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What drives investment in the telecommunications sector? Some lessons from the OECD countries

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ABSTRACT

Regulation of telecommunications sector plays a crucial role in the political and economic agenda for both industrial and developing countries. The regulatory efforts of more developing countries in order to attract investments and enhance the level of effective competition in the industry are hindered by the absence of a sound legal framework, the weak level of regulation and the extended state interventionism. The main aim of this study is to examine the regulatory process in the telecommunications industry within the OECD countries and determine the extent to which it has affected the level of investment and economic growth. For this purpose, we use an updated data set for thirty OECD countries covering the period 1988–2010 and panel data econometric techniques. Our analysis reveals that there is a strong and positive relationship between effective regulation and investment.

1. Introduction

There is no doubt that the telecommunications industry, with a global revenue of $3.1 trillion in 2010, constitutes one of the most important sectors of the new globalized economy (TIA, 2011). It is worth mentioning that, in 2009, the telecommunications industry contributed $1 trillion to U.S. GDP (or 7.1% of GDP), including $600 billion from the sector itself and $400 billion in benefits to other sectors that rely on it. The penetration rate of telecommunications services worldwide is noteworthy since there were approximately 5.3 billion wireless service subscriptions as of March, 2011 (ITU, 2011a). However, the actual number of individuals holding those subscriptions is somewhat less, at approximately 4.2 billion, as many people have more than one subscription (TIA, 2011). Telecommunications remain one of the major providers of employment in the world, with 899,700 employees in the U.S. alone (ITU, 2011b). Furthermore, the market is also critical for the competitiveness and economic growth of the European Union (EU) since it has an impact on all other economic activities.

Telecommunications industry encompasses not only the traditional areas of local and long-distance (trunk) telephone services, but also the advanced technology-based services including wireless communications, Internet, fiber-optics and satellites. In general, telecommunications markets (i.e., international gateway services, wireless local loop services, mobile telephony markets, and third generation market) around the world are becoming more competitive. Fixed line services, however, continue to lag behind in terms of competitiveness. Nevertheless, there has been an increase in the percentage of countries that have opened their fixed line markets to competition, although the number of fixed lines per 100 habitants has remained relatively flat over the past 10 years (ITU, 2011b).

Until the mid 1990s, the European telecommunications industry was vertically integrated and state-owned. In such a centralized regime, prices and tariffs were regulated. This situation has profoundly changed due to the European-wide market opening mainly introduced in mid 1990s. More specifically, in the last decade, the EU policy makers and government officials were challenged to reform the industry due to inefficiencies identified in its vertically integrated segments. The low productivity of the industry along with a high degree of borrowing by the vertically public telecommunications operators (PTO), has gradually led governments to pursue strategies focusing at the opening of the telecommunications sector. In other words, telecommunications industry reform has often been regarded either as a means to raise revenue by privatization or as an investment policy tool for upgrading the inflow of foreign direct investments (FDI) in developed countries (Newbery, 2000).

In order to enhance effective competition in the telecommunications industry, the European Union issued two main directives

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(2002/21/EC and 2009/140/EC). Although the primary goal of these Directives was the promotion of a common regulatory framework within the EU countries in the telecommunications sector, in practice, the implementation process varies considerably across member states. A few European countries like the United Kingdom, Germany, Norway, Finland and Sweden acted as pioneers in the liberalization process and pursued strategies focusing on full market opening and the introduction of effective competition in the various distinct relevant markets (e.g., domestic long-distance fixed telephony, international long-distance fixed telephony, cellular mobile telephony, etc.).[1] Other countries like Spain, Italy, Belgium, the Netherlands and Luxembourg opted for an opening schedule. Countries like Greece, Portugal, Ireland and Luxembourg are still at the initial restructuring stages since they have opened their telecom markets to meet minimum requirements (Newbery, 2000). On the other side of the globe, USA[2] and Chile began the processes of privatizing and restructuring state owned enterprises, liberalizing the markets in which they operated and regulating their conduct. Since then, many Latin and Caribbean countries at all stages of development have implemented their own programs of regulatory reform.

This paper attempts to shed light on the causal link between the telecommunications investments and the national regulatory environment, and to investigate whether the variation in the level of investment across the telecommunications sector is significantly related to the variation in the level of economic growth, expressed by the per capita GDP. For this purpose, data from thirty OECD countries have been used for the period 1988–2010, and panel data econometric techniques and cointegration analysis has been applied. This research is a step toward integrating and analyzing available data in a more comprehensive way which may help the researchers and government officials to approach the telecommunications regulatory issues on a scientific solid base.

The rest of the paper is organized as follows. Section 2 briefly summarizes other related studies, while Section 3 describes the industry structure in the telecommunications sector in OECD. Section 4 specifies the econometric model and the results. Lastly, Section 5 concludes the paper and gives some policy implications.

