Institutions and Telecommunications Investment

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Abstract

Closing the digital divide and fostering the digital economy is considered one of the keys for the countries to increase productivity and to achieve higher growth. To achieve those objectives, investment in telecommunications networks is crucial. This paper develops a theoretical framework to explain the link between public institutions and telecommunications investment. This model is estimated for a sample of 13 European countries during the period 2007-2015. Results were clear in verifying a positive association between institutional quality and investment levels. These findings were robust to different specifications of the model, and to the control of potential endogeneity linked to the institutional variable. Novel findings also pointed out at institutional quality being more relevant for most disadvantaged countries, in terms of development and digital connectivity. Furthermore, we found evidence of Property Rights being the main cause of concern for telecom operators, followed by corruption, judicial independence, transparency, and in a lesser degree, by political favoritism and trust.

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1. Introduction

Telecommunications diffusion has been identified in the economic literature as a potential source for raising productivity and economic growth. Following the relevant contribution of Aschauer (1989) about public capital as a productivity determinant, several authors have found empirical evidence of the economic impact of voice telecommunications (Roller and Waverman, 2001), and more recently, broadband connectivity (Koutroumpis, 2009; Qiang et al, 2009; Czernich et al, 2011; among many others). There is little doubt that broadband nowadays constitutes a key part of the necessary infrastructure for development, in the same way as railroads, motorways and electricity. Current and forthcoming advances, such as Internet of Things, Big Data, Artificial Intelligence and automatization will only make this topic even more relevant in the future.

Then, it is no surprise that most countries have promoted in recent years Digital Agendas or Broadband Plans intending to promote investments in network deployments to massify connectivity. The fact that massive funds are required for these deployments[2] and that networks are largely irreversible, make uncertainties play a critical role in investment decisions in the telecommunications sector. Therefore, such a considerable effort will surely require of a propitious regulatory and institutional environment to become feasible. Thus, the analysis of the determinants of telecommunications investment should be a top priority for researchers and policymakers, especially in those countries that still have a considerable digital divide to close.

While the impact of regulation intensity on investment decisions has been analyzed in the past (see for instance the relevant contribution provided by Alesina et al, 2005), it is surprising to find out that there is very little empirical evidence regarding the role of institutional quality for investment in telecommunications, being this such a critical sector for the economy. This article intends to fill this gap in the empirical literature.

The very few articles that have analyzed the link of institutional variables on the telecommunication sector, have focused on its effect on penetration levels for alternative services, rather than in investment decisions by telecommunications

[2] Henisz and Zelner (2001) stipulate that extending a copper network to every home, adding fiber optic to a copper system, or moving to electronic switching requires a multiyear commitment of funds that often exceeds one percent of a country GDP.

operators (see for instance Henisz and Zelner, 2001; Andonova, 2006; Andonova and Díaz-Serrano, 2009). Another important difference with most related papers is that they rely on ad-hoc empirical specifications, while on the contrary, through these lines we will develop a theoretical model with the specific purpose of understanding the main drivers of investment decisions in the telecommunications sector, specifically disentangling the different effects attributable to regulatory and institutional environment.

This paper is structured as follows: next section reviews the main literature regarding institutions and economic performance, section 3 develops a theoretical model to understand the main drivers of investment decisions, section 4 presents the dataset with its main descriptive statistics, section 5 specifies the empirical specification and reports the estimation results, and finally section 6 ends with some concluding remarks.

2. Literature Review

The link between the institutional quality and economic performance has received considerable attention in the economic literature (see for instance Dawson, 1998; Acemoglu et al, 2001; Rodrik et al, 2004; among many others), with empirical analysis suggesting a positive influence of sound institutions on development through the promotion of the investment channel.

As for investment decisions, several authors argue about the importance of protecting property rights to avoid expropriation risks (Besley, 1995; Dawson, 1998; Acemoglu et al, 2001; Henisz and Zelner, 2001; Rodrik et al, 2004; Andonova and Díaz-Serrano, 2009). In the case of the telecommunicators sector, this risk is even increased, due to the large amounts and the fact that assets invested are largely sunk, which results in temporal horizons for investment returns being often measured in decades (Henisz and Zelner, 2001). Then, it is reasonable to assume that telecommunications may be more sensitive than other forms of capital to these concerns.

An independent justice is particularly relevant, as it can help to ensure property rights (Olson, 1993). Beyond the specific expropriation risk, investors usually present specific concerns to arbitrary or capricious policy changes. In this sense, trust and credibility is key to create a propitious environment for investment, as

well as institutional efficiency to defend investors complaints, such as dispute resolution or the possibility to challenge the introduction of regulations that may be of dubious legality to those concerned.

Henisz and Zelner (2001) describe a principal-agent problem between a government desiring reelection and a profit maximizing firm. Capital already sunk provides a poor basis to lobby political actors, as governments may maximize its political benefits from enhanced infrastructure capacity and telecom services by intervening towards lowering its prices once networks have been deployed.

These risks are costly for enterprises. Moenius and Berkowitz (2004) argue that institutional quality for enforcing contracts and protect property rights influences especially the costs of sectors producing high-value added (complex) products or services, as it is the case of the telecommunications. Moreover, Daude and Stein (2007) argue that imperfect enforcement of contracts might increase uncertainty regarding future returns, having a negative impact on investment. In turn, Esfahani and Ramírez (2003) define contract enforcement as an expression of adjustment rate for investments in infrastructures.

Mishra and Daly (2007) argue that weak enforcement of regulations and ineffective legal systems have forced companies to be increasingly selective as to where they will invest. In that sense, Henisz (2002) states that from the perspective of an investor, countries lacking a credible policy regime will be at an extreme disadvantaged when competing with other countries in infrastructure investment.

