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"The Impact of Shared Telecom Infrastructure on Digital Connectivity and Inclusion"

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FIT IN Initiative

The Impact of Shared Telecom Infrastructure on Digital Connectivity and Inclusion*

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Abstract

A substantial number of individuals remains unconnected to the Internet despite an increasing emphasis on infrastructure-based competition. This paper investigates the impact of shared telecom infrastructure on digital connectivity and inclusion using a new dataset on mobile tower sharing transactions between 2008 and 2020, i.e., acquisitions of towers by independent companies from mobile network operators to be rented back to all operators. Estimates based on difference-in-differences with different timing of treatment suggest that these transactions resulted in a significant drop in the price of mobile connectivity as well as an increase in availability and uptake of mobile Internet, especially by rural households and women. Our findings suggest that increased competition intensity through reduced market concentration appears to be the main driver of these outcomes.

Keywords: Mobile Telecommunications; Vertical Integration; Digital Technology Adoption

JEL Codes: L96, L14, O14

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1 Introduction

The benefits of access to quality digital connectivity have been well recognized since the COVID-19 pandemic; however, one-third of humanity remains unconnected and many more only have access to poor quality connectivity (ITU, 2022). For mobile or wireless telecommunication technologies, such connectivity gap broadly results from a number of challenges including limited affordability, investment and low literacy and income (Chen, 2021), as well as limited availability of relevant contents and access to electricity (Armey & Hosman, 2016; Houngbonon & Le Quentrec, 2020; Houngbonon *et al.*, 2021b).

In the mobile telecommunications industry, infrastructure-based competition, whereby mobile operators deploy their own network infrastructure and compete for end-users, has been considered by regulators to improve service affordability and boost investment (Houngbonon & Jeanjean, 2016; Jeanjean & Houngbonon, 2017; Genakos *et al.*, 2018). However, such a policy met with several challenges, especially the need for frequent investment in network upgrade due to fast-paced technological progress (Koh & Magee, 2006). In developing countries, this challenge is compounded with low ability to pay for connectivity services by end-users. This has resulted in the development of shared infrastructure business models (Strusani & Houngbonon, 2020), both bilateral agreements between network operators (Koutroumpis *et al.*, 2021) or multilateral agreements through independent infrastructure operators (Houngbonon *et al.*, 2021a).

Shared telecom infrastructure, whereby telecom service operators rely on the same network infrastructure to serve end-users, has the potential to improve service affordability and support network investment while preserving or boosting service-based competition (Koutroumpis *et al.*, 2021). By reducing the cost of network deployment and operations for telecom operators and improving their balance sheet, shared infrastructure can accelerate the expansion of high-speed broadband network, potentially increasing availability and quality of digital connectivity for end-users. Cost savings from reduced operating expenditures can result in improved service affordability for end-users, depending on the intensity of competition, especially when infrastructure is shared under an open access and non-discriminatory basis.

In this paper, we investigate the impact of shared telecom infrastructure on access to digital connectivity in developing countries. The study uses a novel dataset on 150 telecom tower transactions from developing countries between 2008 and 2019 in addition to data on the price of mobile telephony and Internet, and the uptake of mobile Internet in rural areas and by women. Our estimation strategy derives from a difference-in-differences setup whereby the treatment involves the transfer of towers from mobile operators to independent infrastructure operators. We estimated treatment effects using augmented inverse propensity weighing approach and difference-in-differences with differences in treatment timing as in Callaway & Sant'Anna (2021). We found that towers transactions have resulted in a significant drop in the price of mobile connectivity as well an increase in uptake of mobile Internet, especially by rural households and women. Our findings lend support to competition as the main channel through which shared telecom infrastructure affect digital connectivity and inclusion.

The findings of this paper fit into the literature on the welfare effects of market structure in the mobile industry. Most studies, including Genakos *et al.* (2018), Jeanjean & Houngbonon (2017) and Elliott *et al.* (2021) investigated the impact of infrastructure-based competition on price and investment. In this study, we focus on shared telecom infrastructure as an alternative to infrastructure-based competition. Other studies like Koutroumpis *et al.* (2021) evaluate the effects of shared telecom infrastructure, but focus on bilateral sharing, whereas this paper considers multilateral infrastructure sharing, a growing trend in the telecom sector.

The remainder of the paper is organized as follows. Section 2 provides some background on the digital divide and the business models of shared telecom infrastructure. Section 3 provides an overview of the related literature. Section 4 presents the conceptual framework, while Section 5 presents the data with descriptive statistics. Section 6 presents the econometric models, the estimation strategies and reports the results. Section 7 concludes.

2 Background on the digital divide and shared telecom infrastructure

■ **The digital divide**

The digital divide is defined as a *division between people who have access to and use of digital technologies and those who do not* (Van Dijk, 2020). As such, it involves (i) an access dimension which pertains to the availability and uptake of digital devices, connectivity services, or applications; and (ii) a usage dimension that relates to the usage intensity of the digital technologies, including the usage capabilities (e.g., literacy and skills) and the ability to direct access towards productive usage.

Several studies are available on the access dimension. Most studies focus on connectivity devices and services (ITU, 2022; GSMA, 2022b), but a growing set of studies document the applications layer of the access dimension, especially e-commerce and digital financial services (Demirgüç-Kunt *et al.*, 2022). As of 2021, the global digital divide in access remained significant: nearly 3 billion people remain unconnected, 90 percent of which live in low or middle-income countries, especially in India (787mn), Pakistan (166mn), Nigeria (133mn), Indonesia (127mn) and Bangladesh (124mn).[1] The unconnected are largely poorer, less educated, female, persons with disabilities, and rural, with 234 million fewer women than men using mobile Internet in developing countries (GSMA, 2022a).

■ **Shared telecom infrastructure**

Telecommunications network infrastructure includes facilities such as fiber optic cables, towers, ducts, poles, submarine landing stations, data centers and cabinets, as well as resources such as radio frequency spectrum and energy. These infrastructure can be shared among telecom service providers (e.g., mobile network operators and Internet service providers) under a variety of business models which can be grouped according to the degree of ownership of the infrastructure by service providers (Gallegos *et al.*, 2018; Strusani & Houngbonon, 2020).[2]

Under full ownership, the network infrastructure can be shared among service providers through bilateral agreements or access regulation (Koutroumpis *et al.*, 2021). Bilateral agreements involve commercial contracts between two telecom service providers, of which at least one own a network infrastructure,[3] without the intervention of a third party GSMA (2012). Examples include roaming agreements between two mobile network operators, sharing of masts or towers between mobile network operators in remote areas, and wholesale broadband network access between an Internet service providers and a vertically integrated fixed broadband network operator.