2. Review of the literature

Telecommunications industry has been of interest to economists for a long time and there is a substantial body of literature assessing the main impacts of regulation and competition in this sector. In most studies, the purpose was to measure the impact of certain structural measures (e.g., privatization, deregulation, etc.) on the performance of the telecommunications industry. The majority of these studies consent that effective regulation tends to positively affect the level of investment, which in turn boosts economic growth (Armstrong and Sappington, 2006; Nicoletti and Scarpetta, 2003; Cadman and Carrier, 2002; Chang et al., 2003; Edwards and Waverman, 2006; Melody, 1997; Alesina et al., 2005; Cadman, 2007; Gutierrez, 2003a; Gutierrez and Berg, 2000; Henisz and Zelner, 2001; Li and Xu, 2002; Röller and Waverman, 2001; Wallsten, 2001a,b). This positive relationship constitutes a major hypothesis that is empirically tested by using different econometric techniques, such as panel data methods (fixed, random effects) or cross-section analysis, in order to evaluate the main drivers of the industry performance. However, the majority of the studies failed to address the existence of cointegration between the relevant variables. The absence of cointegration among the variables may lead to spurious results regarding the existence of causality (one-way or bi-directional). In other words, a cointegration analysis provides the potential information about long term equilibrium relationships of the model. To this extent, the absence of cointegration is consistent with the absence of a linear combination (structural relationship) between the variables of the empirical model (Paleologos, 1996). Thus, an objective of this study is to highlight the relevant gap in the literature by applying panel data cointegration techniques.

Considering the above, Röller and Waverman (2001), investigate how telecommunications infrastructure affects economic growth, by using a panel of 21 OECD countries for the period 1970–1990 in order to examine the impact that telecommunications developments may have. Their findings support a significant positive causal link between telecommunications infrastructure and aggregate output. The authors also find that GDP per capita has a positive and significant influence on the demand for telecommunications infrastructure, while prices of telephone service have a negative effect.

Li and Xu (2002) test the impact of privatization and competition on investment, and find that privatization has a positive effect on investment per capita, as competition. However, although competition is identified as a key complement to privatization, stimulating performance, and investment in telecommunications, the authors do not find the effect to be significant.

Wallsten (2001a) examines telecommunications investment in developing countries. In this study it is found that GDP per capita has a positive and significant effect on investment, while 'exclusivity' arrangements (whereby governments grant monopoly rights to the incumbent telecommunications provider in order to increase the firm's value to private investors) have a negative and significant effect on investment. In a similar study, Wallsten (2001b) explores the relationship between telecommunications reforms and investment, finding that both population and GDP per capita have positive and significant effects on investment.

Henisz and Zelner (2001), examine the institutional determinants of the diffusion of basic telecommunications infrastructure across 55 countries during the period 1960–1994. The econometric analysis is based on cross-sectional and temporal variations in the panel. Their results suggest that national telecommunications firms encountering both relatively low penetration rates and low levels of political constraints are unlikely to exhibit high penetration growth rates in the near future.

In a study of twelve Latin American countries, Gutierrez and Berg (2000) find that their index of regulatory framework is positively associated with network deployment, which means that a better, specific regulatory environment leads to greater investment in telecommunications. In another study, Gutierrez (2003b) examines the effect of reform on telecom performance by using panel data techniques to test how regulatory governance affects sector performance in 22 Latin American countries during the period 1980–1997. This study concludes that sound regulatory governance in telecommunications has a positive impact on network expansion and efficiency in both the static and dynamic specifications. Furthermore, market openness to competition and divestment of former state owned telecommunications operators also positively contribute to better sector performance (Gutierrez, 2003b).

Alesina et al. (2005) assemble data on regulation in several sectors of many OECD countries to provide evidence that the regulatory reform of product markets is associated with an increase in investment. Their results stress that entry liberalization and privatization have a substantial effect on investment.

Boylaud and Nicoletti (2001) examine the relationship between regulation, market structure and performance, specifically in the telecommunications sector. They focus on three measures of economic performance: labor productivity, prices and quality across three services: international, long distance (trunk) and mobile. Their model, by using panel data techniques, investigates the factors that affect telecommunications investment. They find that competition, and the mere prospect of liberalization, bring about productivity and quality improvements and reduce prices.

[1] In the UK, the vertically state owned dominant firm British Telecom (BT) was privatized in 1984 and another firm (Mercury) was licensed to compete with BT in the long distance (trunk) market with the guarantee that there would be a duopoly for seven years (1984–1991). Since the end of the duopoly policy in 1991 entry into all telecommunications markets has been fully liberalized.

[2] In the USA, the dominant incumbent firm (AT&T) was separated vertically into a long-distance company and the regional Bell operating companies back in 1984.

In another study conducted for the European Commission (London Economics, 2006), the relationship between investment, at both firm and national levels, and regulation is under scrutiny. This study gathers data on investment at the firm level by using both published annual accounts and a primary research survey by Price Waterhouse Coopers and identifies primary and secondary drivers of investment. More specifically, the primary drivers are the level of expected return and the subsequent risk and uncertainty they are associated with. Secondary drivers are divided into three main categories at the economy, industry and company side perspectives. The empirical results show that regulation, measured by the OECD (e.g., Regulatory Reform Index[3]) is correlated with investment and when the ECTA Scorecard[4] is used as an alternative measure in their country level model, it is also significant, though only at 7%.

Cadman (2007), examines whether there is a relationship between regulation and investment by using separate measures of regulatory effectiveness and reform developed by the European Competitive Telecoms Association and by the OECD. This study applies cross-sectional, lagged and pooled time-series/cross-section regression models by using investment per capita as the dependent variable and a measure of regulation as one of the explanatory variables. In all model specifications a significant and positive relationship between the level of effective regulation which supports competition and the telecommunications investment is found.

