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DEPLOYMENT OF BROADBAND PLATFORMS: EMPIRICAL EVIDENCE OF A REGULATION FAILURE[*1]

XAVIER FAGEDA
MONTSERRAT TERMES-RIFÉ
Universitat de Barcelona

RAFAEL RUBIO-CAMPILLO
Comisión Nacional de los Mercados y la Competencia
Universitat de Barcelona

This work tries to analyze why, in certain countries, the rivalry between broadband platforms has no effect on broadband deployment. Controlling for demographic features and network variables, we focus on analyzing the impact of regulations on the competitiveness of platforms offering an alternative to the dominant platform (xDSL). To reach this objective, this paper draws on data from cable and optical fiber platforms in the Spanish market. We find that the impact of different regulatory frameworks has critically affected the competitiveness of cable platforms and, in consequence, harmed inter-platform competition. By contrast, our results show that regulation is not discouraging the current spread of optical fiber platforms.

Key words: regulation failure, broadband competition, optical fiber platform, cable platform, investment.

JEL classification: L38, L51, L52, L96.

Maximizing the deployment of broadband networks has been a priority for many governments, who see, in the spread of these new platforms, an opportunity for economic growth and for increasing the productivity of firms. In keeping with this aim, several studies have sought to identify those variables that might encourage a greater distribution of this service across the population.

Inter-platform competition –the competition arising from the rivalry between different technological platforms– has been identified as the most common driver of broadband adoption [Distaso *et al*. (2006); Bouckaert *et al*. (2010)]. However, Fageda *et al*. (2014) showed that the key factor accounting for the development of the broad-

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band market in Spain was competition based on the regulated access of alternative operators to the network of the incumbent operator (or intra-platform competition).

A possible explanation for the modest effect of inter-platform competition in the Spanish market concerns the insufficient development of cable platforms, which have been the main competitor to the dominant broadband platform (xDSL) developed from the traditional public telephone network. The hypothesis we test in this paper is that the regulatory framework designed for the deployment of cable platforms could have skewed the decisions taken by operators with regard to the geographical areas in which they should concentrate their investments. If this is the case, it means that a regulatory failure has precluded the optimal deployment of cable platforms in the Spanish market by distorting economic incentives. According to Sidack and Spulber (1997), the regulator's attenuation of economic incentives would create additional efficiency problems.

Here, we examine, econometrically, the factors influencing the deployment of two distinct technologies –cable platforms and optical fiber platforms– using data for the Spanish provinces during the initial years of development of these technologies. It should be borne in mind that the regulatory frameworks designed for each technological platform were very different in Spain and that this probably conditioned the operators' differing investment location strategies.

Regarding that, similarities at the demand and supply levels between cable and fiber allow us to identify the impact of the different regulatory frameworks. On the demand side, the residential user has been the main target of the cable and optical fiber companies. Several reports by the Spanish regulatory agency show that the volume of residential users among cable and optical fiber operators exceeded 85% of their total client portfolio [CMT (2005); CMT (2006); CMT (2010); CMT (2011)]. On the supply side, both technologies offer a high quality product in relation to alternative products in the market (mainly xDSL technology). In the early 2000s the cable platforms were offering a higher bandwidth than xDSL. This is also the case for optical fiber technology, which, in 2010, offered higher speed data transmission than xDSL technology. Also, unlike xDSL, both technologies are able to offer a product bundling different services, including pay-per-view TV. Pay-per-view television services on xDSL platforms were much more limited and did not reach an optimum level of quality. That is the reason why most Spanish xDSL operators made plans to deploy optical fiber networks, from 2009.

Very few studies have analyzed the impact of regulation on investments of this type. Exceptions are Briglauer *et al.* (2013) and Briglauer (2014), which analyzed the impact of regulating access to the xDSL network[2] on the deployment of alternative telecommunication platforms (cable or optical fiber). Here, however, our fo-

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(2) National Regulatory Agencies based their decision to regulate access to xDSL networks on the so-called "investment ladder" theory [Cave (2003); Cave *et al*. (2001)]. In a first phase, this theory justified the obligation to provide access to the incumbent operator's network as a way of reducing entry barriers to new operators. A second phase consisted in promoting investment from the latter in their own infrastructures, in order to increase competitiveness with respect to the costs of the incumbent operator. Thus, the regulation of access to the xDSL network of the incumbent operator (Telefónica de España) allowed the entry of many alternative operators in the market.

cus is on determining the role played by the regulatory framework specifically designed for alternative networks to xDSL technology. Furthermore, the fact there are two types of operators deploying optical fiber platforms discourages analysis of xDSL regulation. Indeed, the operators which have invested in optical fiber platforms are formed, on the one hand, by the incumbent xDSL operator that owns the regulated xDSL platform and, on the other hand, the alternative xDSL operators that demand this regulated xDSL service. The different nature of these operators makes it difficult to identify the effect of xDSL regulation on optical fiber investments as it depends on the type of optical fiber operator.

To carry out the study, we first need to identify the main explanatory variables of the level of deployment of broadband platforms. Extensive literature finds several links between investment in telecommunication platforms and the attributes of countries or regions, such as income per capita [Friederiszick *et al*. (2008); Montolio and Trillas (2013)], education and age of the population [Fairlie (2004); Goldfarb and Prince (2008); Horrigan (2009)], population density [Chung (2006)] and market size [Prieger (2003); Tang (2009)]. Hence, our empirical analysis takes into account the different drivers of investment in broadband platforms, as identified by the literature.

We assume that one of the primary goals of regulatory policy is to promote competition for the benefit of consumers. In this regard, this article firstly, identifies a case of regulation failure in the Spanish broadband market and secondly, highlights the detrimental effects this regulatory policy has had in relation to the objectives it was designed to meet.

The rest of the paper is organized as follows. Section 1 analyzes the regulatory policy applying to the alternatives to xDSL broadband technology (that is, cable and optical fiber). In Section 2, we present the empirical model explaining the spread of broadband services via cable and optical fiber platforms and discuss the results. Finally, Section 3 summarizes the findings and concludes the paper.

1. Regulatory framework for deploying cable and optical fiber platforms in Spain

In the early 1990s, the regulatory framework that would determine the deployment of cable networks in Spain was designed. Thus, the Cable Telecommunications Act (Act 42/1995 of December 22) determined that cable operators required a prior grant, in the form of a government concession, to initiate their investment in cable networks. Furthermore, it was stipulated that cable operators had to provide their telecommunication services in specific geographical zones. In keeping with this objective, the Spanish government divided the national market into 43 geographical zones.

The Act also established that a maximum of two cable operators could operate in each geographical zone, but that the first of the two government concessions for each zone would be granted to *Telefónica de España* –the former public monopoly– in those areas in which this operator expressed an interest in providing cable services. In the case of the second government concession for each zone, the law stipulated that these would be granted on the basis of public tenders.