Network infrastructure is a strategic asset for competition in the downstream market. It determines both the cost and quality of services. As such, service providers owning the network infrastructure may discriminate by raising the access cost or limiting the quality of services of competitors seeking network access under a bilateral agreement. Access regulation is meant to avert such potential discrimination through (i) ex ante interventions such as wholesale access price fixing or mandating equivalence in the quality of inputs or outputs, and (ii) ex post measures pertaining to dispute resolution mechanisms.[4] Access regulation has been used as part of cooper local loop unbundling in Europe and several advanced economies with well developed cooper-based telephone networks.

Under partial ownership, telecom service operators typically establish joint ventures among them-

[1] See ITU (2022).

[2] Telecom infrastructure can also rely on infrastructure from other sectors such as railways, oil and gas pipeline, electric distribution systems, and city infrastructure like sewage systems, newsstands and bus stations.

[3] Only one service provider own the newtork in the case of sharing agreements with MVNOs.

[4] Cave (2018) discussed the role of access regulation in the context of 5G network roll out.

selves or with a third party specialized in the operations of network infrastructure. For instance, China Tower was formed as a joint venture between the country's three mobile network operators; and MTN, the pan-African mobile network operator, established a joint venture with American Tower Company in Ghana and Uganda in order to share its towers with competitors. Partial ownership can also involves co-investment by rival service providers. Such models were considered as part of the deployment of last-mile fiber optic network in developed economies like France and more generally in Europe. Partial ownership also carries a number of risks, especially coordination failure among service operators with competing interests, potentially resulting in delays in network deployment.

Under a no-ownership scenario, the shared telecom infrastructure is not owned by any service providers.[5] The typical business model under such scenario involves ownership and operations of the telecom infrastructure by an independent provider - for instance tower companies (hereafter 'towercos') in the case of mobile towers (Houngbonon *et al.*, 2021a). The towerco business model is gaining momentum across developing countries, though there are large disparities across countries and regions. As of 2020, three in four mobile towers in emerging markets were managed by towercos (Houngbonon *et al.*, 2021a). The South East Asia region had the highest share of towers managed by towercos (91 percent), primarily driven by the 100 percent rate in China. This was followed by South Asia (76 percent), primarily driven by 84 percent in India; and Latin America (59 percent), primarily driven by Brazil (70 percent) and Mexico (90 percent).

According to Amadasun *et al.* (2020) the sharing potential in EMs is bigger than in developed economies and more than 87% of the total CAPEX costs could be shared, with the biggest savings potential in site acquisition and design (41%), power (31%) and BTS/NodeB (15%). In OPEX, 69% of the totals costs in EMs could be shared, with the biggest potential in software support (20%), power (20%), land rent (15%) and backhaul (14%).

3 Related Literature

The assessment of the economic benefits of shared telecom infrastructure relates to the broader literature on the welfare effects of telecom market structure. A number of studies have investigated the welfare effects of competition among vertically integrated mobile network operators, i.e., owing the network infrastructure and providing Internet services to end-users. Examples include Houngbonon & Jeanjean (2016); Jeanjean & Houngbonon (2017); Genakos *et al.* (2018) and Elliott *et al.* (2021) who

[5] This recognizes instances where network operators retain their network infrastructure while entering into sharing agreement on infrastructure own by an independent wholesale access provider.

typically find positive impact of competition on price, but negative impact on quality or investment, beyond a certain a level of competition intensity. While integrated MNOs may enter into bilateral infrastructure sharing agreements, these studies did not focus on such arrangements. Other studies like Kim *et al.* (2011) considered the effects of shared mobile infrastructure as part of the regulation of network access by mobile virtual network operators, and generally found that incumbent's investment is not affected under voluntary access regulation, but drop under mandated access regulation.

Several studies have investigated the impact of shared fixed broadband infrastructure (cooper or fiber optic networks) on investment incentives and competition in advanced economies, especially in the EU. Examples include Nardotto *et al.* (2015) who assessed the effect of local loop unbundling (LLU) in the United Kingdom and find that LLU only has a limited positive effect on broadband penetration and the effect disappears after the first years when the market reaches maturity; with a positive impact on service quality via competition. Bourreau *et al.* (2018) investigated the impacts of traditional one-way access obligations and co-investments on the roll/out of network infrastructure and found that access obligations lead to a smaller roll-out of infrastructure due to reduced returns to investment and uneven distribution of investment risks (i.e. the investor bearing all risks compared to the new entrant).

Evidence on the benefits of shared mobile telecom infrastructure remains limited at this stage, especially in developing countries. A recent study by Koutroumpis *et al.* (2021) investigated the impact of shared mobile infrastructure but focused on EU countries and pertain to bilateral sharing. That study found that bilateral infrastructure sharing had resulted in lower prices and improved network coverage and quality for consumers driven by cost reductions, higher returns on investment and increased competition intensity.

Few studies have considered the impact of shared telecom infrastructure in developing countries but most are limited in scope or relied on qualitative approaches or executive surveys. Arakpogun *et al.* (2020) investigated barriers to infrastructure sharing in seven SSA countries based on interviews with different stakeholders and found that incumbents might be reluctant to share networks as this would erode their competitive advantage, and many markets have been dominated by one or two MNOs for years, which lack institutional incentives to engage in infrastructure sharing. Mamushiane *et al.* (2018) quantified the economic impact of infrastructure sharing using Software Defined Networking (SDN) and estimated that in the case of South Africa, full implementation of sharing can reduce the time to recover CAPEX investments and reach profitability from 5.4 months to less than 1.3

months in rural areas, suggesting profitable operation even less economically attractive zones.

Other studies have focused on the benefits of shared infrastructure for mobile network operators. Kim *et al.* (2018) assessed the impact of infrastructure sharing deals on firm performance using a DiD methodology and find statistically significant reductions OPEX for national roaming by 14% in the short run and by 19% in the long run. Amadasun *et al.* (2020) estimated that sharing of sites and antennas could reduce CAPEX costs by 20-30%. Sharing of also the radio network can reduce CAPEX by 25-45%. Sharing of all the assets could reduce CAPEX by another 10%.

4 Conceptual framework

Understanding the economic benefits of shared telecom infrastructure through independent towercos would start with a framework to rationalize why mobile network operators divest their towers to an independent operator. The minimization of transaction costs as discussed by Williamson (1979) could shed some light on the rationale for such strategy. However, in this paper, we are taking the cost savings for MNOs from shared infrastructure through towercos as given and focus on how such savings can affect competition in the downstream market for retail mobile connectivity, and ultimately the welfare of end-users.

As reported by the literature, shared telecom infrastructure can generate cost savings for MNOs, ranging from 20 to 30 percent (Kim *et al.*, 2018; Amadasun *et al.*, 2020). These wholesale cost savings in the upstream of the mobile connectivity value chain can benefit end-users by (i) increasing the intensity of competition in downstream markets, and (ii) being passed through to end-users in terms of reduced price, depending on the intensity of competition.