There are other reasons to believe that poor institutions can incur in additional costs for doing business. Bureaucratic and other red-tape costs related to institutional deficiencies can increase adjustment costs to investors, and as a result, to discourage investment decisions. Daude and Stein (2007) even argue that “bad” institutions can act as a “tax”, by increasing the costs of doing business. Likewise, corruption can increase the cost of doing business, as investors may need to bribe officials to obtain licenses and permits, or to avoid incurring in additional requirements or obstacles. In the same line, Henisz (2002) argue about the crucial role played by socio-political factors which affects the costs of bargaining, contracting, monitoring and enforcement.

As for the empirical literature regarding the impact of institutional quality on investment decisions, most research has focused on Foreign Direct Investments (FDI), finding in most cases a positive impact on investment flows (Li and

Resnick, 2003; Busse and Hefeker, 2007; Bénassy-Quéré, 2007; Daude and Stein, 2007; Mishra and Daly, 2007; among others).

As for the telecommunications sector, evidence is much scarcer, and most research has been related to the effect of political-related variables on diffusion indicators, such as penetration levels for specific services, rather than on investment decisions *per se*. Telecommunications depend greatly on institutional factors, because of its own nature as a sector which exhibits large sunk investments, characterized by economies of scale and scope. These features have made this sector to be traditionally heavily politicized (Andonova and Díaz-Serrano, 2009).

Henisz and Zelner (2001) analyzed differences in the levels of checks and balances on executive discretion created by variation in political structures and party systems and how it affects service penetration for a sample of 147 countries during period 1960-1994. They used as dependent variable the number of telephone lines every 10.000 inhabitants, measuring the effects of credibility of policy regimes. In turn, Esfahani and Ramírez (2003) analyzed the impact of some institutional variables in the growth rate of telephones per capita for a sample of 75 countries for the period 1965-1995.

Andonova (2006) studied the determinants of internet and mobile phone penetration, considering a series of institutional variables, finding that internet access is shown to depend strongly on the country's institutional setting because fixed-line internet investment is characterized by a high risk of state expropriation, but on the other hand, mobile phone networks, were found to be less dependent on institutional characteristics. Similarly, Andonova and Díaz-Serrano, 2009 analyzed the link between different telecom services penetration in 183 countries for the period 1990-2004, finding that the dependence to political institutional variables was greatly reduced for the case of mobile networks.

To the best of our knowledge, there are no previous articles in the empirical literature which have provided both a theoretical and empirical contribution regarding the incidence of institutional quality in investment decisions carried out by telecommunicators operators. In this context, the main hypothesis we will test in this paper is to check if sound institutions are associated to larger telecommunications investments, and to find out which countries are the more sensible to institutional quality for this purpose. This is especially relevant as countries differ in their current stage towards the process of closing the digital divide, as well as in other economic features.

3. A Theoretical Model to explain investment decisions in Telecom

The baseline model to be presented in this section builds upon the original framework proposed by Alesina et al (2005) for regulated sectors. In the first place, we assume that the telecommunications sector in country *i* produces according to a linear and homogeneous production function with labour and physical capital as the only factors:

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

Where *K* and *L* denote physical capital stock and labour, respectively. 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 especially relevant in the telecommunications sector.

For the sake of simplicity, demand for telecommunication services will be taken as given and not explicitly considered in the analysis. In the same line, we will not consider in this baseline model the number of firms operating in the sector. All variables are defined at an aggregated sectoral level. As in Alesina et al (2005), we will assume that labour is fixed.

Therefore, firms belonging to the telecommunications sector in country *i* choose the investment and capital levels to maximize the present discounted value of cash flow V:

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

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 the real interest rate is exogenous and constant.[3] As reported in the last term within the brackets in equation [2], the sector face adjustment costs which follow the usual linear quadratic form. The term b_i represents the incidence of certain factors that may affect those adjustment costs. Up to equation [2], the model is similar to that proposed by Alesina et al (2005).[4] However, our main difference lies in the

[3] In any case, any difference will be absorbed by the fixed effects.
[4] While Alesina et al (2005) implicitally constrain $\sigma = 1$, we prefer to let the data decide the magnitude of that parameter.

definition of b_i. In that sense, we will assume that both regulatory intensity and institutional quality have an incidence in these investment adjustment costs, defining:

$$b_i = e^{\psi_i + \gamma REG_i - \beta INST_i} \quad [3]$$

Where ψ_i represents time-invariant idiosyncratic effects, which may make some countries more prone to attract investments because of unobserved characteristics. In turn, REG_i is a measure of regulatory intensity, which takes lower (higher) values the most flexible (rigid) regulatory environment. Regulation intensity is usually considered a key variable affecting telecommunications investment decisions (Cambini and Jiang, 2009). In this sense, Alesina et al (2005), estimated the effect of overall regulation in several sectors, including telecommunications, for a sample of OECD countries from 1975 to 1998, finding a negative effect of regulation intensity on investment levels. Therefore, in this model, regulation intensity is supposed to affect positively this adjustment costs. On the other hand, $INST_i$ is an indicator of institutional quality. Following the literature revised in the previous section, we will assume that good institutions contribute to reduce those adjustment costs, then presenting a positive link with investment decisions.

Therefore, *REG* and *INST* reflect the incidence of all regulatory and institutional environment which may affect the firm's cost of adjusting capital and hamper their capacity to react to market changes. By assuming $\gamma > 0$ and $\beta > 0$, we define equation [3] expecting regulatory rigidity to increase investment adjustment costs, while on the contrary, good institutions can contribute to reduce them.

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

$$\dot{K}_i = CAPEX_i - \delta K_i \quad [4]$$

Where δ accounts for the depreciation rate of current capital stocks.

