Rules, institutions, or both? Estimating the drivers of telecommunication investment in Latin America

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Rules, institutions, or both? Estimating the drivers of telecommunication investment in Latin America [&]

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Abstract

This paper analyzes the link between regulation, institutions, and telecommunications investment in Latin America. The investment levels of the region lag behind those of advanced economies and are impeding substantial progress on digital transformation. Using a database built for this analysis, which covers nearly 90% of Latin American countries for 2007-2017, we confirm the relevance of regulatory and institutional frameworks to explain investment trends in the sector. We also show that a "good" institutional quality contributes significantly to counteract partially a "bad" regulatory environment, and vice versa. Moreover, their impact is significantly stronger when good regulation and institutions interact, suggesting that joint reforms to improve institutions and the regulatory environment would pay off. In particular, improving cybersecurity and piracy control regulation, and fighting corruption and undue influence stand out as the priorities to increase telecommunication investment in Latin America.

JEL classification: L51, L96, L98

Keywords: Telecommunications, Regulation, Institutions

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1. Introduction

What drives investment in telecommunications, and how can it be spurred in emerging countries? Can "good" institutions counteract the effects of "bad" regulations in the sector? Alternatively, do these countries need both modern institutions and adequate regulation to bridge the investment gaps vs the most advanced economies? These questions are addressed in the context of Latin America.

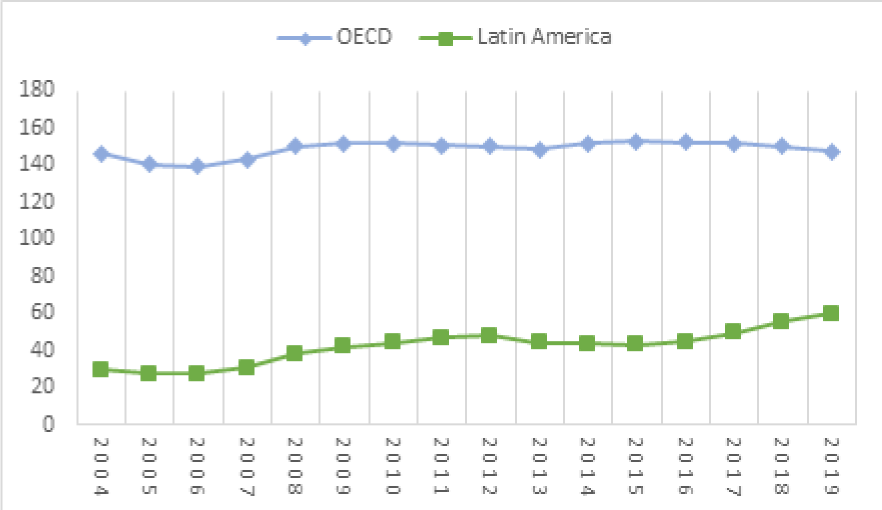
Fostering the digital economy is a necessary condition to increase productivity in Latin America, a region characterized by low value-added activities. To stimulate its *digital economy*, a pressing challenge is closing its *digital divide* so that households, firms, and governments can thrive. As the Inter-American Development Bank showed in its latest flagship *Development in the Americas 2020* (Cavallo et al, 2020), two reachable disruptions - increased digitalization of infrastructures and services, and the introduction of electric vehicles and car-sharing services through digital platforms - could boost Latin American GDP by 6.9% over 10 years.

Given that access to telecommunications infrastructures and services is essential for this digitalization of the economy, this digital divide is impeding a massive transformation of production processes and public services, as well as inclusion possibilities for families, exacerbating current inequalities (OECD, 2020). Based on International Telecommunications Union (ITU) data, in 2019 there were still 27% of Latin Americans who did not used Internet, and more than half of the households did not have a fixed broadband connection.

Raising the level of investment in telecommunications networks is therefore crucial to advance towards a more productive and inclusive Latin America. A conservative estimate by Analysis Mason for the Center of Latin American Telecommunication Studies (cet.la, 2019) stated that Latin America should invest a cumulative amount of USD 161 billion until 2025 (USD 61 billion over current trends) in order to achieve OECD levels of connectivity (namely 95% of the population covered by 4G, and 65% of households passed by fiber). Similarly, García Zaballos et al (2019) estimated that the main Latin America economies (not including Brazil) should invest between now and 2030 an additional USD 147.6 billion (i.e. between 20 and 40% vs current trends) to close key *Sustainable Development Goals* gaps (poverty, hunger, health, jobs, inequalities) vs OECD countries.

Recent trends reported in Figure 1 confirm the existence of an investment gap with respect to OECD countries, despite the ongoing telecommunications industry efforts in the region.

Figure 1. **CAPEX per capita in telecommunications**

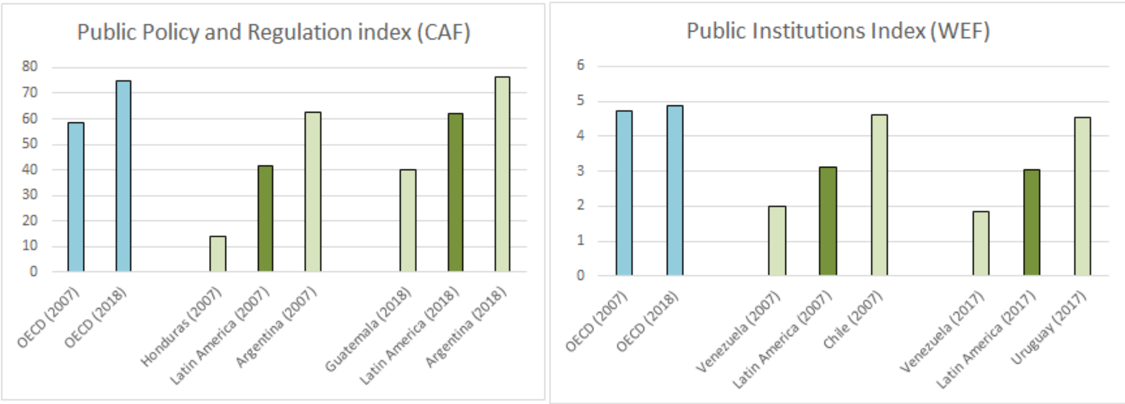


Note: CAPEX per capita at current USD prices (5-year average)
Source: Katz and Jung (2020), from ITU data