Indeed, shared mobile towers dramatically lowers the **cost of entry** into mobile markets by removing that part of capital expenditure dedicated to network deployment, which is replaced by an operating expenditures in the form of a lease rate to access towers. Under such passive infrastructure sharing scheme, MNOs still incur the capex associated with radio spectrum and base stations - i.e., equipment that connect end-users and manage traffic - but the overall capex is nonetheless reduced by up to 40 percent according to Amadasun *et al.* (2020). Such reduction in entry cost contributes to level the playing field between large and smaller MNOs, including new entrants, and, therefore, can enable faster network coverage and increased competition intensity.

Shared mobile towers can also reduce the marginal cost of mobile connectivity services by supporting a drop in operating expenditure for MNOs. In particular, site rental cost and energy cost can be shared under the towerco business model, resulting in a drop in operating expenditure. In addition, MNOs also save on maintenance cost of mobile towers as the towerco business model reduces transportation cost to multiple sites. Part of these savings on marginal cost can be passed on to end-users as a drop in price, for a given level of usage/quality, depending on the prevailing intensity of competition in the downstream market.

Overall, we derive the following testable hypotheses associated with the development of the towerco business model:

1. Increased availability of mobile connectivity, driven by the drop in entry cost
2. Increased competition intensity, also driven by the fall in entry cost
3. Reduced price of mobile connectivity, driven by wholesale cost savings and increased competition intensity
4. Increased uptake of mobile connectivity, derived from increased availability and reduced price of mobile connectivity
5. Digital inclusion, derived from increased uptake of connectivity by end-users from disadvantaged background

5 Data and descriptive statistics

5.1 Data and variables

Data used in this study cover 137 developing countries between 2008 and 2020.[6] We assembled data from five main sources: telecom tower data from TowerXchange (TXC), a leading industry research firm in the tower sector;[7] mobile connectivity data from GSMA, the global association of mobile operators, the International Telecommunications Union (ITU), and the Gallup Survey; and socio-economic data from the World Bank's World Development Indicators database. Table A-1 provides the list of variables retrieved from these data sources. Table 1 provides the summary statistics of the main variables.

In order to test the five hypotheses above, we consider the following outcome variables:

[6]Developing countries are defined as low and middle-income countries according to the WBG's classification of 2020

[7]TX is a research institute dedicated to the global telecom tower industry. As of 2022, TowerXchange is a division of Euromoney Global Limited, a publisher of consumer and business journals and periodicals, and is governed with the support and advice of an informal network of advisors composed of executives from the tower and mobile industries.

- Availability of mobile connectivity, measured by the percentage of population covered by at least 3G or 4G mobile network technology. The population coverage data comes from GSMA Intelligence.

- Competition intensity, proxied by change in market concentration, which is measured by the Herfindahl Hirschman Index (HHI). We obtained the HHI of both mobile telephony and mobile broadband Internet using market share data from GSMA Intelligence.

- Price of mobile connectivity, measured by (i) the price of mobile telephony; and (ii) price of mobile broadband Internet. Price data comes from the ITU's ICT price baskets. More specifically, the price of mobile telephony corresponds to that of the least expensive offer with 70 minutes of voice calls and 20 SMS. The price of mobile broadband Internet represents that of the least expensive offer with 2 GB of data allowance.[8]

- Uptake of mobile connectivity is measured by the number of unique mobile telephony and broadband subscribers, in percentage of population. This data is obtained from GSMA Intelligence, based on the number of subscriptions reported by mobile operators. The number of subscription was adjusted by the number of SIM cards per user to obtain an estimate of the number of unique users.

- Digital inclusion is measured along the access dimension, i.e., number of individuals having subscribed to a mobile network. We considered two attributes of inclusion, namely gender and area of residence. In particular, we use the share of women or rural residents with a mobile broadband subscription as our measures of digital inclusion. The Gallup survey focused on access at the household level between 2010 and 2015, before switching to individual-level access from 2016. Our analysis will focus on the 2010-2015 period where most tower transactions took place.

Our treatment variable is a dummy equals to 1 when a tower transaction occurs in a country at a given year, and 0 otherwise. As such, a country can be treated several times due to multiple tower transactions. A tower transaction is defined as the transfer of towers from mobile operators to an independent company. The towerco typically rent access to the acquired towers backed to all mobile operators. Absent a tower transaction, i.e., when the treatment dummy takes the value 0,

[8]We did not use low and high-usage mobile broadband baskets due to limited historical data – they only started from 2018.

mobile operators may engage in bilateral tower sharing. However, bilateral sharing of towers is not prevalent in developing countries which is the focus of this paper.

The treatment variable derives from two variables built from TXC:

- **Annual tower deal size by country.** We built this variable using tower transactions data. TXC publishes annual reports on trends in the tower industry by country, including a summary of mergers and acquisitions, with the number of tower sites involved, the value of the transaction and the type of deals.[9] From these reports, we retrieved data on 156 towers acquisition deals between 2008 and 2020 which occurred in 36 developing countries. Tables A-2 and A-3 present the number of deals and the corresponding number of sites by country and year. The median deal over the period and sample countries involved 916 towers (See distribution of deal size in Table A-4).

  This data has been collapsed at the country and year level, with a variable *deal_sites* corresponding to the total number of tower sites involved in deals - that variable equals 0 if no deal was recorded in a given year. It is used at the estimation stage to define a treatment variable based on a minimum number of sites involved in tower deals. The number of deals over the period of 13 years varies by country. Most countries (22/36) had 1 or 2 deals over that period; the remaining 14 countries had 3 to 29 deals (See Table A-5). This distribution reflects countries with multiple deals within a given year. When these multiple deals are considered as a single 'treatment', the number of treatments over the period range from 1 to 10 by country (See Table A-6). Our estimation strategy will take into consideration such multiple treatments setup.

- **Tower sites managed by mobile network operators and towercos.** From the TXC annual report, we retrieved the number of towers managed by mobile operators and towercos across 66 developing countries from 2015 and 2020. The share of towers managed by towercos in a country can drop over the year if the market is adding more towers than they manage. Our dataset comes with missing values, making it difficult to compare the share of towers managed by towercos across years. However, the share fluctuates between 30 and 38 percent (Table A-7). Some countries like Colombia, India and South Africa experienced significant rise in the share of towers managed by towercos. Among countries with tower data, the average deal size represents 12 percent of the stock of towers (Table A-8).

