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Drivers of mobile broadband pricing: Cross-national evidence on policy and market dynamics

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ABSTRACT

This paper investigates the reasons underlying the diversity in mobile broadband prices across 182 countries from 2013 to 2022. Our analysis examines the interplay among three groups of variables: policy frameworks, market conditions, and pricing mechanisms. Our results suggest that countries should adopt advanced regulatory practices regarding licensing, infrastructure sharing, spectrum flexibility, and competition to lower mobile broadband prices. In addition, moderate taxation is required to stimulate investment, expand coverage, and promote competition, thereby lowering prices. Reduction of operators' operating expenses can also play a crucial role.

1. Introduction

According to the research literature conducted over the past twenty years, Information and Communication Technologies (ICT) in general, and broadband access to the internet in particular, have been identified as key drivers of economic growth (Koutroumpis, 2009; Czernich et al., 2011; Katz et al., 2012; Bertschek et al., 2013; Arvin and Pradhan, 2014; Harb, 2017; among many others). Beyond economic growth, broadband internet has also been found to be a crucial tool for improving people's quality of life, as it can be a crucial tool for reducing poverty and improving consumer welfare (Xie et al., 2023) to reduce income disparities (Qiu et al., 2021), to increase firms environmental responsibilities (Shen et al., 2023) and even to improve health outcomes (Whitacre and Brooks, 2014; Dutta et al., 2019).

However, broadband adoption shows several disparities across the world, with a large number of people remaining unconnected. Access is reflected in both fixed and wireless broadband subscriptions, although through this study, we will focus solely on mobile broadband due to the better data available and because, in several emerging countries, people rely mainly on this technology for accessing the Internet. This digital divide is apparent when a cross-country comparison of mobile internet unique subscribers' penetration is displayed.[1]

According to Fig. 1, in the developed world (North America, Western Europe, Japan, and Australia), more than 80% of the population is a mobile broadband user. However, those figures considerably diminish when analyzing developing regions such as Latin America, the Arab States, Asia, and Africa. Countries in such parts of the world exhibit significant groups of unconnected populations, albeit at different levels (for example, in 2022, the percentage of the connected population in Latin America is 61.41%, while in sub-Saharan Africa, it is only 28.33%).

This digital divide has been explained through both demand and supply-side factors (Katz and Berry, 2014). For example, on the supply side, network coverage is a key factor (limited-service reach in rural areas precludes the population from accessing service). On the demand side, affordability is generally considered to play a crucial role (Galperin

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[1] "Mobile internet unique subscribers" measures only individuals that own a mobile device capable of accessing the internet and purchase a service plan that includes data communications services. The metric excludes all connections applied to monitoring equipment (so-called Internet of Things) and considers users that own more than one device or SIM card (for example, for professional and personal use) as a single subscriber.

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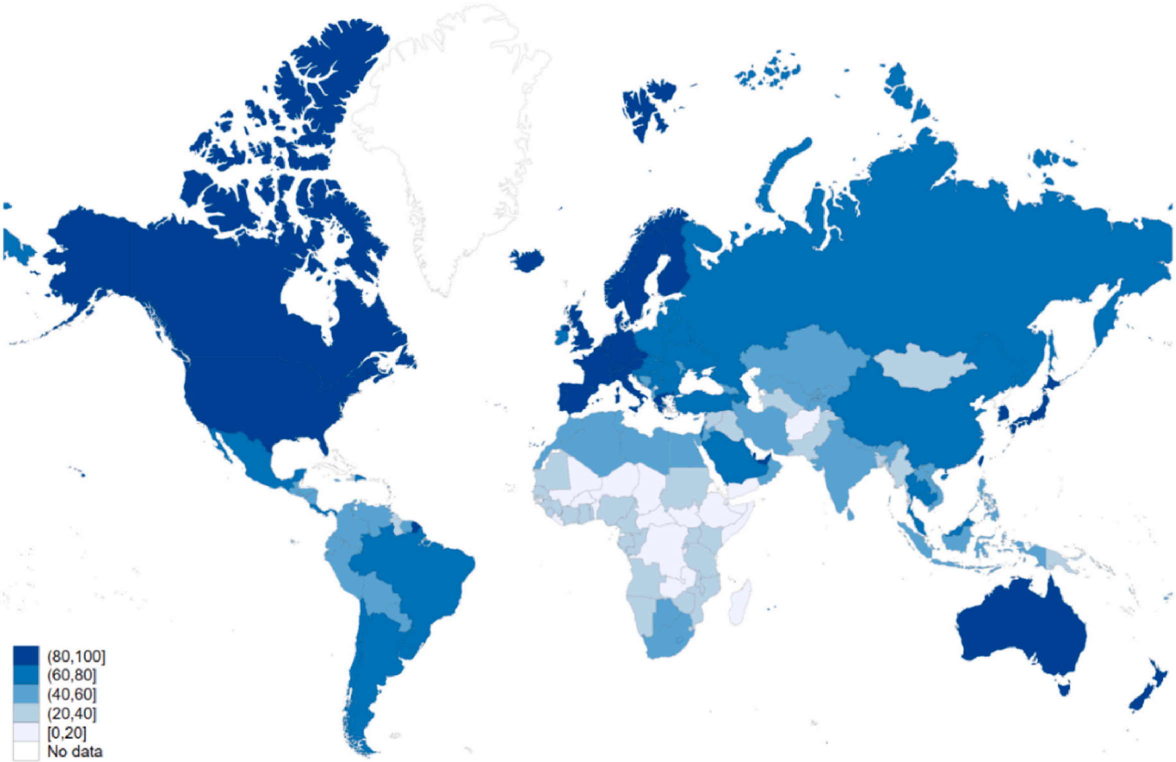

Fig. 1. Mobile internet unique subscribers' penetration 2022 (percentage of population).
Source: GSMA Intelligence

and Ruzzier, 2013). In poorer countries, broadband internet access is more expensive when measured as a share of the monthly income,[2] as shown in Fig. 2.

Fig. 2 reflects the opposite situation of Fig. 1. By comparing both maps, we can appreciate how penetration levels are relatively lower in countries where the price of mobile broadband relative to income is relatively higher and vice versa. This relationship is further confirmed by the scatterplot linking both variables, as reported in Fig. 3, where it is clear that countries reaching higher values of mobile internet penetration (above 60%, for instance) present low prices relative to income levels, while on the other hand, there is not a single country in the sample with such penetration levels among those with prices above 5% of the disposable income.

Considering this evidence, it is straightforward to appreciate how mobile internet prices remain a significant factor in explaining adoption disparities. This situation makes it essential to study why mobile broadband prices differ across countries and what can be done from public policy and industry perspectives to reduce disparities and make the internet more affordable to the whole population.

Despite the wide recognition of this issue among policymakers and specialists, there is limited empirical research investigating the root causes of the variation in broadband prices across countries. While the existing literature typically examines cross-country disparities in broadband adoption, coverage, and speeds, there is a dearth of evidence explaining the driving forces behind price differentials. On the other hand, the studies that have analyzed broadband price differentials through empirical analysis have primarily focused on disparities associated with commercial plans (Calzada and Martínez-Santos, 2014; Wallsten and Riso, 2010; Genakos et al., 2018) rather than focusing on the overall cross-country structural factors. Thus, a research gap exists regarding identifying economic, policy, and industry variables affecting prices. Therefore, our research intends to address this missing area in the literature. In doing so, we intend to contribute with an overarching analytical framework to support regulatory and industry strategic decisions.

In this context, this research aims to formulate an integral approach elucidating global disparities in mobile broadband prices. Identifying the drivers behind these differences is crucial for informing regulatory and competition policies in the telecommunications sector. A comprehensive understanding of cost variations and their influencing factors is imperative for fostering digital economic development.

The remainder of this paper is structured as follows. Section 2 presents an in-depth review of the research literature. Building on the available evidence, Section 3 develops a theoretical model based on microeconomic theory and the surveyed literature to explain price disparities. Section 4 presents the data and the descriptive statistics while analyzing the nature of telecommunications price variations across countries. Section 5 provides the results of the empirical estimations, highlighting the implications for policymakers and operators. Based on these results, Section 6 presents the conclusions and a discussion of further research directions.

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[2] This variable is built by weighting the price over each country monthly disposable income per capita. Disposable income is calculated as households and non-profit institutions serving households consumption (source: World Bank) plus gross national savings as reported by the International Monetary Fund (IMF). As in national accounts Y-T=C + S, the calculated disposable income can be interpreted as a measure that accounts for after tax income. Considering that mobile plans are usually individual (not for the whole household, as fixed broadband) we understand that individual disposable income is more accurate than household income to take as a reference.

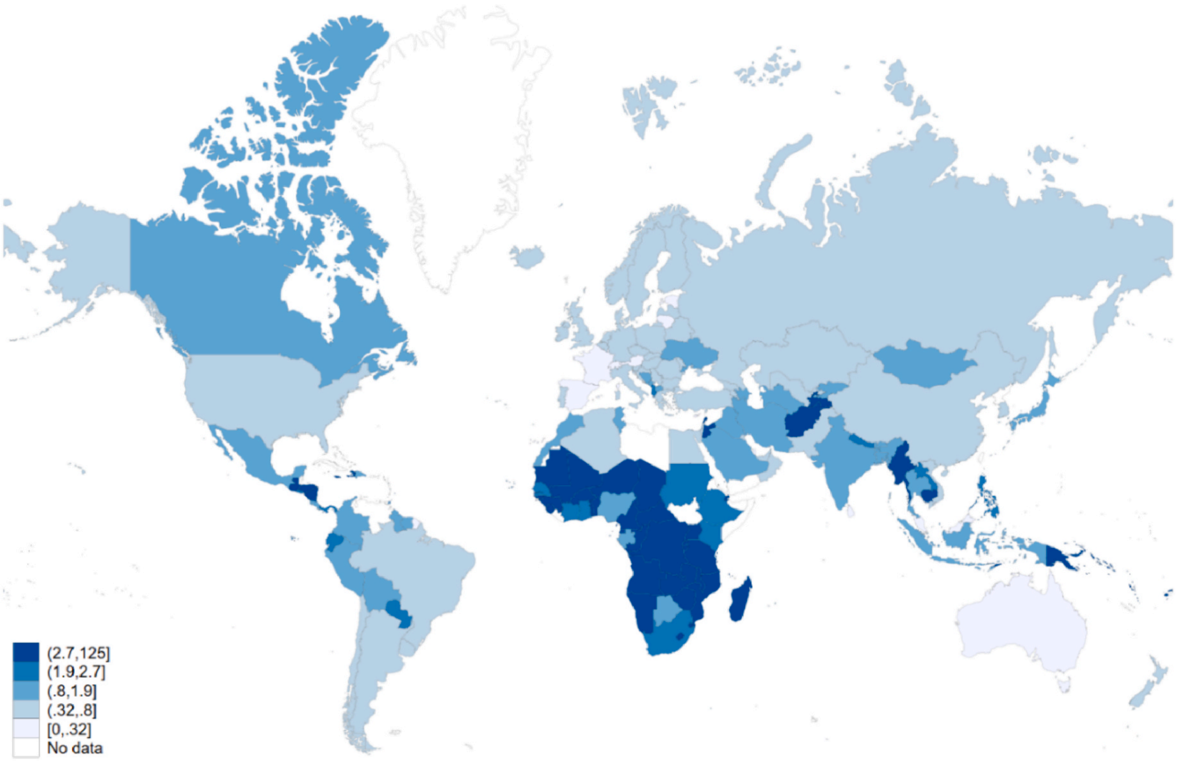

Fig. 2. Price of 2 GB 2022 (as a share of Disposable Income).
Source: ITU; World Bank; IMF; Prepared by the authors

2. Research literature review

2.1. Summary of existing literature

The empirical research focused on understanding the differences in telecommunications prices across countries is surprisingly limited. Studies in this field have mainly focused on explaining only some price drivers rather than developing an integrated framework, usually through ad-hoc approaches, not explicitly formalizing or testing economic and policy variables.[3]

By considering bandwidth as a commodity, Kenyon and Cheliotis (2001) developed a stochastic model for telecommunications pricing, focusing on assessing wholesale transport prices through carrier backbones. Inspired by models explaining electricity pricing but considering the unique features of telecommunications markets, the authors identify the drivers of potential price disparities such as geographical substitution, quantity of service, and pace of technological development. They use data from some of the major carriers across some selected network paths across the United States with some European and Asian cities.