Summarizing, the studies presented above conclude to the following major relationships that may constitute or augment the hypotheses of the present study: a) there is a positive relationship between regulation and telecommunications investment, b) there is a significant positive causal link between telecommunications infrastructure and aggregate output measure by per capita GDP, c) privatization of former state owned network utilities has a positive effect on per capita investment, and d) the level of competition in the telecommunications sector does not always positively affect the per capita investment. However, the aforementioned studies do not capture the impact of the industry structure and the competitive element of the market in the telecommunications investment and economic growth respectively. For this reason, we incorporate several proxies such as market shares of the new entrants, dummy variables representing the level of competition in the various relevant markets, in order to measure the industry effect. In this way, our study differs from earlier works in this field.

3. Market structure in the telecommunications industry

The OECD countries have implemented substantial regulatory and institutional reorganizations of their telecommunications sectors. In the early 1980s the OECD telecommunications markets were still governed by state-owned vertically integrated companies. These firms were usually subject to strict restrictions regarding the structure and the level of prices to meet social and macroeconomic goals (Boylaud and Nicoletti, 2001).

However, in countries like the UK or France, the telecommunications industry was characterized by significant structural changes since vertically integrated monopolies like British Telecom (BT) and France Telecom (FT) were privatized. From the 1990s, policy actions facilitating privatization, opening up markets to competition and establishing independent regulatory authorities for the telecommunications sectors were implemented in various European countries (i.e., UK, Germany, France, Spain, Portugal, Sweden, Greece, etc.). The regulatory bodies must often intervene in the telecommunications sector in order to remedy shortcomings in the functioning of the relevant markets and ensure that competition is working effectively. This intervention imposes some form of regulation (i.e., interconnection charges, cost-oriented tariffs, elimination of restrictions on resale to allow entry of new operators, etc.). In order to boost competition and attract investments in the telecommunications sector, the national regulatory authorities (NRAs) must have a significant degree of independence from both operators and the governments so as to limit the "regulatory capture" (Vettas and Katsoulakos, 2004). Such market confidence promotes increased foreign and direct investment in both incumbent operators and new entrants in the sector. However, such confidence will depend on the demonstrated capability of the NRAs to act in a professional and impartial manner.

4. Econometric analysis

A number of researchers (Hsiao, 1986; Klevmarken, 1989; Notta et al., 2010; Solon, 1989) support that panel data can effectively cope with individual heterogeneity and can give more informative data, more variability, and less colinearity. They also argue that, with panel data, it is easier to identify and measure effects that are not detectable in pure cross-section or pure-time series data, and to construct and test more complicated behavioral models. Moreover, with panel data, both the random and fixed effects specifications constitute improvements over the simple linear OLS model, which does not adequately account for differences in the characteristics of cross-sectional units (Baltagi, 2005; Boylaud and Nicoletti, 2001). In addition, it should be considered that estimating panel data models by OLS techniques, yields spurious and biased results (Moulton, 1986).

Considering the purpose of this study, in order to perform an in depth investigation, we used an updated dataset of thirty OECD countries[5] covering the period 1988–2010 ($n = 30$ and $T = 23$).[6] All variables are in their natural logarithms except for the long-term real interest rates and the variables denoting the market shares of new entrants in the three relevant markets of trunk (TR), international (INTERN) and mobile (MOB) telephony services respectively.

All data other than investment are taken from the OECD statistical database (http://stats.oecd.org). The level of investment for the sample period is taken from the OECD communications outlook (OECD, 2011). Lastly, data on the telecommunications market structure, entry regulation and public ownership (i.e., market shares of new entrants, level of competition, state-owned shares in the PTO, etc.) is taken from the OECD International Regulation Database.

4.1. Static panel data techniques

The static panel data model is given by the following equation

$$y_{it} = \gamma x_{it}^{'} + d_{it}\delta^{'} + \alpha_i + \varepsilon_{it} \quad (1)$$

[3] The Regulatory Reform Index (RRI) includes a range of indicators of product market regulation at both the economy-wide and sectoral levels. All of these indicators measure the extent to which policy settings promote or inhibit competition in areas of the product market where competition is viable. A subset of the overall RRI covers energy, transport and communications regulation, within which are data on reform in telecommunications. The telecommunications sector of the RRI has three main sections: a) entry regulation, b) public ownership and c) market structure covering eight criteria. In contrast to the ECTA Scorecard, a low score is attributed to countries with the best regulatory environment. A more comprehensive description of the RRI can be found in Conway and Nicoletti (2006).

[4] The Scorecard measures the effectiveness of the telecoms sector regulatory regime in a number of EU countries. The Scorecard is calculated by measuring regulatory regimes across a broad range of criteria. The number of criteria, and the criteria themselves, change as the market and regulation develop. Each criterion is allocated a weight, or maximum possible score. Then each country is scored against that criterion where the highest score is awarded to the best performing countries and zero to the worst performing (Cadman, 2007).

[5] The sample countries are the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States.

[6] Summary statistics for included country-years and a correlation matrix for variables included in the econometric analysis are provided in the Appendix (see Table A1).

where the vector y_{it} represents the dependent variables (per capita telecommunications investment and per capita GDP). $x_{it}=(x_{1it},x_{2it},\ldots,xk_{it})'$ represents the telecommunications regulatory reform index as well as the number of other explanatory variables (real per capita GDP, real interest rates, population density, etc.) and $\gamma=(\gamma_1,\gamma_2,\ldots,\gamma_k)'$ their respective coefficients. The set of dummy variables, that represents the level of competitiveness of the various markets, are given by $d_{it}=(d_{1it},d_{2it})'$ and their coefficients are $\delta=(\delta_1,\delta_2)'$. Finally, ε_{it} represents the error term, while α_i is the constant term.