[9] Types of deals include sales and leased back, joint venture, manage with license to lease, portfolio acquisition or transfer

The analysis controls for income and market size using socio-economic data on population and GDP assembled from the World Development Indicators database of the World Bank.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Tower data					
deal	520	0.19	0.4	0	1
sites	520	957.5	6758.1	0	95477
totaltower (2015-2020)	303	62367.4	263807.2	749	2094464
nbrtowerco (2015-2020)	340	43678.9	247292.9	0	2094464
Mobile connectivity data					
cov_3g	1,529	0.6	0.3	0.013	1
cov_4g	810	0.5	0.3	0.010	1
mob_connect (million)	1,780	38.0	137.1	0.000	1604.3
int_connect (million)	1,539	17.8	88.4	0.000	1538.6
sim_subs	1,780	1.7	0.4	0.740	3.4
mob_subs	1,780	0.5	0.2	0.0001	0.9
int_subs	1,495	0.2	0.2	0	0.7
hhi	1,780	4857.8	2079.9	1355	10000
PPP_mcell	1,302	23.3	14.5	1.82	96.57
PPP_mdta	853	26.5	25.5	1.30	286.69
Digital inclusion data					
int_hh_rural (2010-2015)	560	0.18	0.18	0.00	0.87
int_indiv_rural (2016-2020)	463	0.44	0.24	0.03	0.95
int_hh_women (2010-2015)	562	0.23	0.20	0.00	0.84
int_indiv_women (2016-2020)	463	0.46	0.25	0.02	0.97
Socio-economic data					
year	1,781	2014	3.7	2008	2020
population (million)	1,781	44.7	165.0	0.01	1442
GDP (billion USD)	1,713	155.7	955.8	0.03	16073
per_capita p	1,697	6304.5	5648.8	10.63	33762
pop_dens	1,775	132.1	196.6	1.69	1802

Note: See Table A-1 in Appendix for a glossary of the variables.

5.2 Descriptive statistics

We start by assessing correlation between mobile connectivity and shared telecom infrastructure. Table 2 reports the average value of various attributes of mobile connectivity depending on the intensity of sharing. Two measures of sharing intensity were used: the percentage of towers managed by towercos and the occurrence of a tower deal. Overall, Mobile connectivity is higher under shared infrastructure than without it.

Table 2: Mobile connectivity and shared telecomm infrastructure

	Pop. Cov. 3G	Pop. Cov. 4G	Pen. Telephony	Pen. Internet	Price Tel. %GNI	Price Int. %GNI	Obs.
By intensity of tower sharing in 2020							
No towerco	89.1%	64.9%	56.8%	35.3%	6.8%	5.8%	20
At least one towerco	89.1%	73.1%	58.5%	38.2%	4.5%	4.5%	115
By occurrence of tower deal							
Pre-deal	60.1%	49.8%	49.8%	26.1%	7.6%	8.3%	532
Post-deal	74.3%	52.0%	52.4%	30.1%	7.2%	7.8%	267

6 Econometric Estimation

6.1 Difference-in-differences with different timing of treatment

We are interested in estimating the average effect of a tower sharing agreement on (i) availability of mobile Internet, (ii) uptake of mobile Internet, and (iii) access to mobile Internet by women and people living in rural areas. Note, the effect of treatment might take time to materialize, thus we consider outcomes in the year the deal has taken place and the year after. To do that, we carry out a difference in differences analysis. We follow Callaway & Sant'Anna (2021) methodology and use the *R* implementation of their estimator.[10]e also considered causal forest estimates as in Athey & Imbens (2017) and report the results in Appendix 9.

The key estimate from this approach is a per group average treatment on the treated (ATT), that is a treatment effect of treated units in a specific year. For example, if Pakistan and Ethiopia were treated in 2010, the estimated quantity pertains to the average of these two treatments only. Thus, given that there are different treatments happening in different years, we will have several ATT estimates - we present them in figures. Next, we average over these ATT to get the average of the average treatment effect on the treated. This is the standard procedure from Callaway & Sant'Anna (2021).

There are two key assumptions here: (i) conditional parallel trends, and (ii) overlap in the treatment propensity. We ensured the parallel trend assumption by undertaking a propensity matching based on a set of observable variables. As such, outcomes from the control group are re-weighted by the probably of being treated conditional on the observable variables. Recognizing that differences between treated and control groups may be driven by unobservable variables, we conducted a placebo test which is reported in the Appendix showing no effect when the treatment is altered **TBA**. Further, we also reported on the overlapping of the propensity score between the treated and control groups in the Appendix. This reflects the choice of the cutoff point for treatment which leaves ample number

[10]W

of similar units in both treated and control groups.

Formally, the ATT estimator takes the following form:

$$ATT(g,t) = \mathbb{E}\left[\left(\frac{G_g}{E[G_g]} - \frac{\frac{\hat{p}(X)C}{1-\hat{p}(X)}}{E\left[\frac{\hat{p}(X)C}{1-\hat{(p)}(X)}\right]}\right)(Y_t - Y_{g-1})\right], \tag{1}$$

where G_g is a dummy variable equalling one if the unit is in treated group g; C is also a dummy for units in the control group. X is a set of control variables including country and year fixed effects, the type of deal (acquisition or managed with license to lease), GDP per capita, and population. $\hat{p}(X)$ denotes the propensity of being treated conditional on the observable variable X. Y is an outcome variable as defined in section 5.

We focused on deals that involve at least a minimum number of sites, typically 1,000, as such deals are big enough for a new firm to achieve profitability. However, we also present results that are robust to the choice of the cutoff point showing that positive correlation between the size of the deal and the significance of the estimate.

6.2 Results

Availability of mobile Internet. During the period of our analysis, two important technologies have been rolled out to support the availability of mobile Internet: 3G and 4G. Table 3 shows the estimate of the average treatment effect. The dependent variable is the coverage of 3G or 4G, where we adjust for the baseline level.

We found that tower sharing deals have a statistically significant impact on 3G and 4G coverage in the year of the transaction as well as in the following years. This effect amounts to an 8.5 percentage points increase in 3G coverage two years of the transaction, which corresponds to 13%, and a 7.8 percentage points increase in the case of 4G (13.1%). There is no statistically significant impact on coverage of 4G, probably due to the nascent stage of this technology in developing countries during the period covered by our analysis. Figure 1 shows the estimates of ATT per year for 3G coverage in the year of the transaction. The estimates are more significant for earlier transactions because control groups can be better defined for those.

Table 3: Estimates of average treatment effects on internet coverage.

group	ATE	std. error	p. value
Coverage 3G	0.032	0.020	0.110
Next year coverage 3G	0.042	0.015	0.006
Two years after coverage 3G	0.085	0.025	<0.001
Coverage 4G	0.078	0.040	0.049
Next year coverage 4G	0.096	0.031	0.002
Two years after coverage 4G	0.078	0.042	0.066

Note: Outcome variable is the coverage of 3G and 4G. We adjust for the baseline level in the year before the transaction.