In the case of the first concession granted in each zone to *Telefónica de España*, this operator never deployed cable platforms in Spain, as it preferred to offer broadband services via xDSL platforms. The second concession was granted to 29 different cable operators, across the 43 geographical zones, in which a total of 74 different firms participated. This fragmentation of the ownership of cable operators was, in many cases, detrimental to their decision making. In contrast, their main competitor, *Telefónica de España*, enjoyed full autonomy in its strategies, which gave it a significant strategic advantage over the cable operators.

Past studies point to the existence of economies of scale and density in firms that operate in network industries [Douglas and Christensen (1988); Sidak and Spulber (1998)], specifically in the telecommunications sector [Ng (2012); Mancuso (2012)]. That is, they have found a positive and significant effect of these variables (population density and network size) on the competitiveness of firms. In this sense, the division of the territory into zones limited exploitation of the market through economies of scale and density. Further, the long-term investment commitment made by cable operators in each zone meant they were unable to choose where to concentrate their investments in order to maximize economies of scale and density.

It should be noted that the national regulation that determined the expansion of cable networks in Spain was not integrated into a coordinated regulatory policy at the European Community level. In relation to this, it can be said that the European cable operators became regulated by the Community framework, from 2002, in the field of Electronic Communications[3] (known as the Telecom package). By then, practically all European countries (including Spain) had developed their own national cable deployment plans. It should be noted that the deployment of cable platforms has never been affected by specific regulatory access obligations within this community framework.

The deployment of optical fiber networks began more than a decade after the birth of cable networks in Spain, but today this new technology has entered a phase of substantial expansion. Interestingly, the regulatory framework of these platforms is quite different from that governing cable platform. It was in 2009 that Spain's regulatory commission for telecommunication services (*Comisión del Mercado de las Telecomunicaciones*, CMT) finally approved measures to manage the deployment of new optical fiber networks[4]. The CMT ruled that the geographic market for these would comprise a single zone covering the entire national territory.

Additionally, *Telefónica de España* was identified as an operator with significant market power (SMP) and, as such, the Spanish regulator –CMT– imposed specific obligations on the firm. *Telefónica* was required to provide access to its civil works infrastructure (ducts and chambers) to other operators at prices calculated to cover production costs.

(3) The "Telecom package" defined the European regulatory framework and was aimed at making the electronic communications networks and services sector more competitive. It was formed by directives 2002/21/CE (framework), 2002/20/CE (authorization), 2002/19/CE (access), 2002/22/CE (universal service) and 2002/58/CE (privacy and electronic communications). Subsequently, in 2009, these directives were modified by the directives 2009/140/CE (better regulation) and 2009/136/CE (citizens' rights).

(4) On 22 January 2009, the CMT board approved the definition of the market for wholesale (physical) network infrastructure access at a fixed location and wholesale broadband access, the designation of an operator with significant market power, and the enforcement of specific obligations (file nº. MTZ 2008/626).

Alternative optical fiber operators (unlike cable operators) were thereby free to invest in any part of the national territory, and use *Telefónica's* infrastructure, so reducing their deployment costs. The CMT noted that the civil works infrastructure could hardly be replicated by new entrants as this would represent between 50 and 80% of their total investment [CMT (2009): pp. 71]. Thus, the aim was to reduce the investment costs of these alternative optical fiber operators. In relation to bitstream wholesale access to Telefónica's optical fiber network, we must point out that the first regulatory measures were taken by CNMC after the period analyzed in this paper [CNMC (2014)].

The regulation of optical fiber platforms at the national level arose from the Community regulatory framework, applied from 2002, in the field of electronic communications. Regarding this, the European Commission published the Recommendation of 17 December 2007, on relevant product and service markets within the electronic communications sector, liable to *ex ante* regulation in accordance with Directive 2002/21/EC. The availability of wholesale access to network infrastructure at a fixed location was one of the service markets that, according to the aforementioned recommendation, may be subject to *ex ante* regulation. Based on this, the CMT analyzed the access market to broadband networks in Spain and established, in 2009, the main guidelines that would regulate the spread of fiber optic networks, as we have explained above.

In both cases –cable and optical fiber platforms– the operators only began to invest once the national regulatory agencies (NRA) had designed the regulatory framework. To shed light on this process, the following table lists the number of installed accesses[5] by main broadband platforms in the early years of the first and second decades of the current century. It is worth noting that these two periods were the early phases of deployment, corresponding to cable (2003-2005) and optical fiber platforms (2011-2013), respectively.

Table 1: Number of installed accesses by broadband platforms

	Copper pairs (xDSL)	Cable (HFC)	Optical Fiber (FTTx)	Other	Total
2003	17,662,787	5,458,569	–	444,511	23,565,867
2004	16,977,593	6,338,897	–	420,104	23,736,594
2005	16,762,566	7,219,129	–	413,978	24,395,673
2011	16,065,690	9,497,692	2,290,986	248,914	28,103,282
2012	15,740,106	9,797,680	3,925,149	236,754	29,699,689
2013	15,539,052	10,038,178	6,875,813	279,072	32,732,115

Source: *Comisión Nacional de los Mercados y la Competencia* (CNMC).

(5) Installed accesses are defined as those broadband accesses that are currently operative or which could become operative at short notice.

Table 1 shows that the most prevalent platforms in the territory are based on xDSL technology. Using this technology, the incumbent (*Telefónica de España*) and alternative xDSL operators offer broadband services. The prevalence of cable platforms has increased throughout the territory in recent years, although the annual growth rates have been falling. In the case of the latest optical fiber platforms, the annual growth of installed accesses has recently increased exponentially, and it is expected that the number of optical fiber accesses will soon exceed those of cable.

Below, we analyze how the alternative broadband platforms of cable and optical fiber have been deployed throughout the territory. If the investment decisions taken by the operators were based on purely economic reasoning, the two platforms should show similar patterns in terms of the location of their investments. However, if we find very different results for the two platforms, this would support the hypothesis that the regulatory framework has prevented both of these platforms from optimizing their investments in the territory.

2. Empirical analysis of regulatory policies applied to the broadband market

In this section, we assess whether the deployment of cable and optical fiber platforms in Spain has been optimal. As discussed, it should be stressed that the competitiveness of these operators will be determined by the fact that they can take advantage of the economies of scale and density present in telecommunication networks. Thus, if our results reject this hypothesis –that is, an optimal network deployment– then we would conclude that this situation had damaged the competitiveness of the operators. At the same time, this factor would have weakened the effectiveness of inter-platform competition and made intra-platform competition the driving force behind the spread of broadband services in Spain.

The empirical literature has identified the variables that account for the location of broadband operator investments. Briefly, the following table summarizes the characteristics of demand that, according to the economics literature, identify those areas where operators focus their investments in broadband platforms, regardless of the type of technology they employ.

As noted above, we analyze whether these variables have effectively determined the zones in which Spanish cable operators have focused their investments. This exercise is replicated for optical fiber operators. Once we have identified the variables that explain the deployment of cable and optical fiber platforms in the Spanish market, we analyze the role played by regulation, with respect to the economic efficiency of investments.