Therefore, by introducing equations [1] and [3] in the cash flow represented in [2], and considering the capital accumulation expression reported in equation [4], the Hamiltonian which is subject to dynamic optimization can be expressed as:

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

Where λ is the shadow value of capital. Deriving the first order condition with respect to investment yields the first order condition with respect to *CAPEX*:

$$\frac{\partial H_i}{\partial CAPEX_i} = -1 - e^{\psi_i + \gamma REG_i - \beta INST_i}\left(\frac{CAPEX_i}{K_i^{2-\sigma}}\right) + \lambda = 0$$

From which, after some algebra, we can derive the following equation linking investment and institutional quality:

$$CAPEX_i = (\lambda - 1) K_i^{2-\sigma} e^{-\psi_i - \gamma REG_i + \beta INST_i} \quad [5]$$

Where we assume λ>1, as *CAPEX* cannot be negative. Then, it seems straightforward to verify that better institutions will be positively associated with investment decisions, as long as $\beta > 0$:

$$\frac{\partial CAPEX}{\partial INST} = \beta(\lambda - 1) K_i^{2-\sigma} e^{-\psi_i - \gamma REG_i + \beta INST_i}$$

Equation [5] represents the investment decisions for the transition of *K* towards its steady state. Even if most countries are far off reaching steady state values in telecommunications infrastructure, it is interesting to test the incidence of different variables on the equilibrium level of capital. Combining the equilibrium paths for capital and its shadow value, and assuming $\dot{K} = 0$ and $\dot{\lambda} = 0$, we can derive the steady-state value for capital:

$$K_i^{SS} = \left[\frac{\alpha A L_i^{1-\alpha}}{r + \lambda + \lambda\left(e^{\psi_i + \gamma REG_i - \beta INST_i}\right)\left[r + \frac{\lambda}{2}\right]}\right]^{\frac{1}{1-\alpha}} \quad [6]$$

Equation [6] implies that a technological improvement (an increase in *A*) generates an increase in the steady state level of telecommunications capital, fostering investment until the new level is reached. Similarly, deregulation also promotes investment and higher levels of capital. A decrease of the price of capital (given by the interest rate, or by the shadow value λ) also contributes to increase capital levels. Finally, an improvement of institutional quality further promotes investment and higher levels of capital.

4. **Descriptive Statistics**

For the empirical analysis, our dataset consists in a panel of 13 European countries (Table 1) for the period 2007-2015. Limitations in available data required to estimate the model represented in the previous section prevented us from extending the analysis to other countries.[5] In any case, the resulting sample exhibits interesting diversity, as it is composed by countries from the traditional European core, others from the southern periphery, as well as some of the recently incorporated Eastern former communist countries. This diversity is reflected by differences by country size, as well as the development level for economy in general and in particular, by their telecommunications sector. As an example, the "richest" country in our sample, Luxembourg, registered in 2015 a GDP per capita 6.3 times larger than that of the "poorest", Slovak Republic. Similarly, as for the broadband deployment, the most connected country, Denmark with 41.4 fixed subscriptions every 100 inhabitants, almost doubles the penetration levels of that exhibiting the largest digital divide, Slovak Republic, with "only" 21.8 lines every 100 people.

Table 1. Countries included in the sample

Austria	Italy
Belgium	Luxembourg
Czech Republic	Netherlands
Denmark	Portugal
Finland	Slovak Republic
France	United Kingdom
Greece	

Source: Author's own elaboration.

Table 2 reports the description of the main variables to be used in the empirical analysis. The dependent variable, *CAPEX*, is extracted from the ITU World Telecom / ICT Indicators database, and collects investment associated to infrastructures deployment for both fixed and mobile services.

As for the control variables, the measure of physical capital stock, *K*, refers to the fixed assets associated to the telecommunications sector. This data provided by OECD statistics, was converted to USD with exchange rates from the same source. Current investment levels were extracted from capital stocks, in order to avoid the overlapping of same pieces of information with the dependent variable.[6] In turn, the regulation intensity variable, *REG*, is built as an index from of a series of

[5] The main restriction is related to the availability of series for physical capital stocks for the telecommunications sector

[6] In any case, results main results are unchanged if we consider the original series.

regulatory obligations or restrictions for telecommunication operators, as described in Table 2, in order to the indicator to reflect its lowest value in the case of complete flexibility, and the larger measures in the case of most rigidity. The data used to build the *REG* indicator was extracted from the ITU - ICT Regulatory Tracker.

Table 2. Variable description

Variable	Definition	Source
CAPEX	Annual investment made by entities providing telecommunication networks and/or services for acquiring or upgrading fixed assets less disinvestment owing to disposals of fixed assets. Data expressed in million USD.	ITU World Telecom / ICT Indicators database
K	Fixed Assets of the Telecommunications sector, not including investments carried out during the same period. Data expressed in million USD, after currency conversion with OECD exchange rate data.	OECD Statistics - ITU World Telecom / ICT Indicators database
REG	Indicator for regulatory intensity (scale 1-9). Builded as the summation of the following indicators for regulatory requirements: (Local-loop unbundling, fixed and mobile portability, infrastructure sharing mandated, unflexible licences, requirement for interconnection prices and reference offers available to the public, Quality of Service monitoring, band migration not allowed).	ITU - ICT Regulatory Tracker
INST	Public Institutions indicator (scale 1-7). It is composed by several sub-indicators (equally weighted): • Property rights (Property rights, Intellectual property protection) • Ethics and corruption (Diversion of public funds, Public trust in politicians, Irregular payments and bribes) • Undue influence (Judicial Independence, Favoritism in decisions of government officials) • Public-sector performance (Wastefulness of government spending, Burden of government regulation, Efficiency of legal framework in settling disputes, Efficiency of legal framework in challenging regulations, Transparency of government policymaking) • Security (Business costs of terrorism, Business costs of crime and violence, Organized crime, Reliability of police services)	WEF - The Global Competitiveness Index dataset 2007-2017

Source: Author's own elaboration.