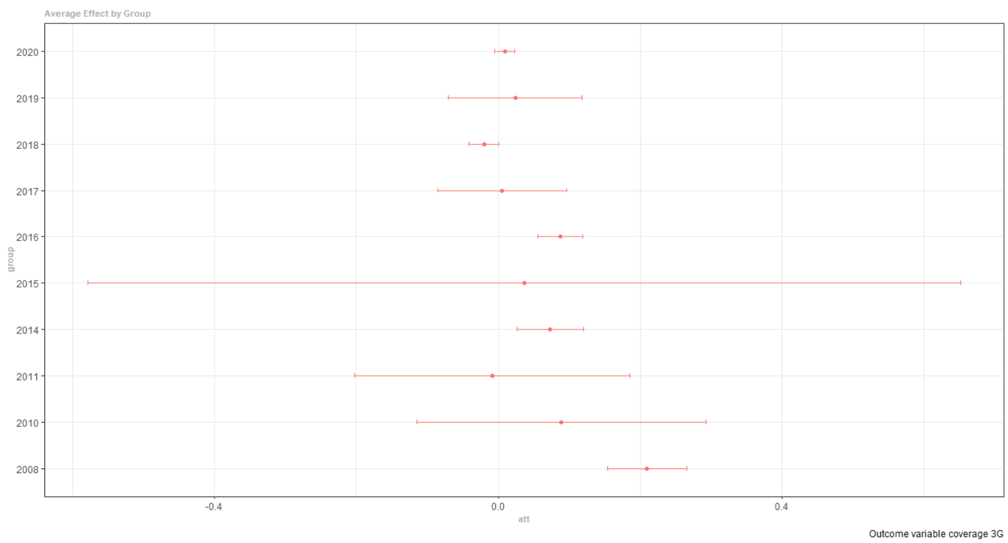


Figure 1: ATT by year

Price of mobile connectivity. Next, we estimated the impact of tower transactions on the price of mobile telephony and the Internet. In particular, we considered two outcome variables: emph-PPP_mcell, which is the price of mobile telephony, and *PPP_mdta*, which is the price of 1.5GB of mobile data (in PPP adjusted USD). Table 4 presents the results. We consider the logarithmic transformation of the outcome variable.

We find negative point estimates for all considered cases. The impact on the price of mobile cellular connections (*mcell*) is negative from the year of the transactions (20% decrease) until two years later - reduction by 18%. However, we do not see a clear impact on data prices. While point estimates are negative for all three years, only considering the impact two years after we find a statistically significant impact.[11]

In Figure 2 which shows the ATE for the price of mobile telephony, we see that the point estimates

[11]Note, prices are market indices derived from a wide range of prices of specific plans. Here we focus on the least expensive plans for a certain usage profile of connectivity.

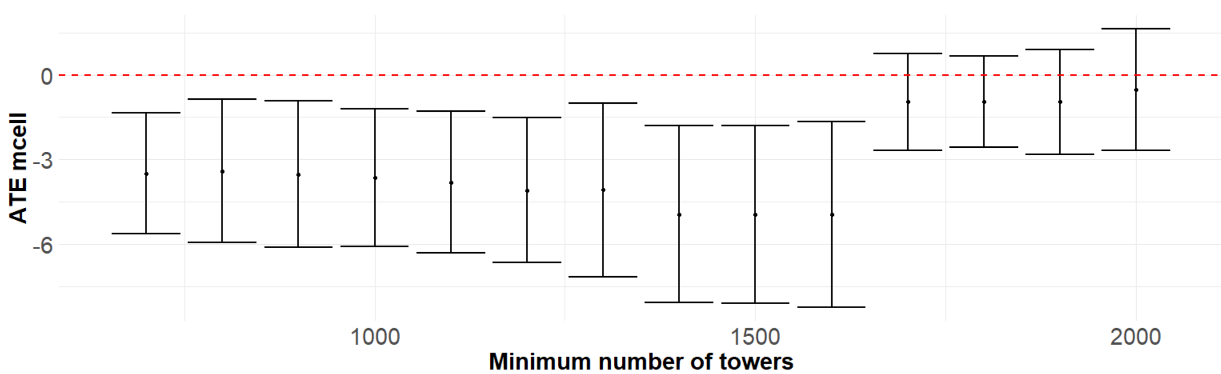
Table 4: Estimates of average treatment effects on prices in logs.

group	ATE	std. error	p. value
PPP_mcell	-0.199	0.055	<0.001
Next year PPP_mcell	-0.136	0.069	0.050
Two years after PPP_mcell	-0.183	0.079	0.020
PPP_mdta	-0.061	0.117	0.605
Next year PPP_mdta	-0.250	0.177	0.157
Two years after PPP_mdta	-0.552	0.195	0.005

Note: Outcome variable in the year of the treatment and an additional effect in the following year. Dependent variables are logarithmic transformations of price indices.

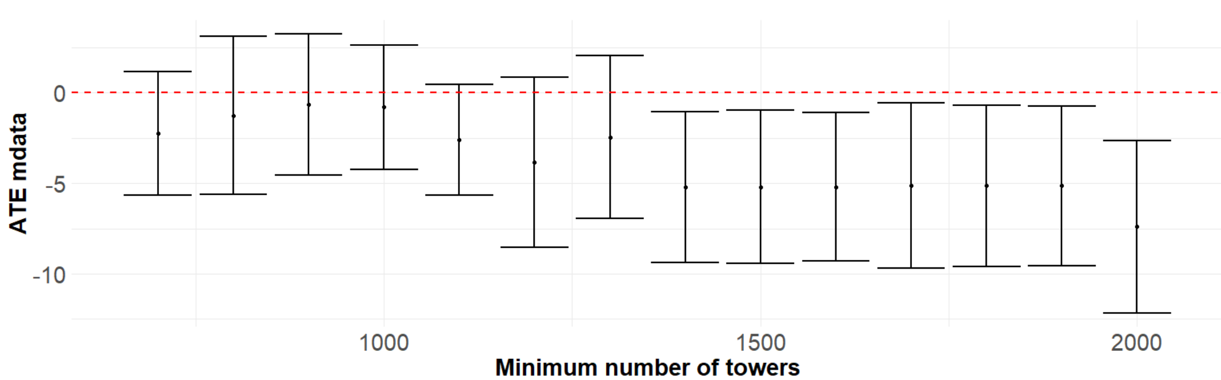
are negative for all thresholds. However, when we focus on only the largest deals the effect is statistically insignificant. In Figure 3 we repeat the exercise focusing on the price of mobile Internet. When we include smaller deals as treatments, we find a small negative, albeit statistically insignificant, effect on the prices of mobile Internet. Focusing on larger deals, specifically larger than 1300 towers, we find that infrastructure sharing decreases the prices of mobile Internet.

Figure 2: ATE on the price of mobile telephony by deal threshold size



Note: Estimate of the ATE for mcell *for various thresholds of the deal size.*

Figure 3: ATE on the price of mobile Internet by deal threshold size



Note: Estimate of the ATE for mcell *for various thresholds of the deal size.*

Uptake of mobile connectivity. Given the evidence on the availability and price of mobile connectivity, we turned to uptake which is determined by these two variables. We considered two measures of uptake: *mob_subs* which denotes the number of unique mobile telephony subscribers in percentage of population; and *int_subs* which denotes the number of unique mobile Internet subscribers in percentage of population. The results are reported in Table 5. We find a statistically significant increase in the uptake of mobile telephony. The impact on the uptake of mobile telephony persists a year and two years after the transaction, whereas the impact on uptake of mobile Internet is not significant the following years.

