Connecting the Periphery: Fast Internet and Exports from Colombia's Hinterland*

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Abstract

Governments around the world strive but struggle to maintain economic activity outside of cities. Whether cost-effective policies exist—and if so, what they are—remains largely unknown, but many policy-makers believe that building fast internet infrastructure is one. The hopes are especially high in developing countries where current urbanization rates are high while agriculture is a comparative advantage, but in such countries the opportunity cost of government spending is also high. In this paper we study Colombia's "National Fiber Optic Project" (NFOP) through which its government subsidized 4G infrastructure connecting remote areas to the global internet. We show how such connectivity—the program tripled internet speeds and doubled internet connections per municipality—causally affects exports, the central force of economic development episodes in modern times. To do so, we compare remote municipalities that get connected early to those that get connected later, whose exports evolve very similarly before the NFOP. Early results from customs records indicate increases in both the probability of exporting and value exported that are large across-the-board but especially so in agriculture (75% increase in probability of exporting) and wholesale (83%). Firms in remote areas are 45% more likely to export to high-income countries once connected and 1700% more likely to export to specific foreign buyers which have not imported from Colombia before. The impact appears to grow over time. In ongoing work we use firm-level data on domestic sellers and foreign buyers to study how this impact on exporting comes about and its ultimate economic consequences.

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1 Introduction

Exporting is widely recognized as a pathway to economic development (World Bank, 2019). It's determinants have been extensively studied in the literature, with factors such as firms' ex-ante productivity, market entry costs, knowledge of foreign markets, export promotion strategies, pricing, and advertising strategies playing a significant role (see, for e.g., Melitz, 2003; Das *et al.*, 2007; Atkin *et al.*, 2017; Dickstein & Morales, 2018). Infrastructure is another critical determinant of trade (see, for e.g., Donaldson, 2018), and, in particular, fast internet has been shown to promote it by alleviating information frictions in the context of high-income countries (Akerman *et al.*, 2022)). However, it remains unclear whether fast internet can promote exports in remote rural areas of developing countries, where comparative advantage often lies in agriculture and the opportunity cost of government spending is high.

In this paper, we study Colombia's "National Fiber Optic Project" (NFOP), a government initiative that subsidized 4G infrastructure to connect remote areas to the global internet. Leveraging the staggered introduction of the program—which tripled internet speeds and doubled internet connections per municipality—we examine the causal effects of enhanced connectivity on exports, a key driver of sustained economic development. By comparing remote municipalities that were connected early to those connected later, whose exports followed similar trends prior to the NFOP, we find significant increases in both the likelihood of exporting and the value of exports. These effects are particularly pronounced in agriculture (a 75% increase in the probability of exporting) and wholesale trade (an 83% increase). Connectivity also makes firms 45% more likely to export to high-income countries and 1700% more likely to engage with first-time foreign buyers. Preliminary evidence suggests that these impacts grow over time. In ongoing, work we explore firm-level data to understand the mechanisms behind these effects and their broader economic implications.

The NFOP was a large-scale initiative implemented by the Colombian government between 2013 and 2016. The program extended fiber optic internet to 786 rural municipalities (out of its 1102 municipalities). By addressing the lack of private investment in rural areas, the NFOP aimed to bridge the digital divide between urban and rural areas and encourage economic connectivity. The project connected urban centers in each municipality to the fiber optic grid and provided free broadband to 2,000 public institutions for five years. The phased roll-out of the program across municipalities allows us to study its causal effects.

To estimate the impact of the NFOP on exports, we combine administrative datasets

from multiple sources. These include municipal-level data on internet connectivity, transaction-level trade data from Colombian customs, and demographic and economic indicators. By linking firms to their municipalities, we construct a panel dataset to explore the program's effects on internet adoption and trade outcomes at the municipality level. Using difference-in-differences (DiD) and event-study (EV) designs we identify the NFOP impact on trade. To address the concerns of negative weights and heterogeneous treatment effects related to differential treatment timing of the program, we follow Callaway & Sant'Anna (2021) and focus on ever-treated municipalities. We find that the NFOP had large positive effects on internet connectivity and export performance in treated municipalities.

The program led to a substantial increase in the number of internet connections and users. Treated municipalities experienced a 95% rise in internet users, with the number of users per 10,000 inhabitants increasing by 176%. Additionally, average download speeds more than doubled. These connectivity gains translated into large trade impacts. The probability of exporting increased by 1.4 percentage points on average, while the value of exports, rose by 12.7% in treated municipalities. The program's effects were particularly pronounced in agriculture and wholesale trade. The probability of a municipality exporting agricultural goods increased by 75%, and the value of agricultural exports rose by 53%. Similarly, the probability of wholesale exports increased by an 83% and its value by 51%.

The NFOP also facilitated access to high-income markets. Treated municipalities exhibited a 45% higher probability of exporting to this group of countries compared to untreated areas. Additionally, exports to first-time buyers increased significantly: municipalities connected to fiber optic networks were 1700% more likely to export to international buyers who had never previously imported from Colombia. This effect was driven primarily by new exporters and transactions with buyers new to these remote areas. Potential mechanisms driving these effects include improved connectivity with international markets, reduced information frictions, and diminished logistical barriers. The program's effects were not limited to volume and probability; they also influenced the composition of exports. We find that most of the impact in treated municipalities was concentrated in agricultural goods, particularly vegetables.

Finally, our event studies results show that the effects of NFOP on exporting grow over time, suggesting that the benefits of enhanced connectivity are dynamic and cumulative. Moreover, the event studies show that treated and control municipalities were on parallel trends before the introduction of the program. These results suggest that digital infrastructure can play an important role in fostering economic integration and in providing

export opportunities for rural, agriculture-focused areas of developing countries.