2.1. Data

In this section, we describe the data and variables used to estimate a model that accounts for the volume of stock investment in broadband platforms at the provincial level (NUTS-3 level). Specifically, we present the dependent variable and the explanatory variables used.

In the case of the dependent variable, several previous studies use the stock of civil infrastructure deployed by operators as their approximation of the level of stock investment [Briglauer *et al*. (2013); Friederiszick *et al*. (2008)]. Here, the dependent

Table 2: Demand features explaining investment in telecommunication networks

Variable	Empirical evidence	Literature
Income per capita	The level of income per capita has a positive and significant effect on investment in telecommunication platforms.	Horrigan (2009); Goldfarb and Prince (2008); Fairlie (2004); Friederiszick, H., Grajek, M. and Röller, L. (2008); Montolio and Trillas (2013)
Education	Education is one of the driving forces promoting investment in broadband platforms.	Horrigan (2009); Prieger (2003); Fairlie (2004); Goldfarb and Prince (2008)
Population density	There is a positive and significant relationship between population density and total investment in broadband platforms.	Montolio and Trillas (2013); Chung (2006)
Market size	Market size positively affects investment in broadband platforms.	Prieger (2003); Tang (2009)
Population distribution by age	The higher the average age of population, the lower the level of investment in telecommunications.	Horrigan (2009)

variable (INFR) is built from the accesses installed by the operators of a given technology (cable or optical fiber), located in each of the Spanish provinces. Broadband access data are taken from the information required by *Comisión Nacional de los Mercados y la Competencia*[6] (CNMC) from the Spanish telecom operators. The data have been directly extracted from this source. Since 2006, the *Informe de penetración de servicios finales y de infraestructuras de Telecomunicaciones* –an annual report of the Spanish regulatory agency of telecommunications– publishes information

(6) At the end of 2013, the Spanish government created a new regulator (*Comisión Nacional de los Mercados y la Competencia*, CNMC) with the aim of reforming the institutional framework of competition and regulatory policies. This agency absorbed the Spanish competition authority (*Comisión Nacional de Competencia*, CNC) and practically all industry regulators (*Comisión del Mercado de las Telecomunicaciones*, CMT; *Comisión Nacional de la Energía*, CNE; and *Comisión Nacional del Sector Postal*, CNSP).

about the stock in facilities in broadband platforms. Furthermore, it can currently be found in the CNMC database (CNMC *Datos estadísticos* <http://data.cnmc.es>).

In order to estimate the deployment of cable platforms, we collected data from the eleven largest cable operators (Auna; Euskaltel; MED Telecom; ONO; Procono; R Cable and telecommunications Coruña, SA; *R Cable y Telecomunicaciones Galici*a; RETECAL *sociedad*; Castilla-Leon telecommunications; *Telecable de Asturias*, and Tenaria), from 2003 to 2005. Note that this sample includes the full supply of cable services throughout the national territory. However, data are not available for all operators for all the years in this period, mainly due to the intense process of mergers that occurred.

The sample only includes data from between 2003 and 2005 because we wished to focus on the investment decisions made by operators in the first few years of activity, given that these decisions had a decisive bearing on their future cost-effectiveness[7]. Moreover, in this way we are able to compare these results with those obtained for optical fiber platforms, which currently find themselves in a similar initial phase (i.e. similar to that experienced by cable platforms between 2003 and 2005).

To estimate optical fiber deployment, the data set comprises data from 2011 to 2013, for the same provinces as identified above for cable operators. Here, we include five operators (Colt Telecom; Jazztel; Orange; *Telefónica de España*, and Vodafone) which, together, accounted for the entire optical fiber supply in the country during that period.

Regarding that, we should point out that the characteristics of the cable and optical fiber operators entering the market were slightly different. The majority of the cable operators, as with optical fiber operators, were subsidiaries of multinational corporations, but there were some cable operators with majority ownership of regional companies (Euskaltel and Telecable). Nevertheless, this potentially confounding factor should have a modest effect in our results.

The explanatory variables considered in our analysis are the same for both technologies examined and refer to the economic and demographic attributes of the provinces and their size. Firstly, we consider income per capita in the province (GDP). As noted above, the economics literature identifies this variable as being key in explaining the geographical areas in which broadband operators concentrate their investments. Accordingly, demand for telecommunication services grows as income levels rise.

Montolio and Trillas (2013) point out that the explanatory variable GDP might be endogenous to the level of investment in broadband platforms, i.e. income per capita by region (GDP) could be significantly influenced by the level of broadband investments made. To avoid this problem, we use the unemployment rate (UNEMPLOYMENT) and the number of large firms in relation to the total population (LARGE_FIRMS) as instruments in our panel data framework. These variables are highly correlated with the GDP per capita variable but much less influenced by in-

(7) Although the Cable Telecommunications Act was passed in 1995, licenses were granted to cable operators in 1998 and 1999. The lack of data for the period 1999-2002 is a limitation of our data that must be taken into account in the interpretation of results. Nevertheless, this limitation should have a modest effect in our results because in our regressions we use the stock of investment variable instead of the year-to-year change in stock. The use of stocks rather than investments allows us to take into account the investment made from the beginning of the deployment in our regressions.

vestments in broadband networks. Note that such investments are capital intensive and are not necessarily executed by large firms located in the region concerned. Indeed, 40 of the 52 Spanish provinces did not have any telecommunication companies among the large firms registered in their territory. The province with the greatest presence of telecommunication companies was Madrid, although they only accounted for 1.3% of its total number of large firms. This fact minimizes the probability of there being a strong relationship between investment level in telecommunications (INFR) and major companies located in the province (LARGE_FIRMS).

We also include several demographic variables. When determining where to focus their investments, operators make their decisions at a geographical scale that is smaller than that of the province. This is because each province may contain a set of highly heterogeneous municipalities. Therefore, broadband operators determine their investments at the municipal level or, if the municipality is especially large, at an even smaller level. For this reason, we collected the demographic features of each province at a smaller level than that of the whole province.

According to the economics literature (see Table 2), population density is an important explanatory variable in the level of investment made by operators. This is based on the argument that areas with a high population density will create significant economies of density (i.e. the higher the population density, the greater the deployment and maintenance cost savings for operators). Therefore, operators are expected initially to choose those provinces with the highest population density.

To capture this effect, we employ the urban density variable by province (DENS _URB). The variable estimates the population living in municipalities of over 10,000 inhabitants, in relation to the whole province. The authors ruled out using the population density of the whole region because this variable includes rural areas (municipalities with less than 10,000 inhabitants), which are not a relevant variable in the investment plans of broadband operators.

Since the relevant geographic dimension is that of the municipal level, we also consider the number of major population centers within each province. To this end, the variable CITY_MEDIUM contains the number of cities in a province of an intermediate size (a population of between 100,000 and 500,000 inhabitants). Likewise, the variable CITY_LARGE refers to the number of cities in a province with more than 500,000 inhabitants. Telecom operators should focus their initial investments in these larger cities where they can take greater advantage of economies of scale and economies of density. To this point, the CITY_MEDIUM and CITY_LARGE variables show the provinces in which there is a higher population concentration. They capture population density at the municipality level, while the variable URBAN density captures population density at the province level.