Finally, the variable used to proxy institutional quality, *INST*, corresponds to the Public Institution indicator developed by the World Economic Forum (WEF) for its Global Competitiveness Index (GCI). The GCI of the WEF assesses the competitiveness landscape of 137 economies since 2007, providing insights into the drivers of their productivity and prosperity.[7] It is composed by 12 pillars, being

[7] http://reports.weforum.org/global-competitiveness-index-2017-2018/

the first one that of Institutions, which in turn, is composed by indicators for both public and private institutions. The Public Institutions indicator, which accounts for 75% of the Institutions Pillar of the GCI, will be used as our reference variable to measure differences in institutional quality across countries. Table 2 reports the variables that compose the indicator.

Table 3 reports the main descriptive statistics for the variables to be used in the analysis. Descriptive statistics for *CAPEX* and *K* variables naturally exhibit the corresponding scale effects resulting for the diversity size of countries in the sample. The largest countries in our sample, France and the United Kingdom, reach the maximum values for investment and physical capital stock, respectively. On the contrary, the smallest country, Luxembourg, reaches the minimum values of both variables.

Table 3. Descriptive Statistics

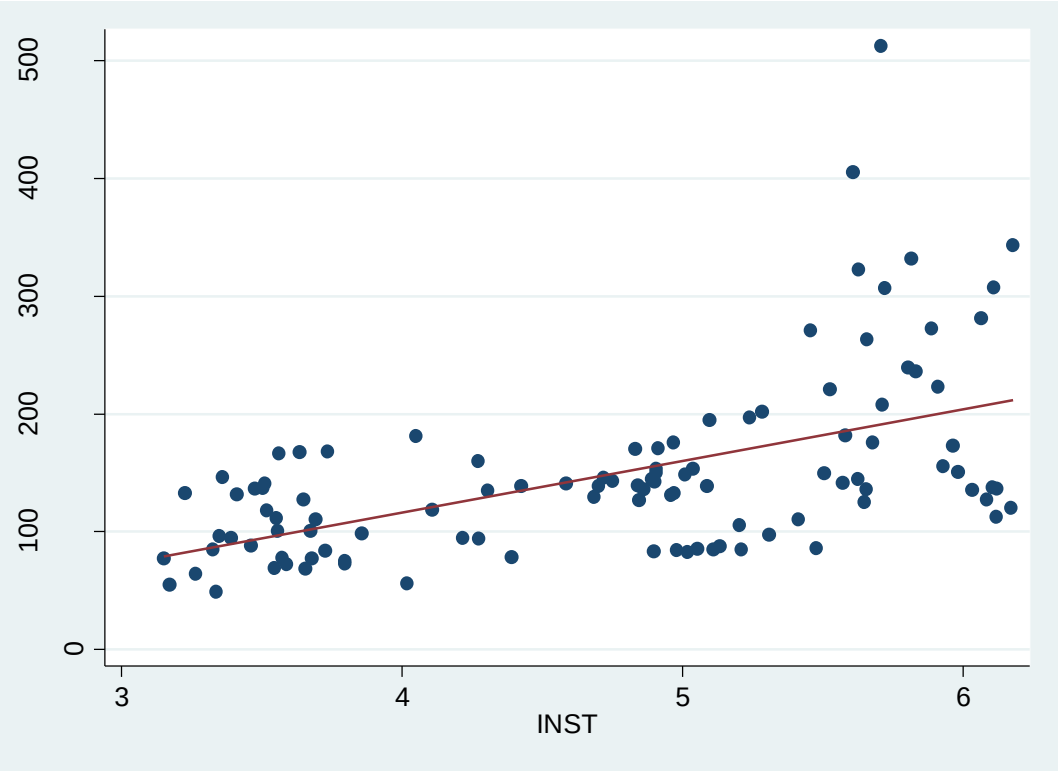
Variable	Mean	Std. Dev.	Min	Max	Obs.
CAPEX	2520	3000	122	10000	107
K	42600	41600	4860	217000	107
REG	6.753	0.422	5.500	7.500	97
INST	4.738	0.941	3.150	6.177	107

Source: Author's own elaboration.

In the case of the remaining variables, *REG* and *INST*, interesting information arises. Largest regulation levels were reached by Portugal and Slovak Republic. On the contrary, lowest regulation intensity is reached by Greece. In the case of institutional quality, the largest levels according to the index are reached by Denmark and Finland, while the lowest levels are registered in Greece, Italy and Slovak Republic.

Finally, in Figure 1 we plot each observation according to the respective values of institutional quality and investment (in this case measured in per capita terms, to allow the comparison between countries). As it can be appreciated, the slope of the linear fit suggests a positive link between the two variables, which is consistent with the literature reviewed in section 2 and with the model proposed in section 3.

Figure 1 – CAPEX (per capita) and INST



Source: Author's own elaboration.