2 National Fiber Optic Project

From 2013 to 2016, the Government of Colombia implemented the National Fiber Optic Project. Before the implementation of the project, only 325 of the 1122 municipalities in Colombia had access to fiber optic internet, and private providers could not provide this technology to most rural municipalities due to the high costs of the required infrastructure. In response, the Telecommunications Ministry created the National Fiber Optic Project to provide fiber optic internet to 786 rural municipalities in Colombia. This program consisted of financing capital investments needed to expand the existing Internet infrastructure (MinTIC, 2011) to expand the Internet network by connecting the main urban center in each municipality (*cabecera municipal*) to the existing fiber optic grid. Additionally, this program included the provision of broadband internet to 2000 public institutions that would receive free internet for 5 years after the installation.

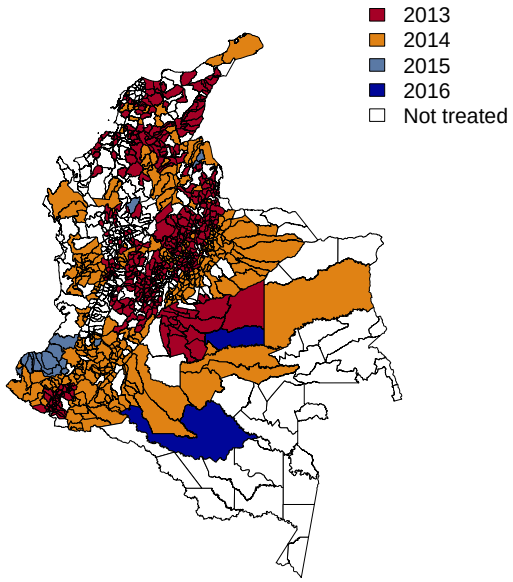
The project was structured as follows. In 2011 the "Dirección de Infraestructura" (infrastructure directorate) estimated that 324 municipalities would receive fiber optic cable connections through the private sector. From the remaining 796 municipalities they selected 400 to be included in the fiber project. The government picked sufficiently populous municipalities for operators to stay in post-project completion and where supplying fiber optic cables was technically feasible. The project was opened to bids in August 2011, and 4 companies submitted proposals. The bids were evaluated along 3 dimensions: coverage, quality, and benefit to the national industry. Three-quarters of the total score was determined by the coverage criteria, which was measured as the total number of additional municipalities – over and beyond the required municipalities –the company could cover with fiber optic cables for the payment. Only municipalities that were not expected to be furnished by the private market – henceforth, "optional municipalities" – counted towards this criteria. There were a total of 396 municipalities that bidders could commit to include in the project, all of which were given equal weight. Bidders, therefore, had an incentive to maximize the number of optional municipalities they would, irrespective of these municipalities' market conditions.

The contract was awarded to Unión Temporal Fibra Óptica Colombia – hereafter, UTFO – who promised to provide 753 municipalities with fiber optic cables, including 353 from the optional group. Constructions started in 2011, the first municipalities were connected

to the fiber optic network in 2013, and the last municipality was connected in 2016.

The project was to be developed in two stages. The first stage consisted of the design, installation, and start of the internet service, while the second was the operation and maintenance of the infrastructure for 20 years (MinTIC, 2011). The program takes place in 788 municipalities in 27 different departments in Colombia, and the operation period is 15 years. After this period, the objective is that private Telecommunication Network and Service suppliers start operating in these municipalities, offering high-speed internet. The total investment in this project was $435,166$ million pesos, and it equipped the country with a high-speed transport network, enabling the provision of telecommunication services in rural areas that, as of 2011, did not have fiber-optic access. This created conditions for the telecommunications sector to expand through infrastructure deployment, increased broadband penetration, and the promotion of using and adopting ICTs (MinTIC, 2023).

Figure 1: Roll-out of the National Fiber Optic Project



In Figure 1, we can see the program's roll-out throughout the years. The municipalities included in the program were all of those that did not have high-quality internet access and were spread throughout the country. Some municipalities were not included in the program because of the difficulty of installing the required infrastructure due to geographic or public order conditions (MinTIC, 2022).

3 Data

To study the effect of the connection of the municipalities to fiber optic internet on trade in rural areas, we combine four administrative datasets. The first dataset contains information from the Telecommunications Ministry on the National Fiber Optic Project roll-out from 2013 to 2016. We have the information on each treated municipality, including the program's starting date, which is the variable of the treatment in this context.

The second dataset consists of Telecommunications Ministry quarterly data on internet connectivity variables covering the years 2010 to 2020. We observe the number of subscribed users, technology type[1], the download and upload speed, the supplier, and the segment[2] for each municipality-quarter. This data records the active connections and allows us to identify if the program's roll-out had an effect on the internet connectivity.

The third dataset contains import and export data from the Colombian customs agency "Dirección de Impuestos y Aduanas Nacionales" (DIAN). Specifically, we are interested in exports, and we have data on the transaction level. Our main outcomes come from this dataset since we observe the exporting producer firm, identified by its taxpayer ID, the traded good, its value and weight, and the destination country. We have information on the export transactions for the period 2006-2020.

Finally, since our object of interest is municipalities, we need to identify where each firm operates. We use the Statistical Directory of Firms from the Colombian Statistical Bureau DANE to achieve this. This directory identifies each firm by its taxpayer ID and links it to a municipality. We have the information on the location of each firm in 2022, and we link each firm in the export/import data of the DIAN to a municipality so we can have trade variables at the municipality level, which is our unit of analysis. In addition, we have the industrial sector code to the 4-digit level for each firm, which we use for the sectoral analysis.

When combining the DIAN trade data with the firm registry information, a measurement error is introduced. This is because we only have the active firms during the registration update. This means we cannot link all the firms to their municipality, and if there is a firm we cannot match between these two databases, we drop this observation. After doing this, we are left with a sample of

[1] Fiber optic, satellite, etc.
[2] Residential, cooperative, etc.

Using these four databases, we construct a municipality-quarter-level panel. We combine our data on internet connectivity and the National Fiber Optic Project using the municipality identifiers. After linking each firm's transactions registered in the DIAN trade data with its municipality, we can aggregate the exports to the municipality level to combine them with the Internet and roll-out the program data. We use an additional municipality-level panel from the Center of Economic Development Studies of Universidad de los Andes to have the population data of each municipality.