The CAPITAL variable measures the concentration of the population in the territory. Specifically, it measures the population of the capital of each province in relation to the total population of that province. As noted above, broadband operators will opt to focus their investments in provinces in which the population is most concentrated.

In short, telecommunications operators decide where to make their investments on the basis of a territory's demographic characteristics. Therefore, if Spanish operators have designed their investment plans based solely on economic criteria, in our econometric model all these variables should have a significant and positive impact on investment.

An additional factor that we consider is the variable ISLAND, which is a dummy variable taking the value 1 when the province is made up of one or more islands and 0 when the region is located on the mainland. If broadband operators decide to provide telecommunication services on an island, they might incur higher deployment costs than on the mainland. Consequently, we would expect a negative relationship between this variable and the investment level in a province.

As we use the total number of installed accesses by province as our dependent variable, we need to take into account the size of each of these provinces. Thus, the variable EXT_URB identifies the total area in km^2 taken up by the urban population in a given region. We consider the urban population variable to be more apt than total population of the province because broadband operators start investment only in areas over a minimum threshold of population size (over 10,000 inhabitants). This may explain why the total population variable was not statistically significant in any additional regression that we ran with this alternative measure of province size.

Finally, our model analyzes the amount of broadband investment by region, over three years. Accordingly, we add year dummies to consider time fixed effects in our model. Thus, the variable YEAR1 takes the value 1 when the data by province refer to the first year, and 0 when they refer to the second or third year in the sample. Likewise, the variable YEAR2 takes the value 1 when the data refer to the second year, and 0 when they refer to the other two years. YEAR3 is the reference year.

As noted above, the economics literature (see Table 2) identifies the educational level of the population as an explanatory variable of investment volume in broadband networks. Despite this evidence, we do not use it as an independent variable in our econometric model as we found a high level of correlation between level of education and income per capita. That is, the educational level in Spain is strongly influenced by income levels. In order to avoid multicollinearity, the empirical analysis focuses on identifying only the effect of the income level of the population on broadband deployment.

The data for constructing most of the explanatory variables (GDP, EXT_URB, DENS_URB, CITY_MEDIUM, CITY_LARGE, CAPITAL, FIRMS_LARGE) have been obtained from INE, the National Institute of Statistics in Spain. In addition, we have taken information from the Spanish Economics Yearbook, published annually by the financial institution *La Caixa d'Estalvis i Pensions de Barcelona*, to create the UNEMPLOYMENT variable.

The analysis of the investment in cable platforms uses unbalanced panel data with a total of 137 observations. Likewise, the investment in optical fiber networks has been estimated from unbalanced panel data comprising 150 observations. The reason for this difference is that cable operators invested in fewer regions between 2003 and 2005 than did the optical fiber operators between 2011 and 2013, i.e. in the respective initial deployments of these technologies, optical fiber networks were implemented in more regions.

Tables 3 and 4 show the descriptive statistics of the variables used to estimate investment in cable and fiber optic platforms by regions.

Table 3: Descriptive statistics of the investment model for cable platforms (HFC)

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
INFR	Number of installed accesses connected by cable technology	137	138807.3	170670.1	4044	971858
GDP	GDP per capita in current EUR$	137	18620.4	3765.7	12524.1	29416.3
EXT_URB	Total area taken up by the urban population (km^2)	137	1957.3	1984.4	94.9	9451.1
ISLAND	Dummy variable equal to 1 if region is made up of islands	137	0.06569	0.24865	0.0000	1.0000
DENS_URB	Percentage of population living in municipalities of over 10,000 inhabitants	137	515.6	548.7	55.77	2736.1
CITY_MEDIUM	Number of intermediate size cities located in the region	137	1.10948	1.40732	0.0000	8.0000
CITY_LARGE	Number of large size cities located in the region	137	0.13138	0.33906	0.0000	1.0000
CAPITAL	Share of the capital's population in its total number of inhabitants	137	0.33207	0.14171	0.0841	0.7584
UNEMPLOYMENT	Percentage of the total labor force that is unemployed	137	0.1091	0.0393	0.0372	0.2577
FIRMS_LARGE	Number of large firms in relation to the total population	137	0.00008	0.00005	0.00001	0.00027

Table 4: DESCRIPTIVE STATISTICS OF THE INVESTMENT MODEL FOR OPTICAL FIBER PLATFORMS (FTTx)

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
INFR	Number of installed accesses connected by cable technology	150	87128.23	318354.70	1313	2709672
GDP	GDP per capita in current EUR$	150	21108.07	4405.1	14717.2	33894.3
EXT_URB	Total area taken up by the urban population (km^2)	150	1994.56	1955.34	94.95	9451.13
ISLAND	Dummy variable equal to 1 if region is made up of islands	150	0.0600	0.238282	0.0000	1.0000
DENS_URB	Percentage of population living in municipalities of over 10,000 inhabitants	150	524.9	570.3	56.66	2909.0
CITY_MEDIUM	Number of intermediate size cities located in the region	150	1.1400	1.54150	0.0000	9.0000
CITY_LARGE	Number of large size cities located in the region	150	0.1200	0.32605	0.0000	1.0000
CAPITAL	Share of the capital's population in its total number of inhabitants	150	0.3163	0.1362	0.0864	0.7582
UNEMPLOYMENT	Percentage of the total labor force that is unemployed	150	0.2375	0.0704	0.0917	0.4124
FIRMS_LARGE	Number of large firms in relation to the total population	150	0.00007	0.00004	0.00001	0.00024

Table 5: Correlation matrix of the investment model for cable platforms (HFC)

	INFR	GDP	EXT_URB	ISLAND	DENS_URB	CITY_ MEDIUM	CITY_ LARGE	CAPITAL	UNEMPLOY-MENT	FIRMS_ LARGE
INFR	1.0000									
GDP	0.1413	1.0000								
EXT_URB	0.3943	-0.3601	1.0000							
ISLAND	-0.0423	0.0288	0.06	1.0000						
DENS_URB	0.4254	0.519	-0.2716	-0.0727	1.0000					
CITY_MEDIUM	0.6937	0.2507	0.2671	0.0423	0.5782	1.0000				
CITY_LARGE	0.6805	0.1276	0.2903	-0.1031	0.3438	0.4165	1.0000			
CAPITAL	0.0561	0.3431	-0.1852	0.0037	0.1968	0.0548	0.3119	1.0000		
UNEMPLOYMENT	0.1117	-0.5723	0.4322	0.0770	-0.1425	0.0950	0.0501	-0.1947	1.0000	
FIRMS_LARGE	0.5161	0.6879	-0.0171	0.1611	0.6520	0.5901	0.4205	0.3179	-0.2656	1.0000

