The Impact of EU Regulation in Network Industries

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PhD in Economics

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Contents

1. Introduction

Within the European Union (EU) framework, economic regulation is often used as a promotion mechanism to achieve specific objectives. In the telecommunications and the energy sectors this is observable through those regulations that promote the participation of new agents and/or new technologies[1].

Access regulation has been implemented in the EU to promote the entrance of new agents in the telecommunications sector (2002/19/EC, 2002/20/EC and 2002/21/EC). With the aim of stimulating competition and achieving its desired effects in markets and among consumers, new entrants have been provided with access to incumbents' fixed-line infrastructure at the wholesale level, and most of the Member States have adopted regulated, cost-based, wholesale prices. Similarly, as part of the EU 2020 energy strategy, the Third Energy Package (2009/72/EC) was designed to complete the liberalization process in the energy sector, while the Climate and Energy Package undertook to implement the "20-20-20" targets by 2020. Among these, arguably the most challenging is raising up to 20% the share of EU energy consumption produced from renewable resources (2009/28/EC). Member States have embraced this target by promoting the production of electricity from renewable energy sources.

As mentioned above, these mandatory frameworks have been established in various EU Directives requiring Member States to adopt effective provisions within their national laws in a pre-determined period of time (albeit that various distinctions are made between countries). This dissertation undertakes an empirical analysis of the impact of EU regulation. More precisely, we analyze the effects of access regulation on the telecommunications sector and of policy mechanisms designed to accelerate investment in renewable energy technologies (or the feed-in tariff regulation) on the energy sector.

Within the telecommunications sector, one of the markets affected by changes in the European regulatory framework is that of the broadband (high speed access to Internet) service. The rationale behind access regulation is that entrants

[1] Trillas (2010) has analyzed EU regulation in these sectors with regard to the way in which regulatory jurisdiction is allocated among different tiers of government.

be allowed initially to provide a service that requires minimum direct investment while relying on the incumbent's existing network; however, subsequently, entrants are expected to increase their investments as they develop their own infrastructure in a process captured by the "ladder of investment" theory (Cave and Vogelsang, 2003). There has been much debate on the impact of access regulation on investment incentives, its proponents claiming that it serves to encourage broadband deployment and to promote facility-based competition, while its opponents argue that it distorts entrants' make-or-buy decisions and so impedes investment incentives. This EU regulation has clear implications for the firms' investment decisions (i.e., broadband deployment) and, as such, for aggregate infrastructure investment at the country level in the telecommunications sector.

From a firm level point of view, in the context of the access regulation implemented in the EU, new market competitors are able to provide broadband access for customers by using the incumbents' infrastructure, the prices for which are regulated. As such, firm performance is, in part, dependent on regulatory decisions, while the implementation of regulated rates directly affects firm performance in two ways: by impacting the entrants' production costs through the input prices and by impacting the incumbents' wholesale and retail income. Therefore, to appreciate fully the impact of EU telecommunications regulation on firm performance the approach adopted must include performance information in both retail and wholesale markets. In addition, a firm's behavior will also be determined by the firm's characteristics, and given that in most countries broadband services are now provided by a broad range of operators, including incumbents and entrants as well as national and multinational firms, these are fundamental for any regulatory analysis.

Within the energy sector, following the setting of the 20-20-20 targets under the corresponding EU regulation, the feed-in tariff regulation has become the most widely adopted mechanism by Member States to encourage the take-up and development of electricity generation from renewable energy sources. Under the feed-in tariff regulation, a specific price is guaranteed per unit of electricity generated by the target technologies. In most Member States the cost of resources assigned to promoting the production of electricity from renewable energy sources is borne by the final consumer. In recent years, however, the recession has caused governments, industry and consumers alike to worry about high retail energy prices, and here some of the blame has been attributed to

climate policies, in general, and to the feed-in tariff regulation, in particular. In this regard, two components of the electricity retail price can be expected to be influenced by the feed-in tariff regulation: the incentives to those firms producing electricity from renewable energy sources and the wholesale price of electricity. On the one hand, based on the way in which the electricity wholesale price is formed and on the low marginal cost of renewable energy generation, the introduction of renewable energy sources in the energy mix can be expected to exert a downward pressure on the wholesale price of electricity. On the other hand, based on the regulatory design of the incentive mechanisms, the feed-in tariff costs will be transferred to the final electricity consumer. Hence, the two components, which act over the electricity retail price in opposite directions, are functions of the proportion of renewable sources in the energy mix. Technology-specific considerations are clearly therefore important: first, from the perspective of the feed-in tariff cost because the economic incentives are technology-specific being granted according to the level of development and the generation costs; and, second, from the perspective of the wholesale price because each technology makes different contributions of electricity to the system during the day and to the total amount of energy consumed. These points must be carefully taken into account in any empirical analysis of the impact of EU regulation on the energy sector.

In short, the three empirical studies presented in the following chapters focus on the effects of regulation within the EU. The remaining part of this introduction is divided in two sections. The first provides a summary of the main chapters of this dissertation, while the second presents the welfare considerations that arise from the empirical studies.

1.1 The impact of EU regulation in network industries: three empirical studies

In Chapter 2 we present a country level analysis of the role of regulation and the internationalization of firms as drivers of infrastructure investment in telecommunications. More specifically, we classify the firms operating in the EU telecommunications market according to their degree of internationalization and their position as either market incumbents or entrants. We then test the effects of this classification and the existence of access regulation on infrastructure investment in EU broadband markets. To do so, we construct a (unique) data set for the

27 EU countries for the period 2002 to 2009. We estimate, by means of panel data techniques (and instrumental variables to control for any potential issues of endogeneity), an infrastructure investment equation for EU countries including aggregate country level information of firms with operations in EU broadband markets.

The results from the analysis conducted in Chapter 2 show that the variable capturing the degree of internationalization of the firm and its position as incumbent or entrant in the market have a positive and signicant effect on broadband infrastructure investment in EU countries. These results suggest that the often controversial role played by access regulation has had no significant direct impact on countries' aggregate infrastructure investment. Moreover, our results indicate that the lower the concentration within the infrastructure subject to access regulation, the lower the rate of aggregate investment made in that network. These results point to the fact that under the current regulatory framework the firms that invest most in infrastructure are the ones that have most international experience in the telecommunications sector, and that the possible increase in competition from the fall in concentration has not been accompanied by infrastructure investment. In addition to these results, the study makes an important contribution to the literature by proposing, constructing, and testing a measure that captures the degree of internationalization of a firm and its position as market incumbent or entrant. This enables us to incorporate an additional dimension to the analysis; one that has been overlooked in previous studies of the impact of access regulation.

Furthering our examination of EU access regulation in the telecommunications sector, in Chapter 3 we empirically estimate the effects of regulated wholesale access prices and firm's multinational status on firm performance by using firm, corporate group, and country level information for the EU broadband market between 2002 and 2010. Three measures of firm performance are used, namely: market share, turnover and productivity. Empirical hypotheses regarding the effects of regulated wholesale access prices are based on the vertical and horizontal relations between incumbents and entrants. Special attention is paid to differences in the impact on the performance measures depending on a firm's position as either a market incumbent or entrant as well as on a firm's multinational status.

In this study of the impact of EU access regulation on firm performance, we find that while wholesale access prices have a negative effect on entrants' market share and turnover, the effect on incumbents' market share, turnover and productivity is positive. Further, we find that multinational entrants perform better than national entrants in terms of market share, but worse in terms of their turnover and productivity. The opposite is true of incumbent multinationals, which perform better than nationals in terms of their turnover and productivity but worse in terms of market share. These findings confirm that a firm's multinational status has a significant impact on its performance, and that this impact differs for incumbents and entrants. Finally, when evaluating the impact of access prices on firm performance at the mean performance of national and multinational firms, we find that the impact of access prices is lower for multinational than for national rms. This result is in line with the approach that sees multinationals as a risk diversifying mechanism.