5. Results

The empirical specification is derived from equation [5], which represents the drivers of investment in telecom sector during the path towards the steady-state. Expressing equation [5] in discrete terms, applying logarithms for linearization, and defining $\Omega_i = \text{Log}(\lambda - 1) - \psi_i$ and $\theta = 2 - \sigma$, we get the final specification for our empirical analysis:

$$\log(CAPEX_{it}) = \Omega_i + \theta \log(K_{it}) - \gamma REG_{it} + \beta INST_{it} + \zeta_t + \varepsilon_{it} \qquad [7]$$

Where *i* and *t* denote respectively the country and the year corresponding for each observation. The term Ω represents a country fixed-effect, which intends to capture all time-invariant unobservable aspects which may have an incidence in investment decisions, typically national idiosyncrasy, as well as scale effects. The term ζ_t represents a measure of time-related effects, common to every country, intended to capture economic cycle related shocks. Physical capital stock level is also expected to capture scale effects attributable to different sizes of countries. As for the parameter related to *REG*, it will measure the impact of regulation intensity

on investment decisions, which is expected to be negative, as light-regulation approaches are supposed to be more prone to business development. Finally, β measures the link between institutional quality and investment. In consequence with our main hypothesis and the evidence shown through the descriptive analysis regarding the link between institutions and investment, we expect $\beta>0$.

The first block of columns in Table 4 report the results for the baseline model estimation. First, in column (i) we estimate the baseline model with the assumption of no time-related effects (in other words, restricting $\zeta_t=0$ in equation [7], for every *t*). Subsequent estimates reported in columns (ii) and (iii) relax that assumption, adding respectively year-fixed effects and a time trend. In all cases, the coefficient associated to the institutional variable enters with the expected positive sign and is statistically significant at 1% level. Results seem to be clear in pointing out the relevance of institutional quality for investments decisions in telecommunications. In Appendix 1 we perform a sensitivity analysis by relaxing some assumptions in the model and incorporating further control variables, with results pointing out at the robustness of this positive link between institutions and investment.

As for the remaining variables, they also meet the expected results according to the model and the theory that lies behind. Physical capital stock presents a positive link with investment levels, although it looses significance when introduced jointly with year-fixed effects (column (ii)). As for the regulatory variable, as expected, it has a negative sign and reaches statistical significance. This negative link between regulatory intensity and investment verifies previous findings, such as Alesina et al (2005), and provides evidence of the relevance of light and flexible regulatory frameworks for spurring telecommunications deployments.

The second block of estimates in Table 4 explores for possible heterogeneities in the incidence of institutions on investment decisions –reported in columns (iv) to (vii). In particular, we explore these heterogeneities in the light of some characteristics of the countries included in the sample, such as its digital divide and its level of development. The hypothesis is that for less developed countries, as well as those facing larger digital divides, the relevance of institutional quality should be even higher in order to promote investments. To test these hypotheses, countries are classified in three groups according to the averages of its development -measured through the GDP per capita- and connectivity levels -

broadband penetration every 100 inhabitants- in the period under analysis.[8] Even if both GDP per capita and broadband penetration are expected to be highly correlated, important differences arise between that classifications. As an example, some countries are classified in a connectivity group that lies behind what we would expect considering its development (Italy, Austria, Luxembourg, Finland). Similarly, other countries are more connected than expected according to its GDP per capita (Portugal, Belgium, United Kingdom, France).

Table 4. OLS Fixed Effects estimations

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Log(K)	0.585**	0.433	0.585**	0.448	0.620**	0.473	0.664***
	[0.255]	[0.498]	[0.257]	[0.497]	[0.239]	[0.434]	[0.206]
REG	-0.205***	-0.203*	-0.205**	-0.163	-0.161	-0.158*	-0.154*
	[0.067]	[0.094]	[0.085]	[0.102]	[0.093]	[0.081]	[0.079]
INST	0.423***	0.418***	0.420***				
	[0.134]	[0.126]	[0.108]				
*LC*INST*				0.646**	0.646**		
				[0.265]	[0.273]		
*MC*INST*				0.394	0.368**		
				[0.224]	[0.164]		
*HC*INST*				0.206*	0.245***		
				[0.112]	[0.078]		
*LD*INST*						0.722***	0.691***
						[0.192]	[0.204]
*MD*INST*						0.243	0.304**
						[0.176]	[0.117]
*HD*INST*						0.151	0.174
						[0.145]	[0.100]
Year Fixed Effects	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
Time-trend	*No*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
R-squared (within)	0.405	0.424	0.405	0.453	0.431	0.487	0.459
Observations	97	97	97	97	97	97	97

*Source: Author's own elaboration. Notes: *p<10%, **p<5%, ***p<1%. Robust standard errors in brackets. All estimates include country fixed effects.*

Columns (iv) and (v) report different coefficients for the *INST* variable according to the level of connectivity of the country. Results seem clear in the sense that less

[8] Low Connected Countries (LC): Slovak Republic, Czech Republic, Greece, Italy; Medium-Connected (MC): Portugal, Austria, Finland, Luxembourg; High Connected (HC): Belgium, United Kingdom, France, Netherlands, Denmark
Low Developed (LD): Slovak Republic, Czech Republic, Portugal, Greece; Medium-Developed (MD): Italy, France, United Kingdom, Belgium; High Developed (HD): Finland, Austria, Netherlands, Denmark, Luxembourg

connected countries in our sample, those exhibiting larger digital divides, are the ones for which institutional quality seems to play a bigger role in investment decisions. In other words, in countries with large digital divides the link between good institutions and telecom investments seems to be stronger. Columns (vi) and (vii) report heterogeneities for different levels of development. Results confirm that less developed countries, as measured for GDP per capita, are those in which institutional quality has a bigger relevance.

While results reported in Table 4 point out to clear evidence related to the relevance of institutional quality for telecom investment, the OLS estimation method does not considers possible endogeneity affecting the link of those two variables. In that sense, both Mishra and Daly (2007) and Daude and Stein (2007) argue about 2 possible reasons for the institutional variables to be endogenous to investment levels. In the first place, there could be a feedback effect, in the sense that established investors –as are the telecom operators- can strongly demand better institutions. As a result, investment levels can be a factor explaining institutional quality, rather than the other way around (reverse causality). The second reason they argue is about subjectivity bias or measurement errors in institutional indicators. In our case, as the *INST* variable is designed from a survey based on perceptions, we cannot rule out these concerns.

