. Finally, another novelty of our paper is to analyze how high-speed Internet availability has modified the export strategy of firms. The richness and granularity of our data allows us to examine the effect of broadband on the number of countries with which Peruvian firms maintain commercial relations and the level of diversification of their exports.

Peru is a good example to analyze how access to high-speed broadband and the reduction of communication frictions can modify the trade strategies of firms. Exports in Peru have traditionally been very concentrated in the mining, agriculture and fishing activities. Moreover, a large fraction of the exports is directed to China, the United States and the European Union. In the last decade, the Peruvian government has tried to diversify the trade relations of firms with the implementation of Free Trade Agreements (FTAs) with its major trading partners. Nowadays, Peru has trade agreements with 58 countries, which have reduced trade barriers and provided exporters with preferential access to some markets. In spite of this, it is an empirical question to verify if these agreements have reduced the dependency of the country with its major partners and if the investment in communications and transportation infrastructures have contributed to this objective. The objective of our analysis is to determine whether the access to fiber technology has helped to diversify the markets

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55 This technology generalized the use of the Internet in most countries around the world.

56 The DSL technology requires the use of a traditional copper phone line to transmit data. A modem connects the computer to the telephone line and a splitter separates the different signals. By contrast, FTTX uses ultra-thin glass strands that carry light instead of electricity. The fiber lines are run directly from a central point to individual buildings (homes, apartments, businesses), which offers lightning-fast speeds and guarantees the stability in the transmission of data during peak hours. As a result, the FTTX technology offers speeds 100x faster than DSL.

to which the Peruvian firms export and whether it has complemented the adoption of the FTAs.

Our study combines several data sources that we can link through the firms' identifiers. We use a firm-level dataset obtained from the Peruvian Customs Exports Registry covering all firms with an export activity in the period 2000–2019. The Registry provides the annual value of the firm' exports, expressed in US dollars, in each sector of activity and to each country. Importantly, the information includes the address of the firms, which allows us to geolocate them. We complement this information with data from the Taxpayers Registry on the firms' number of employees and sales volumes. Data on the deployment of broadband lines in Peru has been obtained from the Peruvian regulator of the telecommunications market (OSIPTEL). The data is at the *Centro Poblado* (CP) level, which is the smallest administrative jurisdiction in the country.[57] This information allows us to determine the exposition of the firms to different types of broadband technologies (i.e. DSL, FTTX, HFC) and to calculate a proxy of the distance of the firms to the telephone local exchanges (i.e. the length of the local loop), which determines the quality of the DSL service they can receive. Considering this, our identification strategy consists in applying a difference-in-differences approach (DiD) that compares the difference in exports of firms exposed to the FTTX technology who were closer and further away from the 2.5 km to the local exchanges, relative to the difference between firms not exposed to the FTTX technology who were located closer and further away from the local exchanges.

Our results show that the deployment of the fiber (FTTX) broadband network in Peru had a significant and positive effect on the firms' export activity. Specifically, firms that benefited from the arrival of the fiber network were more likely to export, exported more and to more countries, and had their exports less concentrated in large trading partners. Moreover, we show that these effects were mostly driven by firms that had a poor DSL service before the arrival of the fiber technology and that were stronger for firms that were exporting before the arrival of the new technology. These results are robust to various specifications of our empirical model,

When we examine the heterogeneous effects of fiber across different types of firms, we find that it was slightly weaker for small firms (in terms of sales and workers) than for the medium and large firms. This suggest that small firms might have more difficulties in reorganizing their exports and to expand to new markets when they reduce communication frictions and have an improved access to ICTs. Finally, we find

[57] Peruvian municipalities (called *distritos*) are divided into smaller population units (called *centros poblados*), which can be classified as either urban or rural depending primarily on size. The population unit with the capital of the municipality is always defined as urban. There are 99 thousand *centros poblados* in Peru.

that the firms that benefited more from the access to the fiber technology were those in the agricultural sector and in the metal-mechanical and steel-metallurgical sectors.

Our analysis and findings have important policy implications. First, we estimate the impact of broadband access on the firms' exports, showing that its positive effects are widespread across different types of firms and industries. Second, we highlight the importance of public programs aiming a universalizing the access to broadband technologies. National authorities in developing countries are concerned about the dependence of their domestic industries on major trading partners such as China, the US and the EU, and are trying to increase the diversification of their exports reaching trade agreements with several countries. Our analysis shows the need of complementing these polities with the development of infrastructures and policies that reduce trade barriers and communication frictions.

The rest of the paper is organized as follows. Section 4.2 presents a review of the literature more closely related to this paper. Section 4.3 explains the main characteristics of the export activity of the firms in Peru. Section 4.4 describes the data used in the empirical analysis and explains our identification strategy. Section 4.5 shows and discusses our results. Finally, Section 4.6 concludes.

4.2 Literature Review

Our paper is related to the empirical literature that analyzes the effects of Internet access on firms' exports, either directly by strengthening the communication with buyers or indirectly by increasing their ICT capital and improving their performance. Initial research was based on country-level data.[58] Freund and Weinhold (2004) use data on bilateral trade for 56 countries during the period 1995–1999 and show that the increase in the number of web sites explains export growth in the following years. They also find that overall trade growth was proximity-biased, but they do not find evidence that the Internet modified the impact of distance on trade. Freund and Weinhold (2002) analyze the effect of the increase of Internet hosts in 31 countries and 14 industries in the period 1996-1999 and find that the Internet expanded trade in services. Clarke and Wallsten (2006) assess the impact of the Internet on exports in 93 countries with data for 2001. They adopt a two-stage instrumental variable approach in which the instruments for internet penetration are country regulations. Their findings reveal that the increase in the access to the internet boosted the exports from developing to high-income economies. Furthermore, Lin (2015) study the effect of the

[58] More generally, our paper is related to the literature that analyzes the impact of public infrastructure on growth and trade. Several papers have examined the relevance of transportation infrastructures (Duranton and Turner, 2012; Duranton et al. 2014; Ghani et al., 2014; Agraval et al. 2017; Banerjee et al. 2020) and of electrification (Dinkelman, 2011; Rud, 2012; Libscomb et al, 2013, Dasso and Fernandez, 2015; Banal-Estañol et al 2017).

Internet on trade by augmenting the gravity equation with the Internet. Using as instrument the civil liberty index from the Freedom House and a sample of 200 countries in the period of 1990-2006, he finds a positive relation between the number of Internet users and international trade.

Similar to our paper, recent research uses firm-level data to analyze the effects of the deployment of broadband Internet on firms' export activity. Ricci and Trionfetti (2012) consider cross-sections of firms across 24 industries in 32 developing countries and identify robust correlations between firms' access to communication networks (email or internet) and export performance. They find that firms are more likely to export if they are more productive, larger, and if they participate in strong networks (foreign financial linkages, links to regulation and communication networks). Kneller and Timmis (2016) report a strong positive causal impact of broadband Internet use by business services firms in the United Kingdom on their propensity to export. Following DeStefano et al. (2014), they use an instrumental variable approach that exploits spatial differences in broadband availability and broadband speeds. Zhou et al. (2022) analyze causal relationship between broadband infrastructure and exports in a panel data of Chinese cities for the period 2005-2019. Using a difference-in-differences (DiD) design they find that the pilot cities participating in a public program to deploy broadband had a significant increase in their exports. Fernandes et al. (2019) combine firm-level manufacturing census data with data on province-level internet penetration in China for the period 1999-2007 to examine the effect of the expansion of the internet on firms' exports. Their identification strategy is based on the assumption that the deployment of broadband generates larger benefits in industries that make an intensive use of the internet. They show that the rollout of the internet boosted firms' manufacturing exports and overall performance, even before large e-commerce platforms became available. Moreover, the effect of the Internet was larger in communication-intensive industries producing differentiated goods and in industries relying on specialized and customized intermediate inputs. Akerman et al. (2022) analyze how and why the adoption of information and communication technologies (ICTs) affects bilateral trade flows. They exploit the stratified adoption of broadband internet in Norway in the period 2000-08, which was promoted by a public program. They augment the standard gravity equation with an indicator for broadband adoption in firms and interaction terms between broadband adoption and the determinants of trade flows. Their results show that the Internet makes trade more sensitive to distance and economic size. Specifically, internet availability increases trade with closer countries.