Table 5: Estimates of average treatment effects on uptake.

group	ATE	std. error	p. value
mob_subs	0.018	0.010	0.076
Next year mob_subs	0.011	0.006	0.089
Two years after mob_subs	0.011	0.006	0.056
int_subs	0.016	0.008	0.036
Next year int_subs	0.002	0.008	0.781
Two years after int_subs	-0.002	0.009	0.786

Note: Outcome variable in the year of the treatment and an additional effect in the following year.

Women and rural households. Finally, we present the results of the analysis of the impact of tower sharing on access to the Internet by women and rural households. Results are in Table 6. We found statistically significant impact of tower sharing on access to the Internet by women-led households and by rural households in the year of the transaction, there is no additional effect in the following years. The effect has also high economic magnitude; in both cases it amounts to approximately 18%.

Table 6: Estimates of ATE on access to the Internet by women and rural households.

group	ATE	std. error	p. value
Rural households	0.041	0.017	0.013
Next year rural households	0.020	0.018	0.279
Two years after rural households	0.025	0.022	0.259
Woman households	0.052	0.023	0.024
Next year woman households	0.030	0.019	0.121
Two years after woman households	0.023	0.017	0.175

Note: Outcome variable in the year of the treatment.

Market concentration. We have highlighted to main channels through which infrastructure sharing can reduce prices and increase access. First, by sharing infrastructure, companies can reduce their own costs and, in this way, increase their efficiency. Second, infrastructure sharing can help increase market competition by allowing smaller firms to access and use infrastructure that would otherwise be beyond their reach. This can help to reduce market concentration by allowing more firms to enter and compete in the market.

While we do not observe costs and, as a consequence, cannot directly test the first mechanism, we do observe concentration in the market. In Table 7, we show estimates of the average treatment effect with the Herfindahl–Hirschman index as the dependent variable. We found a negative impact of infrastructure sharing on market concentration; the effect also increases over time.

Table 7: Estimates of ATE on market concentration.

group	ATE	std. error	p. value
HHI	-79.150	65.796	0.229
Next year HHI	-97.584	50.501	0.053
HHI in two years	-134.349	63.281	0.034

Note: HHI in the year of the treatment, the following year, and two years after. We trim data at HHI strictly below 10000.

Placebo test. To check the robustness of our approach, we carry out the same analysis, but instead of the outcome in the year of the transaction (and the following years), we look at the year before the transaction. Table 8 shows the results.

Table 8: Estimates of ATE on outcomes year before.

outcomes	ATE	SE	p.value
Coverage 4G year before treatment	0.001	0.101	0.995
Coverage 3G year before treatment	0.050	0.034	0.141
PPP mcell year before treatment	-2.168	1.787	0.225
PPP mdata year before treatment	4.345	2.638	0.100
Mob subs year before treatment	0.016	0.012	0.166
Int subs year before treatment	0.003	0.009	0.709
Rural households year before treatment	0.006	0.013	0.616
Woman households year before treatment	0.014	0.019	0.441

We find that the treatment has no statistically significant impact on any of the outcomes in the year before a transaction.

7 Conclusion

The findings of this paper lend support the hypotheses that shared telecom infrastructure through independent operators would result in increased availability, affordability and uptake of mobile connectivity, increased competition intensity and alleviate the digital divide. In particular, we found a significant and positive impact on the coverage of mobile broadband Internet. Price of mobile connectivity drops with shared telecom infrastructure, especially for mobile telephony; the impact on the price of mobile Internet become significant only for large tower transactions. Both women and rural households benefit from shared telecom infrastructure, with increased uptake of connectivity. Increased competition, with a reduction in market concentration 2 or 3 years after the transaction appears to be a driver of these end-users' benefits.

These findings suggest that shared telecom infrastructure through independent tower companies can be an effective approach to increasing access to digital connectivity in developing countries and potentially enable these countries to take advantage of the opportunities offered by digitization of economies. Specific policies recommendations hinge upon a better understanding of the role of access regulation and the drivers of shared telecom infrastructure, both at the extensive and the intensive margins. This could be an avenue of future research.

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Appendix

8 Data and summary statistics

Table A-1: List of variables and data sources

Variable	type	Label	Source
pop	long	Total population	WB
cov_3g	double	3G network coverage; by population	GSMA
cov_4g	double	4G network coverage; by population	GSMA
sim_subs	double	SIMs per unique mobile subscriber	GSMA
mob_connect	long	Total mobile connections	GSMA
mob_subs	double	Market penetration; unique mobile subscribers	GSMA
int_connect	long	Mobile broadband capable connections	GSMA
int_subs	double	Market penetration; unique mobile internet subscribers	GSMA
hhi	int	Herfindahl-Hirschman Index	GSMA
GNIpc_mdta	double	price of 1.5 GB Mobile broadband, % of monthly GNI per capita	ITU
GNIpc_mcell	double	price of Mobile Cellular Low Usage price, % of monthly GNI per capita	ITU
GNIpc_mbb	double	price of Mobile Data and Voice Low Usage, % of monthly GNI per capita	ITU
GNIpc_mbbh	double	price of Mobile Data and Voice High Usage, % of monthly GNI per capita	ITU
PPP_mdta	double	price of 1.5 GB Mobile broadband data, USD PPP	ITU
PPP_mcell	double	price of Mobile Cellular Low Usage, USD PPP	ITU
PPP_mbb	double	price of Mobile Data and Voice Low Usage, USD PPP	ITU
PPP_mbbh	double	price of Mobile Data and Voice High Usage, USD PPP	ITU
USD_mdta	double	price of 1.5 GB Mobile broadband data, USD	ITU
USD_mcell	double	price of Mobile Cellular Low Usage, USD	ITU
USD_mbb	double	price of Mobile Data and Voice Low Usage, USD	ITU
USD_mbbh	double	price of Mobile Data and Voice High Usage, USD	ITU
int_indiv	double	% adults with internet access	Gallup Survey
int_indiv_urban	double	% adults with internet access, urban	Gallup Survey
int_indiv_rural	double	% adults with internet access, rural	Gallup Survey
int_indiv_men	double	% adults with internet access, men	Gallup Survey
int_indiv_women	double	% adults with internet access, women	Gallup Survey
int_hh	double	% households with internet access	Gallup Survey
int_hh_urban	double	% households with internet access, urban	Gallup Survey
int_hh_rural	double	% households with internet access, rural	Gallup Survey
int_hh_men	double	% households with internet access, men	Gallup Survey
int_hh_women	double	% households with internet access, women	Gallup Survey
country_tower_deals	str26	country_tower_deals	TowerXchange
sites	double	Number of tower sites involved in deal	TowerXchange
dealtype	str11	Type of deal: acquisition, mll	TowerXchange
deal	float	dummy variable, 1 if tower deal at year t, 0 if no deal	TowerXchange
ict_tracker	double	overallscore	ITU
gdp	double	GDP (current US$)	WB
gdp_per_capita	double	GDP per capita (current US$)	WB
per_capita_ppp	double	GDP per capita, PPP (current international $)	WB
totaltower	long	total number of towers	TowerXchange
nbrtowerco	long	towers owned by towercos	TowerXchange
sharetowerco	double	Share of towerco of total towers	TowerXchange