More recently, Weiss et al. (2015) studied the drivers of mobile broadband affordability for 108 countries in 2012. The authors' main hypotheses were as follows: i) mobile broadband is more affordable in countries that demonstrate greater social justice; ii) mobile broadband is more affordable in nations that practice more democratic and just governance; and iii) mobile broadband services cost less in countries where the individual capabilities of the average resident are greater (proxied by income per capita). The conclusions point to specific forces of social justice – income inequality and a shared investment in ICTs – and per capita income together determine mobile broadband services affordability. The authors also show that a more competitive telecommunications industry reduces the cost of mobile broadband services.

Grechyn and McShane (2016) analyzed the factors that explain why landline (fixed) broadband prices differ significantly worldwide. They analyze a sample of OECD countries, plus some other economies, such as Ukraine and Bolivia, for 2015. Their empirical analysis is primarily descriptive, without performing a quantitative causal analysis to identify the main drivers of price differentials. Their main finding points to a low correlation between broadband prices and Purchasing Power Parity (PPP) rates, suggesting that the factors determining prices for consumer goods differ from those influencing broadband prices. They analyze qualitatively the role of several factors, grouped into the following categories: supply (market patterns, degree of competition); demand (income); regulatory and policy; aggregate price levels; plus, physical and infrastructure (topography, population density, telecom infrastructure legacy).

More recently, Dine and Atkinson (2022) conducted a study assessing why broadband prices differ between the United States and Europe. Their data source consists mainly of annual reports for 2019 for 11 fixed and mobile operators, including AT&T, Verizon, T-Mobile, Vodafone, Telefonica, and Deutsche Telekom, among others. They focus on studying costs and expenses faced by the operators for both fixed and mobile services. They assert that the usual conclusions that point to lower European prices because of greater competition (such as unbundling requirements) are misleading since they ignore the cost structures that differ across the two economies. Their analysis suggests that US broadband providers bear 53% higher costs than their European peers when considering labor, capital investment, spectrum licenses,

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[3] Even if our study focuses on mobile broadband prices only, in this literature section we also cite some papers that based their analysis on fixed broadband. This is because, despite being two different technologies, there are several common drivers of price variability, such as competition intensity, the taxation framework, some costs that affect both kinds of services (e.g., advertising, wages, etc.), and the critical role of innovation. From a broader perspective, regulation is equally important in both cases, although the nature of specific regulatory measures may vary from one technology to another. From the demand-side, income levels and other consumers factors are also expected to affect the purchase of both kind of services.

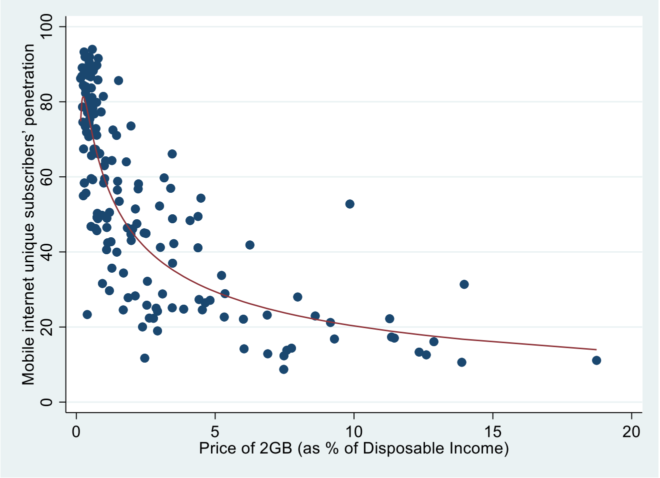

Fig. 3. Scatterplot Price – Mobile internet penetration (2022).
Source: GSMA Intelligence; ITU; World Bank; IMF; Prepared by the authors

advertising, and taxes. For example, wages for telecommunications workers are 13% higher in the United States than in Europe. In addition, European operators are taxed at lower rates while they receive more government subsidies. Moreover, they point out that in the case of spectrum licenses, US telecommunications operators pay nearly twice as much as European ones. Finally, the difference in population density is also relevant, as the United States is considerably more suburban, exurban, and rural on average than the European countries.

Along these lines, the cost of building and maintaining broadband infrastructure is generally considered one of the significant determinants of broadband prices. In areas with high infrastructure costs, such as rural areas, broadband costs are typically higher than in urban areas. Costs directly impact prices because the fixed cost of deploying infrastructure is spread over fewer customers in areas with low population density. These findings were substantiated in a study by Israel et al. (2021) that also intended to explain price differences between the United States and other OECD economies using data from 2017 to 2020 for fixed broadband prices. They argued that a nation with higher expenses for providing broadband compared to other countries may end up charging higher prices for broadband services, even if its industry is competitive.

In addition, Reddick et al. (2020) analyzed the determinants of broadband access and affordability for a microdata analysis in the San Antonio area and neighboring districts during 2020, with information mostly gathered in the American Community Survey. They focus on homes with a broadband connection, contemplating mainly fixed technologies. They argued that factors influencing affordability or adoption could relate to geographic disparities (population density), competition, profit-based discrimination (carriers not entering certain areas because of low expected profits), technology deployment costs, and socioeconomic factors (income, education, race, and age). The relevance of competition highlights how market structure can play a crucial role in determining prices. In markets with more competition, prices tend to be lower than those with monopolistic or highly concentrated structures.

However, the technology used to deliver broadband services can also affect prices. For instance, the costs of fiber-optic rollouts are usually higher than using xDSL or cable modem. Finally, the socioeconomic indicators explain differences in demand-related factors, this being a relevant contribution as they were ignored in some of the other reviewed articles.

One of the research contributions most relevant to our study is that of Calzada and Martínez-Santos (2014), who analyzed the determinants of fixed broadband prices for a group of European countries between 2008 and 2011. Their database consisted of more than 2000 broadband plans compiled from the telecommunications operators' websites. The evidence found points to a positive effect of downstream speed on prices.[4] Broadband prices were also found to increase in the case of bundled offers and to be lower when download volume caps are imposed. In addition, broadband prices were higher in countries where entrants use bitstream access more and lower in local loop unbundling cases. Finally, they did not find a significant effect of inter-platform competition on prices.

In a previous contribution, Wallsten and Riso (2010) analyzed more than 25,000 residential and business fixed broadband plans in OECD countries between 2007 and 2009, covering 169 companies in 12 quarters (2007Q1-2009Q4). They specified a model in which the dependent variable is broadband price, while regressors included download speed, volume cap, taxes, contract length, technology, and number of video channels in bundling offers. The authors found that residential plans with data caps cost less than unlimited ones for consumers that do not exceed the cap. This conclusion stands for both individual and bundled (triple-play) commercial plans.

Finally, Genakos et al. (2018) analyzed the relationship between market structure and prices for a panel of mobile operators across 33 OECD countries between 2002 and 2014. They modeled an equation in which prices are the dependent variable, while on the right-hand side, they introduced market structure characteristics (Herfindahl Hirschman Index, number of operators, operators' entries and exits) and plan characteristics (prepaid or postpaid), GDP per capita, mobile termination rates (MTR), plus time and usage–operator–country-fixed effects. Their results suggest that more concentrated markets lead to higher end-user prices, and the presence of more operators leads to lower prices and higher MTRs to higher prices. Notably, other authors do not necessarily agree with this latest point, as dynamic effects associated with economies of scale efficiencies should also be considered.

2.2. *Critical analysis*

Overall, the analysis of the existing literature points to the absence of empirical research on country price disparities, considering all the potential mechanisms that may have an incidence of it. Moreover, the cited papers do not consider the mechanisms and interrelationships between the variables that affect prices, which we intend to address through this research.

Among the reviewed literature, the papers closer to ours are those of Calzada and Martínez-Santos (2014), Wallsten and Riso (2010), and Genakos et al. (2018). However, their study's scope differs from ours, focusing primarily on price disparities across different commercial plans rather than differences among countries. Their dependent variable is defined by a sample of operator plans, not considering average country price points, and to a certain extent, the regressors selected to explain those disparities are based on plan characteristics. Finally, these studies focus mainly on supply-side factors.

In turn, other studies that intended to focus on cross-country price disparities developed descriptive or qualitative evidence, mostly limited to a reduced sample of economies (see, for instance, Dine and Atkinson, 2022; Israel et al., 2021; Grechyn and McShane, 2016), thus lacking a robust quantitative strategy behind. In a different geographic focus, Reddick et al. (2020) focus only on affordability in the San Antonio area and neighboring districts in the United States.

While using econometric techniques to estimate cross-country prices, a paper by Weiss et al. (2015) is based on a straightforward empirical approach, omitting several variables identified in the literature as pertinent for this purpose and instead emphasizing the role of social justice and institutional indicators. Lastly, Kenyon and Cheliotis (2001) study concentrates on wholesale telecom spot prices as a commodity

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[4] The authors explain these result as in several areas the only technology available is xDSL, and that lack of competition makes prices to be higher.

rather than end-user pricing.

In light of this, we intend to cover a gap in literature: quantitative research to estimate the main drivers of cross-country price disparities while considering all the sets of potential variables that may have an impact.

That being said, the existing literature provides relevant qualitative and empirical evidence on different potential drivers of price disparities that can constitute the building block of our approach when integrating them within a single framework. These are presented in Table 1, which also introduces citations of studies that, while not related to telecom prices, may contribute to the understanding of cross-country price disparities.

3. A model that integrates the factors driving price variation

We start by specifying a microeconomic model, where X^D and X^S are the quantities demanded and supplied by mobile broadband services. In equilibrium, a quantity of transacted services X^* is reached after equalizing demand and supply $X^D = X^S$ for a price P^*. Therefore, the aim is to identify the forces behind the supply and demand curves that drive the price equilibrium level P^*.

The supply function is assumed to depend on price and a series of supply-side factors, as identified above in Table 1, denoted by variables Z_i:

$$X^S = \theta + \eta P + \sum_i^n \alpha_i Z_i$$

Naturally, it is assumed that $\eta > 0$, meaning that operators will be willing to offer more services when prices are higher. These supply-side factors, denoted by Z_i, explain the position of the supply curve, which means that any change in these variables is expected to create a shift, for example, a hypothetical shift to the right of the supply curve because of variations in Z_i, meaning that a new equilibrium will be reached at which the traded quantity is higher than before while prices are lowered. Prices decline because, at the original P^*, there is effectively an excess of supply, so providers will lower prices to increase sales.