Analytically, the telecommunications investment function is given by the following equation:

$$\begin{aligned} INV_{it} = {} & a_0 + a_1 \overset{+}{GDP}_{it} + a_2 \overset{+}{POP}_{it} + a_3 \overset{-}{IR}_{it} + a_4 \overset{-}{RRI}_{it} + a_5 \overset{+}{TR}_{it} \\ & + a_6 \overset{+}{INTER}_{it} + a_7 \overset{+}{MOB}_{it} + a_8 \overset{+}{T}_{it} + a_9 \overset{+-}{COMP\_TR}_{it} \\ & + a_{10} \overset{+-}{COMP\_INTERN}_{it} + a_{11} \overset{+-}{COMP\_MOB}_{it} + a_{12} \overset{+-}{PRIV}_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

where, INV is the real per capita public telecommunications investments (excluding spectrum fees), GDP is the real per capita gross domestic product (base year 2005), while IR is the real long-term interest rates.[7] RRI is the regulatory reform index as provided by the OECD, and POP is the population density measured as the ratio of population and country size (expressed in square kilometers). TR, represents the market share (%) of new entrants in the long-distance (trunk), and INTER and MOB represent the market share of new entrants in the international and mobile telephony market segment respectively. T is a linear time trend denoting the technological effect. In addition, we used three dummy variables (COMP_TR, COMP_INTERN and COMP_MOB) to capture the level of effective competition in the three relevant markets, taking the value of one if competition exists and zero otherwise (monopoly or duopoly). In order to capture the effect of privatization of the telecommunications sector we used a dummy variable (PRIV) taking the value of one when the percentage of shares in the PTO owned by government is less than 50% and zero otherwise. The relevant signs above the control variables show the expected impact (positive or negative) of each variable to the per capita investment (INV). In other words, the direction of the causality between the variables (signs) and the magnitude of the relevant coefficients (elasticities) represent the main hypotheses to be tested. It is worth mentioning that the impact of the control variables related to the market shares of the new entrants in the various relevant markets (TR, INTER, MOB) has not been previously tested by other empirical studies. The main reason for using the relevant variables in the empirical analysis is that we want to assess the impact of the industry structure and the level of the (intra-firm) competition in the telecommunications investment. Furthermore, in order to investigate the main determinants of the economic activity, we estimated the following equation

$$\begin{aligned} GDP_{it} = {} & b_0 + b_1 \overset{+}{INV}_{it} + b_2 \overset{+-}{POP}_{it} + b_3 \overset{-}{IR}_{it} + b_4 \overset{-}{RRI}_{it} + b_5 \overset{+}{T}_{it} \\ & + b_6 \overset{+-}{PRIV}_{it} + \varepsilon_{it}. \end{aligned} \quad (3)$$

4.1.1. Empirical results and interpretation

Table 1 depicts the results of the main determinants of the telecommunications investment in the sample OECD countries for the period 1988–2007[8] by utilizing the two stage generalized least squares fixed effects method (2SFGLS), firstly introduced by Hausman and Taylor (1981). This method is better suited for this study instead of other methods of estimation (OLS fixed or random effects models) because this estimator which is a hybrid of the fixed effects and generalized least squares (random effects) models does not incur a biased regression (Gardner, 1998). More generally, the approach may simply be viewed as a special case of the Generalized Instrumental Variables approach in which data and the instruments are both transformed by using the estimated covariances. This approach has the effect of altering the implied orthogonality conditions (Wooldridge, 2002).

Table 1
Empirical results of the static panel.

Variable	(1) Dependent variable INV	(2) Dependent variable INV	(3) Dependent variable GDP
Intercept	−60.106*	−10.227**	10.639*
	(−4.85)	(−2.16)	(33.99)
INV (−1)	–	0.579*	–
		(10.35)	
INV	–	–	0.051*
			(7.12)
GDP	7.996*	1.585*	–
	(5.61)	(3.00)	
POP	−2.530	−0.712	−0.321*
	(−1.37)	(−1.38)	(−4.47)
IR	0.155	−0.013	−0.023*
	(1.56)	(−0.49)	(−3.01)
RRI	−1.901*	−0.188	−0.169*
	(−2.85)	(−1.23)	(11.98)
TR	0.019	0.001	–
	(1.59)	(0.26)	
INTERN	0.011	0.006**	–
	(1.03)	(1.98)	
MOB	0.032**	0.005	–
	(2.42)	(1.37)	
TREND	−0.366*	−0.074*	0.044*
	(−5.67)	(−3.06)	(33.00)
COMP_TR	4.112**	0.004	–
	(2.18)	(0.01)	
COMP_INTERN	2.613	−0.538	–
	(1.61)	(−1.11)	
COMP_MOB	−1.026	0.230	–
	(−1.12)	(0.80)	
PRIV	0.867**	–	0.030*
	(2.39)		(2.92)
Diagnostics			
Observations	465	465	468
Adjusted R^2	0.874	0.741	0.981
F-statistic	21.819*	43.604*	3624.56*
	[0.00]	[0.00]	[0.00]

The numbers in parentheses are the t-ratios. The numbers in square brackets are the p-values. Significant at *1%, **5% and ***10% respectively.