Finally, our paper is related to the literature that examines how information and communication technologies (ICTs) affects firms' productivity and the labor market. Several papers in this literature have exploited the staggered deployment of broadband networks at the national level to address the endogeneity of firms' internet adoption, but their focus is on how internet connectivity affects workers' productivity and reduces information frictions.[59] Clarke et al. (2015) and Paunov and Rollo (2016) show that the access to the Internet increases firms' productivity. Bertschek et al (2013) consider an instrumental variable model that uses as instrument the availability of the DSL technology in Germany in the period 2001-2003. They show that broadband had no impact on the firms' labor productivity, whereas it had a significant impact on their innovation activity. Haller and Lyons (2015) implement a two-stage least squares estimator that uses broadband availability as an instrument to examine the effects of ICT on productivity in a firm-level panel data for Ireland. They find no significant effect of broadband adoption on firms' productivity or productivity growth. Akerman et al. (2018) examine how broadband internet affected individuals' wages and employment status in Norway in the period 2001-2007. They exploit the staggered rollout of broadband across municipalities that was the consequence of a public program and find that wages and employment of (un)skilled individuals increased (decreased) with broadband availability. They find that broadband availability was associated with increase (decrease) in the output elasticity of (un)skilled labor. DeStefano et al. (2018) analyze the effects of heterogeneous types of ICT on firm performance in the United Kingdom. They implement a two stage least squares (2SLS) estimation that uses firms' access to ADSL as instrument. They find that the firms that are closer to the telephone local exchanges are more likely to invest in ICT, because broadband speeds decrease with the length of the local loop. Moreover, they show that the ICT causally affects firm size, but not productivity. Hjort and Poulsen (2019) examine the effect of the arrival of submarine cables on the Africa's coast in the late 2000s and early 2010s. Their identification strategy is based on the idea that the arrival of the new technology increased the speed of the Internet connections of the population and firms located close to the benefited backbone networks. Access to fast Internet increased the probability of employment and the probability of having a high-skill occupation of exposed individuals, but not the probability of holding an unskilled job. Fabling and Grimes (2021) study the effects of the adoption of ultrafast broadband in New Zeeland on firms' productivity. They implement an instrumental variable strategy exploiting the staggered rollout of ultra-fast broadband in primary and secondary schools, since those firms close to the schools participating in the public program had a better broadband service.[60] The authors find that the average effect of

[59] One exception to this approach is Poliquin (2021), who combines within-firm variation on broadband adoption with microdata on the wages, occupation, and characteristics of workers in Brazil. He finds that wages slightly increased following firm broadband adoption, and that this increase was more important for workers using information technology, performing non-routine and cognitive tasks, and for managers.

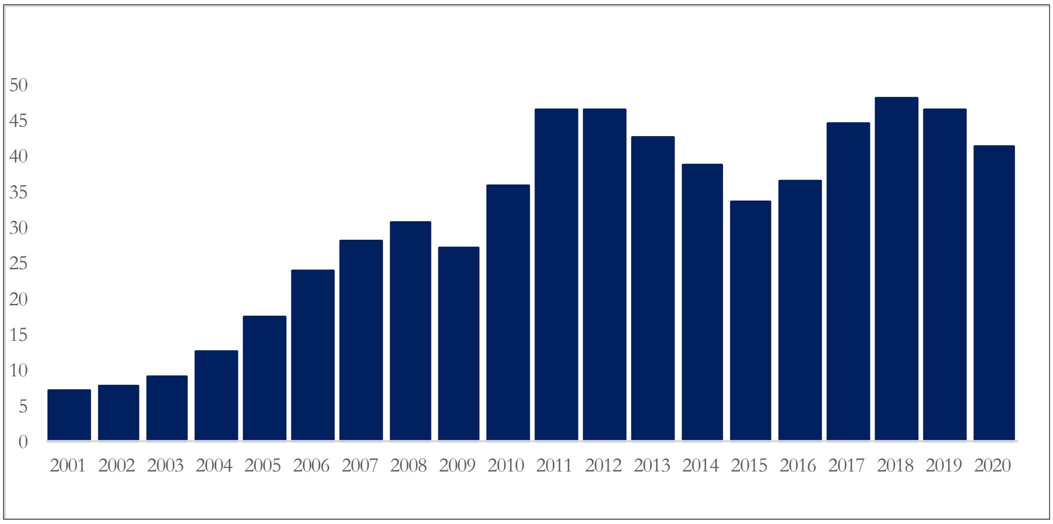
[60] The authors consider that instruments based on school proximity are conceptually superior to instruments that exploit the timing of commercial or "business-oriented" public investment, since these latter investment strategies may be prioritized towards regions with, for example, high growth prospects, which would undermine the validity of the instrument.

the adoption of this technology was negative for employment and had no significant effect on labor productivity, but it had a positive impact on multifactor productivity.

4.3 Background on Peru's Export Activity

Exports have historically played a pivotal role in Peru's economic development, contributing to foreign exchange earnings, job creation, and overall economic growth. Peruvian exports have expanded significantly since the beginning of 2000. For instance, in 2001 the Free on Board (FOB) value of exports was USD 7 billion, and by 2020 it had surged to USD 41 billion (Figure 4.1). Over the past two decades, the volume of exports has experienced fluctuations, reaching a maximum value of USD 48 billion in 2018. Consequently, Peru ranked as the 54th largest export economy in the world by 2020.

Figure 4.1 – FOB Export Value of Peru (USD Billions - 2020).



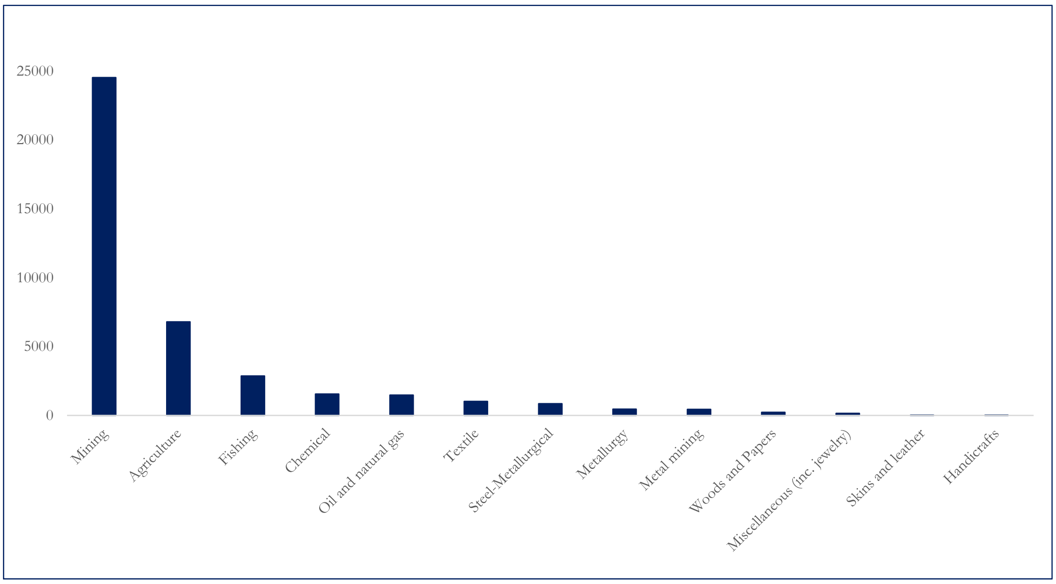
Source: Peru's Ministry of Foreign Trade and Tourism

Exports are very concentrated in the mining, agriculture and fishing activities, although there is a growing trend towards product and market diversification. Figure 4.2 shows that the mining sector accounts for over 60% of the total exports value, with copper alone contributing to nearly a quarter of total export revenue in 2020 (BCRP, 2021). Other important minerals in terms of value are gold and silver.[61] In addition, in 2020, Peru was the 29th largest exporter of natural gas in the world.

[61] Peru is the 2nd largest world producer of copper, silver and zinc; the 3rd largest world producer of lead; the 4th largest world producer of tin and molybdenum; the 5th largest world producer of boron; and the 8th largest world producer of gold.

In 2020, agriculture products represented 17% of the exports and fishing accounted for 7%. Peru is also one of the top 10 food suppliers globally. Its most prominent export products are blueberries, grapes, coffee, avocados, asparagus, and mangoes, which collectively account for 52% of all food products exported (fruits alone represent approximately 50% of the agro-export basket).

Figure 4.2 – FOB Export Value of Peru, by Sector (USD Millions - 2020).

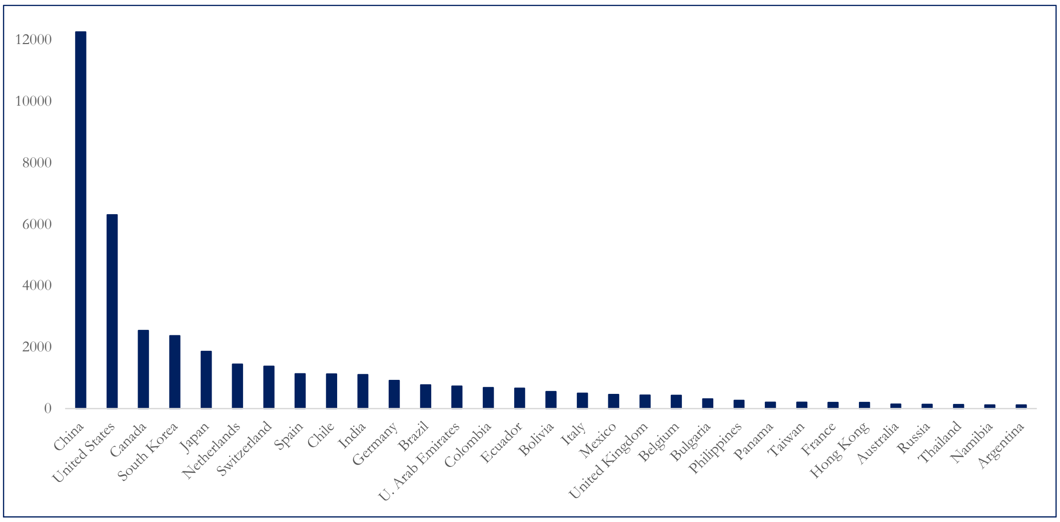


Source: Own elaboration

With respect to the destination of the exports, Peru exported to 175 countries in 2020. As illustrated in Figure 4.3, Peru's main export partners are China (29,7% of total exports), the United States (15,3%), the European Union (9,9%), Canada (6,1%), South Korea (6%), and Japan (4.5%).