Similarly, the demand function will depend on price and a series of V_i demand-side factors as those referred to in Table 1:

$$X^D = \mu + \lambda P + \sum_i^n \sigma_i V_i$$

We expect $\lambda < 0$ as telecommunication services are not Giffen-like goods. As in the previous case, the demand-side factors will explain the position of the demand curve. A potential variation in these factors (for instance, an increase in income per capita) will eventually stimulate demand, shifting the curve to the right and resulting in a new equilibrium where the traded quantity is higher than before, although prices are increased. This situation is explained as at the original P^* there is now an excess of demand. When this occurs, the price tends to increase.

The equilibrium in the model means that supply must match demand, meaning that in equilibrium, $X^D = X^S = X^*$ for a price P^*. Thus:

$$\theta + \eta P^* + \sum_i^n \alpha_i Z_i = \mu + \lambda P^* + \sum_i^n \sigma_i V_i$$

By re-arranging, we can get the equilibrium price resulting from market forces:

$$P^* = \frac{1}{(\eta - \lambda)}\left[\mu - \theta + \sum_i^n \sigma_i V_i - \sum_i^n \alpha_i Z_i\right]$$

As a result, the equilibrium price will depend on factors affecting both the supply and demand sides. An increase in one unit in V_i is going to increase prices of $\frac{\sigma_i}{(\eta-\lambda)}$. Similarly, an increase in one unit in Z_i will lower prices in $\frac{\alpha_i}{(\eta-\lambda)}$.

Table 1
Variables that explain broadband price differences.

Group	Area	Item	Source
Supply-side factors	Regulation	Local loop unbundling	Calzada and Martínez-Santos (2014), Grechyn and McShane (2016)
		Bitstream access	Calzada and Martínez-Santos (2014)
		Infrastructure sharing	Calzada and Martínez-Santos (2014)
		Mobile termination rates	Genakos et al. (2018)
		Trade restrictions	Chen and Huang (2012), Pakko and Pollard (2003), Lipsey and Swedenborg (2010)
		Legal constraints	Lamont and Thaler (2002)
	Commercial strategies	Number of plans	Calzada and Martínez-Santos (2014), Wallsten and Riso (2010)
		Bundling	Calzada and Martínez-Santos (2014), Wallsten and Riso (2010)
		Data volume caps	Calzada and Martínez-Santos (2014), Wallsten and Riso (2010)
		Contract length	Wallsten and Riso (2010)
		Prepaid/postpaid	Genakos et al. (2018)
		Price discrimination	Chen and Huang (2012), Wagner and McCarthy (2004)
	Technology	xDSL/FTTH (for fixed) or 4G/5G (for mobile)	Calzada and Martínez-Santos (2014), Wallsten and Riso (2010)
	Speed	Download speed	Calzada and Martínez-Santos (2014), Wallsten and Riso (2010), Kenyon and Cheliotis (2001)
		Upload speed	Calzada and Martínez-Santos (2014)
	Taxes	Taxes on firms	Dine and Atkinson (2022)
		Subsidies	Dine and Atkinson (2022), Grechyn and McShane (2016)
	Competition	Competition intensity (HHI)	Calzada and Martínez-Santos (2014), Genakos et al. (2018), Grechyn and McShane (2016), Weiss et al. (2015)
		Incumbent position	Calzada and Martínez-Santos (2014)
		Privatization, liberalization	Grechyn and McShane (2016)
		Number of operators	Genakos et al. (2018), Reddick et al. (2020)
		Imperfect competition	Pakko and Pollard (2003)
	Population density		Dine and Atkinson (2022), Grechyn and McShane (2016), Reddick et al. (2020)
	Costs	Advertising	Dine and Atkinson (2022)
		Wages	Dine and Atkinson (2022), Lipsey and Swedenborg (2010)

(*continued on next page*)

Table 1 (*continued*)

Group	Area	Item	Source
		Spectrum licenses	Dine and Atkinson (2022)
		Aggregate price levels	Grechyn and McShane (2016)
		Deployment costs	Dine and Atkinson (2022), Reddick et al. (2020)
		Transportation costs	Chen and Huang (2012), Pakko and Pollard (2003), Lipsey and Swedenborg (2010)
	Topography (such as mountains, forest)		Grechyn and McShane (2016)
	Infrastructure legacy		Grechyn and McShane (2016)
	Non tradable components of goods		Chen and Huang (2012), Bhagwati (1984), Kravis and Lipsey (1988), Kravis et al. (1982), Pakko and Pollard (2003), Lipsey and Swedenborg (2010), Hassink and Schettkat (2001)
	Factor endowments and intensity		Bhagwati (1984), Lipsey and Swedenborg (2010)
	Productivity disparities		Chen and Huang (2012), Bhagwati (1984), Kravis et al. (1982), Pakko and Pollard (2003),
Demand-side factors	Income (e.g., GDP per capita)		Grechyn and McShane (2016), Genakos et al. (2018), Reddick et al. (2020), Weiss et al. (2015), Kravis and Lipsey (1988), Lipsey and Swedenborg (2010)
	Income inequality		Weiss et al. (2015)
	Broadband penetration		Calzada and Martínez-Santos (2014)
	Taxes on goods		Wallsten and Riso (2010), Chen and Huang (2012), Pakko and Pollard (2003)
	Age		Reddick et al. (2020)
	Education		Reddick et al. (2020)
	Race		Reddick et al. (2020)
Macroeconomic factors	Exchange rate fluctuations		Beckmann (2013); Lipsey and Swedenborg (2010)
	Government expenditure		Pakko and Pollard (2003)

Source: Prepared by the authors

Adding complexity to the model, several variables detailed above within Z_i and V_i are expected to be interrelated. Furthermore, these variables' effects on prices are expected to take place through these linkages, which means that it is necessary to account for them empirically.

Considering all these complex interdependencies, we sketch those links in a diagram in Fig. 4 that depicts all the potential causes of price disparities surveyed in the literature (summarized in Table 1), except those that do not appear to be suited for a cross-country analysis.[5] The drivers of price variance can be grouped into three main categories: supply-side, demand-side, and macroeconomic changes. Each of them and the justification for each linkage denoted in Fig. 4 are explained next.

Starting with the supply side, a critical variable in this process is capital investment (CAPEX). This indicator refers to capital spending in fixed assets (acquiring and upgrading property and networks) related to the infrastructure required to deliver services. It includes investments made for mobile broadband services, such as information technology infrastructure and networks. According to the literature, the amount of CAPEX is expected to be influenced by several variables, such as competition intensity[6] (Genakos et al., 2018; Jung and Katz, 2022; Kim et al., 2011), regulatory conditions[7] (Alesina et al., 2005; Jung and Katz, 2022; Kim et al., 2011; Jung, 2019, 2020), population density (Kim et al., 2011), urbanization (Katz and Jung, 2023), and taxation (Katz and Jung, 2023). On the other hand, plenty of research highlights how macroeconomic factors can affect investment levels (see, for example, Shaalan, 1990). Beyond its effects on investment, macroeconomic conditions can also affect prices directly (Beckmann, 2013; Lipsey and Swedenborg, 2010; Pakko and Pollard, 2003).

In turn, CAPEX is expected to affect prices through multiple effects. First, capital spending drives mobile broadband speed through innovation (such as investment in 5G networks). In this respect, some studies point to each new generation of technology being more expensive to deploy than older ones (Tech4i2, Real Wireless, Trinity College, & Interdigital, 2016). This technology can potentially be associated with more expensive mobile broadband plans (although when adjusted by performance, prices have been decreasing). Some researchers have directly linked capital spending and prices, as operators need to recover their investments (Dine and Atkinson, 2022; Reddick et al., 2020). In turn, CAPEX levels should also be drivers of network coverage enhancements (Katz and Jung, 2023). Coverage refers to the extent of network deployment across the country, measured as a share of the population that can potentially access the service. More coverage increases the operator's willingness to supply service for a given price. Higher coverage levels should translate into a price reduction as the operator's supply function shifts to the right, lowering prices (Katz and Jung, 2023).

Beyond investment levels, regulatory measures may also influence coverage, as operators may react to incentives in policies such as network sharing (Jung and Katz, 2023). In addition, topographic complexities are expected to affect network expansion (Grechyn and McShane, 2016), influencing coverage levels and ultimately affecting prices.

As regulatory interventions may also be related to competition regulation, we can expect a direct path from regulation to competitive intensity. According to the reviewed literature, competition should directly impact prices (Calzada and Martínez-Santos, 2014; Genakos et al., 2018; Grechyn and McShane, 2016; Weiss et al., 2015). Regulation may also affect prices directly, as highlighted by several authors for very diverse regulatory measures (Calzada and Martínez-Santos, 2014; Grechyn and McShane, 2016; Genakos et al., 2018; Lamont and Thaler, 2002).

Finally, ongoing operating expenses, usually grouped into the OPEX category, are expected to affect prices directly. OPEX is an indicator of operations costs, as it includes expenditures in personnel, sales,

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[5] For instance, the characteristics of commercial plans (e.g., data volume limit) can be useful for empirical research where observations are service plans but become useless for country-level specifications.

[6] We measure this indicator through market concentration metric of Herfindahl-Hirschman Index (HHI). This is measured by squaring the market shares of market participants. Lower levels of this indicator are associated with higher competition intensity, which is expected to drive price competition by creating incentives to lower them.

[7] Refers to public policies and norms adopted by sector regulators that can potentially affect deployment costs and stimulate or discourage investments. Examples can be infrastructure sharing, spectrum trading in secondary markets, and technological neutral spectrum licensing.

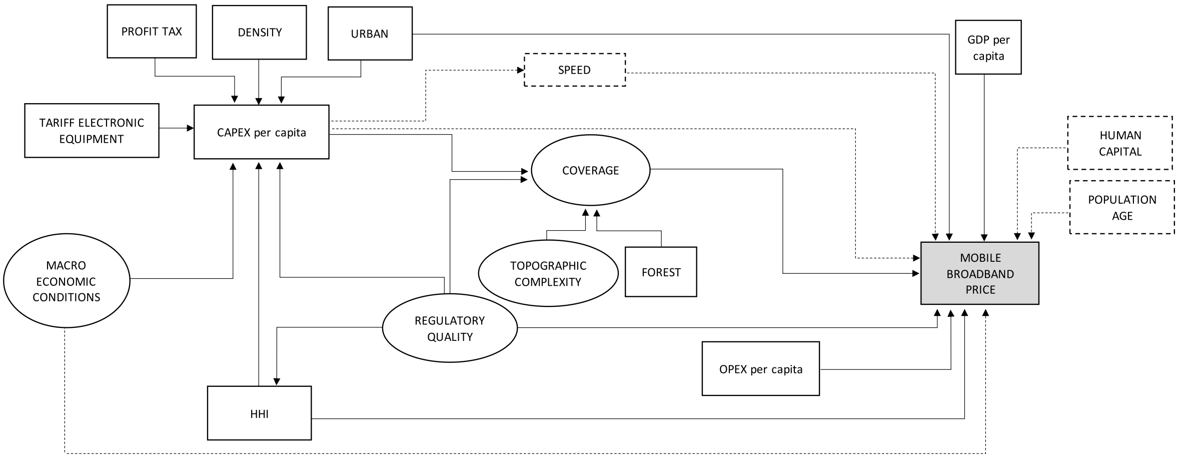

Fig. 4. Proposed model specification.
Source: Prepared by the authors

administration, and advertising expenses, among others. The higher the operating expenses, the more expensive end-user prices should be for broadband services so operators can recover costs. Previous literature suggested how some of these expenses drive prices (Dine and Atkinson, 2022; Lipsey and Swedenborg, 2010).