The main hypothesis in this paper is that the big investment effort required cannot arise without significant improvements in the macroeconomic and industry framework in Latin America. Institutional and regulatory contexts are a crucial factor considered in telecommunications investments, due to the long temporary horizon that conditions the industry decisions. It is worth to say that, in recent years, some countries have promoted important reforms in the sector. As highlighted by Prats and Puig (2017), approximately half of the region's telecommunications and ICT laws were passed during the early 2000s. Just to mention a few examples, Mexico promoted a constitutional reform followed by the *Ley Federal de Telecomunicaciones y Radiodifusión* in 2014, aiming to develop a modern framework to enhance the dynamism of the market and the creation of the *Instituto Federal de Telecomunicaciones* (IFT). Similarly, Colombia was one of the first countries to create a specific ICT Ministry in 2009, and in 2019 approved the *Ley de Modernización del Sector TIC*, which creates a convergent national regulatory agency (NRA) and extends the spectrum license periods, among other reforms aiming to promote investments. Costa Rica, one of the regional technology leaders, promoted deep reforms with a change in its sectoral law in 2009, migrating from a state-monopoly framework to an openness process with private competition.

These efforts have surely contributed to explain the positive trend that investment exhibits in the region, but do not seem to be enough to catch up OECD countries. Evidence still shows that Latin America is lagging high-income countries in regulatory and institutional quality. In addition to the important internal disparities, it seems only regional leaders reach OECD levels (Figure 2).

Figure 2. **Regulation and Institutional quality**



Source: CAF and WEF

This paper analyses empirically the impact of institutions and regulation (using a variety of well-accepted measures of both) on investment levels in the telecommunications sector in Latin America. In order to do so, we built an original database covering 15 Latin American countries during the period 2007-2017. The analysis will pay particular attention to the interaction among policy measures that potentially explain investment trends in the telecommunication sector, shedding light on how institutional and regulatory quality could complement or substitute each other. In particular, the empirical analysis will test whether sound institutions are able to counteract the expected negative effects of "bad" regulations. The existence of an inclusive consultation process to all stakeholders on the implementation of a particular regulatory matter, or the access to an independent and efficient judicial systems are practical examples. To the best of our knowledge, there are no previous contributions in the empirical literature in Latin America on the complementary effects of institutions and regulation on telecom investments. Additionally, in order to be more policy-relevant, we will carry out a sensitivity analysis to get deeper into each of these areas to identify what ingredients in institutions and regulations matter the most.

This paper is structured as follows. Section 2 provides a brief literature review on the link between institutional and regulation quality and investment, with a focus on references covering the telecommunications and information technology sectors in Latin America. Section 3 presents a standard theoretical model designed to explain investment decisions in the industry. Section 4 describes the original dataset assembled and provides a descriptive analysis. Section 5 presents the main empirical results. Section 6 concludes. References and an Appendix close the paper.

2. Brief literature review

The empirical literature on the role of regulation and governance on telecommunications and information technologies investment is relatively thin. In Latin America, from a policy perspective, Cavallo et al (2020) pointed to the combination of inadequate regulatory systems and supply and demand constraints as main reasons being the region´s investment gap. Its policy recommendations stress the need to *create and implement digital agendas to achieve efficient coordination between all the economic sectors impacted by digital technologies, improving accountability and strengthening public institutions.* This draws on a qualitative study by Prats and Puig (2017), who reported the regulatory and governance gaps in the telecommunication sector of the main economies in the region. These authors highlighted the relevance of regulation and institutions: updated IT laws, modern regulation of infrastructure development and access (spectrum, infrastructure sharing, universal service funds), and competition and consumer protection (concentration of broadband markets, access and interconnection, roaming and portability and data protection). On institutions, they point to a specialized IT Ministry/vice ministry, and an independent NRA.

From a microeconomic perspective, Galperin (2017) analyzed empirically the determinants of lower connectivity among households in Colombia, Ecuador, Mexico, and Peru., and confirmed the relevance of low-investment low-competition factors as barriers, namely high connectivity costs and limited service availability; in addition to demand factors (e.g. limited awareness and low skills). The impact of high costs (driven by low competition) on the limited demand for broadband in 23 countries in Latin America vs OECD countries was previously found by Galperin and Ruzzier (2013).

Beyond Latin America, Alesina et al (2005) estimated and found a negative impact overall regulation in several sectors (including telecommunications) on investment for a sample of OECD countries from 1975 to 1998. That is, the more heavily regulated a sector is, the worse are the incentives for investment. Cambini and Jiang (2009) argued that regulation is a key driver of telecommunications investment, providing either incentives or disincentives, due to its incidence on firm financial choices.

As for the institutional quality and telecommunications performance, Henisz and Zelner (2001) analyzed how differences in the political system affect service penetration for a sample of 147 countries during period 1960-1994. Similarly, Andonova (2006) found that Internet access depends strongly on the country's institutional quality, as fixed-line internet investment is characterized by a high risk of expropriation. Jung (2020) confirmed for a sample of 13 European countries during 2007–2015 the positive association between investment and institutional quality, notably property rights, corruption fight, judicial independence, and transparency.

Beyond the telecommunication sector, Andres et al (2008) built an index of regulatory governance and showed regulation and its governance mattered for performance of the electricity sector in Latin America. In particular, the existence of a regulatory agency, and looking deeper its autonomy, transparency, and accountability played a key role. More recently, Balza et al (2020) revisited the relationship between private participation, regulatory governance and the performance of the electricity sector in 18 Latin American countries between 1971 and 2016. Regulatory and governance reforms paved the way for the private sector to become a crucial player in the Latin American electricity sector; and drove improvements in energy security, energy matrix sustainability and overall efficiency.