The implementation of Free Trade Agreements (FTAs) has played a strategic role in the economic development of the country. Over the last fifteen years, Peru has signed agreements with its major trading partners, including the United States (2009), China (2010), and the European Union (2013) (Ministerio de Comercio Exterior y Turismo, 2020). Prior to the adoption of the US-Peru Trade Promotion Agreement, Peru had regional trade agreements with the Andean Community (Bolivia, Colombia, Ecuador and Peru), as well as the Economic Complementation Agreement with Mercosur (Argentina, Brazil, Paraguay and Uruguay). Nowadays, Peru has 22 trade agreements offering access to 58 country markets for Peruvian exporters (See Table A1 in Appendix A). These agreements have reduced trade barriers and provided exporters with preferential access to key markets. In contrast to the temporary unilateral trade preferences offered by certain countries, FTAs allow exporters to embark in long-term export-related investments. The objectives of the agreements are to promote the expansion and diversification of the Peruvian exports, especially in the case of non-commodity products. Nonetheless, they have a limited effect on small businesses and farmers who lack access to modern technologies and techniques to compete in international markets.

Figure 4.3 – FOB Export Value of Peru, by Country (USD Millions - 2020).



Note: Countries with more than USD 100 Million

Source: Own elaboration

In addition to these agreements, in the last decade, the Peruvian government has adopted several initiatives aiming at promoting exports, such as the implementation of the National Strategic Export Plan 2015-2025 (PENX). This policy aims at promoting the internationalization and diversification of firms, developing a competitive export supply, facilitating foreign trade and fostering an export-centric culture.[62] In addition, in 2010 the Ministry of Foreign Trade and Tourism created the Foreign Trade Single Window, which is a centralized and integrated access point (through a webpage) for all the administrative process associated with foreign trade activities (i.e. customs declarations, phytosanitary certificates, origin certificates, etc.). This service reduces transaction costs and simplifies foreign trade operations.[63]

Notwithstanding these institutional efforts, Peruvian firms face several challenges when attempting to export. First, exports are concentrated in a limited range of

[62] This policy has been promoted by the Ministry of Foreign Trade and Tourism (MINCETUR) and the Export and Tourism Promotion Board (PROMPERU).

[63] It has been estimated that the Peruvian Single Window has generated savings amounting to USD 325 million (MINCETUR, 2023).

products and markets, which makes firms vulnerable to fluctuations in global commodity prices. Export firms usually have to rely on a limited number of export destinations, often dominated by a few key trading partners. This dependence exposes firms to the economic conditions imposed by their partners. An additional obstacle for internationalization is the small size of firms. Firms that want to expand their exports need to undertake market research and invest in new production processes. Nevertheless, small and medium-sized enterprises (SMEs) struggle to secure the required funds for these activities due to factors such as high interest rates, stringent lending criteria, and limited access to financial resources. In addition, the diversification of exports is also limited by the reliability of transportation and logistics infrastructure, particularly in regions geographically distant from major ports and transportation hubs. Insufficient road networks, suboptimal port facilities, and limited cold storage capacity reduces the possibilities to transport products to international markets on time and in optimal condition. Finally, limited access to information and communications technologies (ICTs) also place an obstacle for the exports of many firms. The export activity requires broadband connectivity to reach consumers and to develop cheap and effective marketing campaigns. Moreover, firms need to use internet to navigate the complex web of trade regulations and bureaucratic procedures in foreign markets.[64]

4.4 Data and empirical strategy

Our analysis combines firm-level exports data from the Peruvian Customs Exports Registry (Ministry of Foreign Trade and Tourism) covering the period 2010-2019 and data on the coverage of broadband technologies from the Peruvian Regulator of the Telecommunications Market (OSIPTEL). We complement this information with data on the firms' sales and employees from the Taxpayers' Registry of the Peruvian Tax Authority (SUNAT).

[64] Tariffs, customs procedures, and compliance requirements vary from country to country, adding layers of complexity to the export process. Exporters allocate significant time and resources to ensure compliance, and the lack of familiarity with foreign regulatory frameworks can lead to costly delays and errors.

4.4.1 Firms' export activity

We use a firm-level dataset obtained from the Peruvian Customs Exports Registry covering all firms with an export activity in the period 2000–2019.[65] A unique identifier is allocated to each firm, which makes it possible to follow them over time and to connect it with the other datasets. As a result, we obtain an unbalanced panel of exporting firms that in the period examined had access to the DSL technology and whose number varies from 6,217 in 2010 to 5,565 in 2019.

The Registry provides the value of each firm' exports, expressed in US dollars, for each sector of activity in which it participates, to each country and in each year. We use this information to calculate the variable Exports, which represents the Free on Board (FOB) value of the firms exports at the country-sector-year level. Notice that firms can export products that belong to 15 different sectors: (1) agriculture; (2) chemical; (3) agriculture and livestock; (4) fishing; (5) handicrafts; (6) non-metallic mining; (7) metal-mechanics; (8) mining; (9) miscellaneous (including jewelry); (10) oil and natural gas; (11) skins and leather; (12) steel-metallurgy: (13) textile; (14) woods and papers; and (15) unclassified.66 Our final sample excludes exports in mining, petroleum, and gas, since these are monopolistic international markets in which trade takes place among a reduced and well known number of firms and intermediaries, under specific contract arrangements (see Fernandes et al. (2019) and Akerman et al (2022) for a similar approach).

Our dataset includes information on the exports' destination countries. This allows us to create the variable *Relations*, which counts the number of countries to which a firm exported in a given year, and the variable *HHI*, which is a Herfindhal Hirschman Index that measures the annual market concentration of firms' FOB exports to each county. A value of the *HHI* index close to 10,000 means that most of the firm's exports had a unique destination market. A low value implies that the firms had its exports diversified in several countries.

A key variable for our analysis is the firm's distance to the closest telephone local exchange (LE) that provides broadband Internet. The Customs Exports Registry collects the addresses of the exporting firms. We use this information to geolocate the firms and to calculate their distance to the centroid of the corresponding CPs for each firm, which is our proxy of the length of the local loop.[67] The geolocation of the firms allows us to determine if they are located in a CP with access to the DSL, HFC

[65] We restrict the analysis to this period to avoid the effects of the Covid pandemic on international trade.

[66] Firms could also be classified according to the 4-digit classification of the Tax Authority, but our analysis focusses on the 15categories of the Customs Registry

[67] A precise measure of the location of the local exchanges (LE) will be considered in a future revision of the paper.

(DOCSIS) or FTTX technologies. In addition, as we explain in the next section, the length of the local loop determines the quality of the DSL service used by the firm. We also use the address of the firms to calculate their distance to Lima, to the nearest airport and to the nearest port.

Finally, our dataset includes other relevant characteristics of the firms such as the number of employees per year (7-points discrete variable that classifies firms according to the number of workers) and the sales range per year (15-points discrete variable that classifies firms according to the total sales). This information has been obtained from the Peruvian Taxpayers Registry, who collects information for the universe of formal firms in the country (defined as those that pay taxes), with the exception of branches of foreign companies located in Peru. These variables are used as control of our baseline model and are also useful to examine the heterogeneous effects of the FTTX broadband deployment on different types of exporting firms.

We apply several cleaning strategies to get to the final estimating sample: we drop from the sample observations with a missing firm identifier, identifiers that correspond to individuals instead of firms, exports with zero value, and firms with a missing address. Moreover, since the objective of our analysis is to examine the effect of the upgrade in the quality of the broadband service, the final sample excludes firms in CPs that did not had access to the DSL technology.

Table 4.1 describes the main variables used in our analysis, separating the information for the whole sample and the information that we use to examine the effects on the intensive margin.

Table 4.1 – Summary Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
For the Extensive Margin					
Exports (US Dollars)	319652	1426783.000	2.21E+07	1	2.74E+09
Relations (# of destination counti	136846	2.336	3.535	1	60
Relations with EU countries	31835	1.764	1.585	1	17
HHI (destination concentration in	136846	8499.871	2466.823	487.2233	10000
Entry					
Exit					
Fiber Broadband coverage	310823	0.577	0.494	0	1
HFC (DOCSIS) coverage	310823	0.816	0.388	0	1
DSL coverage	310823	0.961	0.193	0	1
Distance to the capital city (Lima)	312350	123.813	273.577	0.088	1206.342
Distance to the closest port	312350	25.089	41.938	0.146	395.577
Distance to the closest airport	312350	16.725	17.208	0.342	319.178
For the Intensive Margin					
Exports (US Dollars)	260409	1594375.000	2.40E+07	1	2.74E+09
Relations (# of destination counti	101206	2.573	3.931	1	60
Relations with EU countries	101206	0.448	1.158	0	17
HHI (destination concentration in	101206	8343.498	2567.387	487.223	10000
Entry					
Exit					
Fiber Broadband coverage	259230	0.510	0.500	0	1
HFC (DOCSIS) coverage	259230	0.795	0.403	0	1
DSL coverage	259230	0.962	0.191	0	1
Distance to the capital city (Lima)	260387	118.029	267.109	0.0938	1206.342
Distance to the closest port	260387	24.433	41.001	0.1462	382.0439
Distance to the closest airport	260387	16.720	16.926	0.3417	319.1776