Finally, in order to examine the impact of the 20-20-20 target established under EU regulation governing the energy sector, in Chapter 4 we estimate the effects that the feed-in tariff regulation has on the electricity retail price for industrial consumers in Spain. The empirical analysis is undertaken by estimating an industrial retail price equation. This enables us to quantify the relative intensity of the effects from both the feed-in tariff cost and the wholesale price of electricity. Our assessment is performed in a two-step strategy using weekly data for the period 2009-2013. First, we estimate an inverse supply equation, in which the wholesale price is a function of the energy supply mix and the equilibrium quantity, and a feed-in tariff cost equation that captures the effect of the production of electricity using renewable energy sources on the cost per unit of electricity consumed. Second, the estimates from the first stage are introduced into the retail price equation to evaluate the relative intensity of both components. Special attention is paid to technology-specific considerations, as well as to short- and long-run effects.

In general, the results from the analysis presented in Chapter 4 concerning the effects of feed-in regulation on the electricity retail price show that the link between the retail and wholesale market for Spanish industrial consumers is not strong. The effects of feed-in tariff regulation on the wholesale price and on the feed-in tariff cost are confirmed. However, these effects are only transferred in part to the retail price, which is presumably attributable to factors that limit

retail market competition. Moreover, when we take into account technology-specific characteristics, our results indicate that an increase in solar generation leads to a greater increase in the industrial retail price than that brought about by wind generated electricity. This indicates that, when comparing the relative effects of the feed-in tariff regulation attributable to solar and wind generated energy on the industrial retail price, the prevailing effect due to the cost of incentives over that due to the wholesale price is stronger for solar energy than it is for wind.

These three empirical studies, albeit that they address distinctive research questions, employ different methodologies and differ in their scope, have several elements in common. First, in all three studies the EU regulation is used as a mechanism to promote the participation of new agents and/or new technologies in the sectors. Second, Chapters 2 and 3 analyze the effects of the same (access) regulation on different dimensions of the market and the firm. Third, in Chapters 3 and 4 the mechanism underpinning the effect of the regulation is the link between the retail and wholesale markets in both the telecommunications and the energy sector. And fourth, both the telecommunications and energy sectors are network industries that act as input providers for other industries.

1.2 Welfare considerations

Analyzing the impact of regulation, as this dissertation has sought to do, is vital when they concern network industries that play a key role in the overall economy. As becomes apparent in each of the chapters that follow (and summarizes in Chapter 5), a number of valuable conclusions can be drawn from these studies. Overall the analyzes conducted represent an initial step towards a future examination of the welfare effects of the EU regulatory framework.

Important information regarding the potential welfare effects of regulation is obtained if both wholesale and retail dimensions are included in analyzes of vertically related industries. In an open competitive retail market there should be a strong link between both dimensions, so that agents are able to make their economic decisions in line with supply and demand fundamentals. While in the case of electricity a significant, albeit not strong, link was identified between the retail and wholesale market prices for industrial consumers, in the case of telecommunications the regulated access price at the wholesale level was found

to have strongly significant effects at the retail level. In this regard, a variety of factors and barriers seem to limit retail market competition in electricity, thus preventing final consumers from experiencing the potential welfare effects resulting from both the competitive wholesale market, in which the feed-in tariff regulation exerts a price suppressing effect, and the cost of financing this mechanism promoting renewable sources of energy.

EU regulation in the telecommunications sector is oriented towards stimulating retail competition by promoting the entry of new agents into the market. This is being achieved via mandatory access and a falling regulated wholesale price. Lower levels of concentration may lead to greater competition, with potentially lower retail prices and gains in consumer surplus. However, the negative impact of competition on investment indicates that increases in competition have not been accompanied by investment in infrastructure. This raises questions as to the effectiveness of regulations for promoting competition combined with their possible long-term effects on telecommunications infrastructure. Moreover, as our results confirm, the sector is characterized by scale economies and the productivity of incumbents is highly sensitive to wholesale access prices. Thus, there are also possible negative welfare consequences of the current EU regulatory framework.

In general, when EU regulations are designed and implemented in network industries differences between Member States are taken into account. However, from the above discussion it is apparent that introducing such regulations has implications above and beyond the specific goals they were designed to achieve, and that these implications are also partially attributable to the context in which they are implemented. Those responsible for introducing supranational EU regulations therefore need to be painstaking in their efforts when evaluating these implications so as to anticipate their potentially negative welfare effects.

2. What drives investment in telecommunications? The role of regulation and firms internationalization

2.1 Introduction

EU broadband regulatory framework has been inspired by the concept of access regulation to the bottleneck elements of vertically integrated providers of infrastructure services[2]. Hence, competitive access is seen as the instrument for eliminating the deadweight loss of monopoly and for establishing efficient service provision. To favor competitive entry, cost-based access pricing regimes have been adopted in most countries. The rationale behind this framework is that local loop[3] access products will allow entrants to provide services with minimum direct investment while relying on the existing network developed by incumbents. Entrants are subsequently expected to invest, and to an increasing degree, in their own infrastructure.

The predicted results of such policies are twofold. On the one hand, new firms (entrants) can be expected to operate increasingly within more markets, while older firms holding monopolistic power (incumbents) are expected to expand their operations beyond their borders. Thus, telecommunications firms should increase the extent of their internationalization. On the other hand, it is also expected that over time entrants will not require elements of the incumbent network and, therefore, will be able to compete by exploiting their own infrastructure. Both predictions have implications for the firms' investment decisions (i.e., broadband deployment) and, as such, for aggregate investment at the country level in the telecommunications sector. Within this framework, we analyze the effects of access regulation and different firm typologies (defined by the extent of their internationalization and their position as incumbent or entrant in

[2] Regulatory framework provided for under EU Directives 2002/19/EC, 2002/20/EC, and 2002/21/EC.

[3] The local loop is the wire used by a telecommunications company to connect each consumer to the service providers network and from there to the rest of the word.

the markets) in order to determine actual infrastructure investment behavior in the EU broadband market.

Previous studies identify different patterns of investment behavior in such markets depending on whether firms are market incumbents or entrants (Wallsten and Hausladen, 2009; Grajek and Roller, 2012). However, these authors (and all others, to the best of our knowledge) fail to account for all possible firm types participating in the market. Thus, in addition to classifying firms as incumbents or entrants, an incumbent firm in one country may also be an entrant in another, while an entrant may operate in several countries. Likewise, different investment behaviors can also be expected from this wider taxonomy of firms that also takes into account the extent of their international dimension.

The extent of a firm's internationalization, i.e., its international participation through investment in assets and/or control of activities in several markets, will afford certain advantages given, among others, the possibilities to exploit economies of scale and scope, to have enhanced power in standard-setting debates (of obvious relevance in a high-tech industry such as telecommunications), and to increase long-term market capitalization, which favors the investment required by infrastructure sectors such as telecommunications. Moreover, increasing internationalization implies that a firm can accumulate knowledge by operating in more than one country. Thus, overall market expansion can benefit from the knowledge acquired in other countries.

Furthermore, firm position as incumbent or entrant in the market is a distinction that should be made when analysing their investment behavior. Given that incumbents are former monopolist operators, they will have accumulated years of experience about customers, regulations and doing business in the local market. By considering these two characteristics of telecommunications firms (i.e., their internationalization and position in the market), we propose constructing a new typology of firms that takes both characteristics into account in a single measure and examining its impact together with the access regulation on broadband investment.