From the main findings, it is evident that an increase in the level of economic growth (GDP/capita) leads to an increase in the per capita investment as expected by the theory. The relevant elasticities range from 1.585 to 7.996 (columns 1 and 2). This finding is in alignment with other empirical studies (Cadman, 2007; London Economics, 2006; Röller and Waverman, 2001) highlighting the strong and statistically significant relationship between the level of economic growth and the telecommunications investment ("the accelerator effect"). The positive relationship can be explained by the fact that as GDP per capita rises due to economic growth, company sales, cash flows and profits, rise too. Expectations of higher future profits and increased business confidence encourage telecommunications companies to increase output and invest in property, plant and equipment (London Economics, 2006). The population density (POP) does not affect the level of investment, a fact that is consistent with other empirical studies (see for example London Economics, 2006).

Similarly, variations in the level of real interest rates (IR) leave unaffected the telecommunications investment activity, since the

[7] The real long-term interest rates are calculated by using the Fisher equation as follows: Real interest rates $=\frac{(1+IR)}{(1+INFL)}-1$, where IR stands for the nominal interest rates, and INFL for the inflation.

[8] Due to data unavailability for the variables TR, INTERN and MOB, the estimated period was restricted to cover the years 1988–2007.

relevant coefficients are not statistically significant in all of the different methodologies and specifications used. This finding can also be traced in Cadman (2007), in which real interest rates are weakly and negatively related to the dependent variable.

On the contrary, the regulation as measured by the OECD regulatory reform index (RRI) is found to be statistically significant at 1% in the first specification (see column 1). This relationship is consistent with the economic theory revealing that a better regulatory environment for telecommunications is definitely associated with better performance in the sector, measured by the per capita real telecommunications investment activity. The sign of this variable is negative indicating that an increase in the relevant index, meaning that the regulatory environment in the OECD countries is getting worse, leads to a recession in the level of investment activity.[9] On the contrary, a decrease in the RRI, by implementing effective regulatory measures in the OECD countries, is related to an increase in the dependent variable (INV), which is supporting other empirical studies (Cadman, 2007; Gutierrez, 2003b). This is explained by the theory since investors are usually looking for a stable environment where investments are insulated from arbitrary administrative action, sudden shifts in policy or market conditions.

The level of market shares of the new entrants in the trunk telephony segment (TR) may not affect the level of investment since the relevant coefficients are not statistically significant. On the contrary, the market opening in the international telephony segment (INTERN) may play a significant role in the investment activity since the estimated coefficients are positive and in one case statistically significant (see column 2). Similar findings may be traced in the relationship between the competitive conditions in the mobile sector (MOB).

Competition in the trunk (COMP_TR) and, to a lesser extent, in the mobile market segment (COMP_MOB) is also positively associated with an increase in the level of investment. This finding is supported by the theory since rigorous competition among network owners is believed to safeguard consumers against incumbents' attempts to extend their monopoly power into adjacent markets and boosts investment activity. On the other hand, the opening of the international market segment seems to leave unaffected the investment activity because the relevant coefficients are not statistically significant and in one specification they have a negative sign (see column 2). The negative sign is attributed to the fact that price competition (à la Bertrand) is likely to reduce the returns on investment. Given the magnitude and the existence of sunk cost in the telecommunications expenditures, and the fact that they are characterized by high risk, diminished returns could greatly reduce incentives to invest (Woroch, 1998). This finding conforms to other empirical studies (Ros and Banerjee, 2000). However, we must bear in mind that the empirical research has shown mixed results on the direction of causality between effective competition and telecommunications investment. The final effect on investment depends on a number of market parameters such as the interaction between incumbents and entrants, the nature of pre-entry and post-entry regulations and the industry structure of the sector (Woroch, 1998).

Privatization is also positively associated with investment activity since the relevant coefficient (0.867) is positive and significant at 5%. This result supports Li and Xu's (2002) finding that privatization has a positive effect on per capita investment, as well as competition.

The economic effect of competition regarding the mobile market segment is less than that of privatization since the estimated coefficients range from −1.026 to 0.230 compared to 0.867 (PRIV), which reveals a weak relationship. This could be explained by the fact that competition in the mobile market segment is a relatively new phenomenon in many OECD countries. It is worth mentioning that in 2007, governments still hold the control of the largest mobile operator in countries pursuing telecommunications privatization schemes, such as Luxembourg (100%), Norway (54%), Belgium (53.5%) and Switzerland (55%).

On the contrary, the coefficient of the dummy variable trunk competition (COMP_TR) exceeds the coefficient measuring the impact of privatization (4.112 > 0.867). This means that competition in the long-distance telephony services goes hand in hand with effective deregulation. From the aforementioned results, it is evident that structural reform involving privatizing former state-owned operators, allowing competition and implementing a better regulatory framework, attracts telecommunications investments. Finally, note that the coefficient on the time trend is negative and statistically significant in all of the specifications, denoting the absence of the technological effect.

Similar results are provided by the estimation of output equation (see Eq. (3)). More specifically, the estimated parameters of the aggregate production equation indicate that per capita investment is positive (0.051) and highly statistically significant. This means that the increasing investment activity is one of the key drivers that boost economic growth. On the other hand the elasticity of population density (POP) is statistically significant but comes with the alternate sign (−0.321). Similarly, we find that the coefficient on the long-term interest rates in the aggregate production equation is negative and statistically significant. This suggests that a decrease in the level of long-term interest rates stimulates the economic growth. The magnitude of this effect is in alignment with other empirical studies (Cadman, 2007; London Economics, 2006).