4.4.2 Broadband Deployment Across Locations

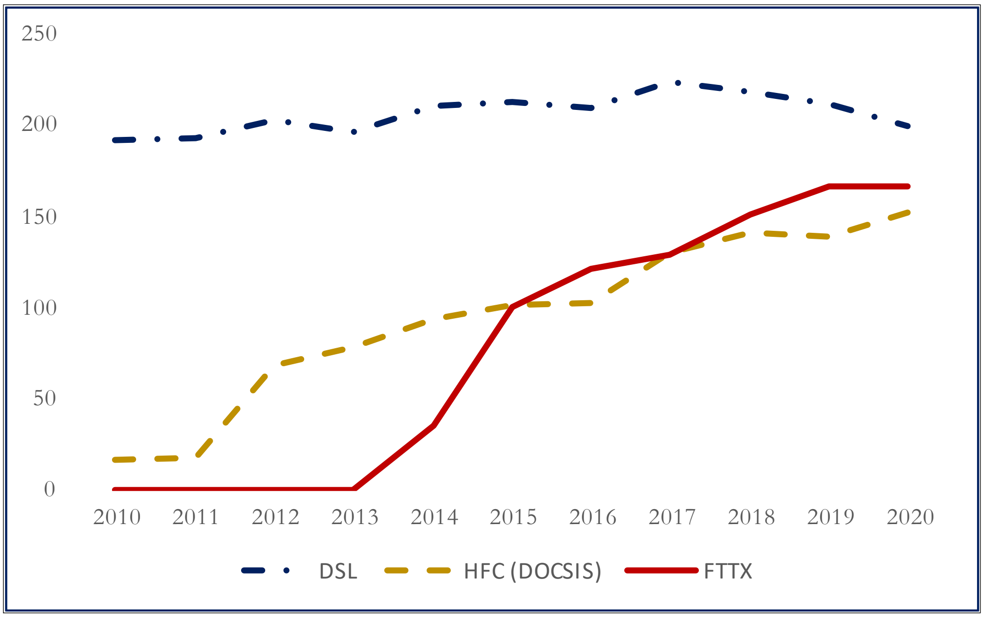
We use annual information on the deployment of broadband lines in Peru for the period 2010-2019. This data has been obtained from the Peruvian regulator of the telecommunications market (OSIPTEL), who collects information from firms to elaborate its market reports and studies. The data is at the Centro Poblado (CP) level, which is the smallest administrative jurisdiction in the country. Peru has 24 regions, including 196 provinces, 1,874 districts and more than 90 thousand CPs, many of them with less than 100 inhabitants. Most of the Peruvian population and economic activity is concentrated in a reduced number of CPs in the Coastal Region.

Our analysis focusses on the CPs that have access to fixed broadband technologies. The dummy variable DSL takes a value of 1 in the years in which firms were located in a CPs with access to the Digital Subscriber Line (DSL). In the early 2000s, the DSL technology allowed to adapt the existing copper lines of incumbent telecommunication operators to offer broadband Internet. The speed of these lines can nowadays seem relatively low, but the DSL technology revolutionized the way to access the Internet. It provided small and medium sized firms low-cost access to a broadband connection, allowing them to create websites, develop e-commerce sales and extend their market reach. The dummy variable HFC (DOCSIS) takes the value of 1 in the years in which the firms were located in a CP with access to the Hybrid Fiber Coaxial (HFC) technology, which were operated using the DOCSIS standard. HFC (DOCSIS) networks are hybrid fiber optic and coaxial cable telecommunications network that allows the transmission of video, voice and data in broadband. The main drawback of this technology is that it uses coaxial cable in the local loop, which is cheaper and easier to install for operators, but offer a reduced quality to the users. Finally, the dummy variable FTTX takes the value of 1 for the years in which firms were located in a CP with access to Fiber-To-The-X network (FTTX). FTTX networks use optic fiber network to the home of the users (FTTH) or to other levels of the network (FTTX). In Peru, this technology was launched in 2014.

Figure 4.4 shows the expansion of broadband internet in the CPs with exporting firms. In 2010, 184 of the 185 CPs with exporting firms had access to the DSL technology and 16 to the HFC (DOCSIS) technology. This number increased in the following years and decreased to 197 CPs in 2020. In the 2010s, a large fraction of the CPs with exporting firms gained access to high-speed broadband technologies (HFC and FTTX networks). The figure shows that in 2020 there were 151 CPs with access to the HFC (DOCSIS) and 163 CPs with access to FTTX lines.

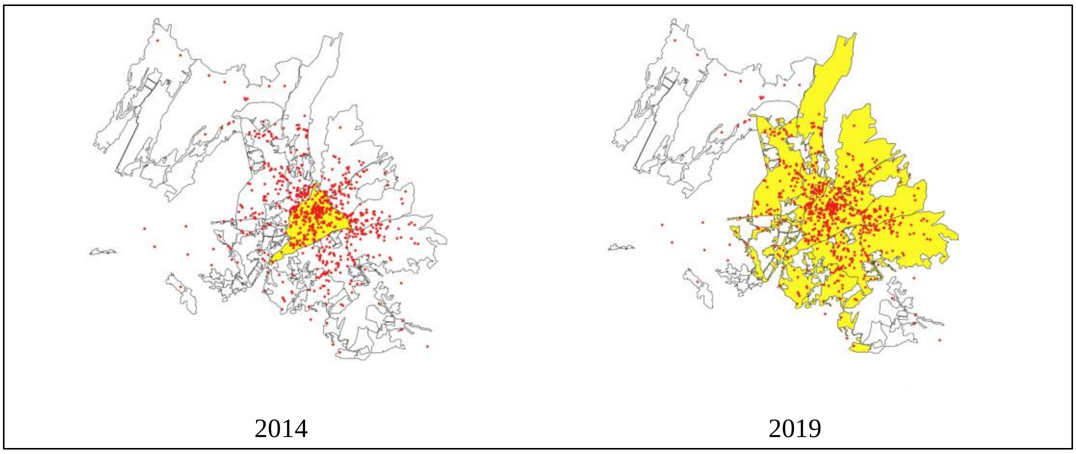
Figure 4.5 shows as an example the deployment of the FTTX in the city of Arequipa in 2014 and 2019. The red dots represent the exporting firms, and the yellow polygons are the CPs with access to FTTX technology. While in 2014 only firms located at the CP of Arequipa city center had access to the FTTX, in 2019 all firm in the surrounding CPs had access to it.

Figure 4.4 – Expansion of broadband internet by Centro Poblado.



Note: The figure shows the evolution of broadband lines in the CPs with exporting firms in the period 2010-2020. *Asymmetric Digital Subscriber Lines* (DSL) use the existing copper wires at a relatively low speed. *Hybrid Fiber Coaxial* (HFC) lines used the DOCSIS standard, which is considered a high-speed technology. *Fiber-to-the-x* (FTTX) uses optic fiber network and could offer speeds higher than 600 Mbps.

Figure 4.5 – Expansion of Broadband Internet and Exporting Firms, city of Arequipa, 2014 and 2019



Note: The figure shows exporting firms in red dots for the period 2014 (left figure) and 2019 (right figure). The yellow polygons are *Centros Poblados* (CP) with access to the *Fiber-to-the-x* (FTTX) technology.

Source: Own elaboration

The deployment of fixed broadband networks in Peru has been driven by the interaction of private and public decisions (Argandoña and More, 2020). In the early years of the construction of the fixed telephony networks, operators based their deployment decisions considering the potential demand of each CP, which was determined by their population density and income. In the 2000s, operators updated their cooper lines with DSL in the high demand areas (Pacheco, 2012). However, DSL networks were not enough to satisfy the new needs of the users. Very soon, the demand for fast speed Internet services led private operators to the rollout a HFC network in the coastal region of Peru, which concentrates most of the economic activity and has low installation costs. In addition, in 2012 the Peruvian government launched a national plan to universalize access to FTTX broadband services in all regions of the country, regardless of their commercial interest. The Government decided to connect the 196 capitals of province of the country and opened a tendering process to determine the operator that had to build and operate the new fiber backbone network (MTC, 2022). The concession was offered to Azteca Communications, which started the deployment of the FTTX technology in 2014 and covered the coastal regions as well as the highlands and the jungle areas. Interesting enough, the new red dorsal incentivized private operators to develop their own fiber infrastructures and had an important effect for market competition, lowering telecommunications prices. It has been estimated that the red dorsal overlaps with the backbone networks of private operators (Telefónica, Claro, and América Móvil) in more than 70% of its coverage. This situation has eroded the attractive of the Azteca network, because private operators usually rent their networks at a lower price. Indeed, Azteca Comunicaciones had little incentives to compete in the market because its fees are regulated. As a result, in 2022 the Government decided to the cancel the contract with the firm and nowadays the red dorsal is operated and maintained by the government.

Finally, it is important to explain that exporting firms could benefit from the new FTTX networks in several ways. First, the irruption of this technology boosted competition and lowered the price of broadband services, increasing the chances for firms to contract a fast Internet line. Second, it improved the quality of the Internet connections, which allowed firms to adopt ICTs. DSL and HFC (DOCSIS) technologies face an attenuation of their speed when the length of the local loop is longer than 2,5 kilometers (Analysos Mason, 2020; Ahlfeldt, et al. 2017). This situation limits the quality of the service that might obtain the firms located at a longer distance from the local exchanges.

4.4.3 Empirical Specification

The objective of this paper is to examine the impact of the deployment of the FTTH technology in the intensity and the diversification of the firms' exports. To do this, we adopt a difference-in-differences approach (DiD) that exploits the staggered arrival of the FTTX technology at the CPs, on firms that are more than 2,5 kilometers away from the telephone local exchanges.