This chapter is organised as follows. Section 2.2 undertakes a review of the literature related to access regulation and internationalization. Section 2.3 outlines our empirical strategy and discusses data issues. Section 2.4 presents the estimations and results of our analysis. Finally, Section 2.5 concludes.

2.2 Literature Review

In EU, high-speed broadband Internet access is provided by two main technologies: DSL (Digital Subscriber Line) and cable. Although other access technologies are available (FTTH, WLL, Satellite and PLC), by July 2009, DSL and cable represented around 80% and 15% of broadband retail lines, respectively[4]. While the cable industry is not subject to access regulation in EU[5], its DSL markets are subject to a form of third-party access regulation, known as mandatory access regulation. Therefore, as it is the dominant technology in EU retail broadband market and because changes to the DSL regulatory framework have sought to promote broadband deployment through competition (EU Directive 2002/19/EC), DSL forms the focus of this study. Below, we review the economic literature dealing with the impact of access regulation and the impact of firms' internationalization on broadband investment.

2.2.1 Access Regulation

During 2002, mandatory access regulation was implemented in EU in order to ensure the entrance of new agents in the sector. With the aim of stimulating competition and achieving the desired effects in markets and among consumers, new entrants were provided with access to the incumbents' fixed-line infrastructure at the wholesale level. This new mandatory framework was set out in several EU Directives obliging Member States to introduce the measures within their national laws in a pre-determined period of time.

The effects of mandatory access regulation in EU have generated considerable debate. Its proponents claim that access regulation serves to encourage broadband deployment and to promote facility-based competition, while its opponents argue that it distorts entrants' make-or-buy decisions, impedes investment incentives and, as such, has been a failure. A leading question in this debate concerns the effects of mandatory access regulation on a firm's investment incentives[6].

[4] Estimation based on EC report (2009).

[5] In 2009, for the first time, access obligations were imposed on a cable network in Denmark (see EC, 2009).

[6] The literature review on broadband and investment regulation in Cambini and Jiang (2009) provides extensive coverage of this debate. The survey by Vogelsang (2013) provides additional insights on this respect from a broader perspective (among other policies areas within the sector).

The theoretical literature, conducted from a variety of approaches and examining the impact of access regulation on investment, does not provide policy makers with any clear-cut answers (Valletti, 2003). Most of the theoretical models assume exogenously determined positions for both incumbents and entrants in the market. Access regulation is viewed as a pro-competitive measure and an instrument for spurring investment. This reasoning underpins the "stepping stone" or "ladder of investment" theory proposed by Cave and Vogelsang (2003). This theory holds that allowing entrants to lease elements of the incumbents' network with minimum direct investment at initial stages of competition acts as a catalyst for them to invest and create their own infrastructure. Based on analyzes of these two types of firm, these models analyze the impact of access regulation on investment (see, for example, De Bijl and Peitz (2005); Vareda (2007)).

Alternatively, some models rely on an endogenous determination of a firm's position, reflecting its own actions and those of other firms. Firms compete with each other to determine their positions and, hence, infrastructure investment decisions are affected by access regulation. Examples of studies conducted from this approach include Gans and Williams (1999), Gans (2001) and Hori and Mizuno (2009).

Given this lack of consensus in the theoretical findings concerning the impact of access regulation on broadband investment, many empirical studies have sought to provide improved insights for policy implementation. The empirical literature examining this issue can, however, be divided in two strands: studies finding evidence in support of mandatory access regulation and studies that point in the opposite direction.

Based on an industry simulation using United Kingdom data, Christodoulou and Vlahos (2001) suggest that a mix of infrastructure and service competition, such as that promoted in the Netherlands[7], stimulates incumbent and entrant investment alike and offers better consumer benefits. The implication of these results for policy makers is that the introduction of "sunset clauses" provides

[7] The Dutch regulator, OPTA, proposed an approach that includes the introduction of "sunset clauses". This meant the gradual introduction of a five-year transition period from tariffs based on historical costs to tariffs based on current costs in an attempt at stimulating competition in both the early stages and in later years. After the five-year period, the incumbent would, in principle, be free to set its tariffs on a commercial basis (Christodoulou and Vlahos, 2001).

new entrants with strong incentives to invest while allowing them to enter in service competition and acquire essential knowledge about their new market.

The OECD Report (2001) claims that, for its Member States, "the evidence indicates that opening access networks, and network elements, to competitive forces increases investment and the pace of development". Likewise, Wallsten (2007) tests the impact of regulation and demographic variables on broadband development in OECD countries for the period 1999-2003, explicitly taking into account different types of access regulations. The author finds that extensive access mandates and certain types of price regulation can reduce broadband investment incentives, although regulations ensuring easier interconnection with the incumbent can increase investment.

Yet, the weight of empirical findings tends to lend greater support to the detractors of mandatory access. Despite the fact that a large number of these studies draw on data for the United States, below we restrict our summary to the main findings within EU, given that this is the framework in which we conduct our study[8].

By comparing the diffusion of broadband access through intra-platform and service-based competition, Distaso et al. (2006) analyze the effects of mandatory access on broadband deployment. Using data for 14 EU countries for the period 2000-2004, they find inter-platform competition to be the main driver of broadband uptake, while competition in the market for DSL services does not play a significant role.

Höffler (2007) studies the costs and benefits from infrastructure competition by estimating the welfare effects of broadband access competition between DSL and cable. The study draws on data for 16 Western EU countries between 2000 and 2004. The author finds that infrastructure competition had a significant and positive impact on broadband penetration. However, when comparing the additional social surplus attributable to cable competition with that derived from cable investment, he concludes that, in the absence of significant positive externalities, infrastructure competition has not been welfare enhancing.

[8] Studies with evidence against mandatory access outside EU include Jorde et al. (2000), Crandall and Singer (2003), Ingraham and Sidak (2003), Zarakas et al. (2005) and Jung et al. (2008); while examples of studies countering the ladder of investment theory in the US are Crandall et al. (2004) and Hazlett and Bazelon (2005).

Friederiszick et al. (2008) analyze the relationship between entry regulation and infrastructure investment, drawing on data for 27 EU countries between 1997 and 2006. Paying careful attention to the endogeneity problem of regulation (by applying instrumental variables), the authors report that entry regulation discourages infrastructure investment by entrants and that it has no effect on incumbent firms in the fixed-line telecommunication sector.

Distaso et al. (2006) and Höffler (2007) made early contributions to the debate on the effects of mandatory access on broadband penetration. However, both studies only examine the two-year period immediately following the implementation of the new regulation. A longer period of time, such as the one adopted in our estimations, is needed to obtain a better appreciation of the consequences of access regulation on broadband uptake.

In short, empirical studies conducted for the EU case provide conflicting evidence on the impact of access regulation on broadband investment and as such the debate remains ongoing.

2.2.2 Internationalization

Similarly to regulation, some studies point to different patterns of investment behavior in broadband markets depending on the typology of operating firms, but to date this classification has been limited to that of market incumbents and entrants. Here, in addition, we propose classifying firms by their degree of internationalization. We then seek to determine whether (and how) this new firm typology affects infrastructure investment decisions in the EU broadband market.

Different patterns of behavior expressed by incumbents and entrants have been described by Wallsten and Hausladen (2009) through the estimation of separate regressions for the two firm types. Using a data set for 27 EU countries over the period 2002 - 2007, they find a significant negative correlation between the number of unbundled DSL connections per capita and the number of fibre connections. They also confirm the negative impact of mandatory access policies on new infrastructure investment (measured by the number of new fibre lines). Similarly, Grajek and Roller (2012), in a study of 20 EU countries over the period 1997-2006 in which they examine just fixed-line operators, find that an

increase in regulatory intensity decreases incumbents' investment but increases total investment across entrants.

