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The impact of taxation in the telecommunications industry

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ABSTRACT

In this article we study the impact of taxation in the performance of the telecommunications sector. To do so, we develop a model that considers the taxes and fees imposed directly or indirectly along the telecommunications value chain. Overall, we find strong evidence of a negative impact on investment from an increase in regulatory fees, profit taxes, and excise taxes. In addition, telecommunication service prices are affected by the fiscal regime, both directly -through taxation over services- and indirectly, through obligations imposed on operators that can ultimately have an impact on service prices. We also find some evidence of the effect of custom duties for equipment and smartphones on the decrease of investment on broadband network deployment and service adoption, respectively. On this basis, we simulate a fiscal-reform scenario, consisting in removing sector-specific contributions to eliminate inter-sectoral asymmetries, with results suggesting significant gains in investment, coverage, and adoption. Considering these findings, and the potential socioeconomic gains from increasing broadband adoption, we believe that governments pursuing the development of digital agendas should consider potential fiscal reforms to accelerate the development of the digital economy. That being said, considering the potential loses in tax collection, a careful trade-off analysis should be performed before determining the nature and the scope of the fiscal reforms to be introduced.

1. Introduction

As supported by extensive research, digitization has been identified as a key driver of productivity and economic growth. This evidence has usually provided support to the launch of national digital agendas to spur the development and adoption of digital technologies by consumers, enterprises, and governments. Undoubtedly, the core of the digital revolution lies in the mass adoption of telecommunications networks, and in particular, of high-speed internet connectivity. Considering that still a third of the world population does not use internet,[1] a top priority for policymakers is to develop suitable frameworks that facilitate closing the digital divide and accelerate the economic impact of digitization.

In addition to competition policy and regulation, the development of digital infrastructure is influenced by fiscal policy, particularly because of its potential effect in stimulating (or discouraging) investment and adoption levels. As it is the case with every economic sector, telecommunication operators face the imposition of general taxes such as income taxes, while ICT services purchased by consumers are usually subject to Value Added Tax (VAT). In addition, however, other specific levies and contributions are imposed on this sector: license fees, spectrum payments (one-off or recurrent), excise taxes, and universal service contributions are some examples of these additional obligations.

The application of taxes, charges and fees in the telecommunications industry is not homogeneous worldwide. Matheson and Petit (2017) argue that governments have "conflicting objectives" regarding the tax treatment of the telecommunications industry, because, on the one hand, they know about the positive externalities generated by this sector on the economy, while on the other hand, they perceive telecommunications operators as being a good source of revenues, due to the sector's formal status and its large turnover. Therefore, it is not surprising that there are multiple taxation approaches applied to this industry. They reflect not only a country's general fiscal framework but also trade-offs around public policy objectives for the sector. Generally, and depending on the tax burden applicable to both operators and consumers, we can identify different fiscal models: on the one hand, countries that have decided to impose a reduced taxation burden to stimulate adoption and investment; and on the other hand, countries that rely on the telecommunications industry to maximize government revenues through taxes.

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[1] According to the International Telecommunications Union (ITU), only 63% of the world population were internet users in 2021.

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In developing fiscal policies, governments need to consider the trade-offs between revenue generation and the potential negative impact on the sector's development and performance. As the evidence regarding the positive socioeconomic impact of digital industries continues to grow, the argument to reduce potential distortions emerging from over-taxation of the sector is gaining ground (ITU, 2022). Furthermore, high fiscal pressures over the telecommunication industry may compromise the sector's long-term sustainability, operating in a context of revenue decline[2] and increasing investment required to deploy next generation networks.

In this context, the objective of this paper is to provide a comprehensive framework to study, both theoretically and empirically, the incidence of taxation in the telecommunications industry. While there are several academic articles that have studied the economic effects of taxation broadly, to the best of our knowledge no published paper has yet addressed the issue exhaustively for the telecommunications industry. Considering that the telecommunications sector is so critical for economic development (Hardy, 1980; Karner and Onyeji, 2007; Jensen, 2007; Katz et al., 2008; Fornefeld et al., 2008; Koutroumpis, 2009; Katz et al., 2012; Rohman and Bohlin, 2012; Mack and Faggian, 2013; Arvin and Pradhan, 2014; Katz et al., 2020), while, at the same time, subject to several impositions beyond regular goods, the main objective of this paper is to fill this gap in the literature. This is relevant because, as highlighted by Matheson and Petit (2017), many of the fiscal instruments currently applied to telecommunications operators generate market distortions, negatively affecting efficiency, affordability, and growth. Along these lines, the contribution of this paper is threefold. First, we provide a comprehensive review all possible taxes, fees and obligations affecting the telecommunications sector. Next, we estimate the impact of those impositions across the whole value chain of the telecommunications sector - from investment decisions to final adoption by end consumers. Finally, we simulate a fiscal scenario of tax reform to provide policymakers with useful inputs on potential policies.

The remainder of this article is structured as follows. Section 2 reviews the research literature on taxation and telecommunications. Section 3 presents, from a theoretical viewpoint, all the different taxes and fees identified as potentially affecting this industry. Section 4 specifies the empirical model estimating the tax impact on each stage of the value chain of the telecommunications sector. Section 5 presents the dataset and main descriptive statistics. Section 6 reports the results from the econometric model estimates. Section 7 presents a simulation scenario of potential fiscal reform, by applying the parameters estimated in the econometric models to the estimation of sector performance. Section 8 summarizes the conclusions of the analysis and draws policy implications.

2. Literature review

Research on the role of taxation affecting sector outcomes addresses both enterprise and consumer effects. In general terms, most macroeconomic research literature has found that taxation regimes play an important role in driving capital flows, when controlling for economic development, unemployment, and currency fluctuations (Slemrod, 1990; Devereux and Freeman, 1994 and 1995; Billington, 1999). When a firm makes an investment decision, taxation plays a significant role. Taxes affect both the incentives of a firm to invest while also reduce the supply of funds available to finance such an investment. Several empirical studies indicate that, all things being equal, marginal and average tax rates have a negative effect on investment decisions. Research has also shown that a reduction of corporate income taxation determines, over time, an increase in the level of gross fixed capital formation (Talpos and Vancu, 2009). These effects can be expected to be more important in emerging market economies, where investment needs are greater.

However, taxes are just one of the many factors driving capital investment decisions. Beatty et al. (1997) showed that high net equity financing activity (access to low-cost funds) and high stock returns (market signaling) are also important variables in explaining high future net capital expenditures. Similarly, as expected, the authors found that high net income and low dividend pay-outs are important predictors. Nevertheless, when controlling for these factors, the authors also found that, for instance, changes in the tax code may have a real effect on the investment behavior of firms.

The mechanisms by which taxes affect technology (particularly telecommunications) investment are complex. In general terms, Devereux (2006) considers that taxation first affects two binary decisions: in which business to invest (e.g., wireless, broadband, or other) and, in which geographic location to invest (e.g., a specific country). In addition, taxes also influence a continuous choice: once a business and locations are agreed upon based on taxation attractiveness, levies affect their capital expenditure allocation process. In other words, taxes will influence how much investment will favor certain locations to the detriment of others.

It should be noted that changes in tax regimes may not affect investment decisions instantaneously. Investment decisions are partially driven by variables that only change gradually (e.g., changes in the cost of capital). As a result, a modification of taxation regimes (e.g., a change in the sales tax rate affecting the initial purchasing of network equipment) might affect the incentives to invest immediately but translate in investment decisions only gradually (Auerbach, 2005). An implication of this is that countries that constantly change tax policies introduce another layer of complexity for firms planning future investment. In other words, by the time the firm is ready to adjust to the tax regime imposed previously, a new change imposed by the government modifies the underlying conditions of future investment. This situation makes it very complex for firms to plan future multi-year capital investments required for the deployment of new infrastructure.