4 Empirical Approach

We exploit the quasi-random experiment given by the roll-out of the National Fiber Optic Project to estimate the effect of access to high-speed internet in rural areas on internet connectivity and exports. We estimate the program's effects using a **?** event study approach. Thus, the equation we estimate is:

$$y_{it} = \alpha_i + \lambda_t + \sum_{t \neq g}^{T} \beta_{gt} Fiber_{igt} + \varepsilon_{it} \tag{1}$$

Where y_{it} is the outcome variable for municipality i in period t, α_i captures the municipality fixed effects, λ_t captures the time fixed effects, and $Fiber_{igt}$ captures the effect of the National Fiber Optic Project of municipality i of cohort g in the year t on the outcome variable. We estimate equation (1) using **?** estimators, where the control group are the not-yet-treated municipalities. That is, we keep in our sample only those municipalities that received the program, and for each cohort, the control group are the ones that had not been connected to the fiber optic network yet.

β_{gt} captures the effect of the National Fiber Optic Program on each outcome in period t for cohort g. The average treatment effect of the program for the treated is calculated as the average β_{gt} across time and cohorts. For β_{gt} to capture the average treatment effect of the National Fiber Optic Project on the outcome variables, parallel trends and no anticipation assumption must hold.

5 Municipalities economies

Municipalities selected in the National Fiber Optic Project correspond to small rural municipalities on average. Panel C of Table 1 shows that in the sample, the municipalities

have $14,392.85$ inhabitants on average and $8,692.62$ rural inhabitants on average.

Panel A of Table 1 shows presents the proportion of each sector in the total value of exports. These results show that most of the exports they have during the sample period correspond to agriculture and manufacturing, representing 38.5% and 40.8% in the total export value, respectively. Moreover, most of the exports of these municipalities are vegetables and foodstuffs, representing 53.3% and 14.2% of the total value of exports, respectively. The details of the proportion of each type of goof in the total value of exports are reported in Panel B of Table 1.

The results show that the municipalities of the sample are mostly small and rural and concentrated in the production of food and agricultural goods. This suggests these are small agricultural economies, which could be associated with difficulties in connecting with international markets. In this sense, a program that could connect these municipalities more effectively with potential buyers could increase their connectedness with those international markets and increase their exports.

Table 1: Descriptive Statistics

	Panel A: Proportion of each sector of the total exports value			
	Mean	St Dev	Min	Max
Agriculture	0.385	0.421	0.000	1.000
Mining	0.070	0.164	0.000	0.500
Manufacturing	0.408	0.427	0.000	1.000
Retail	0.006	0.053	0.000	1.000
Wholesale	0.132	0.209	0.000	1.000
	Panel B: Proportion of each good of the total exports value			
	Mean	St. Dev	Min	Max
Livestock	0.032	0.164	0.000	1.000
Ceramics	0.006	0.050	0.000	0.500
Chemicals	0.015	0.112	0.000	1.000
Foodstuff	0.142	0.335	0.000	1.000
Glass	0.001	0.019	0.000	0.500
Gold	0.031	0.174	0.000	1.000
Leather	0.090	0.284	0.000	1.000
Machinery	0.047	0.202	0.000	1.000
Miscellaneous	0.045	0.178	0.000	1.000
Stone	0.009	0.070	0.000	1.000
Textiles	0.025	0.154	0.000	1.000
Vegetable	0.535	0.486	0.000	1.000
Wood	0.023	0.132	0.000	1.000
	Panel C: Population			
	Mean	St. Dev	Min	Max
Total population	14,392.851	15,401.503	0.000	257,052
Rural Population	8,692.616	9,674.190	0.000	181,095

The descriptive statistics correspond to the restricted sample of the municipalities that were connected to the fiber optic network through the National Fiber Optic Project.

6 Results

We are interested in the National Fiber Optic Project's effect on internet connectivity and how the availability of high-speed internet services affected the interaction of firms located in remote and rural locations with the international markets. This section first presents the results for connectivity variables and then the results for exports of the firms located in the treated municipalities.

6.1 Internet connectivity

Table 2 presents the estimates of equation (1) using the internet connectivity variables as the outcome. In Column (1), we find that the National Fiber Optic Project increased, on average, the number of internet users[3] by 76.256 relative to the municipalities that haven't received the program yet. This is a large effect since the results show that the connection to the fiber optic network increased the number of users by approximately 95% in these municipalities. This effect is even bigger when we look at the number of users per 10,000 inh. This result is reported in Column (2) of Table 2, and shows that municipalities connected to the fiber optic network have 55.171 more users per 10,000 inh. than if they were not connected to the network. This represents approximately 176% more users per 10,000 inh, than the average in the absence of the program. Column (3) shows that the average download speed (kbts) also significantly increased due to the program, being approximately 205%, on average, faster than in the absence of the connection to the fiber optic network.

Table 2: Effects on internet connections (2010 - 2020)

	No. of users	Normalized no. [a] of users	Download speed (kbts)
Fiber Optic Program	76.256***	55.171***	1598.759***
	(7.408)	(2.601)	(344.270)
Observations	18,095	18,095	18,095
No. municipalities	786	786	786
Control group mean	79.514	31.296	779.217

The control group is composed by all not yet treated units. Every municipality-quarter pair in the database received the treatment at some quarter and is considered as treated since then.
[a] Normalized number of users takes the proportion between the number of active internet connections and the municipality population (per 10,000 people).

[3] We restrict the sample to firms, so whenever we refer to users, we leave out the household internet users.

The results reported in Table 2 underscore the importance of the program to internet connectivity. This suggests the program was successful in that one of the government's main goals was to promote the use and adoption of ICTs.