To deal with possible endogeneity associated to institutional variables, most papers have followed an instrumental variables (IV) approach (Mishra and Daly, 2007; Benassy-Quere et al, 2007; Daude and Stein, 2007). In their panel estimates, Benassy-Quere et al (2007) use 5-year lagged values of institutions quality to instrument current levels of that variable. In our case, the short time-dimension of our panel made it impossible to use long-enough lags to break any possibility of the instrument being affected by contemporary shocks. Other authors preferred to use certain characteristics of the different countries, which are expected to be related to institutional quality, but not expected to affect in a direct way the investment levels in a specific sector. That is the case of Mishra and Daly (2007), who used as instruments the indexes of religion, ethnicity and language provided by Alesina et al (2003). Daude and Stein (2007) used as instruments the ethno-linguistic fragmentation index from Easterly and Levine (1997), the average homicides per 100.000 inhabitants, and the fraction of population that speaks English and a western European language. In turn, Acemoglu et al (2001) used mortality rates of colonial settlers as an instrument for institutional quality, something which is inappropriate in our case due to the lack of former colonies in our sample.

In our case, we will use the number of years since each country become independent (in squares), as well as respective indexes of ethnicity, language and religion for each country. The construction of the years from independence variable was based on the stipulated date of declaration of independence available in the CIA Factbook.[9] As in some cases there is not a specific date identified for that purpose, the criteria followed was to take as a reference the oldest date attributable to a success which can be interpreted as the origin of independence according to that source. As for the indexes of ethnicity, language and religion, we used the dataset provided by Alesina et al (2003). Specifically, the ethnicity index provides a measure of ethnic fractionalization, based on a combination of racial and linguistic characteristics. In turn, the language index was built with the shares of languages spoken as "mother tongues", generally based on national census data. Finally, the religion index measures the degree of religious fractionalization across the population of a country.[10] These indexes were introduced as instruments in interaction with the variable of years from independence in each case. Appendix 2 provides the main descriptive statistics of the instruments used in our estimates.

While it can be debatable if the link between these instruments and the institutional variables is close enough (weak instruments), in the case of the indexes of ethnicity, language and religion no concerns should arise from its exogeneity, as they rely on cultural and historic events dating from several years ago. On the contrary, as for the years of independence variable, we should be more cautious regarding its exogeneity because, at a first glimpse, this variable may be correlated to others such as EU accession and as a result, on investment levels.[11] If that was found to be true, then our results may be contaminated by spurious correlation or omitted variable bias. However, further checks provided us with evidence to dismiss these concerns. Specifically, the variable of years of independence was found to be irrelevant to directly explain telecommunications investment, and the contrary it was found to be correlated to the public institutions' variable, then behaving as instruments should.[12]

Beyond endogeneity, there are other concerns that prevent us from deriving firm conclusions on causality. As we were unable to work with information from each specific telecom operator, by relying on country-level data we had to develop our empirical estimates with a limited and highly aggregated dataset, from which it is

[9] https://www.cia.gov/library/publications/the-world-factbook/.
[10] See Alesina et al (2003) for the complete detail of these variables.
[11] We would like to thank an anonymous referee for raising up this point.
[12] All this evidence is available to the readers upon request.

not easy to disentangle causal effects. Moreover, indicators such as ethnicity, language and religion, do not seem to be suitable enough to explain over-time changes in institutional quality within a country. All in all, and due to these concerns, we preferred to follow a cautious approach and not to derive firm conclusions on causality, which will have to be addressed in future research when more suitable datasets become available.

Table 5. IV-LIML Fixed Effects estimations

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)
Log(K)	0.628***	0.135	0.747**	0.300	0.638***	0.445*	0.774***
	[0.218]	[0.418]	[0.380]	[0.357]	[0.233]	[0.265]	[0.195]
REG	-0.161*	-0.125	-0.098	-0.139*	-0.125	-0.095	-0.084
	[0.090]	[0.116]	[0.154]	[0.082]	[0.078]	[0.084]	[0.089]
INST	0.673**	1.805***	1.832*				
	[0.303]	[0.647]	[1.012]				
*LC*INST*				1.065***	1.019***		
				[0.257]	[0.244]		
*MC*INST*				0.897***	0.753**		
				[0.337]	[0.304]		
*HC*INST*				0.285**	0.302***		
				[0.130]	[0.085]		
*LD*INST*						1.348***	1.238***
						[0.249]	[0.246]
*MD*INST*						0.445**	0.491***
						[0.185]	[0.137]
*HD*INST*						0.228	0.225*
						[0.156]	[0.131]
Year Fixed Effects	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
Time-trend	*No*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Underid. test	18.468***	13.388***	10.935**	16.147*	17.340*	23.262***	21.514**
Weak Inst. test	6.815[a]	5.871[a]	5.214[a]	4.339	4.635	21.678	16.135
Hansen-J Statistic	7.106*	6.055	6.398*	13.728	15.128*	10.791	14.942*
Observations	97	97	97	97	97	97	97

*Source: Author's own elaboration. Notes: *p<10%, **p<5%, ***p<1%. Robust standard errors in brackets. All estimates include country fixed effects. (a) Stock-Yogo weak ID test critical values: 10% maximal LIML size: 5.44.*

Results for our IV estimates are reported in Table 5. All estimations were performed following the limited-information maximum likelihood procedure (IV-LIML), which has proven to be more suitable than two-stage least squares in the presence of weak instruments. While the estimates seem to be identified in most

cases (under identification test suggest rejection), the weak instrument test presents reasonable results for the first block of estimates, although more concerns arise when exploring heterogeneities. As for the Hansen test of overidentification, exogeneity of instruments is verified or rejected with only a 10% of significance. Results seem to confirm the main consequences derived from OLS estimates. The parameter associated to institutional quality remained positive and significant in all cases, and further estimates verified that countries more sensible to institutions are those lagging in terms of connectivity and development. The main difference with OLS is related to the size of the coefficients associated to the *INST* variable, which were found to be much larger in the case of IV. This is similar to the results reported in Daude and Stein (2007) in theirs estimates of the impact of institutional quality on FDI flows, as their IV results suggested similar significance levels to OLS, but much larger coefficients. With due caution, we can conclude that OLS estimates represent a lower-bound for institutional coefficients.