3. Theoretical model

The baseline model used in the empirical estimates is inspired on the original framework proposed by Alesina et al (2005) for regulated sectors, used as a reference in diverse empirical researches (e.g. Eicher et al, 2006; Johansson et al, 2008; Vartia, 2008). The model assumes that each sector in country *i* produces according to a linear and homogeneous production function with labor and physical capital as unique factors: [1]

$$F(K_i, L_i) = AK_i^{\alpha} L_i^{1-\alpha} - \Phi \qquad [1]$$

where *K* and *L* denote respectively physical capital stock and labor. All variables are defined at an aggregated sectoral level. For the sake of simplicity, we assume that labor is fixed. Therefore, firms choose the investment and capital levels to maximize the present discounted value of cash flow V:

$$V_i = \int_0^{\infty} e^{-rt} \left[F(K_i, L_i) - WL_i - CAPEX_i - \frac{e^{-\theta b_i}}{2} \left(\frac{CAPEX_i}{K_i} \right)^2 K_i^{\sigma} \right] dt \qquad [2]$$

where W_i, $CAPEX_i$ and r_i denote average wages, investment, and the real interest rate, respectively. As in Alesina et al (2005), we will assume that wages and the real interest rate are exogenous and constant.[2]

As shown in equation [2], each sector faces adjustment costs that follow the usual linear quadratic form. The term b_i represents a measure of the framework quality under which the companies operate. Assuming $\theta > 0$, the better the environment (a larger b), the lower the adjustment costs that hamper the firm's capacity to react to market changes.

We will specify this function [2] for the telecommunications sector and assume that *b* depends on the quality of regulation and institutions (following Henisz and Zelner, 2001; Cambini and Jiang, 2009; Andonova and Diaz-Serrano, 2009). A suitable

[1] As proposed by Rotemberg and Woodford (1995), the production function exhibits decreasing returns to each factor, while allowing the possibility of overall increasing returns, representing Φ a positive constant which captures fixed costs, which are relevant in the telecommunications sector.
[2] In any case, any difference will be absorbed by the fixed effects.

regulatory framework, usually associated to flexible and business-prone environments, should favor telecommunications investment. On the contrary, rigid or strict regulations would increase adjustment costs and to decrease the expected return of investments, thus discouraging investments. Similarly, institutional quality (which ensure certainty and well-functioning government and regulatory bodies) is a key driver of investments, especially those related to the long run. Therefore, we will assume that "good" institutions contribute to reduce those adjustment costs, then having a positive impact on investment decisions.

Investors maximize the present discounted value of cash flow V exposed in equation [2] subject to the law-of-motion capital accumulation equation:

$$\dot{K}_i = CAPEX_i - \delta K_i \qquad [3]$$

where δ accounts for the depreciation rate of current capital stocks, assumed to be constant. Then, by introducing equation [1] in the cash flow represented in [2], and considering the capital accumulation expression reported in equation [3], the Hamiltonian that is subject to dynamic optimization can be expressed as:

$$H_i = AK_i^{\alpha}L_i^{1-\alpha} - \Phi - WL_i - CAPEX_i - \frac{e^{-\theta b_i}}{2}\left(\frac{CAPEX_i}{K_i}\right)^2 K_i^{\sigma} + \lambda[CAPEX_i - \delta K_i\ ]$$

where λ is the shadow value of capital.

Deriving the first order condition with respect to investment, and performing some basic algebra, we can deliver the following equation linking investment to the environmental quality:

$$CAPEX_i = (\lambda - 1)K_i^{2-\sigma}e^{\theta b_i} \qquad [4]$$

where we assume λ>1, as *CAPEX* cannot be negative. Expressing equation [4] in discrete terms, applying logarithms for linearization, renaming the constant term, and defining $\beta = 2 - \sigma$, we get the final specification for our empirical analysis:

$$\log(CAPEX_{it}) = \mu_i + \beta\log(K_{it}) + \theta b_{it} + \varepsilon_{it} \qquad [5]$$

where i and t denote respectively the country and the year, and ε_{it} represents an error term, assumed to verify the desired properties. The term μ_i represents a country individual-effect, which captures all unobservable aspects that may impact investment decisions (typically time-invariant national idiosyncrasy, as well as scale differences among countries).

Therefore, equation [5] defines CAPEX as a function that depends on the capital stock, and the regulatory and institutional environments, represented by b.

4. Data

The empirical analysis relies on an original dataset built for this paper, covering 15 Latin American countries for the period 2007-2017 (Table 1).[3] This panel represents 88.7% of the GDP and 89.3% of the population in Latin America, using World Bank *Development Indicators*.

Table 1. **Countries included in the sample**

Argentina	Costa Rica	Nicaragua
Bolivia	Dominican Republic	Panama
Brazil	Ecuador	Paraguay
Chile	Guatemala	Peru
Colombia	Mexico	Uruguay

Source: Authors own elaboration

Table 2 reports the definition and descriptive statistics of the main variables used in the empirical analysis. The dependent variable, *CAPEX*, comes from the ITU *World Telecom / ICT Indicators database*. Missing data was filled with information from the World Bank and Telecom Advisory Services estimates. As for the control variables, the measure of physical capital stock, *K*, was built applying the *perpetual inventory methodology* to the original CAPEX series.[4]

To measure the quality of the regulation, we rely on the *Public Policy and Regulation* pillar from the *Development Index of the Digital Ecosystem* (CAF, 2017). The index, developed by Katz and Callorda (2018), has recently been updated. The *Public Policy and Regulation* pillar is built using two equally weighted sub-indexes: regulatory framework and competition. The regulatory sub-index measures regulatory maturity according to institutional and regulatory characteristics, as well as the degree of advance of the country in cybersecurity and piracy control. To account for institutional and regulatory characteristics, the index relies on the ITU – *ICT Regulatory Tracker* scores for the following clusters: Regulatory Authority, Regulatory Mandate, Regulatory Regime and Competition Framework. The competition sub-index is built using data of the concentration levels in several fixed and mobile telecommunications, and over-the-top (OTT) markets. To identify those countries that exhibit "good" regulation, we built a dummy variable that takes value of 1 if the respective observation is above the yearly median of the series

[3] The original dataset included El Salvador, Honduras, and Venezuela. However, a preliminary descriptive analysis suggested their exclusion as their physical capital estimates behaved as outliers. These series and the database are available upon request.