From the demand side, as reflected in the general literature explaining price differentials, personal income is expected to drive demand and consequently affect prices (Grechyn and McShane, 2016; Genakos et al., 2018; Reddick et al., 2020; Weiss et al., 2015; Kravis and Lipsey, 1988; Lipsey and Swedenborg, 2010). Usually represented by GDP per capita, income levels represent the purchasing capacity of the population, which sets the maximum value of their willingness to pay for broadband services. Other personal characteristics such as education and age may also affect prices through the demand side (Reddick et al., 2020). More educated people should be willing to pay more for mobile broadband services, thus contributing to higher prices. As for the age of the population, this is usually considered a relevant variable as the older population should be less prone to demand technological services. Finally, we also sketch a direct link between urbanism and prices, which can directly affect it. Urban areas are assumed to be more digitized, and thus, urban residents will be more intensive adopters of mobile broadband internet services.

4. Dataset and descriptive statistics

The sample for this study was built from very different sources. It includes 182 countries for the period 2013–2022.[8] Table 2 summarizes the variables list with their respective description and sources. The focus has been put on compiling all the potential variables that drive price variability in a cross-country context from those presented above in Table 1.[9]

Price data was collected from the International Telecommunication Union (ITU) data-only mobile broadband basket.[10] It refers to the less expensive plan providing at least 2 GB of data (above 256 kbit/s) over 30 days from the telecommunications operator with the largest market share in each country.

Supply-side variables include CAPEX and OPEX (measured in per capita terms), while the share of the population served by 3G and 4G networks will be used to measure coverage. Competitive intensity is measured through HHI. All these variables were extracted from the GSMA Intelligence database.[11]

In addition, population density, urban population, and the variables accounting for forests were sourced from the World Bank. We also compiled variables from diverse sources to account for topographic complexity. Regarding taxation metrics, we considered country profit taxes (source: World Bank) and whether tariffs are imposed in each country on imports of electronic equipment (source: WTO).[12] Finally, selected regulatory variables focused on the licensing framework, spectrum, and competition regulation were compiled from the ITU ICT Regulatory Tracker, which measures the adoption of best regulatory practices worldwide.[13] As for demand side indicators, we focused on GDP per capita sourced from the International Monetary Fund (IMF). To account for macroeconomic changes, we considered exchange rate depreciation and the inflation rate (source: IMF). To minimize potential omitted data, we conducted extensive desktop research looking for secondary sources to fill those gaps from available sources whenever possible.[14] All in all, a sample of 1400 observations was developed.

Considering that some variables present overlapping information, we built some constructs through factor analysis to reduce the dimension of the dataset while keeping as much information as possible.

The Coverage construct ("Coverage") was measured through two items: the share of the population covered by 3G and 4G. The scale reliability of this construct proved to be very good (Cronbach's alpha = 0.781). This construct can be interpreted as a measure of coverage by the wireless technologies deployed worldwide during the period. We excluded 5G coverage as by 2022, this variable registered mostly zeros through the dataset, with only a small group of countries taking positive

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[8] See country list in Appendix (Table A1).

[9] The list only includes the variables that ended being part of the econometric estimate, omitting those from the dotted linkages in Fig. 8 that were finally excluded because of not being significant.

[10] Data available in: https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/IPB.aspx.

[11] GSMA Intelligence is the main source of mobile industry data worldwide. For more info check: https://www.gsmaintelligence.com/.

[12] From a long-term perspective, tariffs for manufactured goods have fallen to historical lows (Grübler and Reiter, 2021). However, there are still several countries that still impose them, affecting the imports of electronic equipment required to deploy broadbands services.

[13] The ITU ICT Regulatory Tracker is a monitoring database that tracks how countries evolve through a pre-specified set of 50 regulatory approaches. Naturally, countries may adopt a policy but then implement it incorrectly, meaning that the expected effect of the policy may not arise. However, the dataset does not provide information regarding implementation, this being a limitation. We thank an anonymous referee for rising this point.

[14] To fill these gaps, we searched for complementary information through reliable sources. For instance, missing exchange rates were filled from www.exchangerates.org.uk, while missing information on tariffs was filled from GSMA reports.

Table 2
Variable description and sources.

Group	Variable		Description	Source
Dependent variable	Price		Price per 2 GB of mobile data (USD PPP).	ITU
Supply variables	CAPEX		Mobile CAPEX per capita (USD PPP).	GSMA
	OPEX		Mobile OPEX per capita (USD PPP).	GSMA
	Coverage	Coverage 3G	3G network coverage (% of total population).	GSMA
		Coverage 4G	4G network coverage (% of total population).	GSMA
	HHI		Herfindahl-Hirschman Index for the mobile market.	GSMA
	Population density		Population density (people per sq. km of land area).	World Bank
	Forest		Dummy variable that takes the value of 1 if 50% or more of the country land area is covered by forest and 0 otherwise.	World Bank
	Topographic complexity	Area	Surface area (sq. km).	World Bank
		Average Elevation	Average elevation of country land area.	Wikipedia
		Elevation range	Difference between max and min country elevation.	Wikipedia
	Profit tax		Amount of taxes on profits paid by the business (% of commercial profits).	World Bank
	Tariffs		Dummy variable that takes the value of 1 if the country imposes tariffs on electronic equipment import and 0 otherwise. Built considering average ad valorem tariffs for goods HS 8517 (most favored nation criteria).	WTO
	Regulation	Types of licenses provided	Variable that takes the value of 2 if unified/global licenses, general authorizations, or simple notification; 1 if multi-service individual licenses, and 0 if service-specific licenses.	ITU
		Infrastructure sharing	Variable that takes the value of 2 if infrastructure sharing for mobile operators is permitted and 0 otherwise	ITU
		Secondary trade	Variable that takes the value of 2 if spectrum secondary trading is allowed and 0 otherwise	ITU
		SMP regulation	Variable that takes the value of 2 if the national competition law recognizes the concept of "dominance" or SMP and 0 otherwise	ITU
		SMP criteria	Variable that takes values between 0 and 2 depending on the number of criteria used in determining dominance or SMP	ITU
		Mobile Portability	Variable that takes the value of 2 if number portability is available to consumers and required from mobile operators, 1 if it is partially available, and 0 otherwise	ITU
Demand variables	GDP per capita		Gross domestic product per capita (USD PPP).	IMF
	Urban		Urban population (% of total population).	World Bank
Macro variables	Macro	Exchange rate depreciation	Annual percentual variation in Exchange Rate (National Currency Per US Dollar, annual average)	IMF
		Inflation	Annual percentual variation in consumer prices	IMF

Source: Prepared by the authors

values in some of the last years covered.

The Topographic construct ("Topography") was measured through the three items related to geographic complexity for network deployment: average elevation, elevation range (difference between higher and lower elevation), and area extension. The higher the value this indicator takes, the more challenging and costly the network deployment. Reliability was also good (Cronbach's alpha = 0.753).

The "Regulatory" construct was built from six variables accounting for mobile-related regulation. Variables included in this case licensing, spectrum, and competition regulation: i) Types of spectrum licenses provided, meaning whether spectrum is allocated for a specific use or on a technology-neutral basis; ii) Infrastructure sharing permitted; iii) Secondary trade for spectrum allowed; iv) Significant market power

(SMP)[15] regulation; v) SMP criteria for measurement; and vi) Mobile number portability.

First, flexible spectrum regulation has been found to be a positive driver of mobile market development.[16] In addition, a technology-neutral spectrum licensing approach allows for using any technology in any frequency band, encouraging innovation and promoting competition, allowing markets to determine which technologies will succeed. Second, infrastructure sharing refers to the possibility of operators performing network-sharing agreements, maximizing investment opportunities, and incentivizing network deployment. Third, spectrum secondary trading consists of a mechanism by which license holders can voluntarily transfer spectrum-usage rights to other operators, which may result in more efficient use of this limited resource, ensuring that it does not go unused. Fourth, competition regulation is also measured through SMP regulation (to provide a suitable framework for competition monitoring) plus mobile number portability, a measure that lowers barriers for consumers to change mobile providers, thus incentivizing operators to lower prices and improve quality. Scale reliability is good (Cronbach's alpha = 0.785).

Next, the macroeconomic changes construct ("Macro") is based on two indicators related to two macroeconomic conditions: the percentage of the average annual currency depreciation (against the US dollar) and inflation, measured as the annual percentual increase in the consumer price index (CPI). These macro effects may create uncertainty, restrict investment, and yield higher prices. Reliability was slightly inferior to the previous constructs (Cronbach's alpha = 0.634), although it was still acceptable according to Hair et al. (2006).

Finally, the constructs are distinct conceptually and in terms of their underlying factors, reducing any potential risk of common method variance. In any case, Harman's one-factor test (an un-rotated factor analysis on all items used in the model) was conducted, with results confirming that the explained variance by the first factor was well under half of the total variance (27.93%), meaning that common method bias is unlikely. The correlation between constructs (presented in Table A2 in the Appendix) is very low, except the one between Coverage and Regulation. To check if this high correlation can be a problem for empirical identification, we conducted divergent validity checks by comparing this correlation index with the squared root of the Average Variance Extracted (AVE) for each. The respective squared roots of AVE were above the correlation index, meaning that this correlation should not be a concern in our sample.

In Table 3, we report the main descriptive statistics of all variables. All those denominated in monetary units were converted to PPP US dollars.

The average price is USD 24.172. The mean CAPEX is USD 51.558 per capita, while the OPEX is considerably higher (USD 227.116). The average population covered in the period is 83.3% for 3G and 59.9% for 4G. In addition, the mean HHI is 4,305, which is expected in a capital-intensive industry such as telecommunications.

Pricing data across countries indicates variation. In Fig. 5, we highlight these variabilities in a representative sample of 60 countries. According to the 2 GB price data compiled from the ITU database, less developed countries are most affected and disadvantaged when assessed relative to income. In other words, while prices in rich countries are typically higher when measured by a percentage of disposable income, the distribution changes. While the average price (measured as a percent of disposable income) across these 60 countries is 1.26% in 2022, in Tanzania and Uganda, the value increases beyond 4%. On the other hand, broadband services in higher-income economies are typically cheaper as a share of income levels.

Table 3
Descriptive statistics.

Group	Variable		Mean	Standard Deviation
Dependent variable	Price		24.172	19.759
Supply variables	CAPEX		51.558	49.520
	OPEX		227.116	296.951
	Coverage	Coverage 3G	0.833	0.229
		Coverage 4G	0.599	0.387
	HHI (Herfindahl Hirschman Index)		4305.252	1618.677
	Population density		353.959	1691.796
	Forest		0.402	0.490
	Topographic complexity	Area	709,614.100	1,971,306.000
		Average Elevation	564.321	583.463
		Elevation range	2698.748	2036.123
	Profit tax		0.162	0.097
	Tariffs		0.596	0.491
	Regulation	Types of licenses provided	1.222	0.903
		Infrastructure sharing	1.729	0.676
		Secondary trade	0.590	0.904
		SMP regulation	1.604	0.785
		SMP criteria	1.354	0.803
		Mobile Portability	1.094	0.906
Demand variables	GDP pc		21,507.630	22,688.710
	Urban		0.586	0.229
Macro variables	Macro	Exch rate depreciation	0.053	0.210
		Inflation	0.058	0.199

Source: Prepared by the authors

Given wide differentials, the next question is determining whether price variation is constant, increasing, or converging over time towards a single price point. For this analysis, we conducted a dispersion analysis over time to determine the trend. A first perspective based on Max/Min analysis indicates that between 2013 and 2022, the price dispersion for the 2 GB broadband plan as a percentage of disposable income appears to be declining (see Fig. 6).[17]

The trend toward reduction in disparities is confirmed when analyzing the evolution of standard deviations over time, indicating that some convergence seems to occur (see Fig. 7).