Up to this point, we have worked with the WEF Public Institutions indicator to proxy for institutional quality. The use of a composite index makes sense as severe collinearities are expected to arise between different institutional indicators. Grouping also contributes to reduce measurement problems of individual components of an index (Daude and Stein, 2007).

However, to rely only on a composite index has some disadvantages, such as the impossibility of disentangling specific aspects of the institutional quality -and the differences among them-, as well as the fact that most composed indicators also include some variables that have little to do with our main focus of analysis, as in our case, in which the selected indicator includes aspects such as terrorism or crime which are far from the scope of this paper. Then, we decided to select a subgroup of the variables which compose the WEF's Public Institutions indicator, and to introduce them in the model directly. The variables were selected considering what the literature review suggests about possible reasons behind investors' concerns regarding institutional quality. Details about the selected variables are provided in Appendix 3. Results are reported in Table 6. For the sake of simplicity, all these estimates were performed with OLS and a time-trend.

Table 6. Fixed Effects estimates for specific institutional variables

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Log(K)	0.513**	0.565	0.541*	0.612*	0.616*	0.570*	0.593**	0.757**
	[0.199]	[0.322]	[0.271]	[0.324]	[0.312]	[0.320]	[0.27·]	[0.294]
REG	-0.161*	-0.207*	-0.258***	-0.229*	-0.272**	-0.296**	-0.236*	-0.653***
	[0.088]	[0.105]	[0.071]	[0.110]	[0.100]	[0.116]	[0.112]	[0.032]
Property Rights	0.368***							
	[0.076]							
Trust		0.127**						
		[0.043]						
Judicial Independence			0.247***					
			[0.062]					
Favoritism				0.141*				
				[0.065]				
Efficiency in settling disputes					0.092			
					[0.100]			
Efficiency challenging regulations						0.013		
						[0.084]		
Transparency							0.137***	
							[0.044]	
Irregular payments								0.327**
								[0.127]
Country Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time-trend	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
R-squared (within)	0.410	0.312	0.427	0.300	0.260	0.248	0.302	0.398
Observations	97	97	97	97	79	79	97	67

*Source: Author's own elaboration. Notes: *p<10%, **p<5%, ***p<1%. Estimation method OLS. Robust standard errors in brackets. All estimates include country fixed effects and a time-trend.*

As reported in Table 6, Property Rights emerged as the main cause of concern for telecom operators, among the selected variables, as it was found to reach the strongest coefficients and significance levels. After that, Corruption –irregular payments-, judicial independence and transparency were also found to have a strong link with investment decisions, followed in a less degree by favoritism concerns and trust on politicians. On the other hand, we were unable to find any significant association between investment and perceptions regarding the efficiency of the legal framework for settling disputes or to challenge regulations. This may reflect the fact that investors are possibly more concerned about the independence of the legal system, rather than on its speed or efficiency.

6. **Conclusions**

Closing the digital divide and fostering the digital economy is considered one of the keys to increase productivity and to achieve higher growth. Then, investment in telecommunications networks is crucial. Thus, creating a suitable environment is necessary to stimulate those deployments. Through this paper we intended to provide a contribution for that purpose, by assessing the link between institutional quality and telecom investment levels.

Results reported over these lines seem to be clear in verifying a positive association between institutional quality and investment levels. These findings were robust to different specifications of the model, and to the control of potential endogeneity linked to the institutional variable. Novel findings also pointed out at institutional quality being more relevant in the case of most disadvantaged countries, in terms of development and digital connectivity. With respect to the specific components of the Public Institutions indicator, we found evidence of Property Rights being the main cause of concern for telecom operators, followed by corruption, judicial independence, transparency, and in a lesser degree, by political favoritism and trust. On the other hand, we were unable to find any significant link between investment and perceptions regarding the efficiency of the legal framework for settling disputes or to challenge regulations.

As for the policy implications, the results provided by this paper seem to be clear in the sense that institutional reforms must be accomplished in those countries were investment climate is not perceived as appropriate by investors.

Finally, our analysis has been partially limited by data availability. In the first place, we were restricted to work with sector-aggregated data, as we were unable to split our main variables across operators, or for mobile and fixed services. Secondly, limited availability of the telecom physical capital stock constrained our sample to just 13 European countries, which prevented us to expand the empirical analysis to emerging regions which still have an important digital divide to close, such as Latin America, Africa or Asia. Finally, in addition to the size and the aggregated level of the dataset, endogeneity concerns prevented us from deriving firm statements in terms of causality. In that sense, we preferred to understand the main results in terms of association between institutional quality and investment rather than on an explicit causality direction. In the future, when more suitable databases become available, we hope to be able to perform further robustness checks in order to make firm conclusions on this subject.