[4] The followed procedure was similar to that applied in Balmaseda and Melguizo (2007). The initial capital stock was computed as $K_0 = \frac{CAPEX_0}{(g+\delta)}$, being $CAPEX_0$ the first observation available for investment (in most cases dating before 1990) and g the average growth rate of the respective series period. Once the initial capital stock was estimated, for the following periods the values were updated using the previous year CAPEX, to avoid any concerns regarding potential endogeneity among contemporaneous values. The depreciation rate considered was set at $\delta = 10\%$, following Martín and Velázquez (2001) and Keller (2001, 2002). The appendix includes a sensitivity using a faster depreciation rate of 15%.

distribution, and zero otherwise. Following the same criteria, we built dummies for each of the sub-components of the index to be used as sensitivity analysis.--

Table 2. **Dataset and Descriptive Statistics**

Variable	Definition	Mean	Observations
CAPEX (million USD)	Investment in telecommunications in current dollars. Series compiled from International Telecommunications Union, World Bank and Telecom Advisory Services data.	1,599.078 [2,520.145]	156
K (million USD)	Physical capital stock of telecommunications sector. Built under the perpetual inventory methodology from the CAPEX series	10,696.740 [18,149.380]	160
Good Institutions	Dummy variable which takes the value of 1 if the observation is over the yearly median in the WEF *Public Institutions Index*	0.540 [0.500]	163
Good Regulation	Dummy variable which takes the value of 1 if the observation is over the yearly median in CAF *Public Policy and Regulatory pillar*	0.533 [0.500]	165
Control variables			
GDP per capita (USD)	GDP per capita at constant dollars. Data from World Bank - *World Development Indicators*	7,631.010 [4,092.606]	165
Rural population	Percentage of country population living in rural areas. Data from World Bank – *World Development Indicators*	26.463 [12.760]	165
Profit tax (%)	Profit tax as a percentage of commercial profits. Data from World Bank – *Doing Business*	17.207 [8.060]	153

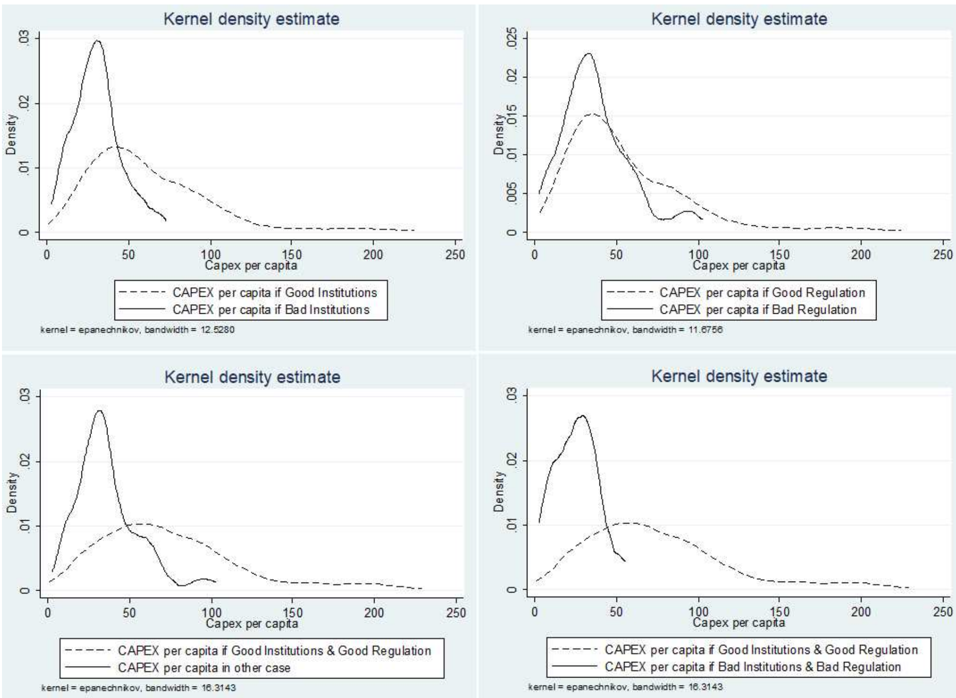
Note: Standard deviation in brackets
Source: Authors own elaboration

Finally, in order to proxy institutional quality, we use the World Economic Forum (WEF, 2018) *Global Competitiveness Index* (GCI), which assesses the competitiveness landscape of 137 economies since 2007. This index is composed by 12 pillars, being the first one that of public and private institutions. We will use the *Public Institutions Indicator*, which accounts for 75% of the Institutions Pillar of the GCI, to measure differences in institutional quality across countries. As on regulation, to identify those countries with "good" institutions, we built a dummy variable that takes value of 1 if the respective observation is above the yearly median of the index distribution, and zero otherwise. Following the same criteria, we will build dummies for each of the sub-components of the index, to provide more specific policy recommendations.

We rely on dummy variables to account for regulatory and institutional quality based on the hypothesis that what matters the most to attract investments is the general perception of a country's framework by the economic agents, rather than marginal increases in a score. Due to its own nature, the telecommunications sector is relatively concentrated and mostly composed by regional or global operators with presence in several countries, commonly viewing ''the map'' of the region and deciding how to prioritize investments.[5] Econometrically, the use of dummy variables also mitigates multicollinearity problems[6]

Figure 3 plots the *kernel density functions* for the CAPEX variable under the different scenarios of regulatory and institutional quality. In this descriptive analysis, the CAPEX variable is measured in per capita terms to avoid distortions due to country size. When comparing vis-à-vis the density function of those observations with "good" and "bad" institutions, the density function for the former scenario points to a larger investment intensity in those cases of better institutional environments (Panel A). In a less degree, the same pattern is evident for the case of regulation (Panel B). Panels C and D plot the density functions of observations which simultaneously exhibit "good" institutions and "good" regulation, in comparison with all the other three combinations ("good" & "bad"; "bad" & "good"; "bad" & "bad"). Clearly, those countries with better institutional and regulatory frameworks have density functions shifted to the right, which suggest larger CAPEX intensity for those cases. This pattern is more pronounced in comparison with the individual analysis of "good" regulatory or institutional quality. Overall, these figures provide preliminary empirical evidence that countries with better regulation and institutions are the ones with larger investment levels in the telecommunications sector.

Figure 3. **Kernel density estimates for CAPEX per capita by regulation and institutional level**



Source: Authors own elaboration

[5] However, we also tested intermediate options with dummies in three levels (above, average, low), but results were not conclusive, probably due to the limited size of the sample.

[6] Both regulatory and institutional indexes reported above are positively correlated (Pearson correlation index of 0.13, significant at a 10% level. In contrast, the transformation into dummy variables contributes to mitigate this problem, as correlation is no longer statistically significant.