In line with these previous studies, we also consider differences between incumbents and entrants, but from a different perspective. The firm classification proposed here considers, in addition to the differences between incumbents and entrants, the possibility that the extent of a firm's internationalization may also affect its investment decisions. In general, to understand the motivations underpinning a firm's internationalization and its investment decisions we rely on arguments drawn from International Business Theory and Management Theory.

The eclectic paradigm of international production (Dunning, 1999; Dunning and Lundan, 2008) is part of the International Business Theory[9] with a three-component structure: ownership, location, and internalization. The ownership component explains how companies manage to obtain sustainable competitive advantage, analyzing their internal resources to correct their weaknesses and develop their potentials. The existence of assets is related to a firm's capacity to expand and stand out from its competitors. Among its tangible assets are economies of scale and patents, while its intangible assets include the firm's brands and reputation. The assets might, furthermore, be specific to a particular location (the location component) in terms of their origin and use, yet at the same time be available to all firms. These assets also include, therefore, the cultural, legal, political, financial and institutional environment in which they are deployed. Finally, the internalization component, with obvious links to Coase's (1960) transaction costs and Williamson's (1967) notion of a firm's boundaries, reflects that these boundaries should be kept as large as possible while it faces transaction costs. Therefore, from the resource base and transaction costs at the root of the ownership and internalization components, by expanding internationally a firm may obtain certain cost reductions and/or exploit its scale economies.

From another perspective, the strategic management literature views the internationalization as a form of diversification. As for firm's product diversification[10], firms invest internationally for several motives. Nachum and Zaheer

[9] Other international business theories include the Uppsala model (Johanson and Vahlne, 1977, 2009) and the internalization theory (Buckley and Casson, 1976, 2003, 2009).

[10] Even though studies use different labels such as international diversification, international expansion, geographic diversification, globalization and multinationality all tend to refer to the same conduct; what we call the firm internationalization.

(2005) labelled these motives as market seeking, efficiency seeking, resource seeking, export seeking, and knowledge seeking, each of which value different resource endowments in the host country. Thus, among other things, firms may emphasize the potential for economies of scale in choosing target countries for internationalization. Essentially this is a decision by firms on how best to configure their activities internally, in line with the comparative advantage of different locations in order to maximize efficiency and reduce costs.

Additional insights are provided by Sarkar et al. (1999), who combine elements of International Business Theory and Management Theory to study the drivers of the internationalization of telecommunication service providers. The authors highlight that the role played by scale as an internationalization driver includes the enhanced negotiating power it affords over equipment suppliers, cost reductions through volume accumulations across country locations and market segments, an increase in long-term market capitalization, and the economies derived from the optimization of network design.

Within the context of internationalization, knowledge also plays an important role. Ghoshal (1987) claims that internationalization can promote the experience or internal learning capabilities of companies helping them to innovate and to meet future changes. The learning effect of internationalization comes from the higher volume of operations, which allows firms to accumulate knowledge while progressively reducing costs.

Moreover, a firm's knowledge of a specific market is closely related to its original position in that market. Depending on whether the firm is an incumbent or entrant, its market knowledge will differ. Incumbents have a better knowledge of the local market than entrants, as the former have years of experience and valuable accumulated experience of that market (customers, regulations, doing business, etc.). This is especially true in markets that were once monopolies but which have been liberalized, such as the telecommunications market and the new markets that have emerged from it, such as the broadband market.

While it is true that incumbents have a better knowledge of the local market than entrants, it is also true that the global knowledge of some entrants may be very important as well, at least compared to other entrants. The overall knowledge of an entrant (incumbent) can differ depending on its position in the international markets (whether it is an incumbent or an entrant in other countries). Thus, to fully appreciate differences in firm's investment behavior coming form their

position as incumbent or entrant, the analysis must consider their positions in both; the local and the internationals markets.

The role of internationalization and firms' position in the markets as drivers of investment can be summarized as follows. First, since firms may invest internationally in an efficiency-seeking process and exploit their scale economies, a positive relation is to be expected between the degree of internationalization of a firm and its investment in the host country. Second, incumbents and entrants have different levels of knowledge of the local market and this may result in different investment behaviors. And, third, different behavior can also be expected within the entrants and within the incumbents depending on their degree of internationalization and their respective positions in the international markets. These three roles provide us with the foundations for classifying telecommunication firms when constructing the measurement for the new "typology of firm" that will be used in the empirical section of this Chapter.

2.3 Empirical Strategy and Data Issues

In this section we present the empirical strategy and the data used in empirically testing the relevance of the investment drivers discussed in the previous section. Eq. (2.1) represents country i infrastructure investment at time t (Inv_{it}) as a function of the typology of firms (TF_{it}) that operate in the market, the regulation (Reg_{it-1}) in the countries, and our three control variables: inter-facility competition ($HHIinter_{it}$), intra-facility competition ($HHIintra_{it}$) and per capita Gross Domestic Product ($GDPpc_{it}$). In addition, λ_i and γ_t are include to account for country and time especific effects.

$$\begin{aligned} Inv_{it} = {} & \alpha_1 TF_{it} + \alpha_2 Reg_{it-1} + \alpha_3 HHIinter_{it} \\ & + \alpha_4 HHIintra_{it} + \alpha_5 GDPpc_{it} + \alpha_6 \lambda_i + \alpha_7 \gamma_t + \epsilon_{it} \end{aligned} \tag{2.1}$$

We combine data from various sources to create an original panel data set for testing the drivers of investment in broadband for the 27 EU countries over the period 2002-2009 (see Table 2.1 for the definitions and sources of the variables). Below we explain the variables used in Eq. (2.1).

TABLE 2.1: Definitions and data sources

Variable	Definition	Source
Dependent		
Inv_{it}	Investment measured as the change in infrastructure stock (penetration rate)	EU Commission
Typology of firm		
TF_{it}	Typology of Firm	Point Topic, NRAs and firms' annual reports
Regulation		
AR_{it-1}	Access Regulation Intensity (0-3)	Plaut Economic and NRAs
$Trans_{it-1}$	Transposition of Community Law in Information Society	EU Commission Application of EU Law
$RegQ_{it-1}$	Regulatory Quality Index	World Bank
Competition		
$HHIinter_{it}$	Herfindahl Inter-facility Index	Point Topic
$HHIintra_{it}$	Herfindahl Intra-facility Index	Point Topic
Income		
$GDPpc_{it}$	Per capita GDP (thousands €, 2000 prices)	Eurostat

2.3.1 Infrastructure Investment

Due to the lack of firm level data regarding specific investment in broadband infrastructure, we use a country level approach in which investment is approximated by the change in the stock of infrastructure. More precisely, following Röller and Waverman (2001) and Koutroumpis (2009), from a broadband infrastructure production function we construct our broadband infrastructure investment variable as shown in Eq. (2.2):

$$Inv_{it} = Ln\left[\frac{pcDSL_{it}}{pcDSL_{it-1}}\right] \tag{2.2}$$

where $pcDSL_{it}$ (the number of DSL lines per capita) represents the stock of broadband infrastructure in country i at time t[11].

[11] This broadband infrastructure investment variable, as shown in Eq.(2.2), is built on the underlying assumption that if the Ln($pcDSL_{it-1}$) is a right hand side variable in Eq.(2.2) its coefficient equals one when the dependent variable is Ln($pcDSL_{it}$). To test this assumption we perform a Wald test under the null hypothesis that the penetration lag coefficient is equal to one. We have confirmed that this assumption holds when estimating Eq. (2.2) by means of GMM techniques with Ln($pcDSL_{it-1}$) as a explanatory variable.

Data on the number of lines by country are drawn from two reports on broadband access published by the EU Commission, namely the Communication Committee Working Documents on "Broadband access in the EU: situation at July 2007" and "Broadband access in the EU: situation at July 2009". These reports have been published twice a year since the implementation of mandatory access in 2002. Data on population comes from Eurostat.