The factors outlined above are especially important in capital-intensive industries such as telecommunications. Typical capital planning processes in telecommunications comprise decisions in three domains: maintenance of existing plant (e.g., replacement of depreciated equipment), network modernization (e.g., deployment of 5G networks, deployment of fiber in the access network), and capacity upgrades (e.g., investment to accommodate sudden growth in demand). Each investment domain is driven by different time constraints. For example, maintenance capital investment is typically multi-year and mostly non-discretionary; therefore, it is largely predictable and relatively less subject to taxation effects. Network modernization capital, while also being multi-year, could be affected by capital allocation decisions influenced by taxation (in other words, if taxation reduces the supply of funds, it could impact investment thereby affecting the rate of network modernization). On the other hand, capacity upgrades have a long-term component driven by demand forecast, but also a very short-term component focused on surgical infrastructure upgrades (e.g., accommodate spikes in demand in certain portions of the network). This area of capital investment might be less affected by taxation regimes since it is directly linked to revenue generation opportunities.

In addition, when discussing about the effect of taxes on investment, an important distinction must be made between statutory tax rates (the legal percentage established by law) and the *effective tax rates*. This metric reflects the percent of their overall accounting

[2] Worldwide average revenue per user (ARPU) from mobile services has been decreasing annually at a Compound Average Growth Rate (CAGR) of −4.26% since 2010 (source: GSMA).

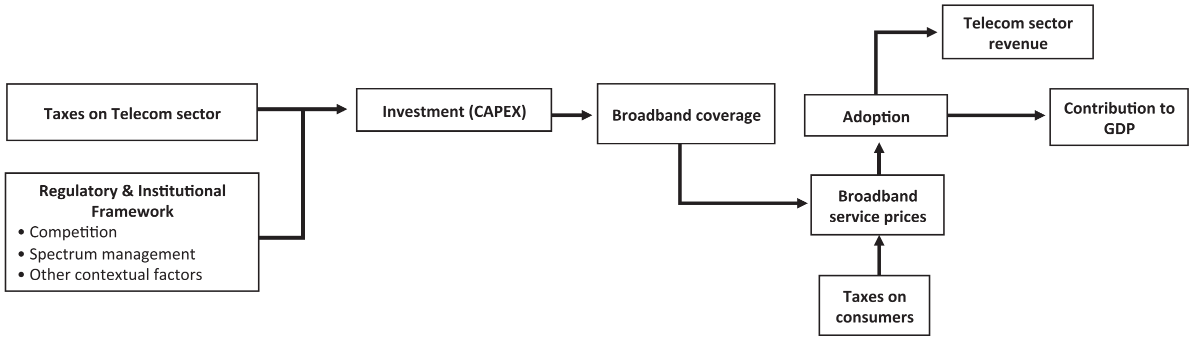

Fig. 1. Causal flows and value creation in the telecom sector.
Source: Developed by the authors

income actually paid in taxes, thereby capturing situations where income at lower brackets gets taxed at a lower rate, and tax deferral strategies that move income into future periods. As suggested by Liu and Altshuler (2013), the effective marginal tax rate is what actually captures how tax incentives to invest differ across industries or countries.

Research on consumer response to taxation changes varies according to the policy under consideration. For example, under a tax reduction policy, consumers are expected to increase consumption. However, research has found that they will increase spending if the reduction in tax liabilities becomes permanent. In addition, consumers will wait to increase spending until a tax reduction affects their take-home pay, not before (Steindel, 2001). On the other hand, an increase in taxes, even a small change, can have an impact on consumer behavior, by eliciting a reduction in consumption. This has been shown to be the case in fuel taxes (Fowler et al., 2011), and can also be the case for telecommunication services. In another study, it was also found that the imposition of a sales tax on products purchased online in the United States (called the "Amazon tax") had an impact on consumer behavior: consumers that face a tax on Amazon purchases tend to partly shift back to local "brick and mortar" retailers or increase purchasing from competing non-taxed online retailers (Baugh et al., 2014).

Beyond the formal economic agent being taxed (operator or consumer), it is important to consider the impact of taxes in relation to the elasticity of demand (Matheson and Petit, 2017). For instance, if demand for a consumer service such as mobile broadband is elastic, a consumers' tax will likely reduce operator's revenues, thus, limiting the funds available for investment. Similarly, impositions on the operators' side may be partially translated into the consumers through increased end-prices. Evidence on the level of the demand elasticity for telecommunication services is still inconclusive.[3]

Considering all of the above, we can expect taxes to affect both investment (by the operators) and adoption decisions (by consumers), with the resulting impact on specific stages of the telecommunication sector value chain. As such, while taxes on operators are expected to have an impact on capital spending, levies on consumers will affect service adoption, as depicted on Fig. 1.

While we understand that, beyond taxation, there are other contextual factors that have an impact on operator's investment decisions (such as the degree of competition, or overall macroeconomic context), we are interested here in assessing the impact of the fiscal framework. Following on the causal flow, CAPEX has an impact on network coverage level: higher investment results in the ability to deploy networks across larger geographies. In turn, network coverage has an impact on prices: coverage improvements resulting from past investments contribute to reduce prices, as the supply curve shifts to the right. Coverage gains can also be interpreted as the result of technological improvements, which from a dynamic perspective, usually translate into lower prices (Jung and Katz, 2022). On other hand, adoption levels (demand) are a function of service pricing, which is also affected by consumer taxes and other contextual factors. Finally, higher broadband adoption has been widely identified to contribute to economic growth.

In sum, the research presented in this paper is framed by the two bodies of work assessing the multi-pronged impact of taxation on the development of the sector (impact on corporate and consumer behavior). The primary objective is to extend prior research in this domain and assess the overall effect, sector outcome and consumer behavior of the multiple channels through which the telecommunications sector contributes to government's revenue collection.

2.1. Empirical studies for the telecommunications industry

With regards to the empirical literature, not many papers assessing the general impact of taxation on the development of the telecommunications sector and the implied market outcomes have been published. In fact, most research to date has typically focused on some specific countries or regions and limited to only few of the several fiscal obligations imposed on the sector.

For example, Katz et al., 2010 conducted the first assessment of the impact of taxation on the development of the mobile broadband sector. The resulting study developed a taxonomy of approaches to imposing taxes on mobility services and assessed the impact of said approaches on the adoption of mobile broadband services. These estimates served as a basis to simulate the effect of changes in taxation on mobile broadband penetration and, consequently, on the economy. By relying on specific case studies from Mexico, Malaysia, South Africa, Brazil and Bangladesh, the authors estimated the economic effects of reducing mobile broadband consume taxes by 1 percentage point. The authors focused on specific contributions such as VAT for services and handsets, finding that a reduction in taxation in the studied countries could potentially reduce the total cost of mobile ownership, increase service penetration, and increase GDP. This study supported some causal linkages represented in Fig. 1 above, such as the impact of consumer

[3] The estimated price elasticity for the telecommunication services varies according to the market, time-period and service involved. Some authors have found evidence of elastic demands, such as Garbacz and Thomson (2007) for penetration with respect to monthly service prices; Caves (2011), Hakim and Neaime (2014) and Koutroumpis et al (2011) for traffic with respect to price; while in other cases, the findings suggest inelastic demands, as in Karacuka et al (2011) and Dewenter and Haucap (2008) for the case of traffic, or Garbacz and Thomson (2007) for penetration with respect to connection charges.

taxes on adoption, with its corresponding effect on macroeconomic outcomes.