Table 3. **Descriptive of CAPEX per capita by regulation and institutional level**

Group	Mean (CAPEX per capita)	Different Mean Test
Good Institutions	62.939 [38.212]	-6.694***
Bad Institutions	30.854 [14.817]	
Good Regulation	56.373 [37.970]	-3.764***
Bad Regulation	37.922 [21.442]	
Good Institutions & Good Regulation	75.191 [43.410]	-7.709***
Other case	36.33 [19.289]	
Good Institutions & Good Regulation	75.191 [43.410]	-6.352***
Bad Institutions & Bad Regulation	25.536 [13.246]	

Note: Standard deviations in brackets. In the mean difference tests, the null hypothesis refers to no difference in the mean of the two samples. *** Significant at 1%
Source: Authors own elaboration

In sum, all these correlation exercises are consistent with the main hypothesis of this paper, i.e. rules and institutions matter, and the interaction of good regulation and solid institutions is especially powerful to explain higher investments in telecommunications in Latin America. However, it remains to be seen if the link between CAPEX and the institutional and regulatory environments is merely a simple correlation, or if it is robust to the addition of other variables that affect investment decisions. This will be explored in Section 5.

5. Results

The empirical specification is derived from equation [5], which explains the level of investment in the telecommunications sector by the drivers set in the model described in Section 3.[7] The CAPEX variable is measured in absolute terms as the individual effects and the physical capital stock variable account for differences in scale among countries. [8]

According to equation [5], the key to understand the link between CAPEX and the environment framework (simply put, *rules and institutions*) lies in the definition of the term *b*. In a first estimate, we will introduce individually the measures of "good" institutions and regulations, proxied by dummy variables. Furtherly, we will get deeper into the interaction effects between the two policy variables.

[7] Following the related literature, we have also tested the model under some transformed specifications. See Appendix for further details and discussion.
[8] Rather than weighted by population as in the descriptive analysis.

5.1. **Main results**

The first block of columns in Table 4 reports the results from the fixed-effects estimations of equation [5], accounting for country-level time-invariant unobservable characteristics. In column (i) we estimate the baseline specification with no time- effects and introducing individually the "good" institutions and "good" regulation variables. As expected, both institutional and regulatory variables exhibit a positive and significant coefficient, confirming the relevance of having a favorable framework (rules and/or institutions) to spur investment.[9]

Column (ii) introduces the interactions between the institutional and regulatory variables. With respect to the baseline scenario (i.e. "bad" regulation and "bad" institutions), the sole presence of a "good" institutional quality contributes to counteract partially a "bad" regulatory environment (coefficients of +0.32). There are many possible mechanisms through which good institutions may "compensate" the effects of bad regulation. For instance, as adequate institutional framework, with public consultations to gather the view of all stakeholders, would allow a better implementation of the regulation by the NRA. ¿Additionally, the possibility of accessing to an independent justice system would open the possibility of stakeholders to challenge eventual harmful interventions from regulatory agents. The inverse relationship is also true, as a "good" regulatory framework has a positive impact on investment decisions (coefficient=+0.38) even in presence of "bad" institutions. Therefore, an investment-friendly regulation for telecommunications (e.g. eliminating red tape) might compensate the uncertainty driven by a weak institutional system in the country. The coefficient difference checks confirm that the impact of improving regulations or institutions is positive, and the difference among both effects is not statistically different.

When "good" institutions and regulations are present simultaneously, the positive effect in investment is much stronger in terms of magnitude and significance of the coefficient (as shown in column ii, the coefficient=+0.60 vs +0.32 with good institutions and +0.38 with good regulation). Further checks confirm that the coefficient of the joint effect is statistically larger than that of the individual presence of "good" institutions or regulation.[10]

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[9] It should be acknowledged that CAPEX series tend to be volatile due to specific infrastructure deployment plans that take place in periods over a single year. While we considered including the lag of CAPEX as a regressor to control for this particularity, we found this variable to be non-significant (see Appendix for full details and discussion). On the other hand, the presence of physical capital stock as a regressor contributes to control for this particularity.

[10] We carried out respective F-tests with the null hypothesis being that the correspondent coefficients were statistically equal.

Table 4. **Drivers of telecommunication investment in Latin America**
(CAPEX, 2007-2017)

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Log(K)	0.390**	0.393***	0.075	-0.196				
	[0.133]	[0.124]	[0.233]	[0.195]				
Good Institutions	0.264**							
	[0.105]							
Good Regulation	0.328**							
	[0.140]							
Good Institutions and Bad Regulation (η)		0.316*	0.342**	0.347**	0.349**	0.332**	0.366**	0.340***
		[0.165]	[0.154]	[0.124]	[0.149]	[0.120]	[0.148]	[0.119]
Bad Institutions and Good Regulation (ρ)		0.383*	0.403**	0.507**	0.411**	0.479**	0.437***	0.467***
		[0.195]	[0.167]	[0.192]	[0.164]	[0.185]	[0.162]	[0.180]
Good Institutions and Good Regulation (Υ)		0.602**	0.631***	0.687***	0.644***	0.656***	0.673***	0.639***
		[0.222]	[0.176]	[0.191]	[0.179]	[0.198]	[0.178]	[0.194]
Log(GDP per capita)$_{t-1}$				1.142**		0.967**		0.954**
				[0.512]		[0.446]		[0.380]
Rural population				0.025		0.026		0.004
				[0.049]		[0.056]		[0.036]
H_0: η=ρ	n.a.	0.26	0.28	1.12	0.30	0.89	0.35	0.67
H_0: η=Υ	n.a.	3.45*	6.98**	4.78**	6.69**	3.44*	6.29**	3.13*
H_0: Υ=ρ	n.a.	3.68*	5.45**	3.08	5.28**	2.93	5.08**	3.10*
Hausman Test	25.68***	26.24***	22.11*	33.86***	0.86	0.69	n.a.	n.a.
Fixed Effects	YES	YES	YES	YES	YES	YES	NO	NO
Random Effects	NO	NO	NO	NO	NO	NO	YES	YES
Year Effects	NO	NO	YES	YES	YES	YES	YES	YES
Observations	154	154	154	154	154	154	154	154

Note: Robust Standard Errors in brackets. * Significant at 10%. ** Significant at 5%. *** Significant at 1%
Source: Authors own elaboration