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Appendix

Appendix 1

While the model represented in section 3 is a simplified version of reality, it neglects possible effects derived from demand-side, costs or competition within markets. Then, to check the robustness of our results regarding the relevance of public institutions, we will intend to replicate the estimate of the baseline model reported in Table 4 but adding further control variables. As for control variables, we will include GDP per capita (to *proxy* for demand-related factors), population density (as a cost-shifter for network deployments) and the average of the competition indexes developed by ITU for telecom services, to consider competitiveness pressure of the markets. To avoid any endogeneity concerns, we will introduce GDP per capita in lagged terms, following Henisz (2002). Table A.1 summarizes the description of the variables to be included, while Table A.2 presents the main descriptive statistics.

Table A.1. Description of further control variables

Variable	Definition	Source
GDP per capita (USD)	Gross Domestic Product per capita at current USD	World Bank World Development Indicators
Population density	People per square km of land area	World Bank World Development Indicators
Competition	Average of the competition level in Basic services (Local fixed line, Domestic fixed long distance, International fixed long distance); in Mobile services (3G, 4G, etc.) and in Broadband services (DSL, Cable modem, Fixed Wireless). For each sub-item, the score is 0 for "Monopoly"; 1 for "Partial competition"; and 2 for "Competition".	ITU - ICT Regulatory Tracker

Source: Author's own elaboration.

Table A.2. Descriptive statistics for further control variables

Variable	Mean	Std. Dev.	Min	Max	Obs
GDP per capita (USD)	43858.83	24069.30	16057.73	119225.40	107
Population density	171.08	120.09	17.39	500.59	107
Competition	1.84	0.19	1.44	2.00	107

Source: Author's own elaboration.

Results reported in Table A.3 seem to confirm the robustness of the relevance of institutional quality to explain investment in telecommunications, as the coefficient associated remains positive and significant in all estimates. The introduction *per se* of the control variables does not affect the coefficient size nor the significance for *INST* -see columns (i), (iv), (vii)-, and not even when we introduce all these controls at the same time -column (x)-, although, when introduced jointly with time-effects, its coefficient is somewhat reduced, but remain significant. As for the control variables, the only one that seems to reach significance levels is population density, which seems to capture part of the effect attributable to physical capital, as this is the only variable which appears to be somewhat affected by this expansion of the model.

Table A.3. Estimate of the baseline model with further control variables

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)
Log(K)	0.71**	0.54	0.69**	0.34	-0.43	0.13	0.59**	0.43	0.59**	0.47**	-0.42	0.03
	[0.27]	[0.43]	[0.30]	[0.20]	[0.38]	[0.19]	[0.26]	[0.52]	[0.26]	[0.19]	[0.36]	[0.22]
REG	-0.17*	-0.09	-0.16	-0.21***	-0.13*	-0.15*	-0.21**	-0.20*	-0.20*	-0.19**	-0.12*	-0.16**
	[0.09]	[0.12]	[0.10]	[0.06]	[0.06]	[0.07]	[0.07]	[0.10]	[0.09]	[0.08]	[0.07]	[0.07]
INST	0.40**	0.36**	0.37***	0.46***	0.24**	0.28***	0.42***	0.41***	0.41***	0.50***	0.27*	0.26**
	[0.15]	[0.15]	[0.12]	[0.13]	[0.11]	[0.09]	[0.14]	[0.13]	[0.11]	[0.14]	[0.13]	[0.09]
Log(GDP per capita)$_{t-1}$	0.30	0.92*	0.28							0.04	-0.43	-0.52*
	[0.37]	[0.47]	[0.34]							[0.35]	[0.37]	[0.26]
Log(Population density)				3.61**	8.85***	6.87***				4.36***	10.92***	9.22***
				[1.19]	[2.02]	[1.96]				[1.23]	[2.13]	[2.13]
Competition							0.06	0.11	0.08	-0.15**	0.21	0.20
							[0.09]	[0.28]	[0.25]	[0.06]	[0.26]	[0.24]
Year Fixed Effects	*No*	*Yes*	*No*	*No*	*Yes*	*No*	*No*	*Yes*	*No*	*No*	*Yes*	*No*
Time-trend	*No*	*No*	*Yes*	*No*	*No*	*Yes*	*No*	*No*	*Yes*	*No*	*No*	*Yes*
R-squared (within)	0.39	0.44	0.40	0.48	0.64	0.56	0.41	0.43	0.41	0.47	0.66	0.60
Observations	87	87	87	97	97	97	97	97	97	87	87	87

*Source: Author's own elaboration. Notes: *p<10%, **p<5%, ***p<1%. All estimates include country fixed-effects. Estimation method: OLS. Robust standard errors in brackets.*

Appendix 2

Table A.4. Descriptive statistics for instruments

Variable	Mean	Std. Dv.	Min	Max	Obs.	Source
Years since independence	494.09	498.42	14.00	1529.00	107	CIA – World Factbook
Ethnic	0.24	0.20	0.02	0.64	107	Alesina et al (2003)
Religon	0.36	0.21	0.09	0.72	107	Alesina et al (2003)
Language	0.21	0.17	0.05	0.56	107	Alesina et al (2003)

Source: Author's own elaboration.

Appendix 3

Table A.5. Descriptive statistics for selected institutional subindicators

Variable	Mean	Std. Dev.	Min	Max	Obs.
Property rights	5.41	0.85	3.84	6.64	107
Trust politicians	3.63	1.44	1.54	6.21	107
Judicial Independence	5.01	1.22	2.26	6.63	107
Favoritism	3.83	1.14	1.86	6.05	107
Efficiency in settling disputes	4.16	1.25	2.03	6.07	83
Efficiency challenging regulations	4.07	1.16	2.24	5.86	83
Transparency	4.59	0.82	2.54	6.13	107
Irregular payments	5.21	1.10	3.35	6.69	70

Source: Author's own elaboration.