In the same vein, Katz et al. (2017) studied the benefits and returns from the telecommunications operations in Latin America. Taking as a reference the statistics from 2014, the authors estimated that nearly 43% of the value added generated by the sector was invested, while a significant amount of the value added (29.7%) contributed to the government treasury through several channels: profit and social taxes, special contributions and taxes, custom fees for equipment imports and spectrum payments. These amounts exclude consumer related taxes. The comparison with other industries reviewed yielded interesting results, as the telecommunications were identified as the economic sector with the larger fiscal pressure in the region (51% over the average of all sectors). For instance, similar sectors such as energy or other public services faced a fiscal pressure 11% lower than telecommunications sector.

Other researchers have focused on the analysis of African countries. Andrianaivo and Kpodar (2011) argued on the risk of African governments finding attractive to increase taxation on mobile communications as these impositions are easy to administer and have a large base, at the cost of lowering penetration growth by leading to higher communication costs. Similarly, Calandro et al. (2013) analyzed the main constraints affecting the development of the mobile sector for a sample of African countries. They recommended removing barriers to investment and warning about the high costs for users as a result of regressive special taxes levied on communications and equipment.

Beyond the cross-country analyses, a number of studies focused on specific countries. For example, Katz and Callorda (2019) provided empirical evidence on the impact of taxation on network investment in the United States. They assessed the impact of sales taxes paid on broadband equipment acquisition on the level of telecommunications and cable industry investment in a model that included data from all US states, plus adding several specific state case studies (Florida, Georgia, Illinois, Kentucky, Oklahoma, Tennessee, and Texas). According to the econometric models developed by the authors, a decrease of 1 percentage point in the average weighted state and local sales tax rate affecting initial equipment purchases (from 4.58% to 3.58%) would increase investment by 1.97% over the current levels. By relying on input-output analysis, the authors also estimate the effect that this investment increases resulting from tax reductions can have in terms of economic contribution (GDP growth and cumulative output driven by broadband construction). A similar analysis was conducted in 2013 by Katz and Callorda (2013) evaluating the impact of repealing a sale and use tax exemption on telecommunication equipment in the state of Minnesota. The study indicated that the telecommunication industry, stimulated in part by a sales tax exemption on the purchase of equipment, had invested USD 5.167 billion between 2006 and 2012, which by virtue of the direct multipliers and spillover effects had contributed to the support of 112,239 jobs/year and generated USD 10.38 billion in output. Based on econometric modeling and the results of survey research, it was estimated that repealing the sales tax exemption would trigger a decrease in capital investment of USD 153 million over two years, and USD 722 million over the long run. Both studies support the link between taxation and investment, as depicted in Fig. 1.

In turn, Koutroumpis et al. (2011) studied the impact of multilayer service taxation on the Greek mobile sector between 2005 and 2010. The authors developed an econometric model linking consumption propensity of mobile voice service usage with the disposable income of users and the price of the product. Their results suggest that the adoption of high sector specific service taxes creates an economic distortion that lowers service usage, shrinks sector revenues, thereby affecting the competitiveness of the telecommunications industry. Similarly, Zamil and Hossen (2012) analyzed the case of Bangladesh, covering the period from 1997 to 2008. The authors focused their analysis on import duties, corporate taxes, and telecom-specific obligations (such as SIM tax). They argued about the potential gains in terms of sector development from a tax reduction, stating that the government should rethink and reconsider its tax policy to boost its digital agenda. In turn, Stork and Esselaar (2018), analyzed the tax imposition on the ICT sector in Uganda and Benin during period 2012–2018. For Uganda, particularly, they stated that the local government was using this economic sector as source for additional tax revenues instead of using it as a growth engine. Finally, Arawomo and Apanisile (2018) performed a study focused on Foreign Direct Investment in the telecommunications sector in Nigeria, covering the period 1986–2014. They concluded that government should remove structural barriers by offering incentives such as tax holidays, import duties exemptions and subsidies to foreign firms.

3. Telecommunications fiscal framework

As explained above, taxes are typically raised on both net income and consumption of goods and services. The first type is collected over income generated in a fiscal year, while the second one is linked to the acquisition of a good or service (for example retail sales tax, VAT, and import duties). At the highest level, taxes applied to the telecommunications sector can be based on the economic subject that directly faces the obligation (*bear the burden of taxation*): the telecommunications operator or the end consumer.

3.1. Taxes on telecommunication operators

Fiscal obligations imposed on telecommunications operators are those that usually affect the resources available for capital expenditure (investment in network deployments). Since taxes tend to raise the required pre-tax rate of return of capital invested, the aggregate capital stock in a given economy depends on the effective tax rate. These contributions can be generic (imposed across sectors) or industry-specific.

Typical examples of generic taxes are the profit tax, the VAT or labor and social contributions. Profit taxes (commonly known as corporate income taxes) are typically applied as a percentage of commercial profits. In addition, telecommunications operators face VAT when purchasing electronic equipment, although this should not impinge on profits or investment (Ebrill et al., 2001; Matheson and Petit, 2017).[4] Labor taxes and contributions refer to those social charges that enterprises must pay for each employee, such as social security contributions. These obligations, again, should not generate disincentives to investment, as the burden of labor taxes does not usually fall on profits (Brittain, 1971).

Among industry-specific contributions, there are several examples imposed on the telecommunications sector. First, regulatory fees are those impositions required to finance the activities of the National Regulatory Agency (NRA). While operators in some countries are not required to pay a recurrent fee, annual payments are imposed in most cases. When these payments are based on a fixed amount, the purpose is exclusively to finance the administrative costs associated to sector regulation. In contrast, other countries choose to establish the fee as a percentage of the operator's gross income, typically at 1% or higher rate (rather than a fixed amount to recover costs). While this option is easier to calculate and collect, it results in a larger transfer of resources from the industry to the government. In addition, some countries have imposed higher

[4] Due to input VAT crediting.

corporate income taxes in telecommunications than in other sectors, an asymmetric approach that has been found to be distortive, thereby creating incentives for multinational companies to shift profits across borders (Matheson and Petit, 2017; Heckemeyer and Overesch, 2017).

Spectrum frequencies can include one-off payments at the allocation or renewal period, and in some cases, include recurring payments. Initial payments are associated to acquiring the rights to use this resource, and its imposition depends largely on the allocation mechanism followed. For example, if the spectrum has been assigned through an auction, interested parties bid to acquire frequencies by offering an amount over the base price set by the authorities. On the other hand, if the allocation mechanism is done through a "Beauty Contest", applicants receive the spectrum license in exchange for a network deployment plan. Recurring payments, when imposed, can be established under different schemes, for example, as a percentage of the operator's income, or as a fixed amount to be paid per MHz or per radio base station. They are normally justified to fund the regulatory administrative expenses associated with spectrum management.

In some countries, operators are also required to pay custom duties for the import of electronic equipment and network components.[5] Most advanced countries have eliminated these duties, with the objective of stimulating telecommunications network deployments.

In addition, a portion of the contributions imposed on operators is usually collected through the Universal Service Funds (USF) with the stated purpose of addressing the digital divide. If properly administered, the USFs have the potential to address market failures. USFs are usually used to finance network deployments in geographic areas where market supply is scarce (or null), and to stimulate demand through aid or subsidies for most disadvantaged families. The most common model used to finance these funds is by imposing a contribution, based on a specified rate on the gross income of each licensed operator (e.g.: 1%). In other countries operators can voluntarily choose whether to contribute to the fund or carry out universal service projects on their own. There are also cases in which the fund is financed exclusively by the government (without contributions from private operators).

Finally, there are other sector-specific contributions that are applied in some countries, such as activation taxes or numbering fees. These contributions can be applied as a fixed amount by SIM card, or by number, or as a percentage of revenues. Beyond contributions imposed at the national level, network deployment can also be subject to municipal permits and fees, which can be one-off or recurrent, and related to the use of public spaces, property taxes, renting costs or environmental fees.