Additional estimates reported in columns (iii) and (iv), introduce further regressors to control for omitted variables and confirm the robustness of our results. In (iii) we added year-fixed effects to control for external shocks and the economic cycle. We also included GDP per capita (to proxy for demand-shifter factors), and the percentage of rural population (as a cost-shifter for telecommunication network deployments). GDP per capita is introduced with a one-period time-lag to avoid reverse causality with the dependent variable. In both cases, focusing on the policy variables, the level and significance of the institutional and regulation regressors are even stronger than in specification (ii). Note physical capital loses significance when introducing these additional controls (in particular year fixed effects), probably due to the fact that capital varies little over time.[11]

Therefore, we replicate the estimates in columns (v) and (vi) omitting the capital variable. Results again hold, confirming that "good" institutions contribute to

[11] This is also the case when we consider a 15% depreciation rate for capital. See robustness checks in the Appendix.

counteract partially a “bad” regulatory environment (and the other way around), and there is a clear interaction effect between both variables. Taking into account the most conservative result (that reported in column ii), countries belonging to the “good” institutions and “bad” regulation group invest 31.6% more than those with “bad” & “bad” characteristics. Similarly, countries with “bad” institutions and “good” regulation invest 38.3% more than those from the baseline scenario. Finally, the interaction effect points out that countries exhibiting both “good” & “good” characteristics invest a 60.2% more than those within the “bad” & “bad” category. If all countries of the region belonged to the “good” & “good” category, overall telecom investment in Latin America will increase in 13.5% according to these estimates. The second block of columns of Table 4 replicate the former estimates through the random effects model, as recommended by the *Hausman test.* Results reported in columns (vii) and (viii) are similar to the previous estimates.

Overall, our empirical analysis confirms that both institutional and regulatory quality are relevant to explain telecommunications investment in Latin America between 2007 and 2017. The effect is stronger when both policy areas interact (the positive impact of institutions ranges from +0.32 to +0.37; in the case of regulations from +0.38 to +0.51; when both regulation and institutions are good, +0.60 to +0.69). In short, while “good” institutions (regulation) partially counteract the effects of a “bad” regulation (institutions), the effect is enhanced when both are present simultaneously. The next sub-section will get deeper in order to identify which regulatory and institutional areas are more relevant.

5.2. **Sensitivity analysis**

In order to be more policy specific, we also performed additional empirical tests using sub-indexes for regulation and institutions. Table 5 details the components we will focus on, following standard recommendations of the literature (see also Section 3).

The analysis focuses initially on the regulatory components, keeping the original institutional aggregate index. Regulatory sub-components will be introduced one by one, using dummies for above/below the median (“good”/”bad”). For the sake of simplicity, we will perform these estimates based only in our preferred estimate specification (viii of Table 4). Results are reported in Table 6.

Table 5. **Sub-components of Regulatory and Institutional indexes**

Index	Sub-components
CAF *Public Policy and Regulatory Pillar*	• Regulatory Maturity (index built from data assessing the authority of the national regulatory authority, the regulatory regime and framework, and the competition model index) • Cybersecurity and piracy (index built using the percentage of licensed software and a measure of cybernetic security) • Competition (index built from the concentration levels of fixed and mobile broadband, mobile telephony, pay-TV, SVOD, and social networks)
WEF *Public Institutions Index*	• Property rights (built on measures of property rights and intellectual property protection) • Ethics and corruption fight (built from assessments on the diversion of public funds, public trust in politicians, and irregular payments and bribes) • Undue influence (refers to judicial independence and favoritism in decisions of government officials) • Government efficiency (refers to the wastefulness of government spending, the burden of government regulation, the efficiency of legal framework in settling disputes and challenging regulations, and the transparency of government policymaking) • Security (built after estimates of the business costs of terrorism, crime and violence, organized crime, and a measure of the reliability of police services)

Source: Authors own elaboration based on CAF and WEF data

Table 6. **Drivers of telecommunication investment in Latin America Focus on regulatory sub-components** (CAPEX, 2007-2017)

	(i)	(ii)	(iii)
Good Institutions and Bad Regulatory Maturity	0.298** [0.125]		
Bad Institutions and Good Regulatory Maturity	0.369** [0.155]		
Good Institutions and Good Regulatory Maturity	0.425*** [0.129]		
Good Institutions and Bad Cybersecurity and Piracy Control		0.214 [0.161]	
Bad Institutions and Good Cybersecurity and Piracy Control		0.524*** [0.148]	
Good Institutions and Good Cybersecurity and Piracy Control		0.593*** [0.169]	
Good Institutions and Bad Competition (fixed, mobile, OTT)			0.200* [0.115]
Bad Institutions and Good Competition (fixed, mobile, OTT)			0.249 [0.173]
Good Institutions and Good Competition (fixed, mobile, OTT)			0.438*** [0.158]
Log(GDP per capita)$_{t-1}$	0.987*** [0.384]	0.880** [0.389]	0.860** [0.344]
Rural population	-0.013 [0.031]	-0.019 [0.030]	-0.007 [0.029]
Random Effects	YES	YES	YES
Year Effects	YES	YES	YES
Observations	137	137	154

Note: Robust standard errors in brackets. * Significant at 10%. ** Significant at 5%. *** Significant at 1%
Source: Authors own elaboration

Results suggest that “good” institutions cannot compensate the negative effects on investment of an inadequate cybersecurity and piracy control (coefficient=+0.21 but not significant), and only weakly if competition is low, suggesting these areas should be prioritized in the regulation agenda. On the contrary, “good” institutions compensate the impact of “bad” regulatory maturity.

A “good” regulatory maturity and a “good” cybersecurity and piracy framework have, respectively, a positive link with investments despite the eventual presence of poor institutions. Finally, in all cases, the interaction among the respective regulatory variables and “good” institutions stands. The best returns (i.e. higher telecommunication investment) stem from “good” institutions and “good” cybersecurity and piracy control (coefficient=+0.59).

Table 7 reports a similar exercise, keeping the aggregate regulatory variable while individually introducing the institutional sub-components. “Good” regulation cannot compensate a weak property rights regime nor lack of security, advising to improve these institutional features as a priority according to the business sector in Latin America (coefficients are +0.37 not significant, and +0.27 not significant at 5%).