6.2 Trade

Given that the program increased the number of fast internet connections used by firms in the treated municipalities, we now estimate the program's effects on international trade. In Column (1) of Table 3, we report the estimates using the probability of exporting as the outcome, and in Column (2), the outcome variable is the total $(\log +1)$ value of export sales. Both results show that the program had a positive effect on exports. The municipalities that were connected to the fiber optic network have, on average, a probability 1.4 percentage points higher than the ones that were not connected yet, and the $(\log +1)$ of the value of their exports 0.127 higher.

Table 3: Effects on exports (2006 - 2020)

	Probability of exporting[a]	Total Value of exports (log+1)[b]
Fiber Optic Program	0.014**	0.127*
	(0.005)	(0.054)
Observations	33,012	33,012
No. municipalities	786	786
Control group mean	0.035	0.418

The control group is composed by all not yet treated units. Every municipality-quarter pair in the database received the treatment at some quarter and is considered as treated since then.
[a] Probability of exporting is defined as a dichotomous variable which takes the value of one if the pair municipality-quarter had any exports and zero otherwise.
[b] The 'log +1' transformation first adds one to the total USD FOB (constant prices 2010) exports for all municipality-quarter pairs and then applies a logarithmic transformation.

To better understand the drivers of the program's effect on trade, we estimated equation (1) within industrial sectors and types of goods. Table 2 reports the results for each sector, where Panel A shows the result using the probability of exporting as the outcome variable, and Panel B uses the $(\log +1)$ of the total export value as the outcome variable. These results show that the main drivers of the effect are the agricultural and wholesale sectors. The probability of exporting for firms operating in the agricultural sector increased by approximately 75%, and the $(\log +1)$ value of exports 53% when compared to the control group. The firms in the wholesale sector increased their probability of exporting in approximately 83% and the $(\log +1)$ value of exports in 51%, compared to the control group.

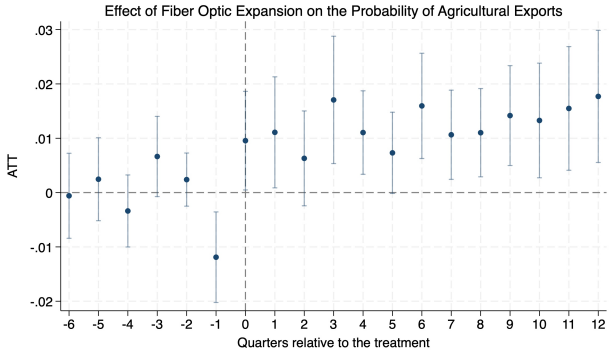
Table 4: Effects on exports by sector

	Panel A: Probability of exporting[a]				
	Agriculture	Mining	Manufacturing	Wholesale	Retail
	(1)	(2)	(3)	(4)	(5)
Fiber Optic Program	0.0120***	0.0051	0.0062	0.0089**	0.0009
	(0.0035)	(0.0028)	(0.0042)	(0.0031)	(0.0031)
Observations	33,012	33,012	33,012	33,012	33,012
No. municipalities	786	786	786	786	786
Control group mean	0.0159	0.0086	0.0223	0.0106	0.0023
	Panel B: Total value of exports $(\log+1)$[b]				
	Agriculture	Mining	Manufacturing	Wholesale	Retail
	(1)	(2)	(3)	(4)	(5)
Fiber Optic Program	0.1030**	0.0343	0.0443	0.0636*	0.0044
	(0.0350)	(0.0248)	(0.0425)	(0.0256)	(0.0210)
Observations	33,012	33,012	33,012	33,012	33,012
No. municipalities	786	786	786	786	786
Control group mean	0.1915	0.0912	0.2546	0.1239	0.0227

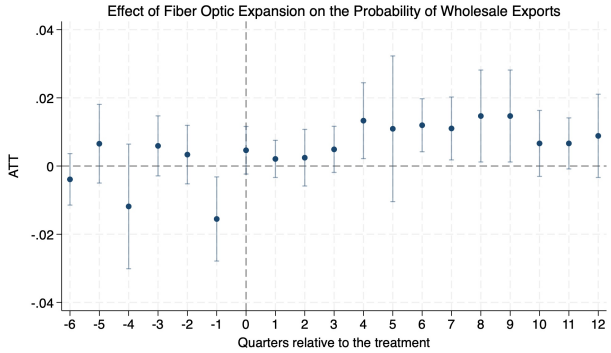
The control group is composed by all not yet treated units. Every municipality-quarter pair in the database received the treatment at some quarter and is considered as treated since then.
[a] Probability of exporting is defined as a dichotomous variable which takes the value of one if the pair municipality-quarter had any exports and zero otherwise.
[b] The '$\log+1$' transformation first adds one to the total USD FOB (constant prices 2010) exports for all municipality-quarter pairs and then applies a logarithmic transformation. This approach ensures that municipality-quarter pairs with no exports are included.

Figure 2 shows the event studies for the probability of exporting and the $(\log+1)$ value of exports for the agricultural and wholesale sectors. These results suggest that the parallel trends assumption holds, and the effect of the program on exports, even several periods after the connection to the fiber optic network.

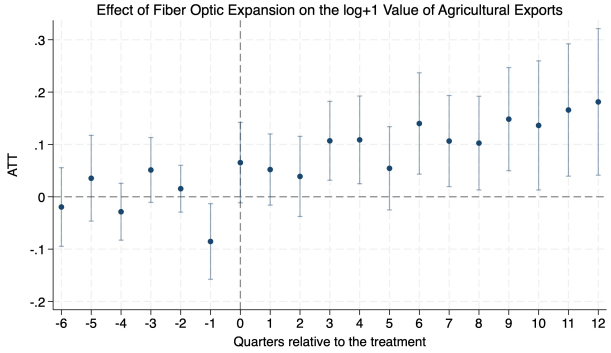
Figure 2: Effects on exports for agriculture and wholesale sectors