3.2. Taxes on consumers

End consumers are subject to VAT payments for the services they subscribe to (for instance, the monthly subscription fee for broadband services). This is a general tax, although some countries charge an expanded VAT or an additional sales tax for the acquisition of certain telecommunication services. Charging telecommunication services with taxes higher than those for average goods reduces affordability for certain segments of the population. In addition, in some countries consumers must pay custom duties for the acquisition of imported devices such as smartphones.

Beyond the taxes mentioned above, certain countries have introduced other specific obligations affecting the acquisition or use of telecommunications services. These impositions are normally associated with a distortion that makes ICT services more expensive and thus, less affordable to the population. Examples of this are service connection fees (for example, a certain percentage of the connection cost), or excise taxes (such as a specific amount per minute of voice or per level of data consumption). These impositions have been identified in the literature as being highly distortive and should be avoided (Matheson and Petit, 2017). Some countries have also proceeded to tax international traffic, establishing a termination charge for international calls (through a fixed amount per minute). In addition to these levies, other countries have established specific taxes with the objective of financing other activities, such as the 911 emergency call service, or taxes imposed to finance public safety. The application of such taxes differs remarkably in their magnitude and scope depending on the country.

3.3. Taxes in the context of the sectoral value chain

The variety of levies discussed above have an impact on specific stages of the telecommunication sector value chain. In Fig. 2 we replicate the causal flows from Fig. 1, but now adding the detailed taxes formally affecting operators and consumers.

4. Model specification

According to the causal relationships depicted in Figs. 1 and 2, it is straightforward to formalize the linkages taking place in the telecommunications sector through a model consisting of four equations: (i) the investment equation, (ii) the coverage equation, (iii) the price equation, and the (iv) demand equation. We proceed to detail each of them, and to specify the extent to which each one is affected by taxation.

4.1. The investment equation

The first equation intends to explain the variables driving telecommunications investment. Capital expenditure – *CAPEX* - is expected to depend on its prior year value,[6] on sector revenues (*REVENUE,* to proxy financial capabilities for investment and market size), on *COMPETITION* dynamics, on *GENERAL TAXES, SECTOR FEES* and *DUTY* obligations applicable, plus a vector *X* combining other control variables. Investment may also depend on some of the taxes and fees formally affecting consumers, depending on the elasticity levels of supply and demand. For this reason, we introduce a variable to account for *EXCISE* taxes on the right-hand side. The equation is defined as follows:

$$\begin{aligned}\log(CAPEX_t) = {} & \alpha + \beta \log(CAPEX_{t-1}) + \gamma \log(REVENUE_{t-1}) \\ & + \zeta(COMPETITION_t) + \delta(GENERAL\ TAXES_t) \\ & + \eta(SECTOR\ FEES_t) + \varpi(DUTY_t) \\ & + \iota(EXCISES_t) + \mu(X_t) + \varepsilon_1\end{aligned}$$

Considering that the imposition of taxes and fees reduce the available funds to invest, we expect a negative sign for coefficients δ,η and ϖ. As for the parameter ι, it may be negative or not significant, depending on the relative elasticities of supply and demand. From an econometric perspective, it is important to consider that the introduction of the lagged dependent variable as a regressor is expected to generate correlation with the fixed effects in the error

[5] The World Trade Organization (WTO) classifies within the code HS 8517 equipment such as base stations (HS 851761), data reception, conversion, or regeneration (HS 851762), or parts (HS 851770).

[6] Some previous studies developed a theoretical model in which *CAPEX* was determined as a function of the sector physical capital stock (Jung, 2020; Jung and Melguizo, 2022). However, the lack of data for telecom physical capital for a worldwide sample prevented us from following that approach. As a second-best possibility, we consider that controlling by past *CAPEX* is an appropriate measure to reflect country-differences in investment. The empirical specification used in this case is roughly similar as that followed by Kim et al. (2011).

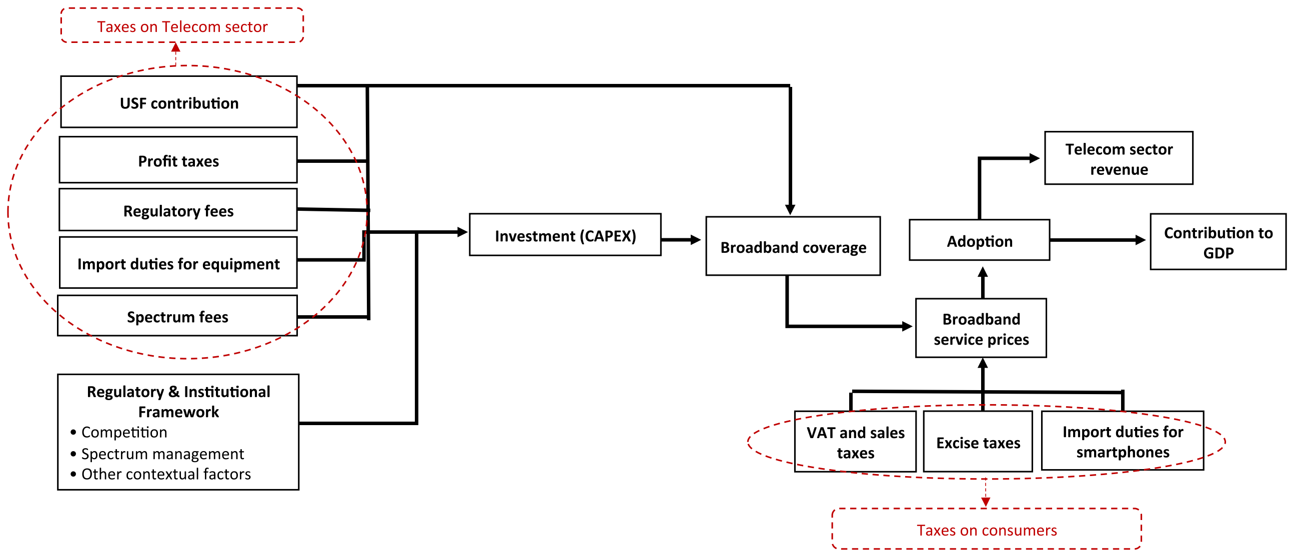

Fig. 2. Causal flows and value creation in the telecommunications sector – with tax detail.
Source: Developed by the authors

term. This situation creates a “dynamic panel bias” (Nickell, 1981), as the reported correlation violates the necessary assumptions for consistency in Ordinary Least Squared (OLS) estimators. As a result, it cannot be estimated through the conventional fixed effects approach.