Table 6: Correlation matrix of the investment model for optical fiber platforms (FTTx)

	INFR	GDP	EXT_URB	ISLAND	DENS_URB	CITY_ MEDIUM	CITY_ LARGE	CAPITAL	UNEMPLOY-MENT	FIRMS_ LARGE
INFR	1.0000									
GDP	0.2668	1.0000								
EXT_URB	0.0967	-0.4556	1.0000							
ISLAND	-0.0049	-0.0268	0.0532	1.0000						
DENS_URB	0.5805	0.5548	-0.2742	-0.0474	1.0000					
CITY_MEDIUM	0.8102	0.2480	0.2377	0.0866	0.6309	1.0000				
CITY_LARGE	0.5538	0.1039	0.2726	-0.0933	0.3736	0.407	1.0000			
CAPITAL	0.1630	0.4196	-0.2213	-0.0111	0.1946	0.0465	0.2846	1.0000		
UNEMPLOYMENT	-0.0564	-0.6943	0.5260	0.2194	-0.3323	0.0210	0.0657	-0.3057	1.0000	
FIRMS_LARGE	0.6294	0.6855	-0.0952	0.0464	0.7650	0.6549	0.4283	0.3411	-0.3323	1.0000

We have used the same explanatory variables in both investment models, but the data correspond to different time periods (2003-2005 in the case of cable platforms and 2011-2013 in that of fiber platforms). Recall that the aim of this paper is to analyze the geographical spread of broadband platforms (cable and optical fiber) made by operators in the initial years of activity, and so the investment model for each corresponds to a different time period.

Tables 5 and 6 provide the matrix of bivariate correlations for the variables used in the cable and optical fiber estimations.

The results from Tables 5 and 6 eliminate the possibility of multicollinearity, as the correlation between the variables is not high for any one pair of variables considered.

2.2. *Econometric specification and results*

Taking the previous hypotheses into consideration, the equation to be estimated can be expressed in the following form:

$$INFR_{i,t} = const + \beta_1 GDP_{i,t} + \beta_2 EXT\_URB_{i,t} + \beta_3 DENS\_URB_{i,t}, + \beta_4 CITY\_MEDIUM_{i,t} + \\ + \beta_5 CITY\_LARGE_{i,t} + \beta_6 CAPITAL_{i,t} + \beta_7 ISLAND_{i,t} + \beta_8 YEAR1_{i,t} + \beta_9 YEAR2_{i,t} + \varepsilon_{i,t}$$

All variables are expressed in logarithms so that the coefficients can be interpreted as elasticities. The level of investment in broadband networks (INFR) in province *i* during period *t* is a function of: (a) the level of income per capita (GDP) in province *i* during period *t*; (b) the urban density (DENS_URB) of province *i* during period *t*; (c) the number of medium-sized cities (CITY_MEDIUM) in province *i* during period *t*; (d) the number of large-sized cities (CITY_LARGE) in province *i* during period *t*; (e) the percentage of population concentrated in the capital (CAPITAL) of province *i* during period *t*; (f) the fact that province *i* is formed by islands (ISLAND); (g) the urban area (EXT_URB) of province *i*; (h) a time variable (YEAR1) that identifies the first year of the sample, and (i) a time variable (YEAR2) that identifies the second year of the sample.

From this econometric specification, we estimate four different models for each broadband platform analyzed (cable and optical fiber). These models were estimated using the two-stage least squares (IV/2SLS) method. In all econometric estimations, the sample was indexed by the region in which the investment is located. As a result, standard errors were clustered by province to correct for the possible presence of autocorrelation and to account for the particularity of the dataset having been designed as panel data.

As explained, the variable income per capita (GDP) is instrumented through the variables unemployment rate (UNEMPLOYMENT) and the number of large companies in relation to the total population (FIRMS_LARGE) by region.

We do not include province fixed effects as this would mean focusing within variations in our data, whereas the focus of our analysis is on the differences in broadband investment across provinces. A further reason why we discard the fixed effects model is that the time variable is limited (just three years) in comparison to the total number of observations. In a fixed effects model, this would result in a lower reliability of the outcome obtained from the estimations.

Interestingly, it has been pointed out that the dependent variable (the number of installed accesses of a given broadband platform by region) may be affected by a potential autocorrelation problem [Grajek and Röller (2009)]. In our context, this is not necessarily the case since the historical series comprises data for just three years. Additionally, and as noted above, clustering investment data by province helps to correct a hypothetical problem of autocorrelation. In any case, and in line with the aim of this paper, the main interest of the empirical analysis is the territorial distribution of investment in the expansion of broadband platforms and not the historical evolution of investment itself.

Based on this methodology, the following table displays the results obtained from four models built to estimate the broadband investment made by cable operators between 2003 and 2005. The different models combine different sets of explanatory variables. Specifically, we do not jointly consider the variables of number of medium-sized cities, number of large cities and proportion of population in the capital.

The results in Table 7 show that the presence of medium- or large-sized cities is not a key factor for cable operators when deciding where to focus their investments at the province level. Likewise, the concentration ratio in terms of population located in the capital of the province is not a significant variable.

However, the urban density variable by province has a significant and positive effect on broadband investment, which seems to indicate that cable operators drew up plans focusing their investment on the most attractive provinces in terms of population density. That is, the diffusion of cable platforms throughout the territory did not occur randomly but rather operators made their investment decisions rationally. Yet, if we focus our analysis at the municipal level, we see that the results for the rest of the demographic variables indicate that the operators did not concentrate their investments in those municipalities that, *a priori*, offered greater opportunities for the exploitation of economies of density and scale.

The income per capita variable is statistically significant, but the coefficient is negative. This means the level of investment in cable platforms was inversely proportional to the province's income per capita. This result is the opposite of that reported in previous studies examining the factors that might account for the deployment of telecommunication platforms.

Note that we ran several specification tests, including an exogeneity test and a robustness analysis of the instruments used in the regression. As shown in Table 7, the Hansen test of over-identifying restrictions fails to reject the null hypothesis of orthogonality between the regressors and the instruments. Meanwhile, the F-statistics of the instruments in the first stage of the estimation (see Appendix A) show that they are strong. In short, these two tests support the instruments used in our econometric model.

The dummy variable indicating whether broadband investment is made in a province comprising one or more islands is not statistically significant. Finally, the dichotomous time variables (YEAR1 and YEAR2) reveal a significant and negative effect. The coefficients for these variables (around 0.30 and 0.21, respectively) show that, from 2003 to 2005, the volume of cable investments grew moderately.