Our analysis uses the plausibly exogenous spatial variation in broadband availability generated by the deployment of the fiber network. Most of the previous works examining the effect of broadband deployment have considered firms that initially accessed the Internet through dial-up connections and estimate the impact of the staggered deployment of DSL technology on different types of outcomes. Our paper departs from this analysis, as we focus on the deployment of the FTTX technology in CPs that already had access to the DSL technology. In Peru, the main expansion of the FTTX technology was initially rolled-out by Azteca Communications in 2014 and it was progressively deployed on the capitals of province of the country. After controlling for firm and year fixed effects, we consider that the availability of fiber broadband for firms was exogenous and that the timing of the deployment was unrelated to potential correlates of the firms' export activity (see Appendix B for a detailed analysis).

We estimate the following DID model, using a fixed effects estimation technique.

$$y_{isct} = \alpha + \beta FTTX_{it} + X_{\gamma} + \eta_i + \tau_t + \lambda_s + \upsilon_c + \varepsilon_{ict} \qquad (1)$$

where y_{isct} is the outcome of interest (i,e, exports, relations, *HHI*) for firm *i* that in year *t* exported products of sector *s* to the country *c*. For the construction of the variables *Relations* and *HHI* we collapse the dataset at the firm level, and we count the number of countries to which firms export and calculate the *HHI* index of the exports to the destination countries. The dummy variable $FTTX_{it}$ takes the value of 1 for the years in which the CP of the firm had access to the FTTX technology, and β is the DiD coefficient that reflects the effect of the FTTX lines on the outcome variables. In the model, X is a vector of control variables about the CP characteristics, such as the coverage of the HFC (DOCSIS) technology. The model includes fixed effects at the level of the firm (η_i), the sector (λ_s) and the country of destination of the exports (υ_c), and it also includes year fixed effects (τ_t). Standard errors have been clustered at the firm level.

In addition to this approach, our analysis exploits the heterogeneous quality of the DSL service that received firms before the arrival of the FTTX lines. In a DSL network, the maximum bandwidth depends on the length of the copper wire between the consumer premises and the telephone local exchange (i.e the length of the local loop). Technical reports have shown that with the DSL the bandwidth slowly decreases for a distance of up to 2 km, then strongly decreases with distance and from approximately 4 kilometers it offers a quality similar to those of the dial up technology.

Considering this, we expect that firms that benefited more with the upgrade of the FTTX technology were those located more than 2.5 km away from the local exchanges. Specifically, our DiD estimation compares the difference in the outcome variables in firms exposed to the FTTX technology who were closer and further away from the 2.5 km to the local exchanges, relative to the difference between firms not exposed to the FTTX technology who were located closer and further away from the local exchanges. We estimate the following model:

$$y_{iscpt} = \alpha + \beta FTTX_{it} * D_i + \boldsymbol{X}_{\gamma} + \eta_p + \lambda_s + \upsilon_c + \tau_t + \varepsilon_{ict} \qquad (2)$$

where y_{iscpt} is the outcome of interest (i,e, exports, relations, *HHI*) for firm i located at CP p that during the year t exported products of sector s to the country c. In this equation, the dummy variable $FTTX_{it}$ takes the value of 1 for the years in which the FTTX lines were available at the CP, and D_i is a dummy variable that takes the value of 1 for the firm that are at least 2.5 kms away from the local exchange. In section 4.5 we assess the robustness of our results when we consider different thresholds for this variable. Finally, β is the DiD coefficient that reflects the effect of the FTTX lines on the export activity of firms located at a distance longer than 2.5 km from the local exchange.

As before, $\boldsymbol{X}$ is a vector of control variables about the CP characteristics (HFC coverage, distance to Lima, distance to the nearest port and distance to the nearest airport). The model in equation (2) includes fixed effects at the level of the CP (η_i), the sector (λ_s) and the destination of the exports (υ_c), and we also include year fixed effects (τ_t). Standard errors have been clustered at the firm level. Finally, notice that the sample used for the estimation of equations (1) and (2) is restricted to firms that in the period 2010-19 had access to the DSL technology.

Our analysis is not the first to use the distance as instrument to deal with potential endogeneity in the deployment of broadband technologies, although most papers use the timing of the broadband deployment as identification strategy. Fabling and Grimes (2016) use the distance of firms to local primary or secondary schools, since these schools were the target of a broadband rollout program in New Zealand. Czernich (2012) examines the effect of the Internet on voter turnout in the German federal election in 2005, using the linear distance to the local exchange as instrument for DSL availability in both East and West Germany. Czernich (2014) uses the distance as instrument to examine the effect of broadband internet on the unemployment rate across German municipalities. Falck et al. (2014) use a similar identification strategy to analyze the causal impact of Internet on voting behavior in Germany. DeStefano et al. (2018) use the distance to the local exchange as an instrument to study the effects of heterogeneous types of ICT on firm performance, but in contrast to the previous works they calculate the local loop distance for each firm, rather than to consider the average distance across many firms within a municipality. The difference of our analysis with respect to these papers is that we consider that the treated firms are those exposed to the FTTX technology and that are located more than 2,5 kilometers away from the telephone local exchanges.

4.5 Fixed Effects Results

4.5.1 Main Results

Table This section presents the main results of our analysis of the causal effects of broadband deployment on firms' export activity. Panel A in Table 4.2 shows the results of the fixed effects model of equation (1). We find that the average impact of the availability of the FTTX technology was a 6.2% increase in the value of exports. Moreover, the deployment of this technology did not have a significant effect in the number of destination countries, but it reduced the concentration on the exports in the destination countries (HHI index) by 1.8%. These results suggest that the deployment of the fiber technology increased the firms' exports and contributed to diversify their commercial activity, specifically by diversifying destination markets.

Table 4.2 – Effects of Broadband Deployment on Exports Value, Number of Relations, and Diversification of Exports

	Panel A			Panel B		
	(1)	(2)	(3)	(4)	(5)	(6)
Type of Firm	All	All	All	All	All	All
Dependent Variable	ln(Exports)	ln(Relations)	ln(HHI)	ln(Exports)	ln(Relations)	ln(HHI)
Fiber Broadband coverage (FTTX)	0.0652*	0.0194	-0.0181**	0.0948	0.0201	-0.0197**
	(0.0340)	(0.0119)	(0.0075)	(0.0474)	(0.0134)	(0.0080)
Distance>2.5K				0.2834**	0.0811***	-0.0341***
				(0.0891)	(0.0262)	(0.0131)
FTTX # Distance>2.5K				0.3553***	0.0859***	-0.0477***
				(0.0965)	(0.0291)	(0.0152)
HFC (DOCSIS) coverage	-0.0241	0.0052	-0.0020	0.0127	0.0076	-0.0038
	(0.0338)	(0.0104)	(0.0067)	(0.0452)	(0.0117)	(0.0070)
Distance to Lima				0.0146	-0.0123	0.0057
				(0.0304)	(0.0078)	(0.0040)
Distance to the closest port				0.0263	0.0023	-0.0003
				(0.0281)	(0.0074)	(0.0039)
Distance to the closest airport				-0.0012	0.0035**	-0.0027*
				(0.0288)	(0.0080)	(0.0042)
Constant	9.8352***	0.4612***	8.9771***	7.4392**	1.6165	8.4393***
	(0.0350)	(0.0123)	(0.0071)	(3.2402)	(0.8071)	(0.4164)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	NO	NO	NO
Centro Poblado FE	NO	NO	NO	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES
Destination country FE	YES	YES	YES	YES	YES	YES
Observations	243585	99333	99333	202011	88983	88983
Number of firms	13898	13429	13429	16786	16784	16784
R-squared	0.49	0.57	0.52	0.27	0.10	0.08

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

Panel B in Table 4.2 presents the estimates of the DiD model of equation (2), where we consider our proxy for the length of the local loop. As discussed above, we consider a threshold of 2.5 km to draw the line between the firms that prior to the arrival of the FTTX technology had a good DSL service (distance $\leq$ 2.5 km) and those that had a poor service (distance > 2.5 km). We find that for the firms located more than 2.5 km away from the local exchanges, the arrival of FTTX technology increased the value of exports by 35.5% and the number of destination markets by 8.5%, while it reduced the concentration of the export activity by 4.7%. As expected, the coefficients of the interaction of the dummies for FTTX and the distance are highly significant, and their value are higher in absolute terms than those of the fixed effect regressions in Panel A. Moreover, we observe that the FTTX variable is only significant and negative in the case of the HHI variable.

The previous results have considered the full sample of firms with an export activity in the period examined. Table A.2 in Appendix A repeats the previous analysis focusing only in the firms that had an export activity in the period 2010-2013, that is, before the deployment of the FTTX technology. The results of this "intensive margin" analysis are very similar to those in Table 4.2. In the case of the DiD regressions of

Panel B we find larger coefficients for the interaction of the FTTX and the distance variable, implying a stronger impact of the new technology for firms with a more extensive export record. Notice that while the analysis of Table 4.2 considers 16,784 firms, the results in Table A.2 are for the 10,400 firms.

Table A.3 in the Appendix A repeats the analysis of Panel B in Table 4.2 but using different thresholds for the distance variable. Panel A considers a threshold of 3.5 kilometers and Panel B eliminates the observations of those firms that are between 2 and 3 kilometers from the local exchanges, which might obtain an ambiguous quality from the DSL service. The results obtained in the two panels confirm our previous findings.

To sum up, our results in this section show that the deployment of the FTTX networks had an important impact in the export activity of Peruvian firms, increasing the value of their exports and the number of countries to which they export. The arrival of the new technology also increased the diversification of export markets. Moreover, we have found that these effects are mostly driven by firms that had a poor DSL service before the arrival of the FTTX and that the effects are more intense for the firms that were exporting before the arrival of the new technology.