4.2. The coverage equation

The variable *COVERAGE* is defined as the percentage of the population covered by broadband networks. Coverage is driven by five variables. First, *CAPEX* is expected to drive future increases in broadband network coverage levels. In addition, current coverage levels are expected to depend on past coverage improvements, even if those advances were specific to prior technologies. Coverage may also depend on other local characteristics, typically the percentage of population living in urban areas (variable *URBAN*), and the average income (*GDP per capita*). Finally, coverage may also be determined by topographic conditions, such as the presence of forests or hilly terrain. As these latest indicators are time-invariant, they will be captured by the country fixed effects υ. Therefore, the second equation is modeled as follows:

$$\log(COVERAGE_t) = \upsilon + \Phi\log(CAPEX_{t-i}) + \nu\log(COVERAGE_{t-i}) + \lambda(URBAN_t) + \partial \log(GDPpc_{t-1}) + \varepsilon_2$$

Where we expect $\Phi > 0$. Given that investment may take some time to be translated into coverage gains, we model *COVERAGE* in period t as a function of *CAPEX* in previous periods. In addition, the possibility to rely on older technologies to account for previous coverage advances contributes to avoid using the lag of the dependent variable, thus preventing the “dynamic panel bias” as described above.[7]

4.3. The price equation

Once network coverage is estimated, we turn to broadband prices (*BB PRICES*). End-user prices are assumed to depend on taxation applying to the services, as well as the competitive intensity. In addition, coverage improvements resulting from past investments contribute to reduce prices. In addition, we introduce the *DUTY CELL* variable to account for the imposition of import duties for smartphones, as another potential driver of prices. Even if the dependent variable represents a monthly subscription payment for an internet connection and not the handset itself, in some countries the smartphones are sold by the telecom operator, with its price being prorated into higher monthly service bills. Then, the price equation is represented as:

$$\log(BB\ PRICES_t) = \Lambda + \pi(TAXES_t) + \psi\log(COVERAGE_t) + \Gamma(COMPETITION_t) + \tau\log(DUTY\ CELL_t) + \varepsilon_3$$

As described above, we expect. $\psi < 0,\ \pi > 0\ and\ \tau > 0$

4.4. The adoption equation

The price level will be a key driver of service adoption, measured as broadband penetration. We also include the *VAT* and *DUTY CELL* variables as, on occasions, end-users are the ones who directly purchase the device rather than relying on a service contract. Accordingly, the higher the smartphone price, the less penetration should be expected. In addition, further sector-specific impositions can have a direct impact on adoption. This is the case of the *EXCISE* taxes, that depending on its design, may limit adoption or alternatively the usage intensity, once adopted. Adoption is also assumed to depend on income levels, which will be proxied through GDP per capita (in lags, to avoid reverse-causality concerns), and on the age structure of the population (*POP AGE*), as elder groups are supposed to be less prone to adopt technology.

$$\mathrm{Log}(BB\ PEN_t) = \Theta + \kappa\log(BB\ PRICES_t) + \varrho(DUTY\ CELL_t) + o(VAT_t) + \vartheta(EXCISES_t) + \varsigma\log(GDPpc_{t-1}) + \sigma(POP\ AGE_t) + \varepsilon_4$$

Naturally, higher prices should reduce demand (that is to say, we expect $\kappa < 0$, $\varrho < 0$, $o < 0$, and $\vartheta < 0$).

5. The dataset

To conduct our empirical analysis, we built an unbalanced panel consisting of 108 countries for the period 2009–2018 (country list

[7] We decided to use the second lag for both CAPEX and cellular coverage regressors, as empirically they provided a better model fit than using the first or third lag.

Table 1
Variables used in the empirical analysis.

Variable	Description	Source
CAPEX	Investment in mobile telecommunication services.	GSMA
4G Coverage	Percentage of population covered by a 4G network.	GSMA
MBB prices	Data-only mobile broadband price for 1.5GB plan.	ITU
MBB penetration	Mobile broadband unique subscribers' penetration.	GSMA
Profit tax	Taxes over business profits (% of commercial profits).	World Bank
VAT	Value Added Tax applicable in the country (% of purchased value)	Trading Economics and GSMA
Regulatory fee	Regulatory fee rate (% of operator revenues).	GSMA
Duty tariff for electronic equipment	Duty tariff applied to the import of electronic equipment (HS 8517).	WTO
Excise tax	Dummy variable taking the value of 1 if excise tax is imposed (either per minute or ad valorem)	GSMA
Mobile service taxation	Tax rate applicable to the mobile cellular tariffs (including VAT).	ITU
Duty tariff for cell phones	Duty tariff applied to the import of cell phones (HS 851712).	WTO
Revenues	Revenues from mobile telecommunication services.	GSMA
Cellular coverage	Percentage of population covered by a mobile-cellular network.	ITU
HHI Mobile	Herfindahl Hirschman Index of the mobile sector.	GSMA
SMP regulation	Index taking values from 0 to 2 depending on the legal definition of Significant Market Power and its scope (geographical, market share, essential facilities, access to financial resources, countervailing power of consumers, economies of scale, etc.).	ITU
GDPpc	Gross Domestic Product per capita in current USD.	IMF
Urban population	Percentage of population living in urban areas.	World Bank
Population age	Percentage of population aged above 65.	World Bank

Source: Developed by the authors.

in Table A.1 in the Appendix). The proposed model will be estimated only for the mobile segment, due to data availability.[8] Table 1 describes the variables to be used to estimate the equations described in the previous section.

The data on taxation variables for each country of the sample was obtained from different sources. Profit taxes were extracted from the World Bank database. Considering that this is a general tax (rather than sector-specific), the data provided for the overall economy is suited for our purpose.[9] This variable is defined by the World Bank as the taxes paid by business that have an impact in their income statements divided by commercial profits. Considering that the World Bank states that it is calculated based on "actual" taxes paid by business, this can be assumed to be a measure close to "effective tax rate", a definition similar to the one in the empirical approaches by Devereux and Griffith (2003) for effective.[10]

Regulatory fees (as a percentage of revenues) and VAT values (as a percentage of equipment purchased value) were collected from GSMA reports on taxation[11] and in the latter case, from Trading Economics as well.

In addition, we will also introduce a variable accounting for the imposition of duties on the import of electronic equipment and cell phones (identified by the WTO with the custom codes HS 8517 and HS 851712, respectively). From GSMA reports, we also include excise taxes, defined as a dummy variable as there is not a homogeneous criteria for comparative purposes (sometimes these taxes are imposed per minute of use, other times as an ad valorem rate). Mobile service taxation is defined as the rate applicable to cellular plans, including the VAT, paid for by end-users. The data, in this case, is extracted from the ITU database.

Due to the lack of data, we were unable to include among the fiscal obligations the contributions to USF and spectrum payments. While these are important contributions from operators to the government, there is not a public complete database available on these indicators.

Table 2
Descriptive statistics.

Variable	Mean	Min	Max
CAPEX (USD million)	1468.160 [4430.825]	10.239	46,536.630
4G Coverage	0.635 [0.331]	0.000	1.000
MBB prices (USD)	16.938 [22.588]	1.265	496.057
MBB penetration	0.397 [0.206]	0.001	0.828
Profit tax (%)	15.435 [8.580]	0.000	38.900
VAT (%)	15.675 [6.239]	0.000	30.000
Regulatory fee (%)	2.193 [3.429]	0.000	19.000
Duty electronic equipment (%)	2.668 [4.240]	0.000	25.800
Excise tax (0/1)	0.226 [0.419]	0.000	1.000
Mobile service taxation (%)	17.400 [8.828]	0.000	52.000
Duty tariff for cell phones (%)	2.637 [5.179]	0.000	26.300

Source: Developed by the authors.
Note: Standard deviations in brackets.

[8] We are not aware of any public database measuring fixed broadband coverage.

[9] Unfortunately, lack of data prevented us to account for sector-specific corporate income tax, imposed by some countries such as Jamaica, Ivory Coast, Jordan and Yemen (Matheson and Petit, 2017).

[10] Devereux and Griffith (2003) stipulate the ratio of tax payments to profit (taken either from aggregate data or accounting data) as a valid approach to proxy the effective marginal tax rate, although they warn that it does not focus on marginal decisions.