Table 7: INVESTMENT IN CABLE PLATFORMS BY PROVINCES (2SLS)

	Model 1	Model 2	Model 3	Model 4
Intercept	10.7288	8.8230	9.0012	9.5358
	(5.1460)**	(4.8176)*	(4.6286)**	(4.4052)**
log GDP	-1.0823	-0.9097	-0.9191	-1.0275
	(0.5270)**	(0.4947)*	(0.4960)*	(0.4894)**
log Ext_urbana	0.7891	0.8155	0.8074	0.8427
	(0.0915)***	(0.0919)***	(0.6822)***	(0.0553)***
Island	-0.2586	-0.3025	-0.2756	-0.3167
	(0.2709)	(0.2537)	(0.2562)	(0.2398)
log Dens_urbana	0.9897	0.9962	0.9915	1.0067
	(0.1279)***	(0.1310)***	(0.1058)***	(0.0991)***
City_medium	0.0184	0.0161		
	(0.0655)	(0.0682)		
City_large	0.1200		0.1157	
	(0.2286)		(0.2236)	
Capital				0.6571
				(0.6767)
Year1	-0.3083	-0.3025	-0.3035	-0.3229
	(0.0747)***	(0.0739)***	(0.0750)***	(0.0716)***
Year2	-0.2189	-0.2156	-0.2163	-0.2230
	(0.0454)***	(0.0455)***	(0.0447)***	(0.0454)***
N	137	137	137	137
Provinces	47	47	47	47
R^2	0.7987	0.7954	0.7962	0.8034
Hansen J	0.142	0.482	0.428	1.105
Test F	10.79***	13.08***	12.02***	13.87***

Notes: Standard errors in parentheses. Statistical significance at 1% (***), 5% (**), 10% (*).

Table 8 shows the results from the same four models as above but here explaining the deployment of optical fiber platforms.

The results in the case of optical fiber platforms, unlike those described above for cable platforms, are very similar to those reported elsewhere in the economics literature. Thus, all the demographic variables have a significant and positive effect on broadband investment levels. Indeed, the urban density variable is positive and significant in all four empirical models. The number of medium- and large-sized cities is also positive and significant, indicating that fiber optic operators have focused their investment on major urban municipalities. Finally, the empirical results show that optical fiber operators have taken into account the degree of concentration of the population in each region (CAPITAL).

Table 8: Investment in optical fiber platforms by province (2SLS)

	Model 1	Model 2	Model 3	Model 4
Intercept	-3.1851	-10.4275	-12.8770	-15.9271
	(6.0700)	(8.3226)	(7.7023)*	(9.7610)*
log GDP	0.9408	1.2879	1.5972	1.4739
	(0.5387)*	(0.7722)*	(0.7183)**	(0.9233)*
log Ext_urbana	0.3225	0.6394	0.5929	0.9185
	(0.1364)***	(0.1670)***	(0.1364)***	(0.1526)***
Island	0.5653	0.0641	0.4684	-0.3125
	(0.7271)	(0.7509)	(0.8407)	(0.8705)
log Dens_urbana	0.2186	0.5290	0.4914	0.7867
	(0.1146)**	(0.1687)***	(0.1159)***	(0.1666)***
City_Medium	0.2766	0.2633		
	(0.0485)***	(0.1096)***		
City_Large	1.7168		1.6716	
	(0.2394)***		(0.3481)***	
Capital				1.5336
				(0.7673)**
Year1	-0.9445	-0.9506	-0.9555	-0.9542
	(0.1283)***	(0.1288)***	(0.1296)***	(0.1290)***
Year2	-0.6710	-0.6714	-0.6706	-0.6717
	(0.1134)***	(0.1135)***	(0.1136)***	(0.1140)***
N	150	150	150	150
Provinces	50	50	50	50
R^2	0.6649	0.5631	0.6085	0.5396
Hansen J	0.387	1.056	1.480	1.275
F-test	16.30***	5.68***	7.01***	4.01***

Notes: Standard errors in parentheses. Statistical significance at 1% (***), 5% (**), 10% (*).

In short, telecom operators that have deployed optical fiber infrastructure in the national territory have concentrated their investments in those municipalities that offer the greatest opportunities for benefiting from economies of density and scale. Here, according to the empirical results, the number of cities with a population of over 500,000 is the most important factor explaining the level of investment by region made by operators. That is, the optical fiber platform has been introduced mainly in larger cities in the early years of its diffusion throughout the territory.

These results also show that, as well as taking into account the urban density of each region, optical fiber operators concentrated their investments in larger municipalities. In contrast, the fact that cable operators did not focus their investments in the largest municipalities indicates that the diffusion of cable platforms occurred in a more uniform manner throughout the country.

The empirical evidence obtained for the density variables reinforces this hypothesis. Specifically, the coefficients estimated for the urban density variable in the regressions for cable platforms are close to 1, whereas for the same variable in the case of optical fiber platforms they are much lower (between 0.2 and 0.7). These results reinforce the hypothesis that the spread of cable platforms occurred more uniformly throughout the national territory and directly proportional to the urban density registered in each province.

In the case of the optical fiber platforms, the operators focused their investments primarily in those municipalities with optimal features to exploit economies of scale and density. This would explain why the relationship between the dependent variable and urban density at the province level is not as high for optical fiber platforms as it is for cable platforms.

As expected, income per capita (GDP) has a significant and positive effect on optical fiber investments at the province level. This confirms that optical fiber operators tended to concentrate their investments in those provinces with higher income levels. Again, the Hansen test of over-identifying restrictions fails to reject the null hypothesis of orthogonality between the regressors and the instruments, and the F-statistics of the first stage (see Appendix B) confirm the strength of the instruments.

All these results show that optical fiber operators based their initial investment decisions strictly on economic grounds. Hence, we may expect the returns on their investment to be higher, although data do not allow us to confirm this.

As in the case of cable operators, the dummy variable indicating whether the region is made up of islands has no significant effect on the investment plans made by optical fiber operators. Finally, the dummy time variables (YEAR1 and YEAR2) have a significant and negative effect. The high coefficients we obtain for these variables (with values close to 0.95 for the first year and 0.67 for the second year) indicate that in a period of just a few years (from 2011 to 2013), the volume of investment in optical fiber platforms grew substantially. By contrast, the coefficients of the time variables in the case of cable platforms are markedly lower. These different outcomes indicate that the deployment of optical fiber platforms was especially intense between 2011 and 2013.

In order to test the robustness of the results in the paper, supplementary equations have been estimated for cable and optical fiber platforms (see Appendix C). Thus, the model 5 shows the results using ordinary least squares (OLS) regressions while model 6 has been estimated using the Two-stage least squares (IV/2SLS) method without clustering standard errors by province. The results in Appendix C are in line with the results discussed above.

3. Conclusions

We have examined the influence of provincial characteristics on the deployment of cable and optical fiber platforms in Spain during the initial years of their diffusion. We found marked differences in the respective investment processes, with the results relating to optical fiber platforms being more consistent with the previous literature.

The empirical analysis shows that the deployment of cable platforms throughout Spain was not based on purely economic decisions. The fact that the great majority of cable operator stock is in the hands of private shareholders, whose objective is to maximize profits, suggests that certain external factors prevented them from making their investment decisions on economic grounds alone. Here, we have noted that specific regulations governing cable platforms significantly restricted operators' decisions as to where to focus their investments. As a result, cable operators have been unable to benefit from the high economies of scale and density that characterize all the network industries.