As indicated in Fig. 7, the standard deviation for prices has progressively decreased over time. However, while a convergence process may be occurring, this process appears to be very slow, as indicated by the shift of the density functions between 2013 and 2022 (see Fig. 8).

As indicated in the analysis of density functions, the difference between 2013 and 2022 indicates no changes in price dispersion and a modest shift towards convergence combined with the emergence of a "twin peak" distribution for the case of prices as a share of income. Reduced dispersion in this latest indicator may be the result of faster income growth in developing countries.

In summary, while price disparities slowly diminish, they remain strong after almost a decade. Despite the apparent convergence of prices, this natural effect is not likely to reduce the disparities significantly

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[15] Significant market power (SMP) is the regulatory status representing a dominant position in a given market. This is sometimes referred to as pricing power, consisting in a company's ability to influence the price of products. It may enable companies to increase their profit margins and impose barriers to entry for other firms.

[16] The positive effects in terms of investment have been analyzed in Jung and Katz (2022).

[17] Naturally, the Max/Min analysis is affected by extreme or outlier situations, meaning that its results should be taken with caution. We thank an anonymous referee for raising this point.

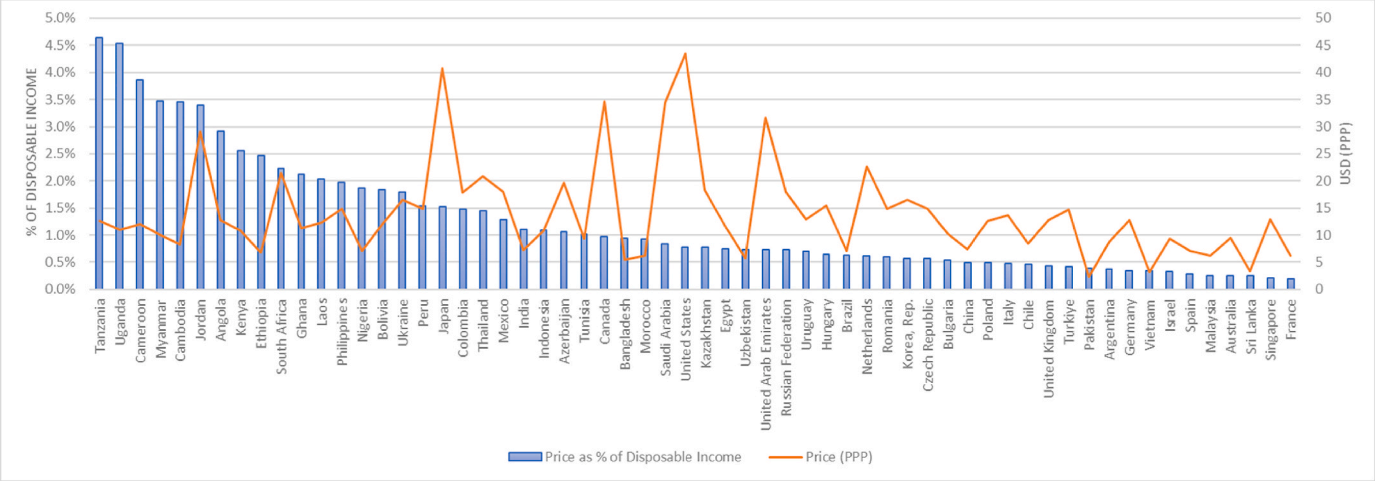

Fig. 5. Price of 2 GB in USD (PPP) (2022).
Source: ITU; World Bank; IMF; Prepared by the authors

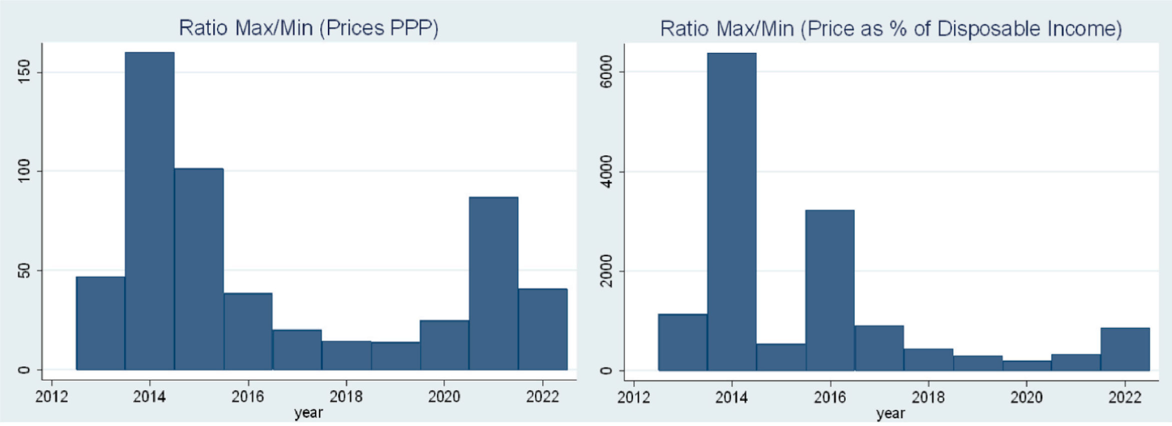

Fig. 6. Price of 2 GB In USD: Max/Min dispersion analysis (2013–2022).
Source: ITU; World Bank; IMF; Prepared by the authors

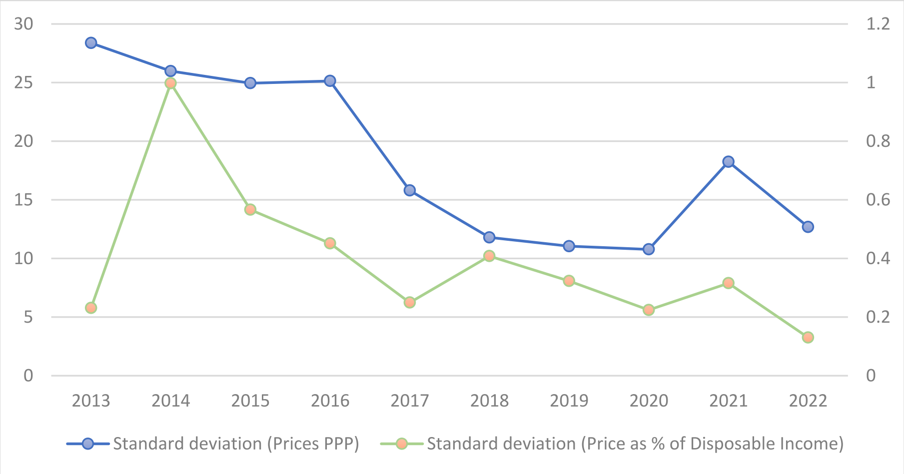

Fig. 7. Price of 2 GB In USD: Standard deviation analysis (2013–2022).
Source: ITU; World Bank; IMF; Prepared by the authors

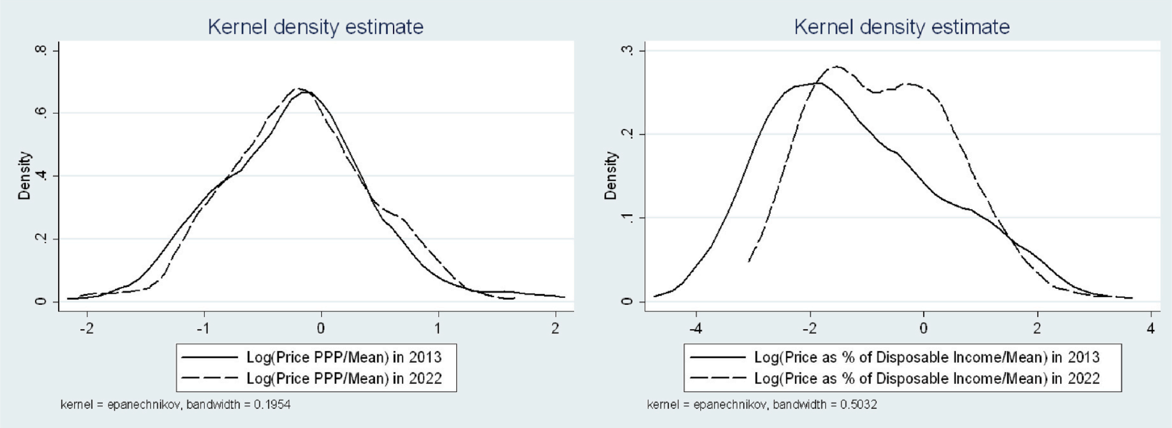

Fig. 8. Density functions for prices and affordability.
Note: kernel density estimation refers to kernel smoothing application for probability density.
Source: ITU; Prepared by the authors

in the short or medium term. Therefore, we can expect price variability in mobile broadband telecommunications will continue to be a permanent industry fixture and a persistent problem in the developing world, which drives the need to understand causes and define possible remedies.

5. Estimation results and practical implications

In this section, we present the main econometric results from the estimated model before applying the results to a case analysis of some emerging regions to draw policy implications.

5.1. Baseline results

Considering the multiple direct and indirect linkages in Fig. 4, Structural Equation Modelling (SEM) is the most appropriate methodology. This empirical approach is useful for validating hypotheses by examining the relationships and connections between multiple variables or constructs. These models allow for examining direct and indirect effects, forming a network of interdependencies among variables. By conducting a comprehensive statistical analysis of the entire system, the model determines whether the observed data aligns with the proposed relationships (Pearl, 2012). Direct effects represent a straightforward relationship between two variables, where the first variable influences the second variable directly. In contrast, indirect effects refer to an indirect pathway where one explanatory variable impacts another with the mediation of a third variable. Total effects encompass direct and indirect effects, representing the overall influence between variables.

SEM consists of a system of simultaneous equations that contemplate all the abovementioned interdependencies. Our estimated results refer all to those linkages established in Fig. 4 above. However, some paths presented in Fig. 4 were insignificant and removed from the final specification to achieve a more parsimonious model and increase model fit indicators (the excluded linkages are those represented in dots in Fig. 4). The model is estimated through the Maximum Likelihood approach with robust standard errors. All variables measured in monetary units were transformed into logarithms. In addition, the variables HHI, Population density, Urban population, and Topographic indicators were also converted into logarithms, as this specification provided a better model fit. Finally, CAPEX (and the variables influencing it) was introduced in lags, as investments are expected to take some time to influence coverage gains due to construction times, permit delays, and equipment imports required.[18]

Results are reported in Table 4. The structural model yielded a good fit, as indicated by various indices. The Comparative Fit Index (CFI) has a value of 0.903, which aligns with the acceptable thresholds defined by some authors (Kline, 2023). Additionally, both the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR) are well below the recommended threshold of 0.08 (Kline, 2023), indicating an adequate fit. The coefficient of determination (CD) also proved to be very good. The standardized regression weights of the construct items were all significant at 1% (except for depreciation in the Macro construct, which was still highly significant with a p-value of 0.018), supporting the convergent validity of the scales.

First, we analyze the direct effects on CAPEX. Increases in profit taxes are found to restrict investment, as verified by the negative coefficient linking this variable with CAPEX. Something similar is verified for the imposition of tariffs on equipment. This analysis confirms the results from Katz and Jung (2023) in telecommunications and a wealth of more general literature, where taxation was found to reduce resources available for investment in network deployments. In turn, macroeconomic disturbances were found, as expected, to restrict investment.