2.3.2 Typology of Firms

Relying on the foundations presented in the literature review, below we classify the firms providing broadband services according to the extent of their internationalization and their position as incumbents or entrants, and construct the typology of firms' measure including both characteristics. After classification and construction, we present some stylized facts of the resulting variable.

2.3.2.1 Classification and Construction

Given that our firm typology is in part based on the degree of internationalization, it is essential to know how it might be measured. Dörrenbacher (2000) proposes three categories of indicator of internationalization: structural, performance and attitudinal. Structural indicators are those that provide a picture of a firm's international network at a given point in time. Two examples of such an indicator would be, first, the number of countries in which the firm is present and, second, its foreign assets expressed as a percentage of its total assets. Performance indicators measure the success or failure of a firm's activities abroad measured in terms of turnover and operating income. Attitudinal indicators focus on how the firm views and treats its subsidiaries abroad. One such measure is the amount of international experience (in terms of the number of years living abroad) that senior managers have.

Although the literature offers many methods for measuring internationalization, some are obviously easier to apply than others. Specifically, the availability of data is a major influence on which of the measures are feasible and which are not; for this reason, in this study we use a variant of the structural indicator, namely the number of countries in which the firm is present.

Since our firm typology is also based on firm's position as incumbent or entrant in the markets it is important to describe how this classification has been made. We mainly rely on the names of firms offering DSL services in different countries based on the data provided by Point Topic's Global Broadband Statistics. As for the number of DLS subscribers in 2009, Point Topic's database accounts for 97% of the number of subscribers reported by the EU Commission Communication Committee Working Document on "Broadband access in the EU: situation at July 2009". In each country, the incumbent operator is the owner of the former monopolistic telecommunication provider, while the entrants are all other firms offering DSL services in that country besides the incumbent. The previously mentioned database was complemented with information from the National Regulatory Agencies and firms' Annual Reports to validate the entry date and the time firms had been operating in each country.

From firm data we construct a country level measure of firm typology based on the extent of the internationalization and the position as incumbent or entrant of firms operating in that country. Firms are assigned an internationalization-position valuation (V_{itf}) for each country and period. In assigning this valuation to each firm, based on the role of internationalization and firms' incumbent or entrant position in the markets as drivers of investment summarized in the previous section, the firms need to be sorted; first, in terms of their position as incumbent or entrant in country i; second, by the degree of their internationalization (the number of countries they operate in besides country i); and, third, according to their role as incumbents or entrants in those countries.

As shown in Table 2.2, the highest valuations are assigned to the more experienced and internationalized firms; the lower valuations are assigned to firms that are market entrants in just one country. This valuation increases if the entrant operates in more than one country, the extent of the increase depending on its position there: the increase is only slight if the firm is an entrant, while the increase is more important if it is an incumbent. This allows us to capture not only the distinct behavior that is to be expected between entrants according to the extent of their internationalization, but also that according to their overall knowledge gained from their position in international markets (as entrants or incumbents). The valuation of the incumbents is assigned analogously. The lowest valuation is assigned to an incumbent that operates in just one country,

while the highest is assigned to an incumbent that is also incumbent in two or more countries and an entrant in another[12].

TABLE 2.2: Valuation of firms' internationalization and position

Internationalization-Position	Valuation
Entrant in country i	0.0500
Entrant in country i and one other country	0.1000
Entrant in country i and two other countries	0.1500
Entrant in country i and incumbent in another country	0.2000
Entrant in country i and in another country and incumbent in another country	0.2500
Entrant in country i and incumbent in two other countries	0.3000
Entrant in country i and in another country and incumbent in two other countries	0.3500
Entrant in country i and incumbent in more than two other countries	0.4000
Incumbent in country i	0.4500
Incumbent in country i and entrant in another country	0.5000
Incumbent in country i and entrant in two other countries	0.5500
Incumbent in country i and in another country	0.6000
Incumbent in country i and in another country and entrant in another country	0.6500
Incumbent in country i and in another country and entrant in two other countries	0.7000
Incumbent in country i and in more than two other countries	0.7500
Incumbent in country i and in more than two other countries and entrant in another country	0.8000

Note: See Appendix A for alternatives valuation scores (V_{itf})

Finally, the valuation (V_{itf}) obtained by firms (f) operating in country (i) is added for each period (t) to obtain the typology (TF_{it}) characterizing the firms in that country and period as shown in Eq. (2.3).

$$TF_{it} = \sum_{f=1}^{n} V_{itf} \; with \; f{=}\text{firms}\{1 \ldots n\} \tag{2.3}$$

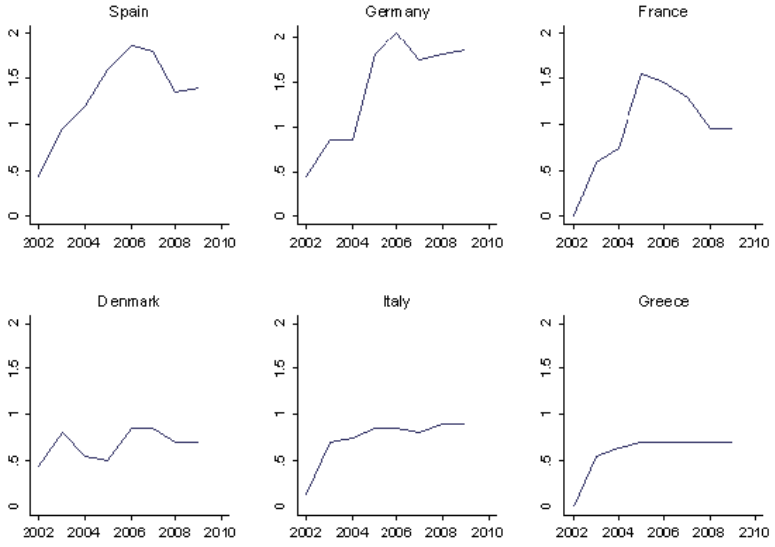
Since the aim is to capture both the effect of internationalization and firms' position as incumbent or entrant in a single country level measure, the same firm can obtain different valuations in different countries. For instance, a firm which is incumbent in country A and entrant in country B, will get different scores in each country (0.5000 for country A and 0.2000 for country B). If we only consider firm internationalization it seems reasonable that a firm should

[12] All the typologies represented in Table 2.2 are based on the casuistic derived from the observation of firms in the EU DSL broadband market. Thus, feasible typologies that do not occur in the periods and countries examined in this study were not included.

have the same valuation in both countries. However, when also considering the effect of firms' position, it cannot be expected that a firm will behave equally in the country in which it is the incumbent as in the country in which it is an entrant.

Figure 2.1 depicts the variable TF_{it} obtained for a selection of countries. A better idea of the variable construction can be obtained from working through an example. During the year 2002 DSL broadband service in Spain was only provided by the incumbent Telefonica, which did not provide this service elsewhere in EU. Thus, the TF_{it} corresponding to that country that year was "Incumbent in country i" (with a score of 0.4500). The next year, besides the incumbent (which did not have international broadband operations within the EU), five firms began to provide services; four of them national and one international. The national firms (Yacom, Comunitel, Euskaltel and R Cable) are assigned the category of "Entrant in country i" (with a score of 0.0500). Meanwhile, the international firm (Orange) was not only an entrant in Spain but also into the United Kingdom, and in addition it was the incumbent in France. Therefore, Orange is assigned the category of "Entrant in country i and in another country, and incumbent in another country" (with a score of 0.2500). Thus, in 2003 the TF_{it} characterizing the Spanish broadband market was the sum of the valuations obtained by the incumbent, the four national entrants and the international entrant (a total of 0.9000).