[11] Data was collected from several country-level and region-level tax reviews conducted by GSMA, 2007, 2011a, 2011b, 2012, 2014, 2015a, 2015b, 2015c, 2015d, 2015e, 2015f, 2015g, 2015h, 2015i, 2015j, 2016a, 2016b, 2016c, 2016d, 2016e, 2016f, 2017a, 2017b, 2017c, 2017d, 2017e, 2018a, 2018b, 2018c, 2018d, 2018e, 2018f, 2018g, 2018h, 2019a, 2019b, 2019c, 2020a, 2020b, 2020c, 2021a, and 2021b). The overall sample covered by all those reports (in terms of countries and time-periods) allowed us to build a panel, including information of periods in which most fiscal reforms were conducted. However, for some countries, those reviews do not necessarily cover every year of our sample. As a result, we followed a conservative approach to impute missing data. If for a certain country we have the data for only two separated periods of time, and in both cases the imposed rate is the same, then we fill the intermediate years assuming that the taxation rate has remained constant within the period. On the contrary, if hypothetically, the data for two separated periods of time is not the same, then we leave empty the intermediate years, as we do not know exactly when the rate was modified.

Table 3
System GMM Dynamic Panel estimation for the investment equation.

Dep. variable: Log (CAPEX)	[i]	[ii]	[iii]	[iv]
Log (CAPEX) $_{t-1}$	0.806***	0.694***	0.601***	0.560***
	[0.116]	[0.099]	[0.128]	[0.112]
Log (Revenue) $_{t-1}$	0.206*	0.302***	0.393***	0.442***
	[0.110]	[0.106]	[0.143]	[0.122]
Log (HHI)	0.117**	0.088	0.030	0.031
	[0.058]	[0.079]	[0.079]	[0.088]
Urban population	−0.001	0.000	0.002	0.002
	[0.001]	[0.003]	[0.003]	[0.003]
Log (GDPpc) $_{t-1}$	−0.062***	−0.082	−0.148*	−0.157**
	[0.019]	[0.053]	[0.084]	[0.066]
Profit tax	−0.015**	−0.014**	−0.015**	−0.013**
	[0.007]	[0.007]	[0.006]	[0.006]
Regulatory fee		−0.036***	−0.028**	−0.032**
		[0.014]	[0.011]	[0.013]
Duty electronic equipment			−0.008	
			[0.011]	
Duty electronic equipment (dummy)				−0.176*
				[0.093]
Excise tax			−0.200*	−0.233**
			[0.120]	[0.118]
Year fixed effects	YES	YES	YES	YES
Arellano-Bond test for AR (1) in first differences (p-value)	0.000	0.000	0.007	0.003
Arellano-Bond test for AR (2) in first differences (p-value)	0.533	0.108	0.313	0.355
Hansen test of overid. Restrictions (p-value)	0.642	0.302	0.806	0.817
Observations	1,032	406	283	283

Source: Developed by the authors.
Notes: Robust standard errors in brackets.
* $p < 10\%$.
** $p < 5\%$.
*** $p < 1\%$.

Table 2 reports the main descriptive statistics for the taxation and sector variables to be used in the empirical analysis. The average country in our sample presents a profit tax of 15.4%, a VAT of 15.7%, a regulatory fee of 2.2% of operator's income, and mobile services taxation of 17.4% (higher than the VAT, suggesting the application of specific taxes above that level). Data also presents an important variability in terms of fiscal approach. For instance, profit taxes range from 0% to a maximum of 38.9% (Cameroon). Some countries do not impose a specific regulatory fee (such as Chile), while on the contrary, the United Arab Emirates imposes the payment of royalties as regulatory contributions. As for mobile taxes applicable to services, some countries have decided not to impose such kind of fiscal obligations, others only impose the standard VAT, while finally others impose service specific taxes above the VAT.

6. Estimation results

We begin by estimating the investment equation. Given the multicollinearity risks associated with the potential correlations among the different taxes and fees imposed, we introduce them gradually, starting with profit taxes. Taxation variables are introduced in levels (not in logarithms) to avoid losing observations (given that convertion into logarithms will eliminate those observations where the contributions are zero).

As presented in the investment equation, *CAPEX* is expected to depend on its own lagged value. To avoid the endogeneity concerns related to adding the lag of the dependent variable as regressor, we need to rely on an estimation strategy that considers the existence of cross-country individual effects, without incurring in the "dynamic panel bias". In contrast to the conventional fixed effects approach, the estimator proposed by Arellano and Bond (1991) based on the Generalized Method of Moments (GMM), and later improved by Arellano and Bover (1995) into the System-GMM methodology, is specifically designed for panels exhibiting short time-periods, larger cross-section dimensions, a left-hand-side variable that is dynamic (that is to say, it depends on its own past realizations), fixed individual effects, and heteroskedasticity and autocorrelation within individuals but not across them (Roodman, 2009). The estimates will be conducted with robust standard errors.

In addition, it is important to consider the risk of reverse causality, as tax reforms may be the result of investment (for instance, a country may reduce the imposed taxation because of low investment levels). Consequently, we treat taxation variables as endogenous, using as instrument the average taxation pressure of the economy (tax revenues as a share of GDP, source: World Bank), in levels and differences. This instrument is suitable as it is expected to explain the natural propensity to tax for a certain country, while as being nationwide means no direct relation with the dependent variable beyond its link with the endogenous regressors. In all cases, Hansen statistics verify the exogeneity of the instrument (see Table 3).

In all estimation results, the lagged CAPEX value and Revenue exhibit the expected sign and significance levels. First, we introduce the profit tax (column [i]), being its coefficients negative and significant (at 5%). This suggests that this general imposition is related to lower investment outcomes. The coefficients estimated suggest that a 1 percentage point reduction in the profit tax rate (for instance, from 10% to 9%) is linked to an increase in investment of 1.5%. This result is consistent with the general statement that taxes tend to raise the required pre-tax rate of return of capital invested. As stated by Devereux (2006): *"(If a) company should invest up to the point at which the marginal product of capital equals the cost of capital (...) the impact of taxation should be measured by the influence of (an effective marginal tax rate) on the cost of capital."*

In column [ii] we introduce the regulatory fee rate. A 1 percent point reduction in the regulatory fee is associated to a 3.6%

Table 4
Estimation results for the coverage equation.

Dep. variable: Log (4G coverage)	[i]	[ii]
Log (CAPEX) $_{t-2}$	0.242**	0.656*
	[0.098]	[0.380]
Log (Cellular coverage) $_{t-2}$	1.371*	1.548***
	[0.773]	[0.587]
Log (GDPpc) $_{t-1}$	0.395	0.361
	[0.287]	[0.224]
Urban population	0.157**	0.121**
	[0.065]	[0.059]
Country fixed effects	YES	YES
Year fixed effects	YES	YES
Underid. Test (p-value)	n.a.	0.000
Hansen test of overid. Restrictions (p-value)	n.a.	0.640
Observations	572	570
Estimation method	OLS	IV

Source: Developed by the authors.
Notes: Robust standard errors in brackets.
* $p < 10\%$.
** $p < 5\%$.
*** $p < 1\%$.

Table 5
Estimation results for the price equation.