The opposite was true in the diffusion of optical fiber platforms. Here, the empirical evidence shows that economic considerations have driven the location of investments throughout Spain. It would seem therefore, that the regulations applied to these platforms have not had a negative impact on their diffusion.

The empirical evidence also suggests that the investments of cable operators were more evenly distributed throughout the territory, while optical fiber operators focused their investments on a small number of municipalities with large populations and high levels of income per capita.

Our analysis identifies the regulatory framework as being the chief factor responsible for the differences in diffusion rates between broadband platforms. Owing to a complex public procurement procedure, the regulatory framework limited the freedom of cable operators to decide where to focus their investments. In the case of optical fiber platforms, the regulatory framework placed no similar restrictions on the geographical areas in which operators could invest nor did it restrict the number of operators who could invest within the same territory.

In short, we conclude that the regulatory framework significantly affected the competitiveness of cable networks and has undermined inter-platform competition. Indeed, this seems to explain why intra-platform competition has become the essential variable in promoting broadband adoption in the Spanish market. Furthermore, it should be stressed that this may well have had an aggregate negative impact on broadband deployment, since the economics literature shows that rivalry between different platforms promotes the adoption of broadband services among the population.

In the more recent case of the deployment of optical fiber platforms, we have not found any empirical evidence suggesting that the regulatory framework has biased investment decisions. Indeed our results indicate that operators have deployed their platforms in line with their efforts to exploit density economies. Thus, the diffusion of optical fiber platforms should offer a new opportunity to reap the benefits of inter-platform competition.

Finally, it is likely that the regulatory framework pursued different objectives in each case. The regulation of cable networks took into account specific objectives of industrial policy, for example, distribution targets, while the regulation of optical fiber network had the main objective of maximizing competition in the broadband market. These differences produced different results, as we have seen above. The main problem in the case of the cable regulatory framework was that, by not prioritizing the profitability of investment, most cable operators suffered financial problems and they were never able to become significant competitors with the xDSL operators. In fact, most of the national cable network was bought in 2014 by Vodafone, an operator which started its activity in fixed platforms as an alternative xDSL operator.

Appendix A

Table 9: Cable platforms regressions. First Stage Results

	Model 1	Model 2	Model 3	Model 4
Intercept	8.6562	8.8243	8.8407	8.9375
	(0.3889)***	(0.3787)***	(0.3611)***	(0.3016)***
log Ext_urbana	0.0079	-0.0041	-0.0055	-0.0130
	(0.0231)	(0.0219)	(0.0211)	(0.0175)
Island	0.0066	0.0245	0.0168	0.0337
	(0.0686)	(0.0654)	(0.0699)	(0.0662)
log Dens_urbana	0.0814	0.0690	0.0655	0.0565
	(0.3366)***	(0.0328)**	(0.0312)**	(0.0274)**
City_medium	-0.0182	-0.0173		
	(0.0108)*	(0.0117)		
City_large	-0.0610		-0.0576	
	(0.3653)*		(0.0367)	
Capital				0.0599
				(0.1405)
Year1	-0.0819	-0.0830	-0.0830	-0.0846
	(0.0111)***	(0.0108)***	(0.0106)***	(0.0112)***
Year2	-0.0235	-0.0247	-0.0246	-0.0257
	(0.0104)**	(0.0101)**	(0.0103)**	(0.0100)**
log Unemployment	-0.2352	-0.2276	-0.2316	-0.2273
	(0.0461)***	(0.0473)***	(0.0448)***	(0.0430)***
Firms_large	1749.2	1718.4	1638.7	1531.5
	(576.92)***	(561.57)***	(548.40)***	(448.71)***
N	137	137	137	137
Provinces	47	47	47	47
R^2	0.7577	0.7511	0.7500	0.7455
Partial R^2	0.5917	0.5812	0.5810	0.5542
Test F	16.36***	39.79***	44.04***	40.64***

Notes: Standard errors in parentheses. Statistical significance at 1% (***), 5% (**), 10% (*).

Appendix B

Table 10: Optical fiber platforms regressions. First Stage Results

	Model 1	Model 2	Model 3	Model 4
Intercept	9.3354	9.3296	9.4199	9.3492
	(0.2084)***	(0.1899)***	(0.1805)***	(0.1862)***
log Ext_urbana	-0.0177	-0.0172	-0.0247	-0.0199
	(0.0142)	(0.0128)	(0.0122)**	(0.0126)*
Island	0.0979	0.0970	0.1011	0.0977
	(0.0506)**	(0.0468)**	(0.0525)**	(0.0472)**
log Dens_urbana	0.0106	0.0111	0.0038	0.0074
	(0.0255)	(0.0229)	(0.0235)	(0.0203)
City_medium	-0.0106	-0.0107		
	(0.0112)	(0.0110)		
City_large	0.0032		0.0062	
	(0.0363)		(0.0368)	
Capital				0.0719
				(0.1376)
Year1	-0.0793	-0.0792	-0.0804	-0.0809
	(0.0176)***	(0.0173)***	(0.0172)***	(0.0176)***
Year2	-0.0409	-0.0408	-0.0417	-0.0422
	(0.0091)***	(0.0089)***	(0.0088)***	(0.0090)***
log Unemployment	-0.3733	-0.3731	-0.3762	-0.3773
	(0.0641)***	(0.0632)***	(0.0627)***	(0.0636)***
Firms_large	2208.4	2214.4	2042.7	1937.1
	(452.39)***	(445.94)***	(451.29)***	(430.33)***
N	150	150	150	150
Provinces	50	50	50	50
R^2	0.7866	0.7866	0.7839	0.7856
Partial R^2	0.6280	0.6303	0.6326	0.6123
Test F	44.88***	43.44***	41.76***	46.57***

Notes: Standard errors in parentheses. Statistical significance at 1% (***), 5% (**), 10% (*).

Appendix C

Table 11: Supplementary regressions results by platform

	Cable platforms		Optical fiber platforms	
	Model 5 (OLS)	Model 6 (IV/2SLS without clustering)	Model 5 (OLS)	Model 6 (IV/2SLS without clustering)
Intercept	13.2969	9.5620	6.6689	-3.1851
	(4.8180)***	(3.0772)***	(7.1874)	(4.5597)
log GDP	-1.3536	-0.9591	-0.0411	0.9408
	(0.4865)***	(0.3140)***	(0.6434)	(0.4149)**
log Ext_urbana	0.7805	0.7929	0.2502	0.3225
	(0.0961)***	(0.0570)***	(0.1453)*	(0.0944)***
Island	-0.2418	-0.2663	0.5924	0.5653
	(0.2962)	(0.1564)*	(0.6870)	(0.5201)
log Dens_urbana	1.0176	0.9771	0.2833	0.2186
	(0.1303)***	(0.0779)***	(0.1192)**	(0.0895)**
City_medium	0.0215	0.0169	0.2990	0.2766
	(0.0685)	(0.0387)	(0.0536)***	(0.0419)***
City_large	0.1262	0.1171	1.763	1.7168
	(0.2431)	(0.1345)	(0.2701)***	(0.1857)***
Year1	-0.3531	-0.3083	-0.9287	-0.9445
	(0.0763)***	(0.1034)***	(0.1309)***	(0.1647)***
Year2	-0.2401	-0.2189	-0.6735	-0.6710
	(0.0435)***	(0.1037)**	(0.1176)***	(0.1714)***
N	137	137	150	150
R^2	0.8001	0.7971	0.6756	0.6649
Hansen J	–	1.115	–	0.794
Test F	32.36***	80.35***	59.84***	104.9***

Notes: Standard errors in parentheses. Statistical significance at 1% (***), 5% (**), 10% (*).