4.5.2 Heterogeneity Analysis

A priori, it is difficult to anticipate whether the arrival of the FTTX had a stronger impact on micro, small, medium or large firms. Small firms could have little mechanisms and resources to compensate the absence of high-speed internet in their *Centros Poblados* and therefore they could benefit relatively more after the arrival of the new technology. However, these firms also had less capacity to re-organize their activities and fewer resources to acquire new equipment to improve their performance after the arrival of the fiber. In this section, we explore the heterogeneous effects of broadband access by examining its impact on firms that have different sizes (considering their total sales and the number of workers) or that belong to different sectors.

As explained in Section 3.1, the Peruvian Tax Authority has created the variable Sales Range to classify firms according to their total sales (which include exports). Table 4.3 repeats the analysis of Panel B of Table 4.2, when we divide the sample of firms in two groups according to this classification. Specifically, we consider that Micro-Small firms are those with sales up to 2.3 million dollars and Medium-Large firms are those with sales higher than 2.3 million dollars.[68] The results of this analysis show that the

[68] The variable Sales Range is expressed in terms of a tax unit value (UIT) whose monetary value is updated every year. One UIT was equivalent to 1,370 US dollars in 2013. Micro firms

deployment of the FTTX technology boosted the exports value of Micro-Small and Medium-Large firm by 26,9% and 33.1%, respectively. The new technology also increased by 11.7% the number of destination countries in the case of Medium-Large firms and had a positive and non-significant effect for Micro-Small firms. Finally, the arrival of the new technology reduced the concentration of the destination countries by 2.4% for Micro-Small firms and by 5.6% for Medium-Large firms. Overall, we find slightly weaker effects of the new technology for Micro-Small firms than for Medium-Large firms.

An alternative way to classify firms is to consider their number of workers. Table 4.4 repeats the previous analysis when we divide the sample of firms between those with less than 50 workers and those with 50 or more workers. We find that the deployment of the FTTX technology increased the exports value of the two types of firms by 28.1% and 41.1%, respectively. The new technology also increased by 9.3% the number of destination countries in the case of Medium-Large firms and reduced by 2.9% the concentration of the destination countries in the case of Micro-Small firms. Therefore, the results are very similar than those in Table 4.3.

Finally, we examine the effects of the FTTX technology for each of the 12 sectors considered in our analysis (mining, non-metal mining and petroleum and natural gas sectors are excluded from the estimated sample). Table 4.5 presents the results of the interaction of the FTTX and the distance variables. We find that the firms of the metal-mechanical sector and the steel-metallurgical sector experienced an expansion in their exports and an increase in their diversification after the arrival of the FTTX technology. In addition, the agriculture, farming and livestock, miscellaneous (including jewelry), and woods and papers had an increase in their exports. The firms in the skins and leather sector increased their diversification after the arrival of the FTTX.

are those with annual sales up to 150 UITs (205.5 thousand dollars), small firms are those with sales higher than 150 UITs up to 1,700 UITs (2.3 million dollars), medium size firms have sales that go from 1,700 UITs up to 2,300 UITs (3.2 million dollars), and large firms have annual sales higher than 2,300 UITs.

Table 4.3 – Effects of Broadband Deployment on Exports Value, Number of Relations, and Diversification of Exports, by Sales Range

	Panel A			Panel B		
	(1)	(2)	(3)	(4)	(5)	(6)
Type of Firm	Micro-Small	Micro-Small	Micro-Small	Medium-Large	Medium-Large	Medium-Large
Dependent Variable	ln(Exports)	ln(Relations)	ln(HHI)	ln(Exports)	ln(Relations)	ln(HHI)
Fiber Broadband coverage (FTTX)	0.0550	0.0207	-0.0193**	0.1283*	0.0230	-0.0196
	(0.0575)	(0.0145)	(0.0087)	(0.0697)	(0.0311)	(0.0191)
Distance>2.5K	0.1941***	0.0452**	-0.0244**	0.2999**	0.0884*	-0.0259
	(0.0768)	(0.0218)	(0.0123)	(0.1375)	(0.0479)	(0.0243)
FTTX # Distance>2.5K	0.2690***	0.0295	-0.0242*	0.3315**	0.1175**	-0.0565*
	(0.0845)	(0.0237)	(0.0138)	(0.1458)	(0.0554)	(0.0304)
HFC (DOCSIS) coverage	0.0109	0.0134	-0.0048	-0.0012	-0.0230	0.0075
	(0.0539)	(0.0136)	(0.0082)	(0.0662)	(0.0229)	(0.0138)
Distance to Lima	-0.0205	-0.0052	0.0037	0.0491	-0.0086	0.0030
	(0.0222)	(0.0056)	(0.0035)	(0.0490)	(0.0142)	(0.0075)
Distance to the closest port	-0.0178	-0.0012	-0.0002	0.0349	0.0058	-0.0003
	(0.0219)	(0.0061)	(0.0034)	(0.0434)	(0.0137)	(0.0076)
Distance to the closest airport	0.0034	-0.0037	0.0020	0.0433	0.0232	-0.0149
	(0.0228)	(0.0058)	(0.0034)	(0.0469)	(0.0155)	(0.0083)
Constant	11.7541***	0.9953	8.5694***	4.0049	0.8909	8.8785***
	(2.6992)	(0.6753)	(0.4267)	(4.6659)	(0.9947)	(0.5269)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO
Centro Poblado FE	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES
Destination country FE	YES	YES	YES	YES	YES	YES
Observations	97031	58858	58858	104960	30108	30108
Number of firms	14190	14188	14188	4232	4226	4226
R-squared	0.28	0.08	0.07	0.27	0.19	0.15

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

Table 4.4 – Effects of Broadband Deployment on Exports Value, Number of Relations, and Diversification of Exports, by Number of Workers

	Panel A			Panel B		
	(1)	(2)	(3)	(4)	(5)	(6)
Type of Firm	<50 workers	<50 workers	<50 workers	>= 50 workers	>= 50 workers	>= 50 workers
Dependent Variable	ln(Exports)	ln(Relations)	ln(HHI)	ln(Exports)	ln(Relations)	ln(HHI)
Fiber Broadband coverage (FTTX)	0.0491	0.0117	-0.0159*	0.1913**	0.0337	-0.0198
	(0.0567)	(0.0146)	(0.0088)	(0.0853)	(0.0352)	(0.0206)
Distance>2.5K	0.2463***	0.0551***	-0.0266**	0.3632**	0.0932*	-0.0317
	(0.0791)	(0.0208)	(0.0117)	(0.1476)	(0.0506)	(0.0265)
FTTX # Distance>2.5K	0.2815***	0.0369	-0.0294**	0.4117***	0.0936*	-0.0403
	(0.0884)	(0.0234)	(0.0137)	(0.1515)	(0.0552)	(0.0301)
HFC (DOCSIS) coverage	-0.0168	0.0075	-0.0022	0.0427	-0.0211	0.0113
	(0.0533)	(0.0126)	(0.0075)	(0.0716)	(0.0278)	(0.0168)
Distance to Lima	-0.0346	-0.0076	0.0046	0.0523	-0.0078	0.0027
	(0.0237)	(0.0054)	(0.0033)	(0.0535)	(0.0139)	(0.0074)
Distance to the closest port	0.0134	0.0004	-0.0001	0.0343	0.0095	-0.0022
	(0.0261)	(0.0062)	(0.0036)	(0.0446)	(0.0135)	(0.0074)
Distance to the closest airport	0.0248	0.0011	-0.0012	0.0169	0.0127	-0.0078
	(0.0257)	(0.0059)	(0.0035)	(0.0506)	(0.0152)	(0.0080)
Constant	12.5327***	1.1459	8.5372***	3.5392	1.0009	8.7907***
	(2.8221)	(0.6028)	(0.3750)	(5.3230)	(1.1750)	(0.6274)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO
Centro Poblado FE	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES
Destination country FE	YES	YES	YES	YES	YES	YES
Observations	111557	62502	62502	90873	26849	26849
Number of firms	14761	14753	14753	6129	6116	6116
R-squared	0.29	0.10	0.09	0.27	0.16	0.12

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

Table 4.5 – Effects of Broadband Deployment on Exports Value, Number of Relations, and Diversification of Exports, by Sector

	(1)	(2)	(3)
Dependent Variable	**ln(Exports)**	**ln(Relations)**	**ln(HHI)**
Agricultural	1.1410**	0.0177	-0.276
	(0.4859)	(0.1663)	(0.0925)
Chemical	0.3628	0.0624	-0.0195
	(0.2691)	(0.0569)	(0.0331)
Farming and Livestock	0.3270**	0.0513	-0.0367
	(0.1385)	(0.0680)	(0.0376)
Fishing	-0.0685	0.1759	-0.2656
	(0.3374)	(0.1524)	(0.0841)
Handicrafts	0.7952	0.0656	-0.0469
	(0.5752)	(0.0855)	(0.0420)
Metal-Mechanical	0.6883***	0.1316***	-0.0585**
	(0.2016)	(0.0417)	(0.0229)
Miscellaneous (including jewerly)	-0.4839**	0.0328	-0.0231
	(0.2024)	(0.0458)	(0.0249)
Skins and leather	0.2013	0.1262*	-0.1039**
	(0.2723)	(0.0645)	(0.0412)
Steel-metallurgical	0.7624**	0.1474**	-0.0910**
	(0.3512)	(0.0699)	(0.0383)
Textile	0.036	0.0235	-0.0231
	(0.1802)	(0.0508)	(0.0278)
Woods and papers	0.6895**	0.0885	-0.0497
	(0.2908)	(0.0682)	(0.0419)
Unclassified	-1.3476	-0.4378	-0.0910
	(1.0258)	(0.3895)	(0.0383)
Year FE	YES	YES	YES
Firm FE	NO	NO	NO
Centro Poblado FE	YES	YES	YES
Destination country FE	YES	NO	NO