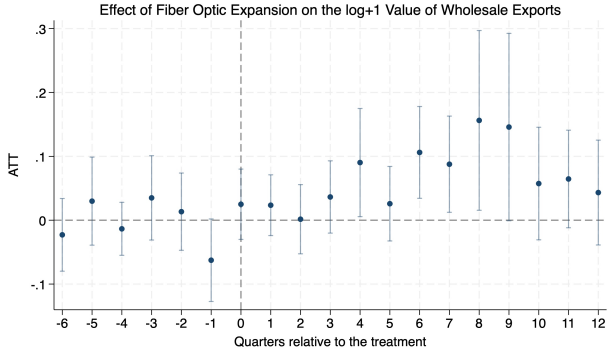
(a) Exports in Agriculture, Probability



(b) Exports in Wholesale, Probability



(c) Exports in Agriculture, Value



(d) Exports in Wholesale, Value

Similar to sectors, we can estimate the program's effect by the type of exported goods. In Table 3, we show these results, where each Column corresponds to a type of good. Column (2) shows that the program's effect on exports is mainly driven by vegetables. The connected to the fiber optic network municipalities show a probability 1.2 percentage point higher than the average of the non-connected municipalities, which represents an increase of approximately 75% in the probability of exporting. In addition, the $(\log+1)$ value of export sales increased approximately 53% for the connected to the fiber optic network municipalities relative to the control group's average.

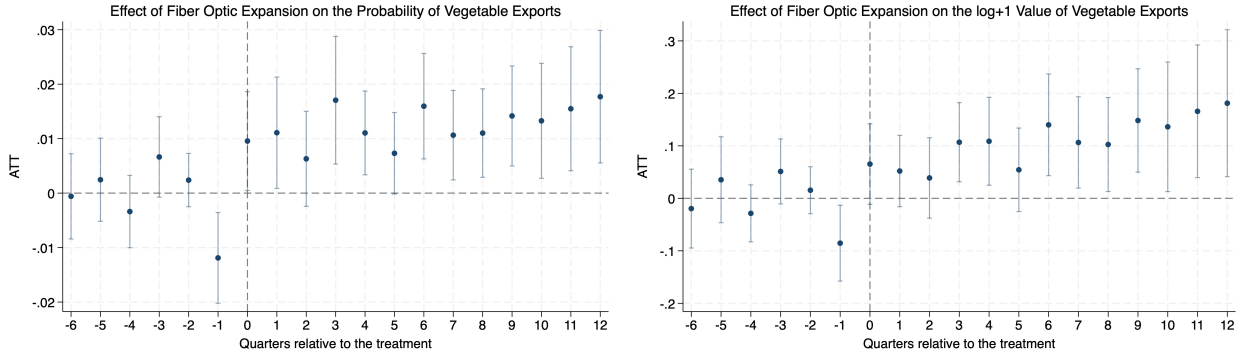
Table 5: Effects on exports by goods

	Panel A: Probability of exporting[a]									
	Livestock	Vegetables	Foodstuff	Chemicals	Leather	Wood	Textiles	Stone/Glass	Machinery	Miscellaneous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Fiber Optic Program	0.0055	0.0120***	0.0050	0.0048	-0.0009	0.0043*	0.0060*	0.0046	-0.0050	0.0004
	(0.0036)	(0.0035)	(0.0029)	(0.0039)	(0.0032)	(0.0019)	(0.0026)	(0.0031)	(0.0041)	(0.0030)
Observations	33,012	33,012	33,012	33,012	33,012	33,012	33,012	33,012	33,012	33,012
No. municipalities	786	786	786	786	786	786	786	786	786	786
Control group mean	0.0025	0.0159	0.0066	0.0032	0.0054	0.0040	0.0022	0.0012	0.0028	0.0046
	Panel B: Total value of exports $(\log+1)$[b]									
	Livestock	Vegetables	Foodstuff	Chemicals	Leather	Wood	Textiles	Stone/Glass	Machinery	Miscellaneous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Fiber Optic Program	0.0461	0.1030**	0.0255	0.0247	0.0000	0.0115	0.0150*	0.0365	-0.0431	-0.0054
	(0.0301)	(0.0350)	(0.0168)	(0.0281)	(0.0271)	(0.0126)	(0.0069)	(0.0259)	(0.0357)	(0.0148)
Observations	33,012	33,012	33,012	33,012	33,012	33,012	33,012	33,012	33,012	33,012
No. municipalities	786	786	786	786	786	786	786	786	786	786
Control group mean	0.0286	0.1915	0.0837	0.0282	0.0567	0.0356	0.0195	0.0087	0.0313	0.0556

The control group is composed by all not yet treated units. Every municipality-quarter pair in the database received the treatment at some quarter and is considered as treated since then.
[a] Probability of exporting is defined as a dichotomous variable which takes the value of one if the pair municipality-quarter had any exports and zero otherwise.
[b] The '$\log+1$' transformation first adds one to the total USD FOB (constant prices 2010) exports for all municipality-quarter pairs and then applies a logarithmic transformation. This approach ensures that municipality-quarter pairs with no exports are included.

Figure 3 shows the event study of the probability of exporting and the $(\log+1)$ value of sale for vegetables. This figure suggests that the parallel trends hold for this result, and the program had a positive effect, increasing both the probability of exporting and the value of exports after the municipality was connected to the fiber optic network.

Figure 3: Effects on exports vegetables



(a) Vegetable exports, Probability

(b) Vegetable exports, Value

Table 6 shows the effect of the National Fiber Optic Project by income level of buyers. These results show that the high-income buyers are the ones that started to import the

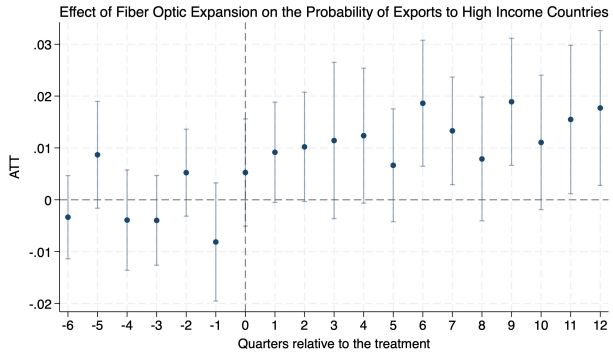
most from these municipalities thanks to the connection to the fiber optic network, which we can also see in the event studies plotted in Figure 4. On average, the probability of exporting to high-income countries from the treated municipalities increased by 1.22 percentage points, which represents an increase of 45% with respect to the average probability of exporting to these countries for the unconnected municipalities.