FIGURE 2.1: Typology of Firms ($TFit$): a selection of countries



The next three years were the most active in terms of changes in the characterization of broadband providers in Spain. Yacom (one of the national entrants) was bought by Tiscali (an international entrant), which in turn was purchased the following year by the German incumbent, Deutsche Telekom. In addition, two entrants began to provide services; one national (Jazztel) and one international (Tele2, which acquired Comunitel). Moreover, Telefonica greatly expanded its broadband operations in EU during these years; it entered into two new countries (United Kingdom and Germany) and acquired the incumbent of a third (Cesky Telecom in the Czech Republic). From the year 2007 there was a decrease in the value of TF_{it} for Spain (from 1.8000 to 1.3500, see Figure 2.1), this was mainly driven by the fact that Deutsche Telekom's (one of the two international entrants, incumbents of other countries) broadband operations in Spain were absorbed by Orange (the other international entrant, incumbent of another country).

Comparatively, from Figure 2.1 we can rank countries by the degree of internationalization and the position in the markets of the firms operating within each of them. In this case, Germany has significantly more internationalized telecom firms than Italy or Greece. Following on this line, below we present more stylized facts.

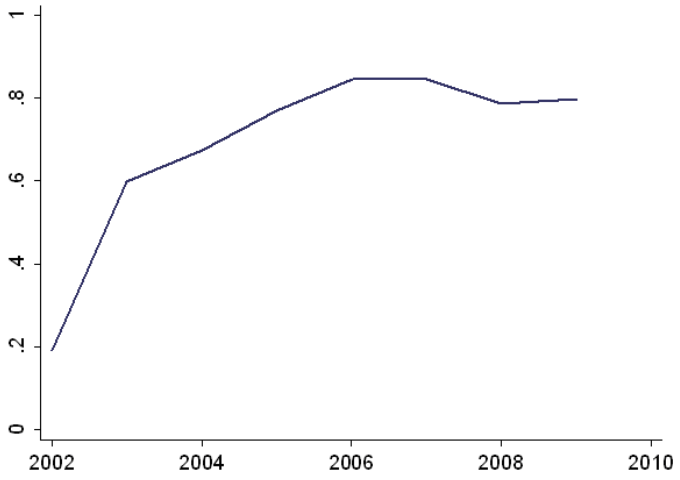
2.3.2.2 The Typology of Firms: Some Stylized Facts

From the internationalization component of TF_{it} it can be expected a high correlation between our variable and one of the traditional measures of internationalization. Therefore, we have constructed a variable measuring the number of countries in which a given firm has been present. This variable has been constructed with our sample as an exercise to compare it with the variable TF_{it} previously described. As expected, the correlation between the two variables is positive and high (0.8348).

After comparing our variable with a more traditional measure of internationalization, next we describe the evolution of TF_{it}, first from a EU average perspective and, second, from a detailed country level perspective. Figure 2.2 shows the typology of firms characterizing the EU DSL market when considering EU 27 mean values. At the beginning of the period the service was provided by either, solely the incumbents or the incumbent plus one entrant. As the time went by,

the number of national and international providers grew (both incumbents and entrants expanded), and on average, TF_{it} increased its value continuously until the years 2006-2007 when it stabilized, to slightly decrease during the last two periods of our sample.

FIGURE 2.2: Typology of Firms ($TFit$) evolution: EU27 mean values



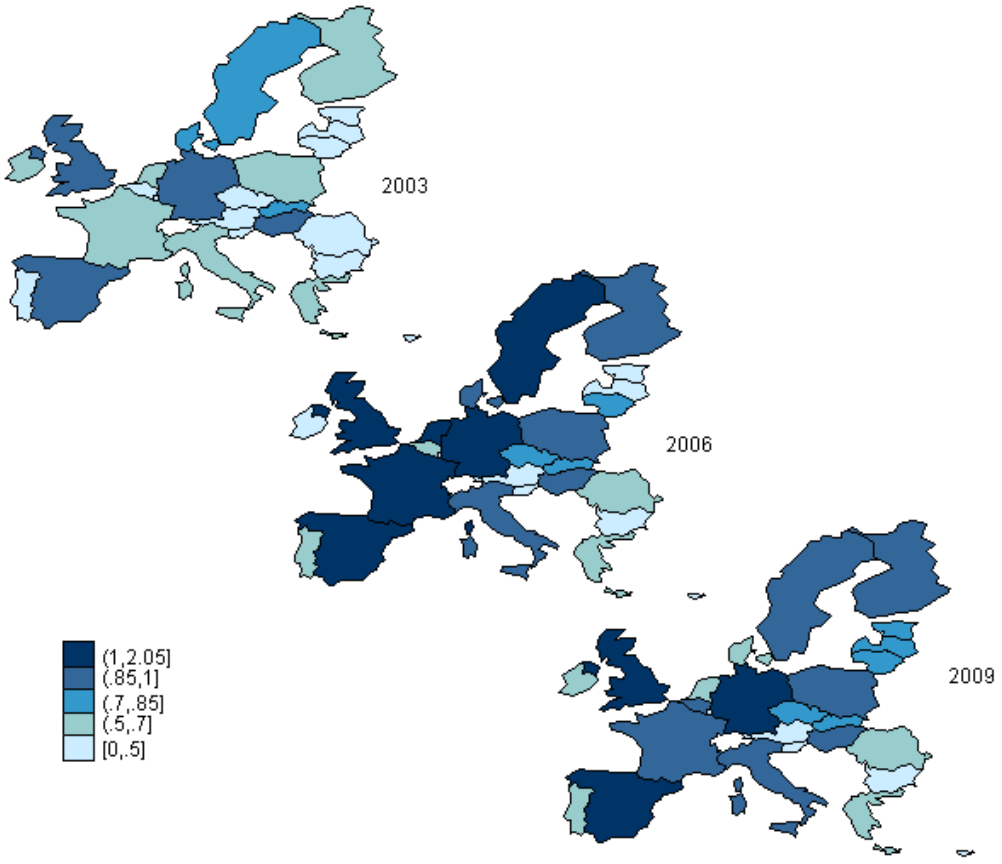
From a country level perspective, Figure 2.3 illustrates the evolution of TF_{it} with three maps representing the beginning (2003), the highest levels (2006), and the slight decline (2009) of the internationalization process.

The period between 2003 and 2006 was characterized by a big expansion of telecommunication providers within EU. The greater changes in TF_{it} took place in the biggest markets such as Germany, Spain, France and UK (some exceptions are the Netherlands and Sweden), this may respond to the combination of two effects; the enlargement of the countries' incumbents (looking for new business opportunities), and the incursion of a high number of entrants (biggest markets attracts more operators). But not all countries experienced such pronounced changes in TF_{it}, while in some countries the growth was moderated (Italy, Poland and Romania), in others there was a little growth (Belgium, Cyprus, Estonia, Hungary, Latvia, Slovakia, and Slovenia) or remained unchanged (Austria, Luxembourg, Malta, and Ireland).

The period between 2007 and 2009 was characterized by a slight decline of the TF_{it} value (with some exceptions) in many countries. At one end, some of the countries that account for the biggest increases in the previous period (and

therefore reached highest levels) were those that declined the most (as France, the Netherlands, Sweden, UK, Germany, and Spain)[13]. At the other end, the countries undergoing the highest growth where those that during previous period experienced little changes like Belgium, Estonia and Latvia. The remaining countries account for either small growth or decline in the TF_{it} variable but, in general, keeping the conditions achieved in 2006 and 2007.