Dep. variable: Log (MBB price)	[i]	[ii]	[iii]	[iv]
Log (4G coverage)	−0.176***	−0.408**	−0.155***	−0.428**
	[0.047]	[0.178]	[0.046]	[0.195]
SMP regulation	−0.110	−0.132*	−0.162**	−0.189***
	[0.069]	[0.077]	[0.064]	[0.070]
Duty cell	0.003	0.007	−0.014	−0.009
	[0.024]	[0.022]	[0.021]	[0.019]
VAT	−0.022	−0.029		
	[0.030]	[0.026]		
Mobile service taxation			0.008*	0.014***
(VAT+sector specific)			[0.005]	[0.005]
Country fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Underid. Test (p-value)	n.a.	0.000	n.a.	0.001
Hansen test of overid. Restrictions (p-value)	n.a.	0.922	n.a.	0.781
Observations	550	457	531	437
Estimation method	OLS	IV	OLS	IV

Source: Developed by the authors.
Notes: Robust standard errors in brackets.
* $p < 10\%$.
** $p < 5\%$.
*** $p < 1\%$.

increase in investment. The fact that the coefficient for regulatory fees is larger than that of profit taxes, can be assumed as evidence that industry-specific fees are more relevant than general taxes for operators. The reason may be because sector-specific charges represent the imposition above the average of other economic industries. In column [iii], we further introduce the tariff rate for equipment and the excise tax dummy. The duty tariff presents a negative but not significant coefficient, while the excise tax imposition is associated to lower investment levels. As explained above, while the excise tax is usually applicable to consumer's use, depending on the elasticity levels, it may also fall on the operator's side, as it seems to be the case.[12]

Finally, and considering that the tariff rate for imported equipment is not significant in the equation of column [iii], we replicated the previous estimate in column [iv], now considering the imposition of duties as a dummy. In contrast from the continuous version of this variable, the binary indicator on tariffs presents a negative and significant (at 10%) coefficient. A possible interpretation for this is that, from an investor's perspective, the absence of tariffs is what matters the most, not necessarily a marginal variation in an existing one. Due to its own nature, the telecommunications sector is relatively concentrated and mostly composed of regional or global operators with presence in several countries, commonly viewing 'the map' of the different countries and regions to decide where to prioritize investments (in this case, in countries without imposing tariffs).

Overall, we can summarize these findings as evidence of a negative impact of regulatory fees, profit taxes, and excise taxes. As for the incidence of import duties on investment, the evidence suggests a negative effect, although we should not draw firm conclusions on this as the significance level is only 10%.

Once estimated the investment equation, we turn into the next step of the value chain: network coverage. The estimate of the coverage equation (Table 4) was conducted through OLS and through the Instrumental Variables (IV) procedure, treating as endogenous the CAPEX variable. In the IV estimate, we instrument lagged CAPEX with its further lags (in levels and differences), plus a further lag of revenue (its determinants in the investment equation). In both estimates we include country and year fixed effects, and robust standard errors.

Results are quite similar for OLS and IV estimates. Lagged CAPEX is found to be positive and significant, as expected. On average, a 1% increase in CAPEX is translated into approximately 0.24%–0.66% coverage gains, with a 2-period lag. In addition, past cellular coverage is also relevant to explain coverage levels of the latest technologies, again as expected. Finally, the higher the share of urban population, the larger the coverage levels, something expected as rural areas are the most expensive and difficult to cover.

Table 5 reports the results of the price equation, estimated through both OLS and IV approaches. We first estimate the price equation introducing the general VAT (columns [i] and [ii]), and next, we introduce an indicator of mobile service taxation that also includes sector specific impositions above the standard rate (columns [iii] and [iv]).

In columns [ii] and [iv] (IV estimates) we treat coverage as endogenous, instrumenting it with its main determinants according to the previous equation (with further lags of CAPEX and cellular coverage). As expected, the larger the coverage (an increase in supply), the lower the prices. The coefficient associated to coverage increases considerably (in absolute values) when endogeneity is controlled through the IV estimation. In addition, competition is relevant to ensure lower prices, as the more monitored the market is (as represented by the Significant Market Power regulation regressor), the lower the prices. As for taxation variables, the VAT is found to be not significant.

Next, we replicate the estimates including overall taxation to mobile services, which includes both VAT and sector specific fees (columns [iii] and [iv], respectively, for OLS and IV estimates). When including the overall taxation on mobile services, this variable is found to be positive and significant as expected (higher taxes result in higher prices to end-users). The comparison between these estimates and those introducing only the standard VAT allow us to conclude that sector-specific fees are the main source of price increases, rather than generic taxes applied.[13] On the other hand, the duty rate for smartphones was found to be non-significant in all the estimations. This suggests that prorating

[12] We would like to thank an anonymous referee for raising up this point.

[13] We are grateful to an anonymous referee for suggesting this.

Table 6
Estimation results for the demand equation.

Dep. variable: Log (MBB penetration)	[i]	[ii]	[iii]
Log (MBB price)	−0.065***	−0.729***	−0.503***
	[0.017]	[0.273]	[0.151]
Log (GDPpc) $_{t-1}$	0.236***	0.156	0.252*
	[0.079]	[0.215]	[0.130]
Log (Population age)	−0.534*	0.316	0.165
	[0.301]	[0.493]	[0.363]
VAT	0.005	0.000	0.000
	[0.006]	[0.018]	[0.012]
Excise tax	−0.007	0.017	
	[0.033]	[0.107]	
Duty cell	−0.000	−0.015	
	[0.004]	[0.017]	
Duty cell (dummy)			−0.224*
			[0.122]
Country fixed effects	YES	YES	YES
Year fixed effects	YES	YES	YES
Underid. Test (p-value)	n.a.	0.029	0.002
Hansen test of overid. Restrictions (p-value)	n.a.	0.292	0.129
Observations	559	463	524
Estimation method	OLS	IV	IV

Source: Developed by the authors.
Notes: Robust standard errors in brackets.
* $p < 10\%$. ** $p < 5\%$.
*** $p < 1\%$.

the smartphone price into the monthly service bill is not necessarily the most usual practice in most countries.[14]

Finally, Table 6 reports the demand equation, again estimated through both OLS and IV approaches (in the latest case, treating prices as endogenous, and instrumenting it with mobile taxation and 4G coverage).

As expected, the lower the prices, the higher the service penetration. The coefficient for prices increases considerably in absolute values when endogeneity is addressed (IV estimate). Considering that smartphones can be paid by end-users, we also introduce fiscal variables affecting the affordability of devices, the VAT and the duty rate for smartphones, plus also taxes affecting the intensity of use (excise tax). The coefficient associated to these variables is never significant. In column [iii] we omit the excise tax variable (as it was found to be not significant, possibly because it may limit the intensity of use rather than the decision to subscribe to a line *per se*) and considering the duty applying to smartphones as a binary variable. At this point, the duty dummy is negative and significant in the IV estimate, albeit only at a 10% significance.

Overall, we can summarize that the imposition of regulatory fees, of profit taxes and excise taxes seems to restrict investment, and indirectly, to affect coverage, prices and adoption (through the linkages established in the value chain depicted in Figs. 1 and 2). Finally, taxes on mobile services increase end-user prices, in particular for the case of sector-specific impositions.

Next, we turn into assessing through simulations how much the sector can be developed if sector-specific taxes are eliminated.

7. Simulation of fiscal reform to eliminate sector-specific contributions

The scenario to be simulated is based on a potential elimination of sector-specific contributions intending to accelerate the development of the telecommunications market. The underlying premise is that even if government tax collection is reduced, general welfare may be positively affected by the socioeconomic impact from increasing the adoption of telecommunications technologies. The reform to simulate is described in Table 7.

We discarded a simulation of a regime that reduces general taxes to the sector (e.g.: reduced profit taxes and VAT for this industry), even if this type of reform could be justified from what economic theory says about goods generating positive externalities. We decided against doing so because this is not a reform that generate consensus in the literature. To cite an opposing perspective, we highlight Matheson and Petit (2017), who argue that reduced profit taxes are difficult to justify, and that reduced VAT rates are an inefficient subsidy to the poor that can complicate the administration of this tax.

Another possibility would have been to simulate the elimination of import duties for electronic equipment and devices such as smartphones. Considering the relevance of these goods for network development and service adoption, removing these obligations is expected to stimulate investment and adoption. While this move should be theoretically justified, we also discarded this scenario, as the empirical evidence on the effects of duties was found to be weaker.