The regulatory environment (RRI) in the telecommunications sector does affect the level of economic growth. The magnitude of the elasticity equals −0.169. This finding implies that a better regulatory environment for telecommunications is definitely associated with better performance in the economy as a whole measured by the per capita GDP (Cadman, 2007; Henisz and Zelner, 2001; London Economics, 2006; Röller, and Waverman, 2001).

Furthermore, privatization of the telecommunications sector has a positive and statistically significant impact on the economic activity, revealing that structural reforms such as the sale of a former state-owned telecommunications utility coincide with economic growth. Finally, the coefficient on the time trend is positive and statistically significant (0.044) as expected by the economic theory. This finding, in contrast to other empirical studies (see Röller and Waverman, 2001), implies that technological development boosts economic growth.

4.2. Dynamic panel data techniques

The previous analysis was performed within a static framework. In order to check for the robustness of our findings and allow for the dynamic aspects in our models we proceed by using dynamic panel data techniques, such as dynamic generalized method of moments (DGMM) (Arellano and Bond, 1991) and cointegration analysis. It is worth mentioning that among the GMM, the estimators by Arellano and Bond (1991) are the most widely applied in empirical analysis (Gutierrez, 2003b).

Consider the simple dynamic model with invariant individual term α_i,

$$y_{it} = \beta y_{it-1} + \alpha_i + \varepsilon_{it}. \quad (4)$$

[9] In contrast to the ECTA Scorecard, a low score in the RRI is attributed to countries with the best regulatory environment. It is noteworthy that in countries with effective regulation and low values of RRI index, such as the USA and the United Kingdom, the per capita investment in the telecommunications sector is significantly high compared to other countries (i.e., Greece, Spain, Portugal, etc.).

Fist differences eliminate the invariant individual term α_i and the model becomes

$$y_{it}-y_{it-1}=\beta(y_{it-1}-y_{it-2})+\varepsilon_{it}-\varepsilon_{it-1}. \quad (5)$$

By extending the dynamic model (4) with additional independent variables (Hansen, 1982), we get

$$y_{it}=\beta y_{it-1}+\gamma x_{it}^{'}+d_{it}\delta^{'}+\alpha_i+\varepsilon_{it} \quad (6)$$

where notation of terms is as before.

Accordingly, our dynamic model specifications become as follows:

$$\begin{aligned}INV_{it}=a_0&+a_1\overset{+}{GDP}_{it}+a_2\overset{+}{POP}_{it}+a_3\overset{-}{IR}_{it}+a_4\overset{-}{RRI}_{it}+a_5\overset{+}{TR}_{it}\\&+a_6\overset{+}{INTER}_{it}+a_7\overset{+}{MOB}_{it}+a_8\overset{+}{T}_{it}+a_9\overset{+-}{COMP\_TR}_{it}\\&+a_{10}\overset{+-}{COMP\_INTERN}_{it}+a_{11}\overset{+-}{COMP\_MOB}_{it}+a_{12}\overset{+-}{PRIV}_{it}+\varepsilon_{it}\end{aligned} \quad (7)$$

and

$$\begin{aligned}GDP_{it}=b_0&+b_1\overset{+}{INV}_{it}+b_2\overset{+-}{POP}_{it}+b_3\overset{-}{IR}_{it}+b_4\overset{-}{RRI}_{it}+b_5\overset{+}{T}_{it}\\&+b_6\overset{+-}{COMP\_TR}_{it}+b_7\overset{+-}{COMP\_INTERN}_{it}\\&+b_8\overset{+-}{COMP\_MOB}_{it}+b_9\overset{+-}{PRIV}_{it}+\varepsilon_{it}.\end{aligned} \quad (8)$$

Table 2
Panel unit root test results.

Variable	Levin, Lin and Chu-*t* test	Im, Pesaran and Shin W-tests	ADF-Fisher Chi-square	PP-Fisher Chi-square	Hadri z-statistic
Levels					
INV	−2.19**	–	59.87	73.27	12.91*
GDP++	4.15	4.00	1.87	62.49	8.83*
POP+	−1.31***	1.90	20.12	19.61	16.00*
IR+	−8.96*	−9.06*	206.14*	339.79*	3.87*
RRI++	1.75	2.31	1.62	38.29	7.92*
TR+	1.00	9.13	19.72	16.58	12.37*
INTER+	−0.96	7.58	29.96	25.95	13.32*
MOB	0.97	1.95	2.76	44.76	9.89*
First differences					
Δ(INV)	−26.81*	–	607.39*	623.85*	1.76**
Δ(GDP)++	−8.36*	0.37	−6.37*	161.12*	7.42*
Δ(POP)+	−6.13*	−7.08*	71.02*	67.41*	1.16
Δ(IR)+	–	–	–	–	–
Δ(RRI)	−10.73*	−11.86*	−10.34*	206.61*	0.84
Δ(TR)	−8.44*	−9.44*	195.38*	197.95*	2.02**
Δ(INTER)	−10.04*	−8.00*	169.86*	159.67*	1.90**
Δ(MOB)	−9.02*	−6.00*	−6.89*	146.57*	1.85*

Under the null hypothesis Hadri test assumes the absence of a unit root whereas the other unit root tests assume a unit root. The lag lengths were selected by using Schwarz criterion. + denotes the inclusion of an individual intercept as an exogenous regressor, ++ denotes the inclusion of an individual intercept and trend as exogenous regressors. Significant at *1%, **5% and ***10% respectively.