Table A-2: Number of recorded telecom tower deals

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Argentina									1					1
Bolivia												2		2
Brazil				2	5	9	3	3	1	1		2	3	29
Burkina Faso							1					1		2
Cameroon					1	1								2
Colombia				2					1	3		2	1	9
Congo							1							1
Congo; DR			1						1					2
Costa Rica						1								1
Cote d'Ivoire					1	1								2
Dominican Rep.								1	1		1			3
Ecuador								1				1		2
Egypt								1						1
El Salvador										1	1			2
Ghana			3				1					1		5
Guatemala											1			1
India		3	2					2	2	2	3			14
Indonesia	2		1	1	4	1	1		1	1	2	1		15
Jamaica											1			1
Kenya							1				1	1		3
Laos												1		1
Malawi							1							1
Malaysia							1		2	1				4
Mexico				2		2			1	1		1		7
Myanmar								1	1		1			3
Nicaragua									1			1		2
Niger							1					1		2
Nigeria			3				3	1	2					9
Pakistan										2				2
Paraguay										1				1
Peru					1				1	2		1	1	6
Rwanda							2							2
Senegal									1				1	2
South Africa			1						1			1		3
Tanzania			1			1			1					3
Thailand												1		1
Uganda				1	2		1					1		5
Ukraine									1					1
Vietnam									1					1
Zambia							2							2
Total	2	3	12	8	14	16	19	10	21	15	11	19	6	156

Table A-3: Average number of sites involved in recorded telecom tower deals

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Argentina									1000					1000
Bolivia												600		600
Brazil				1012	1122	1501	4250	2176	1655	1200		807	1726	1726
Burkina Faso							800					1102		951
Cameroon					827	1000								914
Colombia				1126					120	483		589	770	641
Congo							393							393
Congo; DR			521						967					744
Costa Rica						400								400
Cote d'Ivoire					931	1000								966
Dominican Rep.								190	545		1049			595
Ecuador								130				1000		565
Egypt								2000						2000
El Salvador										202	800			501
Ghana			1119				900					1102		1072
Guatemala											20			20
India		6686	10975					21291	42790	47739	21033			23482
Indonesia	2118		1482	595	854	300	3500		2500	371	1400	3100		1487
Jamaica											451			451
Kenya							981				723	1102		935
Laos														
Malawi							219							219
Malaysia							309							309
Mexico				1069		1275			120	142		200		736
Myanmar								1250	100		1300			883
Nicaragua									119			150		135
Niger							600					1102		851
Nigeria			536				5335	555	648					2162
Pakistan										6850				6850
Paraguay										1400				1400
Peru					350				900	125		1000	760	543
Rwanda							357							357
Senegal									450				1220	835
South Africa			1400						300			900		867
Tanzania			1200			1149			185					845
Thailand												778		778
Uganda				962	350		2681					1102		1089
Ukraine									811					811
Vietnam									1972					1972
Zambia							849							849
Total	2118	6686	2626	996	845	1244	2187	5323	5190	8157	6386	924	1322	3276

Table A-4: Distribution of deals' size

Percentile	Number of sites
Min	20
1%	75
5%	119
10%	150
25%	397
50%	916
75%	1698
90%	4630
95%	13000
99%	43379
Max	90255

Table A-5: Tower deals per country, 2008-2021

Unique deals	Number of countries	Average sites per deal
1	10	899
2	12	1213
3	4	883
4	1	309
5	2	1157
6	1	627
7	1	561
9	2	1193
14	1	25085
15	1	1622
29	1	1717
Total	36	

Table A-6: Shared tower treatment variable

Number of treatments	Countries	Average sites per treatment
1	15	1774
2	8	1474
3	5	3190
4	2	12454
5	3	4726
6	1	328744
9	1	50066
10	1	22299
Total	36	