Again, in all the reported cases, the interaction among the respective institutional variables and “good” regulation holds, supporting once again that the stronger effects for investment happen when “good” rules and institutions appear together. The best returns stem from the combination of “good” regulation and lack of undue influence (coefficient=+0.62), security (coefficient=+0.50) and corruption fight (coefficient=+0.48).

Table 7. **Drivers of telecommunication investment in Latin America Focus on institutional sub-components**
(CAPEX, 2007-2017)

	(i)	(ii)	(iii)	(iv)	(v)
Good Regulation and Bad Property Rights	0.372 [0.234]				
Bad Regulation and Good Property Rights	0.117 [0.259]				
Good Regulation and Good Property Rights	0.420* [0.223]				
Good Regulation and Bad Ethics and Corruption Fight		0.428*** [0.154]			
Bad Regulation and Good Ethics and Corruption Fight		0.209* [0.115]			
Good Regulation and Good Ethics and Corruption Fight		0.478*** [0.189]			
Good Regulation and Bad Undue Influence			0.474** [0.217]		
Bad Regulation and Good Undue Influence			0.315* [0.186]		
Good Regulation and Good Undue Influence			0.621*** [0.235]		
Good Regulation and Bad Government Efficiency				0.410** [0.167]	
Bad Regulation and Good Government Efficiency				0.137 [0.105]	
Good Regulation and Good Government Efficiency				0.406** [0.186]	
Good Regulation and Bad Security					0.271* [0.142]
Bad Regulation and Good Security					0.155 [0.255]
Good Regulation and Good Security					0.496* [0.277]
Log(GDP per capita)$_{t-1}$	1.025** [0.429]	0.955** [0.400]	1.010** [0.401]	0.998** [0.436]	0.878** [0.384]
Rural population	0.005 [0.038]	0.004 [0.036]	0.007 [0.036]	0.003 [0.038]	-0.006 [0.037]
Random Effects	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES
Observations	154	154	154	154	154

Note: Robust standard errors in brackets. * Significant at 10%. ** Significant at 5%. *** Significant at 1%
Source: Authors own elaboration

6. Conclusions

This paper analyzes the link between regulation, institutions, and telecommunications investment in Latin America. Increasing digital connectivity ¿ is an economic priority for the region, in order to spur productivity and inclusiveness. All available estimates suggest that investment in telecommunications should increase significantly to reduce the gap versus not only high-income economies, but also the dynamic Asian economies.

Using a novel database built for the analysis covering 15 Latin American economies (nearly 90% of the regional GDP and population) during 2007-2017, our results confirm that regulatory and institutional frameworks are key to explain investment levels in telecommunications. We also show that a "good" institutional quality contributes significantly to counteract partially a "bad" regulatory environment and the other way around.

The interaction of good regulations and institutions would pay off significantly even more. Therefore, for the region to foster telecommunications investment and close the digital divide, significant advances are needed in both fronts. Going more granular, on the regulatory front a clear priority is improving cybersecurity and piracy control, as good institutions could compensate their negative effects, and those countries with "good" cybersecurity and piracy control show higher investments even in presence of poor institutions. In the case of institutions, ethics and corruption fight, and undue influences stand out.

As usual, these results should be taken with caution. Our sample, despite being rich enough to capture Latin American heterogeneity and representative of the region in terms of GDP and population, and cover a key period for the industry, is relatively small. An extension of the paper could be to expand the time series for the Latin American countries, and combine them with other emerging and high-income regions (Asia, Europe and North America). This could enrich the policy implications, as some of these countries would show *good practices* in both regulations and institutions. In addition, further robustness checks could be done using additional measures of institutional and regulatory quality.

On the other hand, data availability restricted us to work with sector-aggregated information, as we were unable to split our main variables across telecom operators, or for mobile and fixed services. That prevented us to decode further insights about possible differences between services, or among incumbents and challengers in terms of investment dynamics. Similarly, the lack of reliable panel data on sectoral taxes prevented us to get deeper into the role of taxes on investment decisions.

Finally, further extensions could exploit in more detail the time-dimension of the data. Regulatory and institutional reforms usually take some time to happen. Moreover, once institutional reforms are put in place, it may take a while before the economic agents fully internalize those changes and decide to invest more. How long do the markets take to react to framework reforms? That temporal dimension was not considered in our analysis but should be addressed in the future when richer datasets become available. All these are natural extension of our research.

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Appendix. Further empirical analysis

i. Controlling for CAPEX volatility

CAPEX series may be very volatile due to specific infrastructure deployment plans that take place in periods over a single year. To control for this particularity, we conducted a robustness check by replicating estimation (i) in Table 4, adding the lagged CAPEX as a regressor (see Table A.1).

Table A.1. **Estimation controlling for previous CAPEX (2007-2017)**

	(i)	(ii)
$CAPEX_{t-1}$	0.141	-0.118
	(0.096)	(0.097)
Log(K)	0.259*	0.255*
	(0.149)	(0.138)
Good Institutions	0.283**	0.129
	(0.116)	(0.123)
Good Regulation	0.413***	0.528***
	(0.141)	(0.152)
Fixed Effects	YES	NO
Observations	139	123
Estimation Method	OLS-FE	GMM (Arellano-Bond)

Note: Standard errors in brackets. * Significant at 10%. ** Significant at 5%. *** Significant at 1%
Source: Authors own elaboration

Column (i) report fixed effects estimations and show the lagged dependent variable to be not significant. However, the fixed effects approach may not be appropriate to perform this estimate, as the introduction of the lagged dependent variable as regressor can generate correlation with the fixed effects in the error term. This situation creates a "dynamic panel bias" (Nickell, 1981), as the reported correlation violates the necessary assumptions for consistency in OLS estimators. The dynamic panel GMM estimator developed by Arellano and Bond (1991) provides consistent estimates under these circumstances; see column (ii). Instruments used for the differenced equation were the lagged dependent variable after second lags (GMM-style instruments), and the remaining covariates as standard instruments. Again, the lagged dependent variable is not significant. On the other hand, the presence of physical capital stock as a regressor seems to control for this particularity. Overall, this supports our main specification.

ii. Alternative specifications of the model

Alesina et al (2005) and Eicher et al (2006) estimated a transformed specification of equation [5], using the ratio CAPEX – Capital (which implies to assume $\sigma = 1$ in equation [4]) as the dependent variable, and adding a lag of the dependent variable as a regressor to control for past investment intensity. Following these criteria, the empirical specification is represented as:

$$\log(CAPEX_{it}/K_{it}) = \mu_i + \psi\log(CAPEX_{it-1}/K_{it-1}) + \theta b_{it} + \varepsilon_{it} \qquad [5']$$

Estimation results are reported in Table A. 2. Columns (i) and (ii) report fixed effects estimations and show the lagged dependent variable to be not significant. However, the fixed effects approach may not be appropriate to estimate equation [5'], due to the "dynamic panel bias" explained above. By performing the Arellano and Bond (1991) estimates, the results reported in columns (iii) and (iv) show again that the lagged dependent variable is not significant. In addition to that, the implied σ in the estimates reported in Table 4 was never close to 1, as required to perform the transformation. Overall, this evidence provides support to the specification followed in the main text.