FIGURE 2.3: Typology of Firms ($TFit$) evolution: EU27



The differences in TF_{it} observed among countries and time grounds on providers' international scope and their position as incumbents or entrants in the markets. As outlined in the literature review, the extent of a firm's internationalization and its position (as an incumbent or entrant) will influence its investment decisions across countries and time. We do a first approximation of empirical testing in this direction through the introduction of the variable TF_{it} in the analysis of the investment determinants.

[13] It is important to highlight that in any country the decline was not sufficiently important to reach lower values that reported in 2003.

2.3.3 Regulation

The relevance of regulation as a driver of broadband investment was reflected in the literature review. Normally, a firm's investment decisions are taken in line with strategic investment plans, within which annual investment levels for the forthcoming year are decided at the end of that current year (if there is no information regarding future changes in regulation). Thus, regulations that can affect investment decisions for the forthcoming year are those that come into effect at the end of the current year. In order to capture the fact that firms do not react immediately to regulation, in Eq. (2.1) we introduce the various regulatory variables lagged one period[14].

Several studies of the EU telecommunications markets use the Plaut Economic regulation index (either all or just some of its components) as a regulation indicator. Here, we also use it as our access regulation intensity variable. However, since we do not want our results to be dependent on a single regulation indicator, we perform our estimations using three different indicators: Access Regulation Intensity (AR_{it-1}), Transposition of Community Law in Information Society ($Trans_{it-1}$), and Regulatory Quality ($RegQ_{it-1}$). Below, we provide further details of these regulatory variables.

2.3.3.1 Access Regulation Intensity (AR_{it-1})

In an unbundled DSL network, market competitors can provide customers with broadband access by different means. These means are related to the unbundled network elements (UNEs) and represent the different types of access that the entrants have to the incumbent network.

The access regulation intensity variable is composed of the regulation of each access type (full ULL, shared and bitstream). For each type of access, the variable represents whether access regulation exists or not. Therefore, it takes the value of 1 when it exists and 0 otherwise. The access regulation intensity variable in a country i during period t is the sum of the access regulations to the three access types. Hence, it takes discrete values between 0 and 3:

[14] The introduction of the regulatory variables lagged one period also allows us to avoid possible endogeneity problems. In additional IV estimations, we use the lag of regulatory variables as instruments. Results are highly consistent with those presented in this Chapter.

$$AR_{it-1} = ULL_{it-1} + Share_{it-1} + Bitstream_{it-1} \tag{2.4}$$

Note that once the access regulation has been implemented for an access type in a country, it will be maintained for all successive periods. Data on access regulation for these three types of access come from the Plaut Economic regulation index (Zenhaeusern et al., 2012).

2.3.3.2 Transposition of Community Law ($Trans_{it-1}$)

Much of EU regulation law takes the form of Directives that set out general rules and provisions, but which leave to Member States the choice as to how to implement them. Primary responsibility for applying EU law lies with the national administrations in the Member States. From the Secretariat General of the EU Commission we obtained data on the percentage of Directives implemented (by Member State and sector) showing the link between the provisions in EU Directives and national rules. The sector classification related to telecommunications is that of the *Information Society*.

Our variable, $Trans_{it-1}$ captures the percentage of Directives associated with telecommunications that have been implemented in a country in each period. Since the access regulation is contained in EU Directives and the Member States must transpose these Directives to national laws in a pre-determined period of time, the $Trans_{it-1}$ variable, though less specific, can be seen as analogous to the access regulation variable.

2.3.3.3 Regulatory Quality ($RegQ_{it-1}$)

From a broader perspective, regulation extends beyond specific measures such as mandatory access; hence, we attempt to validate our results by accounting for the quality of regulation. Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit, and promote, private sector development. Our regulatory quality variable ($RegQ_{it-1}$) is a World Bank index built at the country level. It is measured in units that can range from -2.5 to 2.5, although the range in our

sample is from -0.1 to 1.8, with higher values corresponding to higher levels of quality[15].

2.3.4 Competition

To capture the effects of competition at the retail level, we introduce two Herfindahl indexes (HHI) for each country and period in Eq. (2.1): one for intra-facility competition ($HHIintra_{it}$) within the DSL network (full ULL, shared-access, bitstream access and resale) and one for inter-facility competition ($HHIinter_{it}$) between networks (DSL, cable, FTTx and wireless). A Herfindahl index measures the degree of concentration of the market, and is defined as the sum of the squares of a firm's (or networks in the case of inter-facility) market shares. Data for the construction of these indexes are taken from the information provided by Point Topic's Global Broadband Statistics.

Previous studies of broadband penetration and diffusion have also controlled for intra-facility and inter-facility competition effects. In the case of intra-facility competition, Bouckaert et al. (2010) find a negative effect, while Distaso et al. (2006) report an insignificant effect. In the case of inter-facility competition, while Bouckaert et al. (2010), Höffler (2007) and Distaso et al. (2006) find a positive effect, Gruber and Koutroumpis (2013) report a negative effect.

2.3.5 Income

We use per capita Gross Domestic Product ($GDPpc_{it}$) as our income control variable. Previous studies report a positive relationship between broadband penetration and economic growth (Koutroumpis, 2009; Czernich et al., 2011). Yet, broadband studies, such as Grajek and Roller (2012) and Distaso et al. (2006), which used income as a control variable, find no significant effect on

[15] Besides the Regulatory Quality index, we review on several known indexes to measure regulatory quality but the World Bank index is the one that better fits to the sample covered in this study (2002-2009, EU27). While Gual and Trillas (2004) index is built for a single year, 1998, Edwards and Waverman (2006) covers the period 1997-2003, and both have information for only EU15 countries. In addition, the Waverman and Koutroumpis (2011) TRGI index is calculated worldwide but only for the year 2006. The correlation coefficient between the TRGI index and the Regulatory Quality index we use in the year 2006 is 0.5036 (p-value 0.0074) for the 27 EU countries.

either investment or penetration. To avoid possible problems of endogeneity from employing this variable, we use the lag of the $GDPpc_{it}$ as an instrument in our instrumental variable estimations[16]. The data on $GDPpc_{it}$ are from Eurostat. Table 2.3 contains the summary statistics of the database used in this study.

Table 2.3: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Inv_{it}	161	0.4927	0.6100	-1.2054	4.1540
TF_{it}	216	0.6888	0.3787	0.0000	2.0500
AR_{it-1}	189	2.1587	0.9710	0.0000	3.0000
$Trans_{it-1}$	161	0.9755	0.0658	0.6842	1.0000
$RegQ_{it-1}$	189	1.2372	0.3861	-0.1000	1.8900
$HHIinter_{it}$	201	0.6421	0.1956	0.3202	1.0000
$HHIintra_{it}$	201	0.8046	0.2216	0.2255	1.0000
Ln$GDPpc_{it}$	216	2.6293	0.8427	0.6620	4.1222

2.4 Estimation and Results

In order to analyze the impact of regulation and TF_{it} on infrastructure investment we use the investment equation (Eq. 2.1) to perform the estimation of three models corresponding to the three regulatory variables explained above. We are particularly interested in testing whether the different "typologies of firm" operating in a country influence the aggregate investment in that country. In all estimations we use country fixed effects to control for time invariant determinants at country level, and time fixed effects to control for any EU-wide time-trend in the data.

First, we estimate Eq. (2.1) by means of panel data techniques and report the results in columns (1) to (3) of Table 2.4. To avoid possible endogeneity problems of the variable GDP per capita we make use of the instrumental variables (IV) method (results are presented in columns (4) to (6) of Table 2.4). Since our equations are exactly identified (the number of instruments equals the number

[16] The endogeneity in this case derives from the possibility of spillovers generated by broadband networks that might result in externalities in other sectors of the economy, thus affecting the country's GDP (see Koutroumpis, 2009). By adopting the instrumental variables approach applied in this study, our aim is to avoid problems of simultaneity bias and spurious correlation deriving from the possible endogeneity problems.

of endogenous regressors), we are unable to test statistically for overidentification of all instruments (i.e. instrument exogeneity). However, we test for weak instruments with the F-statistics from first-stage regressions following the rule of thumb (see Stock and Watson, 2007). Our results show that weak identification is not a problem in our estimations, hence validating the relevance of our instruments.