In addition, the direct effect between HHI, as the indicator of industry concentration, and CAPEX was found to be non-significant. This non-significant link between HHI and CAPEX is not surprising, as the literature has widely found that two opposite effects coexist around the link between competition intensity and investment in the telecom market. On the one hand, Schumpeter (1942) developed a theory of innovation and creative destruction, establishing a negative link between competition and incentives to innovate. Lower competition levels imply higher expected returns from innovation. On the other hand, Arrow (1962) argued that more intense competition yields more innovation activity due to competitive pressures that push enterprises to innovate to gain market share. The views of Schumpeter and Arrow are incorporated in the development provided by Aghion et al. (2005) through the “inverted-U” theory, which establishes a nonlinear relationship between competition and innovation.

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[18] Lagged CAPEX has been already modeled as a driver of coverage in previous research (Jung and Katz, 2022). We also tested the model incorporating all these variables without lags, with results mostly unchanged, although it provided a worse fit.

Table 4
Baseline SEM model for Prices.

Variables	Standardized direct effects												
	CAPEX	OPEX	Coverage	HHI	Density	Tariffs	Profit tax	Regulation	Forest	Topography	Macro	GDP pc	Urban
HHI								−0.545***					
								(0.000)					
CAPEX				0.028	−0.122**	−0.143***	−0.077***	0.127**			−0.801***		0.418***
				(0.149)	(0.017)	(0.000)	(0.001)	(0.015)			(0.000)		(0.000)
Coverage	0.197***							0.685***	−0.049*	−0.234***			
	(0.000)							(0.000)	(0.060)	(0.000)			
Price		0.125***	−0.378***	0.127***				−0.423***				0.355***	0.228***
		(0.002)	(0.000)	(0.000)				(0.000)				(0.000)	(0.000)
	Standardized indirect effects												
Price	−0.075***			−0.002	0.009	0.011***	0.006***	−0.337***	0.018*	0.088***	0.060***		−0.031***
	(0.000)			(0.136)	(0.190)	(0.000)	(0.010)	(0.000)	(0.062)	(0.000)	(0.002)		(0.000)
	Standardized total effects												
Price	−0.075***	0.125***	−0.378***	0.125***	0.009	0.011***	0.006***	−0.760***	0.018*	0.088***	0.060***	0.355***	0.197***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.190)	(0.000)	(0.010)	(0.000)	(0.062)	(0.000)	(0.002)	(0.000)	(0.000)
Model Fit Statistics													
Chi-squared MS	1449.698												
Chi-squared BS	13,516.521												
CFI	0.903												
RMSEA	0.075												
SRMR	0.060												
CD	0.997												
Observations	1400												

Note: ***p<1%, **p<5%, *p<10%. p-values from robust standard errors in brackets. MS and BS denote model vs. saturated and baseline vs. saturated. Indirect and total effects are only reported on prices because of space limitations, although complete results remain available upon request.
Source: Prepared by the authors

Table 5
SEM model for Prices – controlling with unobservable factors.

Variables	Standardized direct effects												
	CAPEX	OPEX	Coverage	HHI	Density	Tariffs	Profit tax	Regulation	Forest	Topography	Macro	GDP pc	Urban
HHI								−0.397*** (0.000)					
CAPEX				0.098*** (0.000)	0.125*** (0.000)	−0.149*** (0.000)	−0.114*** (0.000)	0.100*** (0.001)			−0.160** (0.046)		0.471*** (0.000)
Coverage	0.452*** (0.000)							0.299*** (0.000)	−0.110*** (0.000)	0.011 (0.551)			
Price		−0.104 (0.199)	−0.229*** (0.000)	0.143* (0.073)				−0.049 (0.497)				0.148 (0.611)	−2.414*** (0.000)
	Standardized indirect effects												
Price	−0.104*** (0.000)			−0.010*** (0.004)	−0.013*** (0.001)	0.015*** (0.001)	0.012*** (0.001)	−0.132*** (0.000)	0.025*** (0.001)	−0.002 (0.555)	0.017* (0.071)		−0.049*** (0.000)
	Standardized total effects												
Price	−0104*** (0.000)	−0.104 (0.199)	−0.229*** (0.000)	0.133* (0.097)	−0.013*** (0.001)	0.015*** (0.001)	0.012*** (0.001)	−0.181*** (0.010)	0.025*** (0.001)	−0.002 (0.555)	0.017* (0.071)	0.148 (0.611)	−2.462*** (0.000)
Controls in the Price equation													
Country Fixed Effects		YES											
Time-trend		YES											
Model Fit Statistics													
CD	0.997												
Observations	1400												

Note: ***p<1%, **p<5%, *p<10%. p-values from robust standard errors in brackets. MS and BS denote model vs. saturated and baseline vs. saturated. Indirect and total effects are only reported on prices because of space limitations, although complete results remain available upon request.
Source: Prepared by the authors

Table 6

Summary of total effects on Prices and Affordability.

	Variable	Rationale
Variables that lower prices	Coverage	More coverage will shift the supply curve of telecom operators to the right. For any price, ISPs will be willing to offer more services, pushing down prices.
	CAPEX	Higher investment helps expand coverage and supply and push down prices.
	Regulation	Better regulation can incentivize investment, improve efficiency, reduce costs, optimize resources, and thus lower prices.
	Density	After controlling for fixed effects, the estimated results suggest that higher population density lowers prices through stimulated investment (because of lower per capita investment) and increased coverage.
	Urban	After controlling for fixed effects, the estimated results suggest that higher urban population lowers prices through stimulated investment and increased coverage (as is in the variable above).
Variables that raise prices	OPEX	An increase in costs included in OPEX (such as advertising, personnel, sales, and administration) will cause telecom operators to raise prices to cover these expenses. However, when introducing country-level fixed effects, the coefficient associated with OPEX loses significance, possibly because it is a variable dominated by large time-invariant components.
	HHI	A higher HHI indicates less competitive intensity, meaning that operators with more market power can undermine competition, increasing prices in a more concentrated market.
	Tariffs	Tariffs on electronic goods increase the acquisition cost of critical equipment for network deployment, reducing incentives and available funds for investment, negatively affecting coverage, and raising prices.
	Profit tax	Higher profit tax reduces available funds to invest and the post-tax expected returns from it, discouraging investment and, by extension, coverage improvements, raising prices.
	Forest	The presence of forests makes it costly and unprofitable to cover those areas, to the detriment of the population segments that live there, which harms coverage expansion and increases prices.
	Topography	A more complex topography makes it challenging and costly to deploy networks, thus reducing coverage expansion and pushing up prices. However, when introducing country-level controls, this effect loses significance.
	Macro	Macroeconomic disturbances such as currency depreciation and inflation create uncertainty and increase the price of imported inputs, reducing incentives for investment, limiting coverage expansion, and raising prices.
	GDP pc	Higher personal income increases the willingness to pay for mobile broadband, shifting the demand to the right and increasing prices. However, when introducing country-level fixed effects, the coefficient associated with GDP per capita loses significance, possibly because the fixed effects now capture disparities in country development.

Source: Prepared by the authors

Table 7

Policy and industry strategies to lower internet prices.

Variable	Potential changes
Regulation	Adopt a regulatory framework where licenses are technology-neutral, infrastructure sharing is allowed, and secondary trade for spectrum is permitted. As depicted in the ITU Regulatory Tracker, these changes will increase the value of the index.
OPEX	Reduce energy and deployment costs due to infrastructure sharing and enhance cloud computing to achieve economies of scale in IT.
Profit taxes	Reduce firm taxes and eliminate sector-specific impositions
Tariffs	Eliminate or reduce tariff prices applied to network equipment imports.

Source: Prepared by the authors

Regulation was found to be a crucial variable, as it has positive direct effects on both CAPEX and Coverage, while on the other hand, it presents a negative link with HHI (increasing competition intensity) and prices. Thus, a sound regulatory framework is vital to induce diverse effects leading to lower prices.

In turn, Coverage is positively affected by CAPEX, as expected. However, Coverage was found to be negatively affected by more complex topographic conditions and forests. All things being equal, we should expect lower coverage levels in countries with more geographic complexities, meaning that supply will be restricted in those cases, pushing up prices.

Finally, there are several direct effects on prices, including OPEX. Increases in sales, marketing, administrative, or personnel expenditures will likely result in higher prices; otherwise, financial results may be negatively affected. This view is consistent with findings by Dine and Atkinson (2022) and Lipsey and Swedenborg (2010). In addition, higher coverage is associated with lower prices since when coverage increases, the supply curve shifts to the right, with equilibrium prices decreasing. A higher HHI is associated with more expensive broadband services, reflecting a lower competition intensity and, thus, lower operator incentives to keep prices down. This finding is aligned with those research that identified the influence of competition intensity on prices (Calzada and Martínez-Santos, 2014; Genakos et al., 2018; Grechyn and McShane, 2016; Weiss et al., 2015).

We then calculate indirect and total effects. For brevity, we only report in Table 4 the indirect and total effects on prices, as this is the primary purpose of our analysis.[19] CAPEX has a negative indirect effect on prices, as the link between these two variables is fully mediated by Coverage. Both taxation measures, in turn, indirectly yield higher prices, with their effect fully mediated through investment and coverage. Thus, there is a critical need to maintain moderate fiscal regimes to stimulate broadband deployment and adoption.

Regulation, in turn, indirectly reduces prices through its mediated effects by CAPEX and Coverage, which are highly significant. These findings, again, highlight the relevance of adequate regulation to lower prices.

Forestry and topographic complexities indirectly yield higher prices, as expected. These effects are fully mediated by coverage because, as explained above, geographical complexities are expected to render the deployment of networks across the territory more difficult.

Macroeconomic disturbances, in turn, will yield higher prices through an indirect effect that materializes through investment. Uncertainties created by macroeconomic shocks will undermine the incentives to invest in network deployment. Despite only verifying this impact indirectly, it can be considered aligned with literature such as Beckmann (2013) or Lipsey and Swedenborg (2010).

To sum up, mobile broadband prices are affected by numerous variables generating a combination of direct and indirect effects. CAPEX and Coverage negatively influence prices, while better regulatory quality reduces them. Higher operational expenditures will result in higher prices. Lower competition intensity (measured through a higher HHI) will generate effects in the same direction. Additionally, the more intense the fiscal pressure is, the more expensive broadband services will be. Macroeconomic changes and more complex topography also present total effects reflecting price increases.

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[19] Complete results remain available upon request.

Table 8

Quantifying impact channels associated with policy and industry strategic variables.

Channel description	Estimated effect	
	Baseline	Fixed Effects
Regulation → CAPEX → COVERAGE → Price	−0.009	−0.010
Regulation → HHI→ CAPEX → COVERAGE → Price	Not significant	0.004
Regulation → HHI→ Price	−0.069	−0.057
Regulation → COVERAGE → Price	−0.259	−0.068
Regulation → Price	−0.423	Not significant
OPEX → Price	0.125	Not significant
Tariffs → CAPEX → COVERAGE → Price	0.011	0.015
Profit tax → CAPEX → COVERAGE → Price	0.006	0.012

Source: Prepared by the authors

5.2. *Robustness checks*

SEM models have the disadvantage of being unsuitable for controlling fixed effects. This issue is relevant, as fixed effects are typically used in regression analysis to control for unobservable factors, such as time-invariant country characteristics.

In this section, we introduce fixed effects into our SEM specification. However, adding so many dummy variables make the estimation computationally intensive, preventing the model from converging and reporting reliable results. To overcome this limitation, we performed the estimation in two steps. First, the constructs were estimated through principal component analysis. Afterward, the SEM model was run by directly introducing the predicted constructs to avoid the procedure of estimating them within the overall model in the same routine. In the now less computationally intensive SEM estimation, we incorporated country-level fixed effects and a time trend in the main equation: prices.