Table 6: Effects on exports by destination's income level

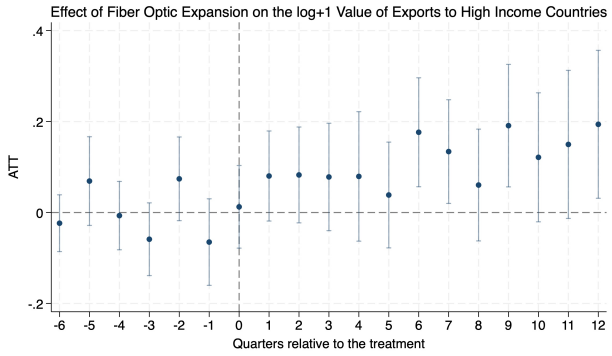
	Panel A: Probability of exporting[a]			
	High Income	Upper-middle Income	Lower-middle Income	Low Income
	(1)	(2)	(3)	(4)
Fiber Optic Program	0.0122**	-0.0042	0.0059*	0.0038
	(0.0044)	(0.0042)	(0.0029)	(0.0042)
Observations	33,012	33,012	33,012	33,012
No. municipalities	786	786	786	786
Control group mean	0.0270	0.0013	0.0047	0.0197

The control group is composed by all not yet treated units. Every municipality-quarter pair in the database received the treatment at some quarter and is considered as treated since then.
[a] Probability of exporting is defined as a dichotomous variable which takes the value of one if the pair municipality-quarter had any exports and zero otherwise.
[b] The 'log +1' transformation first adds one to the total USD FOB (constant prices 2010) exports for all municipality-quarter pairs and then applies a logarithmic transformation. This approach ensures that municipality-quarter pairs with no exports are included.

Figure 4: Effects on exports to high income countries



(a) Exports to high-income countries, Probability



(b) Exports to high-income countries, Value

To analyze if the effect is driven by new buyers or the ones that already bought to the treated municipalities before the program, we ran equation (1) using the probability of exporting and the value of the exports as the dependent variables within new and old buyers. These results are reported in Panel A and Panel B of Table 7. We refer to new-to-remote-Colombia buyers as the buyers that already bought from Colombian firms but, before the program, did not buy from firms within the treated municipality. On average, the probability of exporting to ne-to-remote-Colombia buyers increased 1.1 percentage points, which means approximately 550% higher than in the absence of the treatment. The $(\log +1)$ value of exports increased by 0.107, representing approximately a 445% higher value of exports compared to the control group.

Similarly, Panel C and Panel D of Table 7 reports the results for new and old exporters. These results show that the effect is driven by new exporters, while for the old exporters, the results are not statistically significant, as for old-to-remote-Colombia buyers. On the one hand, or new exporters the probability of exporting increased in 1.8 percentage points, that is, on average 1800% higher than the control group. On the other hand, the $(\log +1)$ value of exports of the connected to the fiber optic network municipalities was 2200% higher than the ones that were not connected.

Finally, if we see the effect on New-to-Colombia buyers, meaning countries that did not buy from any Colombian firm before the program, we can see that the probability of exporting to these countries and the value of exports also increased after the National Fiber Optic Project. The probability of exporting increased in 1.7 percentage points, and the $(\log +1)$ value of exports in 0.172, that is, 1700% and approximately 1228% higher than in the control group, respectively.

Figure 5 and Table 6 show the even studies for the new-to-remote-Colombia buyers and new exporters, and new-to-Clombia buyers, respectively. These results show the positive dynamic effect of the program on these groups.

Table 7: Effects on exports for buyers and exporters

	Panel A: New-to-remote-Colombia buyers[a]		
	Probability of exporting	Total export value[e]	Total export value ($\log+1$)[f]
	(1)	(2)	(3)
Fiber Optic Program	0.011*	3,904.6*	0.107*
	(0.005)	(1,674.3)	(0.049)
Observations	29,868	29,868	29,868
No. municipalities	786	786	786
Control group mean	0.002	300.3	0.024
	Panel B: Old-to-remote-Colombia buyers[b]		
	Probability of exporting	Total export value[e]	Total export value ($\log+1$)[f]
	(1)	(2)	(3)
Fiber Optic Program	0.007	8,456.4	0.044
	(0.005)	(9,936.7)	(0.049)
Observations	29,868	29,868	29,868
No. municipalities	786	786	786
Control group mean	0.035	40,730	0.423
	Panel C: New exporters[c]		
	Probability of exporting	Total export value[e]	Total export value ($\log+1$)[f]
	(1)	(2)	(3)
Fiber Optic Program	0.018***	2,113.7	0.176***
	(0.004)	(1,248.5)	(0.045)
Observations	29,868	29,868	29,868
No. municipalities	786	786	786
Control group mean	0.001	73.5	0.008
	Panel D: Old exporters[d]		
	Probability of exporting	Total export value[e]	Total export value ($\log+1$)[f]
	(1)	(2)	(3)
Fiber Optic Program	0.004	11,091.0	0.021
	(0.005)	(7,069.8)	(0.045)
Observations	29,868	29,868	29,868
No. municipalities	786	786	786
Control group mean	0.035	41,736.8	0.425

The control group is composed by all not yet treated units. Every municipality-quarter pair in the database received the treatment at some quarter and is considered as treated since then.

[a] New-to-remote-Colombia buyers are foreign firms that initially purchased from non-treated Colombian municipalities but started buying to importing from treated municipalities following the implementation of the fiber project.