4.2.1. Stationarity and cointegration

To test for the existence of a unit root in a panel data setting (test for integration), we use various econometric tests (Im, Pesaran and Shin W-test, Fisher type tests, Levin, Lin and Chu-*t* test, and Hadri test). In all the above tests except for the Handri test, the null hypothesis is that of a unit root. Applying the relevant tests (Table 2), we observe that the null hypothesis of a unit root cannot be rejected at 5% critical value for all of the relevant variables, except for the real long-term interest rates (IR). In other words, all variables but IR, are integrated of order one I(1). IR is stationary, and thus, it has been excluded from further analysis.

Next, panel cointegration tests are used in order to draw sharper inferences, since time spans of economic time series are typically short. The basic idea behind cointegration is that if in the long-run, two or more variables move closely together, the linear combination between them is stationary and hence we may consider those series as defining a long-run equilibrium relationship (Hall et al., 2012; Paleologos, 1996; Paleologos and Papazoglou, 2008). In order to investigate the existence of one or more cointegrated vectors we apply several tests (Johansen, 1988; Kao, 1999; Pedroni, 1999).

Table 3 presents the results of the panel cointegration tests. It is clear that the null hypothesis of no cointegration is rejected at the 1% level. Specifically, by employing the Fisher test, (Johansen, 1992; Maddala and Wu, 1999), it is evident that there is one cointegrating vector at the 5% level.

4.2.2. Empirical results and interpretation

In this section, we present our empirical findings from the estimation of the long-run (cointegrated) equations. The models are estimated incorporating corrections for autocorrelated errors within cross-sectional units (Pedroni, 2000). In order to handle cross-section fixed effects we use differenced data in the estimation procedure (Arellano and Bond, 1991).

Focusing on our telecommunications investment variables (Table 4), we conclude that under the assumption of full exogeneity, a better regulatory environment is always positively associated with better telecommunications performance in a dynamic context, confirming the results obtained in the static model.

Furthermore, an increase in the relevant level of economic growth (GDP/capita) leads to an increase in per capita investment confirming the previous findings. However, the relevant elasticities are on average higher than their static model counterparts, ranging from 1.172 to 1.371. Moreover, the estimated coefficient of the lagged dependent variable INV(−1) is positive and equal to 4.775 (column 2). Similarly to the static model, population density is not statistically significant in explaining the performance of the telecommunications sector.

The level of market shares of the new entrants in the trunk telephony segment (TR) is positively related to the level of investment, implying that an increase in the number of the competitors in the relevant market will tend to lower market concentration fostering investment activity. This finding is consistent with the well-known Structure–Conduct–Performance paradigm (S–C–P) of industrial organization, first introduced by Bain (1968).[10] Similarly, the market opening in the international telephony segment (INTERN) and mobile market segment (MOB) plays a significant role in the investment activity since the estimated coefficients are positive and statistically significant. Competition in the trunk (COMP_TR) and in the international market segment (COMP_INTERN) is also positive and statistically significant only in one specification (column 2). Moreover, privatization is also positively associated with the investment activity. This means that the transfer of the ownership of the vertically integrated state-owned utilities into a more competitive and privatized telecommunications schemes increases the investment activity of the stakeholders, generating multiple effects in the economic activity.

Finally, the underlying estimated equations pass a series of diagnostic tests. More specifically, the instrument rank is greater than the number of estimated coefficients, while the reported J-statistic cannot reject the null hypothesis implying that the instrument list satisfies the orthogonality conditions.

[10] This model attempts to assess the performance of a given industry and explain the two-way causal links and relationships that exist among key variables that run the S–C–P model. The key concept of this paradigm is that market performance is determined by the conduct (behavior) of market participants, which in turn, is determined by market structure and vice versa.

Table 3
Panel cointegration tests.

Dependent variable	Fisher (combined Johansen)	Kao (Engle–Granger based)	Pedroni (Engle–Granger based)
INV	*Trace statistic* 105.0* [r = 0] 26.0 [r >= 1] *Maximum eigenvalues* 88.5* [r = 0] 26.1 [r >= 1]	−2.45*	−183.58* (panel v-statistic) 4.08* (panel rho-statistic)
GDP	*Trace statistic* 125.9* [r = 0] 17.59 [r >= 1] *Maximum eigenvalues* 102.4* [r = 0] 26.91 [r >= 1]	−2.59*	−0.86* (panel v-statistic) 4.06* (panel rho-statistic)

Notes: Null hypothesis implies absence of cointegration, while r denotes the number of cointegrating equations with no deterministic trend. Significant at *1% level of significance.

In columns 3 and 4 we try to determine the main parameters that affect the level of economic activity in the OECD countries. Specifically, the estimated parameters indicate that per capita investment is positive and significantly associated with per capita GDP.

The regulatory environment in the telecommunications sector is one of the main GDP drivers. The relevant elasticities are −0.042 and −0.031 respectively, which are a little higher than those of the static model. The coefficient on the time trend is positive and significant in both specifications (0.035 and 0.014 respectively) capturing the technological effect in the economic activity. On the other hand privatization of the telecommunications sector has a positive but not significant impact on the economic activity, implying that the effect of the privatization in the real economy is rather ambiguous. Finally, the estimates meet the usual diagnostic tests.

Table 4
Empirical results of the dynamic panel.