Results for the estimated SEM that incorporates controls for unobservable factors are presented in Table 5. Most results stand, although there are differences in the significance of some coefficients and their magnitude.

First, the direct effects linking regulation quality and OPEX with prices are now not significant from a statistical viewpoint. Introducing country fixed effects controls for all time-invariant unobservable factors, while OPEX and regulation may change only marginally on a year-to-year basis. This does not mean that OPEX and regulation are no longer relevant to explain price variation, since we consider most of their effects to be now absorbed by the fixed effects. Moreover, the total effect linking regulation and prices remains statistically significant (although with a lower coefficient) due to the indirect effects that materialize through coverage, investment, and competition.

In addition, it is worth mentioning that the time trend proved insignificant, meaning that the common yearly variations seemed to be adequately captured by the time-variant variables without the need to control for these exogenous effects that occur over time. For example, technological improvements that cause prices to reduce over time seem to be successfully captured through the coverage (and before it, by investment) indicator.[20]

Overall, in the estimation conducted with fixed effects, the total effects suggest that investment and coverage improvements contribute to reducing prices, while more market concentration, taxation, and macroeconomic disturbances contribute to increasing them. Critically, good regulation contributes significantly to reducing prices, although the magnitude of the effect is smaller than in the baseline estimation conducted without introducing fixed effects.

As further robustness checks, we conducted additional estimates using as dependent variable other indicators reported by the ITU that account for additional communications services beyond mobile broadband, such as the “Mobile data and voice low-consumption basket (70 min + 20 SMS + 500 MB)” and the “Mobile data and voice high-consumption basket (140 min + 70 SMS + 2 GB),” estimations that verified the sign and significance level of the estimated effects from the baseline model for policy and industry initiative variables.[21]

5.3. *Summary of results*

Table 6 summarizes the estimated overall effects and an economic explanation for each. Variables presented in Table 6 include a mix of non-controllable exogenous factors (e.g., geography and urbanism) and variables that are subject to policy (regulation, competition, or taxation) or industry strategic initiatives (e.g., OPEX reduction, infrastructure sharing agreements).

From the list of variables in Table 6, we focus our discussion on those that fall under the purview of governments or telecommunications operators, intending to describe the direction of desirable policy actions that can be conducted to lower prices, making internet access cheaper for the population. These reforms are presented next in Table 7.[22]

The regulatory indicator proved critical for its direct effects on prices or as a driver of investment, coverage, and competition. Consequently, countries should pursue flexible and modern regulatory approaches that are aligned with the technology and network convergence industry trends and suited to the fast pace of technological development. This approach can be exemplified in concrete measures such as licenses that do not refer to specific technologies (being then technologically neutral in order to stimulate innovation), regulatory measures that facilitate infrastructure sharing agreements between operators, allowing the possibility of operators conducting spectrum trade (facilitating that this resource will end up in the hands of who can give a more productive use of it), and taking measures to incentivize competition (accurate SMP regulation and mobile portability). According to our estimation, ensuring the adoption of the best international practices is expected to contribute positively.

Reducing operating expenses is also relevant and can be incentivized through specific regulatory policies, although telecommunications operators have responsibilities to fulfill in this area. Possibilities for cost reduction can come from lowering administrative and energy costs (for example, by supporting the energy needs of wireless towers with solar panels rather than diesel generators) or from an enhanced use of cloud computing (cost-efficient data processing due to economies of scale). The relevance of OPEX in driving prices makes it necessary to consider

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[20] It is worth to say that in simple fixed effects models conducted for the price equation, the inclusion of yearly fixed effects was also found to be insignificant.

[21] Complete results for these robustness checks are available upon request.

[22] These policy recommendations are naturally broad, meaning that they may not apply to all countries in the same way. The focus of this section is simply to provide an orientation towards which policy directions may be useful to follow, independently of the necessities and peculiarities of specific countries. We thank an anonymous referee for suggesting this clarification.

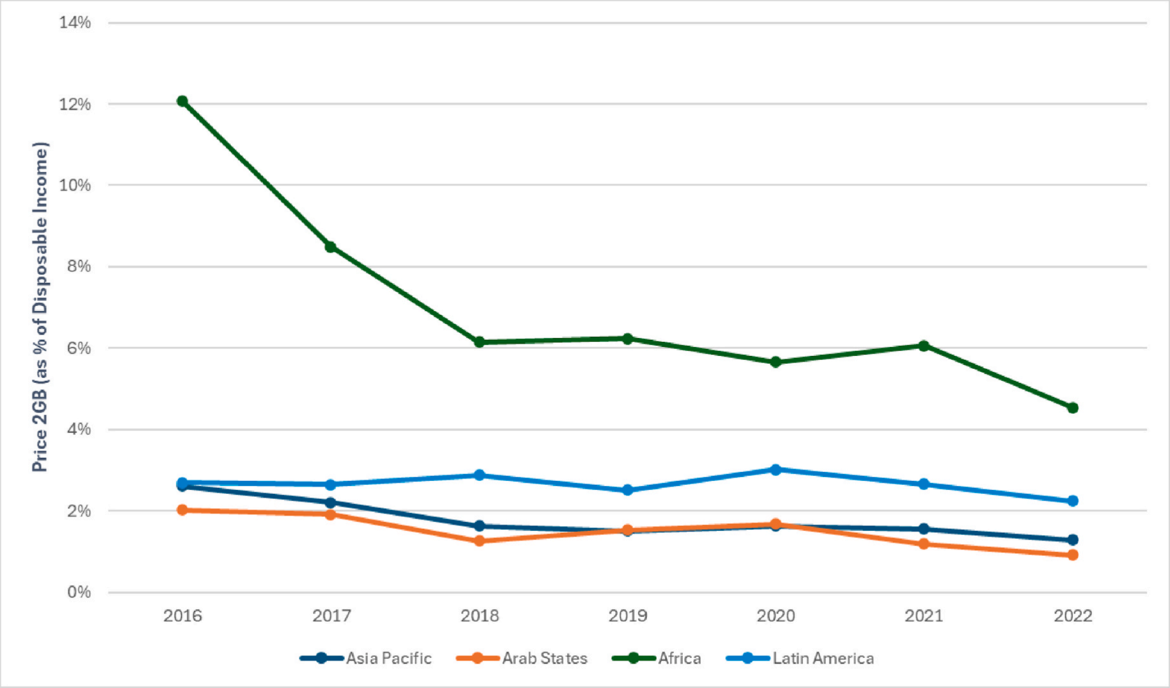

Fig. 9. Median mobile broadband prices (as a share of disposable income).
Source: Prepared by the authors

Table 9
Policy reforms to simulate.

Policy	Benchmark		Explanation
	Moderate	Aggressive	
Regulation	0.472	2.118	Increase to the level of the median (moderate scenario) and the 75 percentiles of the sample (aggressive scenario)
Profit tax	16.45%	10.00%	Reduction to the level of the median (moderate scenario) and the 25 percentiles of the sample (aggressive scenario)
Equipment tariffs	Eliminate	Eliminate	Best practices

Source: Prepared by the authors

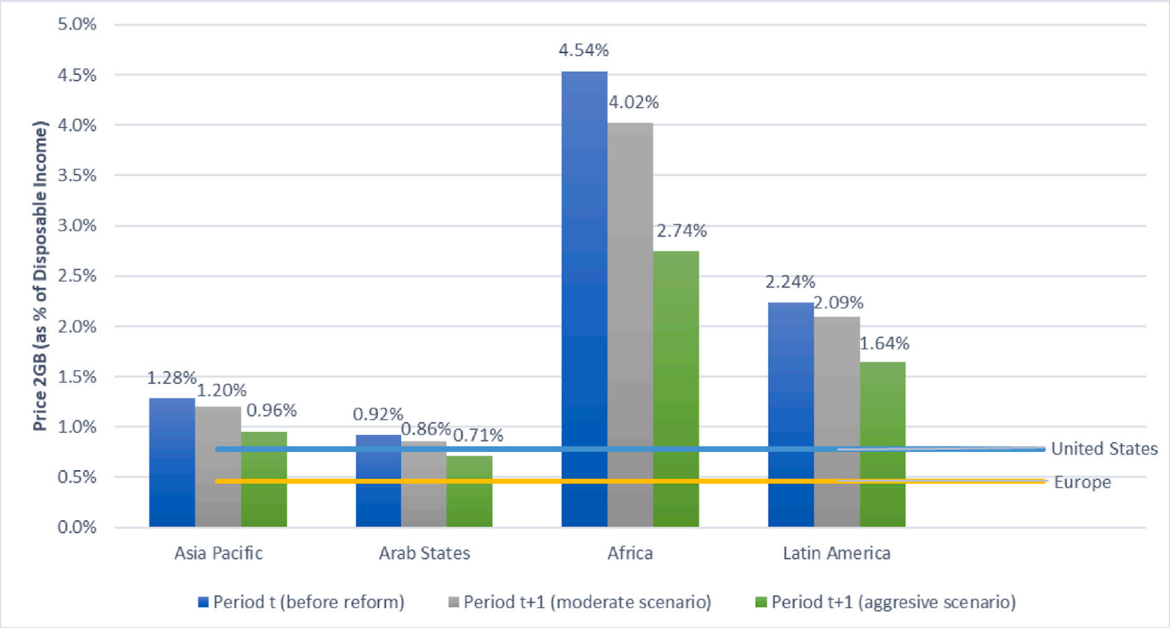

Fig. 10. Simulation of policies to lower prices.
Source: Prepared by the authors

approaches that contribute to reducing these expenses. The search for efficient business models, the accelerated digital transformation of operations, and the examination of new operating models mimicking some of the initiatives of "digital natives" (enterprises created under current technologies, such as cloud computing and artificial intelligence) are some of the critical areas that the industry should explore.

In competitive scenarios, mobile telecommunications operators can also reduce prices by increasing willingness to share network infrastructure. Research indicates that, independently from the incentives displayed by regulators to stimulate operators to share infrastructure, especially in rural areas, their willingness to open their networks or rely on infrastructure "specialists" (such as tower companies) is not consistently applied around the world (see Katz et al., 2024a, 2024b). Some operators believe wholly owned networks convey some competitive advantages and are reluctant to share their infrastructure. This situation could impede service deployment into more rural and isolated areas.

A taxation policy that considers the impact of high rates should also be pursued, given evidence of the negative role of profit taxes and tariffs on capital spending for network deployment and, ultimately, end-user prices. For example, imposing tariffs on electronic equipment imports should be considered a bad practice since it reduces investment in network expansion. Although not considered in this empirical analysis, it is essential that the controlled fiscal pressure also applies to spectrum license prices, as this is a critical resource needed for mobile network investment and expansion.

Using the coefficients estimated in the SEM models of sections 5.1 and 5.2, we detail in Table 8 the impact channels and their corresponding effect on prices according to the estimated models.

These coefficients will be used to conduct an impact simulation of regulatory, fiscal, and industry practice changes.

5.4. *Practical application of estimated results*

For the simulation analysis, we focus only on emerging regions with the highest relative prices, and the digital divide is a serious concern for segments of the unconnected population, as described in the introduction. The emerging regions contemplated in this section are Asia-Pacific, Arab States, Africa, and Latin America. The complete details of the countries included in each section are presented in Table A3 in the Appendix. While the median mobile broadband prices (as a share of disposable income) in these regions have declined in the past few years, these reductions have been slow (except in Africa during 2016–2018), as seen in Fig. 9.