Table A.2. **Alternative specifications of the model** (CAPEX/K 2007-2017)

	(i)	(ii)	(iii)	(iv)
Dependent variable:	Log(CAPEX/K)	Log(CAPEX/K)	Log(CAPEX/K)	Log(CAPEX/K)
Log(CAPEX/K)$_{t-1}$	0.132	0.127	-0.036	-0.042
	[0.086]	[0.088]	[0.084]	[0.085]
Good Institutions and Bad Regulation	0.152	0.135	-0.036	-0.107
	[0.169]	[0.170]	[0.178]	[0.180]
Bad Institutions and Good Regulation	0.262	0.292	0.368*	0.399*
	[0.189]	[0.191]	[0.212]	[0.215]
Good Institutions and Good Regulation	0.583***	0.642***	0.559**	0.587***
	[0.207]	[0.214]	[0.220]	[0.225]
Log(GDP per capita)$_{t-1}$		0.038		-1.509**
		[0.463]		[0.595]
Rural population		0.068		0.040
		[0.055]		[0.063]
Fixed Effects	YES	YES	NO	NO
Year Effects	YES	YES	YES	YES
Observations	139	139	123	123
Estimation Method	OLS-FE	OLS-FE	GMM (Arellano-Bond)	GMM (Arellano-Bond)

Note: Standard errors in brackets. * Significant at 10%. ** Significant at 5%. *** Significant at 1%
Source: Authors own elaboration

iii. Alternative estimate of physical capital (δ=15%)

As an additional robustness check, we built an alternative physical capital series using a 15% depreciation rate, as a reflection of the higher turnout of new technologies. Table A.3 replicates Table 4 specifications, obtaining similar results.

Table A.3. **Drivers of telecommunication investment in Latin America** (CAPEX 2007-2017; δ=15%)

	(i)	(ii)	(iii)	(iv)
Log(K) - with δ=15%	0.381***	0.383***	0.068	-0.229
	[0.127]	[0.119]	[0.202]	[0.177]
Good Institutions	0.260**			
	[0.106]			
Good Regulation	0.330**			
	[0.138]			
Good Institutions and Bad Regulation		0.310*	0.342**	0.352**
		[0.165]	[0.154]	[0.124]
Bad Institutions and Good Regulation		0.382*	0.404**	0.514**
		[0.194]	[0.167]	[0.194]
Good Institutions and Good Regulation		0.599**	0.631***	0.696***
		[0.223]	[0.177]	[0.191]
Log(GDP per capita)$_{t-1}$				1.187**
				[0.538]
Rural population				0.027
				[0.047]
Fixed Effects	YES	YES	YES	YES
Year Effects	NO	NO	YES	YES
Observations	154	154	154	154

Note: Robust standard Errors in brackets. * Significant at 10%. ** Significant at 5%. *** Significant at 1%.
Source: Authors own elaboration

iv. Controlling for corporate taxation

Taxation is potentially a relevant factor to influence v investment decisions. A recent research carried out by Katz and Callorda (2019) for the United Sates found that a decrease of 1% in the average weighted state and local sales tax rate affecting initial equipment purchases would increase investment by 2%. Specifically, for Latin America, taxation is claimed to be a constraining factor inhibiting investments, due to the relatively high fiscal pressure borne by the sector. A seminal paper by Katz et al (2017) showed that in Latin America taxation borne by the telecommunication sector is significantly higher than the economy average (12,1% vs 8,0% of value added in 2011). Unfortunately, we are not aware of any reliable panel data on taxation on telecommunications for the region. The best source would be GSMA (2019), covering general and sector-specific tax payments on the mobile sector for 15 countries in Latin America, but it is only referred to the year 2017. So we relied, as an admittedly imperfect proxy, on the series of profit taxes for the aggregate economy as a percentage of commercial profits, taken from the World Bank – *Doing*

Business dataset. We replicate in Table A.4 the estimates reported in columns (v) to (viii) in Table 4. Results suggest that taxation pressure discourages investment (regressor statistically significant in both fixed effects estimates) although loses significance with random effects). More relevant, controlling for the level of corporate taxation, the relevance of the institutional and regulatory frameworks to explain telecommunication investment is confirmed once again.

Table A.4. **Drivers of telecommunication investment in Latin America Controlling for corporate taxation**
(CAPEX, 2007-2017)

	(i)	(ii)	(iii)	(iv)
Good Institutions and Bad Regulation	0.340**	0.330**	0.381**	0.344***
	(0.159)	(0.117)	(0.152)	(0.119)
Bad Institutions and Good Regulation	0.410**	0.462**	0.477***	0.453**
	(0.177)	(0.187)	(0.166)	(0.181)
Good Institutions and Good Regulation	0.598***	0.619***	0.673***	0.601***
	(0.166)	(0.177)	(0.170)	(0.191)
Profit tax	-0.063***	-0.060***	-0.031	-0.027
	(0.016)	(0.013)	(0.021)	(0.019)
Log(GDP per capita)$_{t-1}$		1.169**		0.898**
		(0.462)		(0.368)
Rural population		0.025		-0.005
		(0.055)		(0.034)
Fixed Effects	YES	YES	NO	NO
Random Effects	NO	NO	YES	YES
Year Effects	YES	YES	YES	YES
Observations	142	142	142	142

Note: Robust Standard Errors in brackets. * Significant at 10%. ** Significant at 5%. *** Significant at 1%
Source: Authors own elaboration