REFERENCES

Bouckaert, J., Van Dijk, T. & Verboeven, F. (2010): "Access regulation, competition, and broadband penetration: an international study" *Telecommunications Policy*, 34, pp. 661-671.

Briglauer, W. (2014): "The impact of regulation and competition on the adoption of fiber-based broadband services: recent evidence from the European Union member states" *Journal of Regulatory Economics*, 46(1), pp. 51-79.

Briglauer, W., Ecker, G. & Gugler, K. (2013): "The impact of infrastructure and service-based competition on the deployment of next generation access networks: Recent evidence from the European member states" *Information Economics and Policy*, 25(3), pp. 142-153.

Cave, M. (2003): "Remedies for broadband services" Study for the Commission, Sept.

Cave, M., Majumdar, S., Rood H., Valletti, T. & Vogelsang, I. (2001): "The Relationship between access pricing regulation and infrastructure competition". Report to OPTA and DG Telecommunications and Post by Brunel University.

Caves, D.W., & Christensen, L.R. (1988): "The importance of economies of scale, capacity utilization, and density in explaining interindustry differences in productivity growth" *The Logistics and Transportation Review*, 2, pp. 3-32.

CMT (2011): "Informe económico sectorial" *Comisión del Mercado de las Telecomunicaciones.*

CMT (2010): "Informe económico sectorial" *Comisión del Mercado de las Telecomunicaciones.*

CMT (2009): "Resolución por la que se aprueba la definición y el análisis del mercado de acceso (físico) al por mayor a infraestructura de red (incluido el acceso compartido o completamente desagregado) en una ubicación fija y el mercado de acceso de banda ancha al por mayor, la designación de operador con poder significativo de mercado y la imposición de obligaciones específicas, y se acuerda su notificación a la comisión europea". *Comisión del Mercado de las Telecomunicaciones,* pp. 71.

CMT (2006): "Informe Anual". *Comisión del Mercado de las Telecomunicaciones.*

CMT (2005): "Informe Anual". *Comisión del Mercado de las Telecomunicaciones.*

CMT (2000): "Informe Anual". *Comisión del Mercado de las Telecomunicaciones.*

CNMC (2014): "Resolución por la cual se aprueba la definición y análisis del mercado de acceso local al por mayor facilitado en una ubicación fija y los mercados de acceso de banda ancha al por mayor, la designación de operadores con poder significativo de mercado y la imposición de obligaciones específicas, y se acuerda su notificacion a la comisión europea y al organismo de reguladores europeos de comunicaciones electrónicas (ORECE) (ANME/DTSA/2154/14/MERCADOS 3a 3b 4)". *Comisión Nacional de los Mercados y la Competencia*.

Chung, I. (2006): "Broadband, the information society, and national systems" Global broadband battles: Why the US and Europe lag while Asia leads, 87-108.

Distaso, W., Lupi, P. & Manenti, F.M. (2006): "Platform competition and broadband uptake: Theory and empirical evidence from the European Union" *Information Economics and Policy*, 18, pp. 87-106.

Fageda, X., Rubio-Campillo, R. & Termes-Rifé, M. (2014): "Determinants of broadband access: Is platform competition always the key variable to success?" *Information Economics and Policy*, 26, pp. 58-67.

Fairlie, R.W. (2004): "Race and the digital divide" *Contributions in Economic Analysis & Policy,* 3(1).

Friederiszick, H., Grajek, M. & Röller, L.H. (2008): "Analyzing the relationship between regulation and investment in the telecom sector" *ESMT White Paper* WP-108-01.

Goldfarb, A. & Prince, J. (2008): "Internet adoption and usage patterns are different: Implications for the digital divide" *Information Economics and Policy*, 20(1), pp. 2-15.

Grajek, M. & Röller, L.H. (2012): "Regulation and investment in network industries: Evidence from European telecoms" *Journal of Law and Economics*, 55(1), pp. 189-216.

Horrigan, J. (2009): "Home broadband adoption 2009" *Pew Internet & American Life Project.*

Mancuso, P. (2012): "Regulation and efficiency in transition: the case of telecommunications in Italy" *International Journal of Production Economics*, 135(2), pp. 762-770.

Montolio, D. & Trillas, F. (2013): "Regulatory federalism and industrial policy in broadband telecommunications" *Information Economics and Policy*, 25(1), pp. 18-31.

Ng, E.C. (2012): "What determines productivity performance of telecommunications services industry? A cross-country analysis" *Applied Economics*, 44(18), pp. 2359-2372.

Prieger, J.E. (2003): "The supply side of the digital divide: is there equal availability in the broadband Internet access market?" *Economic Inquiry*, 41(2), pp. 346-363.

Ros, A.J. (1999): "Does ownership or competition matter? The effects of telecommunications reform on network expansion and efficiency" *Journal of Regulatory Economics*, 15(1), pp. 65-92.

Sidak, J.G. & Spulber, D.F. (1997): "Deregulatory takings and the regulatory contract: the competitive transformation of network industries in the United States" *Cambridge University Press*.

Tang, M. (2009): "An empirical model of investment by cable operators in broadband digital services". Pennsylvania: Department of Economics – Lehigh University (Working Paper).

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RESUMEN

El objeto de este trabajo consiste en analizar por qué, en ciertos países, la rivalidad entre plataformas de banda ancha no ha tenido un efecto positivo sobre el despliegue de esta tecnología. Controlando por las características demográficas y las variables de red, identificamos el impacto que ha tenido la regulación sectorial sobre la capacidad competitiva de las plataformas alternativas a la plataforma dominante (xDSL). Para alcanzar este objetivo, analizaremos el despliegue de las plataformas de cable y fibra óptica en el mercado español. Encontramos que el marco regulatorio específico que se diseñó para el despliegue de las plataformas de cable perjudicó de forma crítica su competitividad y, en consecuencia, perjudicó la competencia surgida entre las distintas plataformas tecnológicas. Por el contrario, nuestros resultados también muestran que la regulación específica de las plataformas de fibra óptica no ha desincentivado un despliegue eficiente de esta tecnología.

Palabras clave: fallo regulatorio, competencia en banda ancha, plataforma de fibra óptica, plataforma de cable, inversión.

Clasificación JEL: L38, L51, L52, L96.