[b] Old-to-remote-Colombia buyers are foreign firms that purchased from treated Colombian municipalities before the implementation of the fiber project.

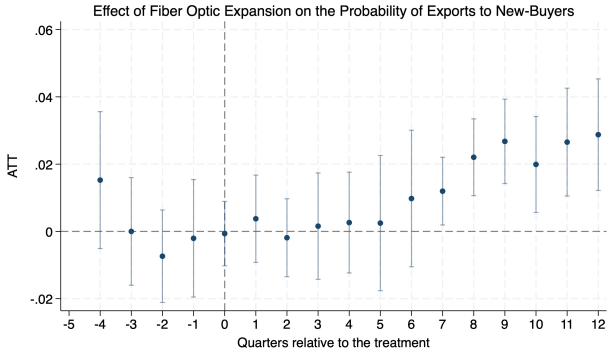
[c] New exporters in a given treated municipality are Colombian firms that were not originally based there but began exporting from it after the fiber project was implemented.

[d] Old exporters in a given treated municipality are Colombian firms that were exporting from it before the fiber project was implemented.

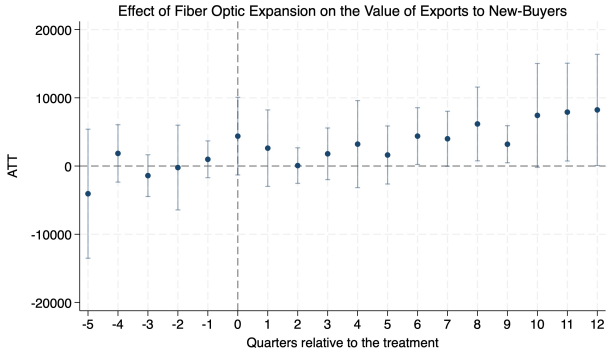
[e] Probability of exporting is defined as a dichotomous variable which takes the value of one if the pair municipality-quarter had any exports and zero otherwise.

[f] The '$\log+1$' transformation first adds one to the total USD FOB (constant prices 2010) exports for all municipality-quarter pairs and then applies a logarithmic transformation. This approach ensures that municipality-quarter pairs with no exports are included.

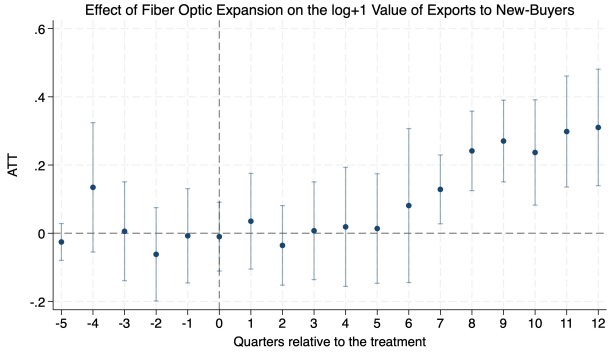
Figure 5: Effects on exports for new buyers and exporters



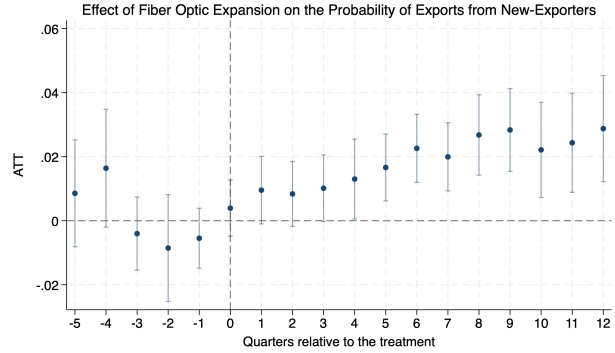
(a) Exports to new buyers, Probability



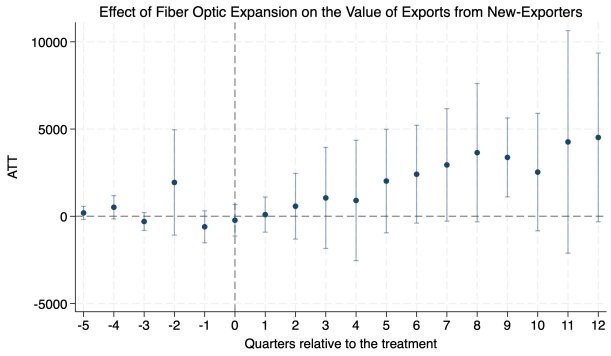
(b) Exports to new buyers, Value



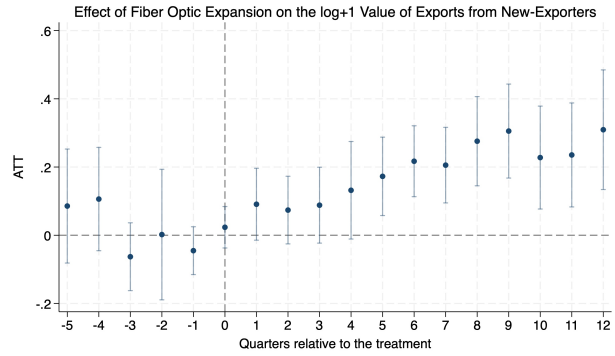
(c) Exports to new buyers, Value $(\log +1)$



(d) Exports of new exporters, Probability



(e) Exports of new exporters, Value



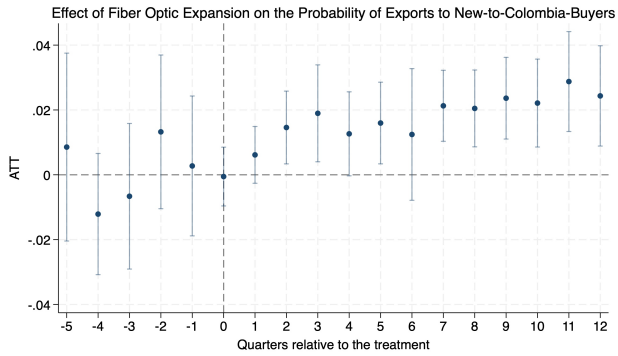
(f) Exports of new exporters, Value $(\log +1)$