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

4.5.3 The Free Trade Agreement with the European Union

In 2013, Peru signed a Free Trade Agreement (FTA) with the European Union (See Table A1 in Appendix A). The objective of the FTA is to reduce the trade barriers and help exporters to develop long-term relationships with the European countries. Notice, however, that the success of these agreements depends on the availability of Peruvian firms to reorganize their activities to intensify their exports to this region. Our next analysis examines whether after the signature of the FTA Peruvian firms increased their exports to the EU and whether the broadband availability contributed to the intensification of their exports. We estimate the following model:

$$y_{isct} = \alpha + \beta FTTX_{it} * \ FTAEUS_{it} + X_{\gamma} + \eta_i + \lambda_s + \varepsilon_{ict} \qquad (3)$$

where y_{isct} is the outcome of interest (i,e, exports, relations, HHI) for firm *i* that in year *t* exported products of sector *s* to the country *c*. The dummy variable $FTAEUS_{it}$ takes the value of 1 when the firm exported to the EU and after the signature of the agreement, and β is the DiD coefficient that reflects the effect of the FTTX availability on the outcome variables if the firm was affected by the agreement. The vector ***X*** includes the same control variables than the model (1) above. In addition, in order to reflect the trade agreements signed by Peru, we use dummy variables that reflect whether the exports have as destination China (FTAChina), the United States (FTAUSA) and the European Union (FTAEU), Finally, the model includes fixed effects at the level of the firm (η_i) and the sector (λ_s). Standard errors have been clustered at the firm level.

Panel A in Table 4.6 shows the results of our analysis when we do not interact the variables FTTX and FTAUES. We obtain that the signature of the agreement did not affect the value of the exports, but it increased the number of relations of the exporting firms and reduced market concentration. Panel B presents the estimates of equation (3) and reveals that after the signature of the FTA firms with access to the FTTX technology exported relatively more and increased the number of relations and the level of diversification relatively more than the firms without access to the fiber. These findings confirm that the availability of communications infrastructures is essential for the success of commercial policies such as the signature of FTAs.

Table 4.6 – Fixed Effects Regressions of Fiber Broadband Destination and EU Free Trade Agreements on Exports

	Panel A			Panel B		
	(1)	(2)	(3)	(4)	(5)	(6)
Type of Firm	All	All	All	All	All	All
Dependent Variable	ln(Exports)	ln(Relations)	ln(HHI)	ln(Exports)	ln(Relations)	ln(HHI)
Fiber Broadband coverage (FTTX)	0.0602**	0.0210*	-0.0191***	0.0651*	0.0249*	-0.0221***
	(0.0340)	(0.0101)	(0.0068)	(0.0345)	(0.1126)	(0.0070)
FTA EU	-0.0094	0.7097**	-0.3424***	0.0504	0.0296**	-0.0147*
	(0.3441)	(0.0115)	(0.0075)	(0.0423)	(0.0126)	(0.0088)
FTTX # FTA EU				0.0957*	0.0417***	-0.0264**
				(0.1032)	(0.0154)	(0.0107
Controls	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES
Destination country FE	NO	NO	NO	NO	NO	NO
Observations	243599	99333	99333	243599	99333	99333
Number of firms	13899	13429	13429	13899	13429	13429
R-squared	0.47	0.72	0.63	0.44	0.72	0.63

4.6 Conclusions

Digitalization has modified the organization of firms and the way they communicate with their clients and providers. This paper has shown that firms with access to high-speed Internet are more likely to participate in international markets, increase their export sales, and diversify their destination markets. Moreover, we have explained that the benefits of broadband adoption are not limited to large firms or specific sectors but are widespread across different types of firms and industries. These findings have important implications for policymakers, business leaders, and investors who seek to promote economic growth and competitiveness in the digital age.

Our research contributes to the literature on the impact of ICT on trade by providing new empirical evidence on the role of broadband Internet in firms' export behavior using a large-scale dataset. We have shown that fiber broadband deployment can help firms overcome barriers that limit the scale of their participation in international markets, such as information and coordination barriers and transaction costs. These findings are consistent with the view that ICT is a key driver of globalization and that firms that embrace digital technologies are more likely to succeed in the global marketplace.

Similar to DeStefano et al. (2018), we have found that is not only the access to broadband technologies but the speed of the service what matters for firm scale. In the case of Peru, the arrival of the high-speed Internet has had a larger impact in firms that previously had a poor-quality DSL access. Specifically, we have shown that for those firms located more than 2.5 kilometers away from the local exchanges, the arrival of FTTX technology increased the value of exports by 35.5% and the number of destination markets by 8.5%, while it reduced the concentration of the export activity by 4.7%.

While our study focuses on the causal effects of broadband deployment on firms' export activity, there are several avenues for future research that could extend our analysis. For example, future studies could examine the heterogeneity of the effects of broadband adoption across different regions and countries. They could also investigate the mechanisms through which broadband affects firms' export performance, such as the investment in and use of ICT at the firm level, role of online platforms, social networks, and digital marketing strategies. Finally, they could explore the implications of broadband adoption for other aspects of firms' operations, such as merging decisions and industry concentration, productivity, innovation and human capital, or for other sectors of economic activity such as education, healthcare and public services.

Our findings have important policy implications for governments, regulators, and industry associations that seek to promote the adoption and use of broadband Internet, and also for those that seek to promote exports and market diversification. First, policymakers should prioritize investments in high-speed broadband infrastructure and digital skills development, especially in regions and sectors that are lagging behind in terms of connectivity and digital literacy. Second, they should foster a supportive regulatory environment that encourages competition, innovation, and consumer protection in the digital sector. Third, they should promote international cooperation and standardization in areas such as data privacy, cybersecurity, and cross-border e-commerce, to facilitate firms' participation in global value chains.

Appendix A

Table 4.A1 – Peru Trade Agreements

Andean Community	**Signature**	**Effective**
Bolivia, Ecuador, Colombia	May 1969	May 1969
FTA (Free Trade Agreements)	**Signature**	**Effective**
United States	April 2006	February 2009
Chile	August 2006	March 2009
Canada	May 2008	August 2009
Singapore	May 2008	August 2009
China	April 2009	March 2010
Switzerland (EFTA)	July 2010	July 2011
Liechtenstein (EFTA)	July 2010	July 2011
Iceland (EFTA)	July 2010	October 2011
South Korea	March 2011	August 2011
Thailand	November 2010	December 2011
Mexico	April 2011	February 2012
Japan	May 2011	March 2012
Panama	May 2011	May 2012
Norway (EFTA)	July 2010	July 2012
European Union	April 2011	February 2013
Costa Rica	May 2011	June 2013
Venezuela (Partial FTA)	January 2012	August 2013
Pacific Alliance	February 2014	May 2016
Honduras	May 2015	January 2017
Australia	February 2018	February 2020
United Kingdom	May 2019	December 2020
New Zealand (CPTPP)	March 2018	September 2021
Vietnam (CPTPP)	March 2018	September 2021
Malaysia (CPTPP)	March 2018	November 2022
Brunei (CPTPP)	March 2018	July 2023
ACE Agreements	**Signature**	**Effective**
Cuba	October 2000	January 2001
Mercosur	August 2003	November 2005

Note: FTA with other countries have concluded: Guatemala (signed December 2011). Others are in negotiations: El Salvador, Hong Kong, India, Turkey.

Source: https://www.acuerdoscomerciales.gob.pe/

Table 4.A2 – Effects of Broadband Deployment on Exports Value, Number of Relations, and Diversification of Exports, Intensive Margin.

	Panel A			Panel B		
	(1)	(2)	(3)	(4)	(5)	(6)
Type of Firm	All	All	All	All	All	All
Dependent Variable	ln(Exports)	ln(Relations)	ln(HHI)	ln(Exports)	ln(Relations)	ln(HHI)
Fiber Broadband coverage (FTTX)	0.0632*	0.0145	-0.0154*	0.1263**	0.0322**	-0.0266***
	(0.0358)	(0.0129)	(0.0082)	(0.0493)	(0.0157)	(0.0095)
Distance>2.5K				0.2829***	0.0807***	-0.0328**
				(0.0932)	(0.0286)	(0.0142)
FTTX # Distance>2.5K				0.3808***	0.1196***	-0.0638***
				(0.1079)	(0.0355)	(0.0186)
HFC (DOCSIS) coverage	-0.0246	0.0028	-0.0007	0.0176	-0.0013	-0.0001
	(0.0340)	(0.0105)	(0.0068)	(0.0471)	(0.0129)	(0.0077)
Distance to Lima				0.0183	-0.0144	0.0067
				(0.0336)	(0.0090)	(0.0047)
Distance to the closest port				0.0237	0.0019	0.0004
				(0.0314)	(0.0085)	(0.0046)
Distance to the closest				0.0038	0.0041	-0.0030
				(0.0327)	(0.0094)	(0.0049)
Constant	9.9397***	0.5070***	8.9548***	7.1478***	1.8343	8.3240***
	(0.0340)	(0.0105)	(0.0068)	(3.5228)	(0.8958)	(0.4658)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	NO	NO	NO
Centro Poblado FE	NO	NO	NO	YES	YES	YES
Sector FE	NO	NO	NO	YES	YES	YES
Destination country FE	YES	YES	YES	YES	YES	YES
Observations	208850	79782	79782	169119	69271	69271
Number of firms	9306	9049	9049	10411	10410	10410
R-squared	0.47	0.52	0.51	0.27	0.12	0.10