Accordingly, our aim with this simulation is to consider that the telecommunication sector should be exposed to the same fiscal treatment as other industries (reduction of potential asymmetries). This means leaving unchanged general taxes but reducing to the minimum the sector-specific fees. This is consistent with best taxation principles, that usually stipulate that few taxes should be applied to a wide base uniformly across the entire economy (Matheson and Petit, 2017). The reform will consist, thus, in lowering the regulatory fee to a maximum of 0.1%, for the sole purpose of contributing to the administrative costs of the NRAs and eliminating sector specific taxes on services, such as expanded VAT or sale taxes, and excise taxes. It is important to consider that other sector-specific taxes not included in the econometric regressions cannot be simulated.

The starting point is a hypothetical country that imposes excise taxes. We consider sample averages rates for regulatory fees (2.19%) and mobile services tax (17.40%) as the starting point. The average economy in our sample presents a mean CAPEX of USD 1468 million, 4G coverage of 63.5%, monthly service price of USD

[14] We also tested this variable converted to a binary indicator but also yielded a not significant coefficient.

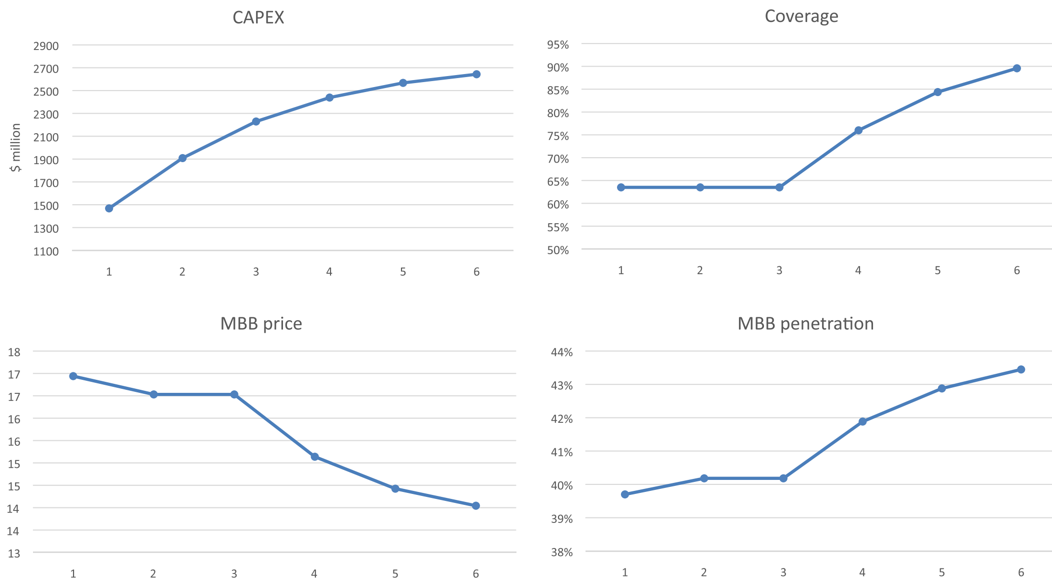

Fig. 3. Simulation of sector-specific tax elimination.
Source: Developed by the authors

16.94, and mobile broadband unique subscribers' penetration of 39.7% of the population. The coefficients to be used in the simulations are those reported in column [iv] of Tables 3 and 5, in column [ii] of Table 4, and in column [iii] of Table 6. Fig. 3 presents the evolution of the main outcome variables resulting from the simulation exercise, for a hypothetical period from t to t+5.

The simulation points to a CAPEX increase of 30% in the first period, followed by gradual increases in the following years due to inertia (cumulative increase 50.5% by t+5). This is the result of reducing regulatory fees and eliminating excise taxes. Considering the higher investment levels, coverage will experience a gradual increase starting on the second year after the fiscal reform, reaching nearly 90% of the population after 5 years. In turn, service prices will decrease starting in t+1 with the elimination of sector-specific taxes on services and continuing in t+3 due to the increased coverage induced by larger investment levels. Finally, unique subscribers' penetration will be increased in respond to the lower prices, up to 43%. In short, the gains in terms of sectoral outcomes can be significant if tax reductions are promoted.

8. Conclusions

In this paper we provided a comprehensive review of most taxes and fiscal obligations affecting the telecommunications sector, and we provided empirical evidence on how the different levies affect the main outcome variables, namely investment, coverage, prices and adoption. After analyzing the incidence of each tax or fee imposed, we simulated a specific fiscal-policy reform to assess the potential gains from hypothetically removing sector specific-impositions.

Overall, we can summarize that the imposition of regulatory fees, profit taxes, and excise taxes seem to restrict capital investment, and indirectly, affect coverage, prices, and adoption. On the other hand, taxes on mobile services increase end-user prices, while we found some evidence suggesting that the imposition of import duties for equipment and smartphones limit investment and adoption levels, respectively.

As usual, our study faced with some data limitations. We were unable to include in our estimates the role of the USF contribution. Considering that when these obligations are imposed to operators, we can expect them to reduce investment, although these funds are supposedly used to allocate resources for the development of the sector, through expanded network deployment and adoption. Thus, an interesting exercise will be to use our framework to assess the overall effect of the USF in the sector. In addition, the lack of publicly available data for spectrum payments, either initial or recurrent, prevented us to include this much-important obligation that affects the operators' finances.

All in all, we believe that this evidence is useful for governments pursuing the development of digital agendas to consider potential fiscal reforms to accelerate the digital revolution. Naturally, trade-offs should be considered as tax reductions are will generate lower government revenues, at least in the short and medium term. In any case, the findings of this study reinforce the arguments pointing to reduce potential distortions emerging from overtaxation of the sector.

Declaration of Competing Interest

The authors declare no conflict of interest.

Table 7
Fiscal scenario for simulation.

Tax	Current level (Sample average)	Proposed reform	Rationale
Regulatory fee	2.19%	0.1%	Reduction to exclusively recover administrative costs. Benchmark is Australia (0.14%), Germany (0.09%), Canada (0.07%), and United States (0.06%).
Excise taxes	Assumed to be imposed	Eliminate	Excise taxes are highly distortive and should be eliminated according to Matheson and Petit (2017).
Mobile services tax	17.40% (VAT + sector specific)	15.68% (Apply only standard VAT)	Apply to ICT services the same tax as regular goods.

Source: Developed by the authors.

Appendix

Table A.1
Countries included in the sample.

Algeria	France	Oman
Angola	Germany	Pakistan
Argentina	Greece	Panama
Armenia	Guatemala	Paraguay
Australia	Haiti	Peru
Austria	Honduras	Philippines
Azerbaijan	Hungary	Poland
Bahrain	Iceland	Portugal
Bangladesh	India	Qatar
Barbados	Indonesia	Romania
Belarus	Ireland	Russia
Belgium	Islamic Republic of Iran	Saudi Arabia
Benin	Israel	Senegal
Bolivia	Italy	Singapore
Bosnia and Herzegovina	Jamaica	Slovak Republic
Botswana	Japan	Slovenia
Brazil	Jordan	South Africa
Bulgaria	Kazakhstan	Spain
Burundi	Kenya	Sri Lanka
Cameroon	Korea	Sweden
Canada	Kuwait	Switzerland
Chile	Latvia	Tanzania
China	Lebanon	Thailand
Colombia	Lithuania	Trinidad and Tobago
Costa Rica	Luxembourg	Tunisia
Côte d'Ivoire	Madagascar	Turkey
Croatia	Malaysia	Uganda
Cyprus	Malta	Ukraine
Czech Republic	Mexico	United Arab Emirates
Denmark	Morocco	United Kingdom
Dominican Republic	Mozambique	United States
Ecuador	Netherlands	Uruguay
Egypt	New Zealand	Venezuela
El Salvador	Nicaragua	Vietnam
Estonia	Nigeria	Zambia
Finland	Norway	Zimbabwe

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