Table A-7: Total and towercos towers

	# towers (mnos & towercos)						%towers (towercos only)					
	2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020
Afghanistan					6645	6917					0.0%	0.0%
Algeria	17500	17500	18000	18000	19000	19350	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Angola			2500	2600	3318	3318			0.0%	0.0%	1.1%	1.1%
Argentina		16000	16000	16150	17252	17729		0.0%	0.0%	8.3%	6.7%	9.2%
Bangladesh	27000	29693	30000	30000	39500	33734	41.9%	26.9%	27.7%	32.7%	25.6%	28.6%
Bolivia				4600	4200	4490				0.0%	9.5%	14.5%
Brazil	48606	54595	55875	57127	60500	64966	66.2%	96.3%	94.0%	97.9%	56.2%	70.4%
Bulgaria						8320						31.5%
Burkina Faso				1700	2380	2517				41.2%	28.2%	26.5%
Cambodia	9000	9250	9310	9200	9200	9200	0.0%	0.0%	21.5%	0.0%	39.4%	39.4%
Cameroon				3200	3072	3718				71.4%	79.5%	65.7%
Chad				2000	2000	2000				0.0%	0.0%	0.0%
China	1180000	1750000	1945384	1968000	1968000	2094464	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Colombia		15353	15349	15553	16351	4000		26.2%	30.3%	32.1%	36.9%	63.2%
Congo				800	800	848				48.0%	57.9%	54.6%
Congo, Democratic Republic	4200	4350	4350	4293	4293	4698	19.0%	41.2%	42.2%	41.3%	53.5%	48.9%
Costa Rica		2924	3238	3352	3889	4113		84.6%	86.1%	78.1%	80.3%	50.4%
Cote d'Ivoire			3679	4142	4271	4271			66.0%	60.8%	63.7%	63.7%
Egypt	19000	19000	19000	19000	22704	24989	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
El Salvador		1246	1267	1683	1807	1811		19.7%	36.9%	28.7%	41.6%	58.9%
Ethiopia			6600	6600	8000	7300			0.0%	0.0%	0.0%	0.0%
Gabon			1000	1000	1000	1000			0.0%	0.0%	0.0%	0.0%
Ghana	5983	5983	5983	6296	6605	6609	71.3%	72.4%	0.0%	76.2%	77.3%	77.3%
Guatemala		3593	3661	3680	3908	1340		24.9%	26.2%	26.6%	28.1%	70.1%
Honduras		1200	1200	1200	1200	4026		16.7%	16.7%	16.7%	16.7%	29.7%
India	450000	455521	461550	461121	601800	617351	57.3%	75.0%	77.0%	76.2%	84.2%	84.0%
Indonesia	69458	85537	93549	93378	95556	98385	55.3%	60.8%	64.5%	62.0%	70.1%	65.6%
Iran		38000	38000	38000	37106	41106		0.0%	0.0%	0.0%	3.0%	12.4%
Iraq	12300	12300	12300	12300	14769	14769	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Jordan	5900	5900	5900	5900	6836	6853	0.0%	0.0%	0.0%	0.0%	14.9%	14.9%
Kazakhstan				15400	15400	16000				0.0%	0.0%	0.6%
Kenya	17500	6600	6600	6629	7571	7661	0.0%	10.6%	33.3%	29.0%	26.6%	27.3%
Laos		7374	7374	7374	7374	7374		100.0%	100.0%	100.0%	100.0%	100.0%
Lebanon	2000	2000	2000	2000	2600	2600	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Madagascar			2100	2020	2310	2310			42.9%	51.0%	51.9%	56.3%
Malawi				1000	1000	1000				100.0%	100.0%	100.0%
Malaysia	20000	22117	22682	22802	32412	35313	47.3%	54.5%	56.2%	55.9%	71.0%	62.0%
Mexico	22722	27205	29159	30349	32584	35242	98.5%	90.1%	91.4%	90.4%	88.3%	88.9%
Mongolia			1000	1000	1000	1000			0.0%	0.0%	0.0%	0.0%
Morocco	17000	17000	17000	17000	19054	21052	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mozambique	4800	4400	4400	4400	4400	4400	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
Myanmar	7410	10750	13620	15827	16000	23916	65.1%	66.5%	60.4%	46.2%	73.4%	46.6%
Namibia		2000	2000	2000	749	749		0.0%	0.0%	37.5%	100.0%	100.0%
Nepal		6000	6000	6000	6000	6000		0.0%	0.0%	0.0%	0.0%	0.0%
Nicaragua		1004	1115	1195	1295	1810		65.1%	68.6%	70.7%	71.0%	44.2%
Niger				1800	1800	1853				100.0%	100.0%	97.1%
Nigeria	30941	27675	28241	29652	30540	31570	75.1%	76.7%	81.2%	75.7%	77.5%	78.4%
Pakistan						32000						6.3%
Paraguay			4250	4250	4250	4296			58.8%	58.8%	30.8%	33.2%
Peru		9118	9193	10646	11202	15041		24.3%	9.1%	17.6%	22.8%	42.0%
Philippines		16300	16300	17850	17850	17850		0.0%	0.0%	0.0%	0.0%	0.0%
Russian Federation		117100	117700	60850	126660	140900		0.0%	0.0%	0.0%	40.3%	10.3%
Rwanda			1300	1300	1300	1300			59.0%	62.6%	62.6%	62.6%
Senegal	2900	3350	3350	3151	3925	4045	0.0%	0.0%	0.0%	0.0%	0.0%	30.2%
Serbia					5146	5146					32.0%	32.0%
South Africa	22288	25000	30431	28581	30183	30560	9.4%	9.9%	20.6%	32.9%	31.3%	37.3%
Sri Lanka		7000	7500	7500	8000	8000		0.0%	0.0%	0.0%	1.6%	1.6%
Tanzania		8800	7415	8278	8278	8422		40.7%	47.1%	42.4%	42.5%	43.6%
Thailand	47483	52483	52483	52483	52483	52483	71.6%	64.8%	64.8%	64.8%	64.8%	64.8%
Tunisia	7000	7000	7000	7000	8383	7955	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Turkey					49032	50215					18.7%	19.7%
Uganda	2547	3485	3517	3554	3816	4123	100.0%	85.9%	85.1%	84.2%	79.0%	80.6%
Ukraine			12000	21601	21600	21655			10.0%	5.6%	5.6%	5.3%
Vietnam	55000	70000	70000	90000	90000	90000	0.0%	0.0%	0.0%	0.0%	3.7%	3.7%
Zambia				2300	2300	3164				74.5%	81.8%	59.5%
Zimbabwe		1400	2700	2700	2700	3000		0.0%	0.0%	0.0%	0.0%	0.0%
Average	81098	69375	62349	53760	56174	57791	34.4%	31.0%	30.2%	35.9%	38.3%	38.1%

Table A-8: Deal size in % of the number of towers

	2015	2016	2017	2018	2019	2020	Average
Argentina		6.3%					6.3%
Bolivia					28.6%		28.6%
Brazil	13.4%	3.0%	2.1%		2.7%	8.0%	5.8%
Burkina Faso					46.3%		46.3%
Colombia		0.8%	9.4%		7.2%	19.3%	9.2%
Congo; DR		22.2%					22.2%
Egypt	10.5%						10.5%
El Salvador			15.9%	47.5%			31.7%
Ghana					16.7%		16.7%
Guatemala				0.5%			0.5%
India	9.5%	18.8%	20.7%	13.7%			15.7%
Indonesia		2.9%	0.4%	3.0%	3.2%		2.4%
Kenya				10.9%	14.6%		12.7%
Mexico		0.4%	0.5%		0.6%		0.5%
Myanmar	16.9%	0.9%		8.2%			8.7%
Nicaragua		11.9%			11.6%		11.7%
Niger					61.2%		61.2%
Nigeria	1.8%	4.7%					3.2%
Paraguay			32.9%				32.9%
Peru		9.9%	2.7%		8.9%	5.1%	6.6%
Senegal		13.4%				30.2%	21.8%
South Africa		1.2%			3.0%		2.1%
Tanzania		2.1%					2.1%
Thailand					1.5%		1.5%
Uganda					28.9%		28.9%
Vietnam		2.8%					2.8%
Average	10.4%	6.8%	10.6%	14.0%	15.9%	15.6%	11.9%

9 AIPW analysis

We supplement the analysis in section 6 by considering a simpler average treatment effect estimation.

To compute estimates of the average treatment effect we used *grf* implementation of causal forest (Athey & Imbens, 2017). We defined a treatment to be a deal involving more than 1000 towers, there are 76 such events in the dataset. We considered outcome variables with a lag of one year and two years. We used following outcome variables: *PPP mcell*, *PPP mdta*, *mob connect*, *cov 4g*. As controls we considered: *deal type*, *gdp per capita*, *pop*, *year*, and the outcome variable in the year before the treatment.

Note: the estimates from AIPW are doubly robust so it's enough that either the outcome regression or propensity regressions are properly specified. Nevertheless, we still assume unconfoudedness. We need to work on the covariates that we have or try to think of specific cases where we think it might hold

Results Table above presents the results. First column gives the name of the outcome variable, second column is the estimate of the average treatment effect, column three gives standard error. We can see that the estimates of ATE on mobile data and cellular prices two years after the deal are statistically significant. Economic magnitudes are also high.

outcome	ATE	SE	stat.significant
Mcell t+1	0.419	0.924	no
Mcell t+2	-4.031	1.676	yes
Mdta t+1	-8.319	2.628	yes
Mdta t+2	-12.38	4.652	yes
4G t+1	0.030	0.030	no
4G t+2	0.072	0.048	no
Mobile devices t+1	466.19	898.8	no
Mobile devices t+2	1236.18	1586.3	no