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

Table 4.A3 – Effects of Broadband Deployment on Exports Value, Number of Relations, and Diversification of Exports

	Panel A			Panel B:		
	(1)	(2)	(3)	(4)	(5)	(6)
Type of Firm	All	All	All	All	All	All
Dependent Variable	ln(Exports)	ln(Relations)	ln(HHI)	ln(Exports)	ln(Relations)	ln(HHI)
Fiber Broadband coverage (FTTX)	0.0894*	0.0189	-0.0191**	0.0794*	0.0195*	-0.0187*
	(0.0458)	(0.0131)	(0.0075)	(0.0470)	(0.0143)	(0.0184)
Distance>3.5K	0.1651	0.0702	-0.0291*			
	(0.1251)	(0.0309)	(0.0079)			
FTTX # Distance>3.5K	0.2529*	0.0728**	-0.0432**			
	(0.1294)	(0.0119)	(0.0174)			
Distance>3.5K				0.1709	0.0602	-0.0258
(without distance >2.5 & <3.5)				(0.1329)	(0.0313)	(0.0131)
FTTX # Distance>3.5K				0.24119*	0.0651**	-0.0402*
(without distance >2.5 & <3.5)				(0.1328)	(0.0327)	(0.0152)
Controls	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	NO	NO	NO
Centro Poblado FE	NO	NO	NO	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES
Destination country FE	YES	YES	YES	YES	YES	YES
Observations	202011	88983	88983	180944	80206	80206
Number of firms	16786	16784	16784	15152	15150	15150
R-squared	0.27	0.10	0.08	0.27	0.11	0.09

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

Appendix B

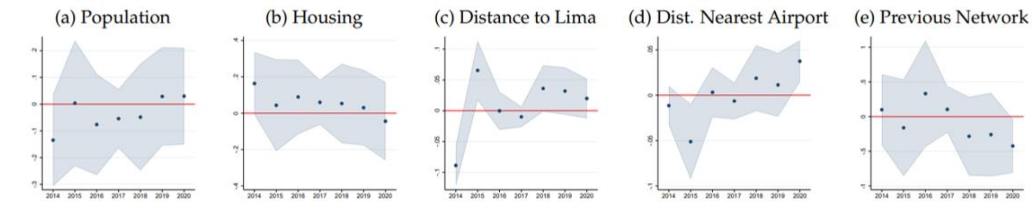
A key assumption of our identification strategy is that the timing of the deployment of the FTTX lines across CPs is not associated to the evolution of the firms' export activity. We validate this assumption by examining whether the deployment of FTTX was correlated with the characteristics of the CPs (population, housing, distance to Lima, distance to the nearest airport, previous existence of a DSL network, number of firms, number of workers). Specifically, we estimate the following model that examines whether the expansion of the FTTX networks were related to baseline CP characteristics:[69]

$$\Delta z_{ct} = \sum_j \gamma_{j,1} 1\,(j = t)\, x_{1,c}^{baseline} + \dots + \sum_j \gamma_{j,q} 1\,(j = t)\, x_{q,c}^{baseline} + \lambda_c + \mu_{c,t}$$

where Δz_{ct} is a dummy variable that takes the value of 1 for the year of the arrival of the FTTX technology to the CP c and zero otherwise. Moreover, $x_{j,c}$ is the baseline characteristic j of CP c. Notice that if the timing of the deployment was unrelated to baseline characteristics the coefficient $\gamma_{j,q}$ should not be different from zero, where j is a period after the expansion and q is the studied characteristic.

The figure B.1 below shows the results of this analysis. While the estimations of the figure refer to the universe of Peruvian firms, results do not change when we use our sample of firms with an export activity. The results shows that the deployment of the FTTX was not related with most of the variables, except in the case of the variables that indicate the distance of the firms to Lima and to the nearest airport. Notice that for 2014, the first year of the roll-out, there is a clear negative correlation between the access to the FTTX and the distance to Lima, which indicates that the CP's near the capital of Peru were among the first that benefit from the availability of the FTTX technology. Hence, the technology first reached those areas outside the capital that were political or economically most relevant (proxy by the proximity to an airport). For the rest of the years, results are not statistically relevant. We do not find significant results for other variables, but in the case of housing, previous presence of the DSL technology and number of workers per firm, there seems to be a trend in the yearly evolution of coefficients from positive to negative. This suggest that the roll-out continued to less populated, more remote areas or places that where not previously attended by the DSL technology. Previous research has also found that urbanization is a variable correlated to the deployment of broadband technologies (Akerman et al., 2015; Calzada et al. 2018). Importantly, export indicators are not only not statistically associated with the roll-out of the fiber technology and the coefficients do not show a consistent trend. Finally, notice that our baseline estimations control for distance to Lima and *centro poblado* fixed effects.

Figure 4.B1 – The Relation Between FTTX roll-out (2014-2020) and Log of Baseline *Centro Poblado* Characteristics (2013)



Note: The shadowed areas represent the 95% confidence bands. Population and number of houses are in logs. Distances have been calculated as the average distance in km of the firms to Lima or to the nearest airport. Previous network is a dummy variable that reflects the availability of the DSL technology in the CP. The number of firms is the log of the number of firms geolocated in the CPs. The number of workers is a categorical variable showing different ranges.

Source: Author's elaboration.

Chapter 5 – Final Remarks

This PhD thesis has studied three important topics contributing to the literature on development economics. The second chapter has assessed the impact of US-led free trade agreements on telecommunication prices and service penetration in Latin America. The third chapter has analyzed the impact of the deployment of high-speed fiber network on the Peruvian credit market. Finally, the fourth chapter has examined the effect of fiber broadband deployment on firm export strategies, including market concentration. Next, I summarize the main contribution of each chapter.

Chapter two highlights the effects of free trade agreements (FTAs) on the telecommunications industry in Latin America. It examines the FTAs that several Latin American and Caribbean countries signed with the United States during the 2000s. These treaties were among the first to contain specific chapters on telecommunications, aiming to promote liberalization, competition and foreign investment in the markets of signatory countries. I employed a difference-in-differences econometric strategy to evaluate the impact of these exogenous reforms in the telecommunications industry. The results show that the FTAs produced an estimated reduction of 45.5% on the average revenue per user (ARPU) in the subscribing countries, and that this competitive effect was mainly due to the decrease in the prices of mobile calls, which experienced a 34% reduction. No significant impacts of the FTAs are found on fixed and mobile telephone penetration, nor in private investment in these services. These results can reflect the reduction in the profitability of these services after the strengthening of competition that the FTAs generated.

Future research should continue examining the impact of this new generation of FTAs on national markets. In particular, the impact of trade agreements in topics such as customs procedures, intellectual property rights, government procurement, financial services, investment, and electronic commerce, among other areas.

Chapter three exploits the staggered deployment of broadband internet networks in Peru in the period 2010-2019 to investigate the effects of digitalization on non-financial firm performance and bank credit dynamics. We demonstrate that broadband deployment stimulated firm growth, increased firms' entry, and reduced the probability of exit in the locations benefiting with the arrival of the new technology. The entry and exit of firms in the credit market followed a similar pattern, although the results took longer to materialize in the credit market than in the real economic activity. The increase in firms' sales acted as a signal to banks regarding their profitability, prompting them to provide more credit. Our research disentangles the supply and demand effects of broadband deployment, highlighting the importance of the demand channel in reducing the observed interest rates. Interesting enough, these findings are mainly generated by micro and small firms, as well as firms with thin credit files, which are often perceived as riskier.

Future studies could explore potential spillover effects of broadband deployment, delving into areas such as innovation, the adoption of electronic payment methods, and other areas shaping the evolving digital landscape.

Finally, chapter four analyzes the impact of fiber broadband deployment in the export activity of firms in Peru. Specifically, we examine the effect fiber availability in the firms' value of exports, the number of relations with other countries and the concentration of their exports in terms of destination markets. We consider the distance of the firms to the telephone local exchange (i.e. the length of the local loop) as a measure of the quality of the DSL service and we use this distance as mechanism to identify the impact of the arrival of the fiber technology. We find that firms with access to high-speed internet increased participation in international markets, exported more, and had more diversified exports in terms of the destination countries. Specifically, the arrival of the fiber technology for those Peruvian firms located more than 2.5 kilometers away from the local exchanges increased the value of exports by 35.5% and the number of destination markets by 8.5%, while it reduced the concentration of the export activity by 4.7%.

Future research could focus on the heterogeneity of the effects of broadband adoption across different regions and countries. Specifically, future research could investigate if broadband deployment has a differentiated impact depending on the characteristics of each region or sub national administrative division. Moreover, heterogeneity of the effects of broadband adoption could be studied across different type of countries, such as developed and developing Additionally, future studies could investigate the mechanisms through which broadband affects firms' export performance (i.e. an increase in demand from distant countries or a more efficient provision of imported inputs), or the implications of broadband adoption for other sectors of economic activity such as trade in services.

In conclusion, this thesis not only advances our understanding of critical economic phenomena but also points toward promising directions for future research in the evolving landscapes of trade, digitalization and the credit market, and international business.

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