Table 8: Effects on exports of to new-to-Colombia buyers[a]

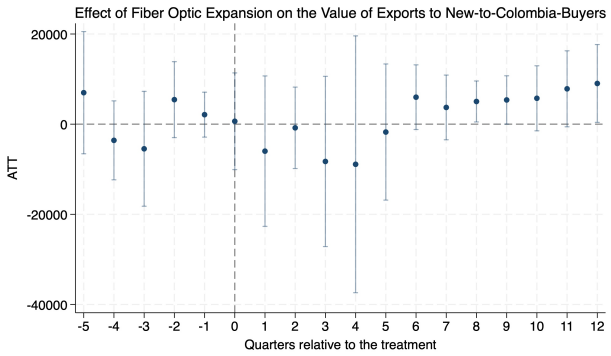
	Probability of exporting	Total export value[b]	Total export value $(\log +1)$[c]
Fiber Optic Program	0.017***	823.6	0.172***
	(0.004)	(4,872.0)	(0.046)
Observations	29,868	29,868	29,868
No. municipalities	786	786	786
Control group mean	0.001	300.3	0.014

The control group is composed by all not yet treated units. Every municipality-quarter pair in the database received the treatment at some quarter and is considered as treated since then.
[a] New-to-Colombia buyers are foreign firms that had never previously purchased from either treated or untreated Colombian municipalities but began importing from treated municipalities following the implementation of the fiber project.
[b] Total USD FOB (constant prices 2010) exports for all municipality-quarter pairs.
[c] The '$\log +1$' transformation first adds one to the total USD FOB (constant prices 2010) exports for all municipality-quarter pairs and then applies a logarithmic transformation. This approach ensures that municipality-quarter pairs with no exports are included.

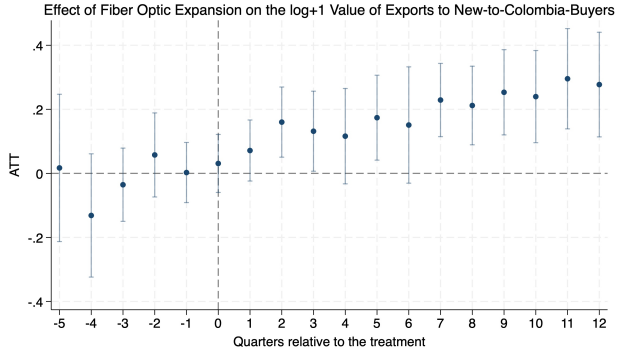
Figure 6: Effects on exports for new-to-Colombia buyers



(a) Exports to new buyers, Probability



(b) Exports to new buyers, Value



(c) Exports to new buyers, Value $(\log +1)$

Appendix

Table A.1: Descriptive Statistics: Number of exporters and buyers in Colombia between 2007 and 2019.

	Pre-2013	Post-2013
No. Exporters	9,623	17,333
No. Buyers (perfect match)	131,471	162,665
No. Buyers ($h = 0.3$)[a]	75,565	103,982
No. Buyers ($h = 0.5$)[a]	49,730	65,738

[a] Since the customs data does not include an identifier for buyers (foreign firms), we use a clustering algorithm to generate a unique identifier for each buyer. This process depends on the hyperparameter h, where larger values of h allow for larger clusters.

Table A.2: Distribution of the Number of DIAN Municipalities Associated to a Single Exporter[ab]

Year	Mean	Std. Dev	Min	$p25$	Median	$p75$	Max
2005	1.18	0.50	1	1	1	1	6
2010	1.40	0.74	1	1	1	2	7
2015	1.30	0.64	1	1	1	1	7
2019	1.28	0.60	1	1	1	1	6

[a] Customs data (DIAN) has a municipality variable named DPTOMPO3. It is different to the municipality variable we have been using, which comes from DANE's firm registry.
[b] A single exporter in a given year can be associated with multiple DPTOMPO3 values, indicating association to multiple municipalities in the customs database. This analysis examines the average number of municipalities linked to a single exporter, along with the corresponding distribution.

Table A.3: Descriptive Statistics: Number of exporters and buyers in treated and untreated exporting municipalities between 2007 and 2019.

		Mean	Std. Dev	Min	$p25$	Median	$p75$	Max
				A. Exporters				
Treated	Pre-2013	0.9	1.7	0	0	0	1	11
	Post-2013	2.0	2.5	0	1	1	2	18
Not-treated	Pre-2013	48.4	355.0	0	1	2	10	4,855
	Post-2013	86.9	589.8	0	1.5	5	25	7,969
				B. Buyers - perfect match				
Treated	Pre-2013	28.4	117.9	0	0	0	5	873
	Post-2013	37.9	111.0	0	1	3	16	790
Not-treated	Pre-2013	788.2	4,699.3	0	1	17	218.5	63,202
	Post-2013	1,020.9	5,676.7	0	5.5	43.5	400.5	75,777
				C. Buyers $h = 0.3$[a]				
Treated	Pre-2013	19.5	75.8	0	0	0	4	551
	Post-2013	32.7	95.5	0	1	3	15	668
Not-treated	Pre-2013	528.9	2,911.4	0	1	13.5	174	38,599
	Post-2013	772.6	3950.1	0	5	38.5	335.5	51,970
				D. Buyers $h = 0.5$				
Treated	Pre-2013	17.8	68.0	0	0	0	4	485
	Post-2013	30.3	86.7	0	1	3	15	592
Not-treated	Pre-2013	431.6	2,123.9	0	1	13.5	167.5	27,540
	Post-2013	630.0	2,821.8	0	5	37	306.5	36,121

[a] Since the customs data does not include an identifier for buyers (foreign firms), we use a clustering algorithm to generate a unique identifier for each buyer. This process depends on the hyperparameter h, where larger values of h allow for larger clusters.

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