Variable	(1) Dependent variable INV	(2) Dependent variable INV	(3) Dependent variable GDP	(4) Dependent variable GDP
GDP	1.172*	1.371**	–	–
	(3.85)	(2.64)		
INV	–	–	0.010***	0.007***
			(1.48)	(1.55)
GDP (−1)	–	–	–	0.329**
				(1.84)
INV (−1)	–	4.755**	–	–
		(1.91)		
POP	−4.257	−6.854	−0.414	−0.282
	(−0.89)	(−0.15)	(−0.54)	(−0.85)
RRI	−0.125**	−0.144**	−0.042***	−0.031**
	(−2.89)	(−1.99)	(−1.62)	(−2.40)
TR	0.147**	0.227**	–	–
	(2.08)	(2.29)		
INTERN	0.015**	0.076**	–	–
	(1.78)	(2.20)		
MOB	0.032**	0.061**	–	–
	(2.14)	(2.31)		
TREND	0.879***	1.115**	0.035**	0.014***
	(1.57)	(2.05)	(2.38)	(1.64)
COMP_TR	1.425	0.199**	0.051	–
	(0.742)	(2.01)	(−0.79)	
COMP_INTERN	−0.873	0.097**	0.117	–
	(−0.102)	(2.23)	(−1.19)	
COMP_MOB	7.333***	2.439	−0.029***	–
	(1.52)	(0.44)	(−1.59)	
PRIV	0.028*	0.045**	−0.148	0.052
	(3.25)	(2.31)	(−1.21)	(0.89)
Diagnostics				
Observations	498	498	498	498
S.E. of regression	0.428	0.229	0.053	0.029
Instrument rank	14	14	17	14
J-statistic	0.432	0.480	5.024	3.281
	[0.933]	[0.783]	[0.540]	[0.656]

The numbers in parentheses are the t-ratios. The numbers in square brackets are the p-values. Significant at *1%, **5% and ***10% respectively.

5. Concluding remarks and policy implications

In this paper we try to investigate the relationship between telecommunications investments and regulation, and assess whether economic growth is affected by a better regulatory environment in the OECD countries. For this reason, we consider a model covering thirty OECD countries for the period 1988–2010 applying static and dynamic panel data econometric techniques. We find a significant relationship between telecommunications investment and effective regulation in all of the alternative specifications used. Concretely, in all specifications, the coefficients are significant, reinforcing the importance of a sound regulatory framework. It is noteworthy that the estimates of the two econometric techniques (static and dynamic models) are similar, revealing the robustness of the empirical results. Privatization is also positively associated with investment activity. The magnitude of the estimated coefficient denotes that strengthening of the privatization policies will increase the per capita investment.

The regulatory environment in the telecommunications sector does affect the level of economic growth. This finding implies that a better regulatory environment for telecommunications is definitely associated with better performance in the economy as a whole, measured by the per capita GDP. Privatization of the telecommunications sector has a positive and significant impact on the economic activity.

The message for policy makers is that effective implementation by the national regulatory authorities in order to foster competition helps to achieve one of the policy goals set out in the Community Directives that is to encourage investment. This can be implemented by pursuing policies aiming at the removal of entry barriers, empower consumers and prevent discrimination by owners of bottleneck assets.

Given the above considerations, our analysis can be further extended in order to tackle a number of constraints which may be addressed in future work. An analysis using more disaggregated firm level data (i.e., cost of capital, mergers and acquisitions, company performance, etc.) may enrich our conclusions. Given the validity of the econometric results, the regulatory reform index may be improved with the addition of new parameters especially those regarding price formulation. Furthermore, as more information and data become available, especially at the firm level, and more companies enter the telecommunications sector, more in-depth analysis can be made in order to examine aspects that are not covered by the OECD database, since it may not collect information from all the new small entrants. Such a consideration will better capture the competitive dynamism of the telecommunications sector and lead the research to further outcomes concerning consumer policy.

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Appendix A

Table A1
Summary statistics for variables used in econometric analysis (1988–2010).
Source: Authors' elaboration.

	Investment/capita	Real GDP/capita	Population density	Real long-term interest rate	Regulatory Reform Index	Trunk market	International telephony market	Mobile market
Statistical measures								
N-obs	683	679	689	612	690	600	600	600
Cross sections	30	30	30	30	30	30	30	30
Mean	5.00	10.20	4.30	1.11	0.90	15.00	20.50	31.40
Median	4.94	10.18	4.69	0.86	0.87	5.05	13.90	34.14
Maximum	10.10	11.20	6.70	28.77	1.80	68.80	84.70	88.00
Minimum	1.80	9.10	0.80	−7.73	−2.00	0.00	0.00	0.00
Standard deviation	0.70	0.42	1.38	1.90	0.79	18.14	22.42	23.16
Coefficient of variation	0.14	0.04	0.32	1.71	0.88	1.21	1.09	0.74
Correlations								
Investment/capita	1.00							
Real GDP/capita	0.21	1.00						
Population density	−0.10	−0.14	1.00					
Real long-term interest rates	−0.01	0.07	0.02	1.00				
Regulatory Reform Index	0.04	−0.37	0.02	−0.04	1.00			
Trunk market	−0.01	0.40	−0.07	0.15	−0.82	1.00		
International telephony market	0.01	0.46	−0.02	0.01	−0.82	0.88	1.00	
Mobile market	−0.17	0.24	0.05	−0.003	−0.77	0.65	0.73	1.00

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