Despite the slow tendency towards price reductions, the price as a share of income lies ahead of those from high-income economies, meaning there is plenty of room for improvement. The 2022 median price (measured as a share of the disposable income) for Asia-Pacific is 1.28%, for the Arab States is 0.92%, for Africa is 4.54%, and for Latin America is 2.24%. All cases are above those of the more advanced economies, such as the United States (0.78%) and Europe (0.46%). If the developing regions can accelerate their price reduction trends, the unconnected population may be able to access the benefits of digitalization, thus reducing the digital divide.

To simulate potential reforms, we select some reference benchmarks to achieve in the variables reported in Table 9.[23]

We create two distinct scenarios: an aggressive one with more profound changes and a moderate one with some modifications. According to the 2022 average values for the construct that evaluates regulatory quality, the four regions that have lower regulatory quality than the sample median are Asia Pacific (0.07), Arab States (−0.17), Africa (−0.02), and Latin America (0.16). The construct's maximum value, 2.118, which is equivalent to the sample's 75 percentile, reflects the best possible outcome in terms of implementing the best regulatory practices. For the aggressive scenario, this will serve as the regulatory standard. However, we consider a less ambitious objective for the moderate scenario: to meet the sample's median value (0.472). From a practical viewpoint, achieving these improvements will consist of adopting the best practices regarding licensing, infrastructure sharing, spectrum trade, and competition.

We then also consider lowering profit taxes. The average profit tax rate in 2022 is higher than the global median in two regions considered: Africa (19.04%) and Latin America (20.08%). We model a decrease in these rates to the level of the sample distribution's 25 percentiles, 10.00% (for the aggressive scenario), and the global median, 16.45% (for the moderate scenario).

Lastly, we also consider reforming import taxes on equipment. Since it impacts investments in network deployment, the four regions under examination contain nations that apply tariffs on importing electronic equipment, which is generally viewed negatively. Since this is the norm typically followed by developed countries, we model the removal of these tariffs under both aggressive and moderate scenarios.

The timing of the simulated effects contemplates a 1-year lag in their effects, as these variables were lagged in the model. For conservative purposes, we took the coefficients estimated from the model with fixed effects (Table 5), which reports a more moderate impact of price regulation than the baseline model.

The estimation of the aggregated effects by region is presented in Fig. 10. In all cases, a price reduction occurs, although the effects are, as expected, greater under the aggressive scenario. After a year, we can expect median prices to be reduced in Asia Pacific from USD 12.27 to USD 11.52 according to the moderate scenario (USD 9.17 according to the aggressive one), in Arab States from USD 18.63 to USD 17.34 (USD 14.49), in Africa from USD 13.75 to USD 12.20 (USD 8.31) and in Latin America from USD 23.53 to USD 21.99 (USD 17.26). According to this simulation, the price as a share of disposable income can reach a value of 1.20% in Asia Pacific under the moderate scenario (0.96% in the aggressive one) and 0.86% (0.71%) in the Arab States (similar to the United States), while in Africa and Latin America the corresponding values are 4.02% (2.74%) and 2.09%, (1.64%) respectively (still high within an international comparison, but registering improvements).

Based on this exercise, we intend to apply our findings practically to highlight how the potential for price reductions is significant in emerging regions. These results can be translated into increased penetration figures, reducing the digital divide and triggering the usual positive socioeconomic effects of digitization in the specialized literature.

6. Conclusions

The digital divide leaves millions of unconnected people behind, especially in developing countries. International disparities in mobile internet pricing are a critical factor behind these connectivity gaps, as the highest prices relative to income levels are reached in those countries exhibiting lower penetration figures. This situation makes it relevant to study cross-country disparities in mobile broadband prices and what can be done from public policy and industry perspectives to lower them and make internet access more affordable to the population.

Despite some recognition of the diversity of internet prices within the research community (Calzada and Martínez-Santos, 2014; Wallsten and Riso, 2010; Genakos et al., 2018), there is a limited body of research investigating the root causes of variation across countries. The main contribution of this research is to formulate an updated framework elucidating the disparities in mobile broadband prices globally, an imperative task for fostering digital development, especially in emerging markets.

This study has demonstrated that a mix of non-controllable

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[23] While further simulations could be conducted around some reductions in operating expenses as addressed in the econometric analysis, we decided not to include them due to a non-significant direct effect form OPEX to prices in the robustness check presented in Table 5.

exogenous factors and variables subject to policy or industry strategic initiatives drives mobile broadband price variations across various countries. Given the relevance of the factors subject to policy and strategic initiatives to drive mobile broadband prices down and close the digital divide, the shared responsibility of public authorities (policymakers and regulators) and industry stakeholders appears to be imperative. In sum, a virtuous cycle appears to be at work: improved affordability should lead to higher adoption, yielding higher economic growth and adoption. Moreover, this dynamic may incentivize operators to invest in the latest technologies and innovate to attract new adopters. As highlighted above, intensive competition and investment will yield further price reductions, reinforcing the referred virtuous circle.

The model results indicate a significant relationship between investment and prices: higher capital spending drives prices down, making the services cheaper for the population. If the preeminent objective of governments is to address the digital divide (which in turn is primarily driven by low affordability), increasing capital spending by network operators is critical. The focus of the initiatives should also be directed to the following areas: adoption of best regulatory practices, promoting competition, moderate taxation, and taking measures that help firms reduce operating expenses.

We highlight that some cross-country price disparities may correspond to factors not controlled by the policymakers. These sometimes refer to exogenous aspects that cannot be modified. As an example, coverage levels are affected by geographical or topographic complexities, which directly affect the costs of deployment and end up affecting prices. Also, exposure to international macroeconomic shocks plays a role in this process, as they directly affect investment in the sector. Population density and the degree of urbanism are factors that vary little over time, and that end up affecting prices, as highlighted in the results presented above.

Looking forward, evidence in this research still indicates that there is plenty of room to lower prices, starting with those regulatory indicators that lie under the scope of sectoral authorities, such as adopting the best practice in terms of licensing, infrastructure sharing, flexible approaches for spectrum policies, and pro-competition measures. These findings could point to a roadmap for policymakers to make reforms to conduct more affordable internet. In other cases, we found factors affecting prices that depend on policy decisions but not on the sectoral authorities. Notably, profit taxes and tariffs on equipment significantly affect prices. It may also be the case for some expenses that affect OPEX, such as labor or energy regulations. Political leadership in promoting transversal digital agendas and institutional coordination are necessary to ensure that all the administrative bodies are aligned with this purpose. Finally, operators also have an essential role to play here, making additional efforts to reduce operational expenses and becoming more open to cooperative infrastructure sharing, for example.

Still, our analysis also faced some limitations that constrained our efforts. In particular, it was impossible to include some relevant variables due to the lack of available data. Such is the case of operator profits, which can affect how prices are determined.[24] Another relevant variable that is missing from public sources and restricts our analysis is spectrum prices. It can be expected that countries that charge higher spectrum prices should also have higher end-user prices. Another potential limitation was the lack of fixed broadband competition and investment variables for our sample of 182 countries, which was one of the reasons for deciding to focus our analysis only on mobile broadband. All these caveats mean that future research can expand this analysis once richer datasets become available. Future research should also contemplate the effects on specific prices regarding high-speed internet networks, such as 5G and FTTH, as these are the ones that are expected to have a deeper impact on socioeconomic transformation.

CRediT authorship contribution statement

Raúl Katz: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Funding acquisition. **Juan Jung:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Raul Katz reports financial support was provided by Huawei Technologies Co Ltd. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Table A.1
List of countries included in empirical analysis

Afghanistan
Albania
Algeria
Angola
Antigua and Barbuda
Argentina
Armenia
Denmark
Djibouti
Dominica
Dominican Rep.
Ecuador
Egypt
El Salvador
Laos
Latvia
Lebanon
Lesotho
Liberia
Lithuania
Luxembourg
Romania
Russia
Rwanda
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Samoa

(*continued on next page*)

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[24] We thank an anonymous referee for rising up this issue.

Table A.1 (*continued*)

Aruba
Australia
Austria
Azerbaijan
Bahamas
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Central African Rep.
Chad
Chile
China
Colombia
Comoros
Congo (Rep. of the)
Costa Rica
Côte d'Ivoire
Croatia
Curacao
Cyprus
Czech Republic
Dem. Rep. of the Congo
Equatorial Guinea
Estonia
Eswatini
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong, China
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Kiribati
Korea, Rep.
Kuwait
Kyrgyzstan
Macao, China
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Micronesia
Moldova
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal (Republic of)
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
North Macedonia
Norway
Oman
Pakistan
Palau
Palestine
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Sao Tome and Principe
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
Solomon Islands
South Africa
Spain
Sri Lanka
Sudan
Suriname
Sweden
Switzerland
Tajikistan
Tanzania
Thailand
Timor-Leste
Togo
Tonga
Trinidad and Tobago
Tunisia
Türkiye
Turkmenistan
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Uzbekistan
Vanuatu
Vietnam
Zambia
Zimbabwe

Source: Prepared by the authors

Table A.2
Correlation Matrix (Cronbach's alpha in brackets)

	Price	CAPEX	OPEX	Coverage	HHI	Density	Urban	Tariffs	Profit tax	Regulation	Forest	Topography	Macro
CAPEX	0.015												
OPEX	0.016	0.683											
Coverage	−0.319	0.382	0.333	(0.781)									
HHI	0.232	−0.066	−0.125	−0.297									
Density	0.009	0.377	0.691	0.091	−0.072								
Urban	−0.039	0.452	0.447	0.477	−0.255	0.212							
Tariffs	0.030	−0.306	−0.270	−0.320	0.088	−0.144	−0.279						
Profit tax	0.083	−0.215	−0.164	−0.162	0.237	−0.025	−0.185	0.177					
Regulation	−0.251	0.224	0.215	0.462	−0.399	0.011	0.465	−0.199	−0.135	(0.785)			
Forest	0.118	0.027	0.012	−0.102	0.154	−0.091	0.016	0.073	0.170	−0.051			
Topography	−0.111	−0.431	−0.463	−0.146	−0.170	−0.389	−0.141	0.030	0.069	0.022	−0.032	(0.753)	
Macro	−0.004	−0.118	−0.114	−0.077	0.012	−0.039	−0.057	0.048	−0.005	−0.074	−0.036	0.121	(0.634)
GDP pc	−0.077	0.539	0.643	0.513	−0.232	0.375	0.647	−0.418	−0.250	0.467	−0.100	−0.339	−0.109

Source: Prepared by the authors

Table A.3
Countries included in the regional simulation

Africa	Average values for Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Rep., Chad, Comoros, Congo (Rep. of the), Côte d'Ivoire, Dem. Rep. of the Congo, Equatorial Guinea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Jordan, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia, Zimbabwe
Arab States	Average values for Bahrain, Djibouti, Egypt, Iraq, Kuwait, Lebanon, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Tunisia, United Arab Emirates
Asia Pacific	Average values for Afghanistan, Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Fiji, Hong Kong, India, Indonesia, Iran (Islamic Republic of), Japan, Kiribati, Korea, Laos, Macao, Malaysia, Maldives, Micronesia, Mongolia, Myanmar, Nepal (Republic of), New Zealand, Pakistan, Palau, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Timor-Leste, Tonga, Vanuatu, Vietnam

(*continued on next page*)

Table A.3 (*continued*)

Latin America	Average values for Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Curacao, Dominica, Dominican Rep., Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay
Europe	Average values for Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkiye, Ukraine, United Kingdom

Data availability

Data will be made available on request.

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