TABLE 2.4: Typology of Firm and regulation effects on investment

	Panel			**Panel IV**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Typology of Firm						
TF_{it}	0.678*	0.654*	0.684*	0.693**	0.655**	0.684**
	(0.388)	(0.372)	(0.379)	(0.328)	(0.309)	(0.327)
Regulation						
AR_{it-1}	-0.0651			-0.0882		
	(0.0804)			(0.0764)		
$RegQ_{it-1}$		0.502			0.510	
		(0.636)			(0.551)	
$Trans_{it-1}$			-0.713			-0.711
			(0.554)			(0.674)
Competition						
$HHIinter_{it}$	2.009	2.096	2.166	2.331*	2.147	2.157
	(1.334)	(1.354)	(1.335)	(1.393)	(1.399)	(1.434)
$HHIintra_{it}$	1.480**	1.455**	1.291**	1.448**	1.449**	1.292**
	(0.703)	(0.663)	(0.588)	(0.641)	(0.641)	(0.586)
Income						
Ln$GDPpc_{it}$	-0.420	-0.574	-1.163	0.696	-0.425	-1.191
	(1.288)	(1.288)	(1.376)	(2.112)	(1.873)	(2.327)
Constant	-0.634	-1.040	2.024			
	(4.206)	(4.394)	(4.508)			
Observations	161	161	159	161	161	159
R-squared	0.448	0.449	0.456	0.445	0.449	0.456
№Countries	27	27	27	27	27	27
F-statistic				47.36	64.31	46.41

Note:Dependent variable TF_{it}. All estimations are control by country and time fixed effects. Robust standard errors in parenthesis. In panel IV estimations (columns (4) to (6)) the endogenous regressor (income) is instrumented by its first lags.

Overall, the results from the estimations of Eq. (2.1) support a positive relationship between firm typology and infrastructure investment. When controlling by country and time fixed effects, the variable capturing the type of firm operating in the market is positive and significant (see Table 2.4). These results support the hypothesis of a firm's internationalization and position in the markets acting

as drivers of investment in the EU broadband market. Moreover, our estimates indicate that when one firm enters into a country, the investment (increase in the stock of infrastructure) will be between 3.3% and 3.5% higher if the firm is also an entrant in another country than if it is the first country in which the firm operates[17].

Although firm level information would be needed to confirm these results, they seem to reflect the fact that firms invest internationally as part of an efficiency-seeking process or to exploit their scale economies. Furthermore, the relevance of firms' position in the markets seems to be important for investment decisions.

As for the effects of regulation on investment, none of the three regulatory variables (access regulation intensity, regulatory quality and transposition to community law) are significant at an acceptable confidence level[18]. Although these results are highly consistent, they must be interpreted with caution. Since the estimated effect is for total aggregate infrastructure investment, from an aggregate country point of view the implementation of some sectoral regulatory policies seems to have no effect on investment incentives[19].

Regarding the additional control variables, the intra-facility competition results are in line with those of Bouckaert et al. (2010). The variable is positive and significant in most cases, thus, the greater the competition within the DSL facility, the lower the investment in DSL. At the same time, the inter-facility competition variable is not significant at the usual confidence levels in any of the estimations performad. Thus, at the aggregate country level, changes in the distribution of the respective market shares enjoyed by DSL and alternative technologies have no significant effects on DSL infrastructure investment. Finally, GDP per capita does not have a significant effect on investment across all estimated specifications. These results are in line with those of Grajek and Roller (2012) and

[17] From the semi-log linear function nature of Eq. (2.1) we used finite-difference methods to compute the marginal effect coming from a change in the typology of firms participating in the markets.

[18] We also estimate Eq. (2.1) introducing individual components of the aggregate access regulation indicator (AR_{it-1}) to account for possible different effects of regulation in each access type. The results of these regressions (see Appendix A) are consistent with the results for the aggregate access regulation indicator, that is, the various regulation components are not significant.

[19] When we control by country fixed effect (without the time effect), the transposition of community law is significant and negative. Therefore, if we do not take into account the time component, the effect of regulation, if any, would be negative.

Distaso et al. (2006), who also used income as a control variable and found no significant effect.

2.5 Conclusions

In this study we have assessed the impact on investment behavior in EU broadband markets following major changes to the sector's regulations (including the introduction of access regulation) in 2002. We have classified firms in the EU telecommunication market according to the degree of internationalization of their operations and their position as incumbent or entrant in the markets, and have tested the effect of this classification (that we called "typology of firms") and market regulation on infrastructure investment in EU DSL markets.

From the "typology of firms" values we understand better how the international dimension within the broadband market has changed over time and across countries. On average for the EU 27 the "typology of firms" value grew continuously from 2002 until 2006-2007, and slightly decreased in 2008-2009. The maps showing the values by country highlights, what is the most interesting feature of the evolution, that both the growth and the slightly decrease was mainly driven by those countries with the biggest markets (more potential subscribers for entrants) and/or the more internationalized incumbents. The analysis of the causes of this pattern is an interesting topic for future research.

This study sheds some light on the controversial role played by regulation, firm's internationalization and position in the markets as drivers of investment at aggregated country level. Overall, our results suggest that regulation has not had a significant, direct impact on aggregate infrastructure investment, and on the contrary, the firm's internationalization and position in the markets are significant drivers of investment. Results on internationalization and market position might be supported by the hypothesis from the International Business Theory and the Management Theory, according to which firms invest internationally as part of an efficiency-seeking process and/or to exploit their scale economies. In addition, the negative impact of competition on investment might indicate that the increase in competition has not been accompanied by infrastructure investment, but rather by subscribers switching from incumbents to entrants. This, together with the possibility that DSL markets are currently at a stage in which the relationship between competition and investment is negative, raises

questions as to the effectiveness of regulations in promoting competition, and their possible long-term effects on DSL infrastructure.

In short, our results would seem to indicate that, under the current regulatory framework, firms that choose to invest more in infrastructure are those that have most international experience in the sector. As such, firm's position in the markets (specific and overall) plays an important role in telecommunication sector.

Although a number of valuable conclusions can be drawn from this Chapter, certain shortcomings should be noted. First, given data availability, broadband infrastructure investment is not directly observable at either the firm or the country level. Second, detailed firm-level data would enable us to disentangle more clearly the respective roles being played by firms' position in the markets, on the one hand, and their internationalization, on the other.

This chapter is a first step into the analysis of the impact of firms' internationalization and firms' position as incumbent or entrant in the markets on infrastructure investment. Subsequent studies need to incorporate disaggregated data collection, which should facilitate a better understanding of how the two factors in EU broadband markets are related to each other. This is addressed in the empirical study presented in the next chapter where firm performance is analyzed using firm, group, and country level information.

3. Regulatory Environment and Firm Performance in EU Telecommunications Services

3.1 Introduction

As in most network industries, telecommunications services were traditionally provided by a single, state-owned, vertically integrated operator. All this changed in the 1980s and 1990s with the liberalization process and the privatization of many of these operators. More recently, in 2002, the EU implemented the mandatory access regulation aimed at ensuring the entrance of new agents in the sector[20]. In order to stimulate competition and to obtain the desired effects for markets and consumers, new entrants accessed the incumbents' fixed-line infrastructure at the wholesale level, and cost-based, access (wholesale) regulated pricing regimes were adopted in most countries. As detailed in Chapter 2, the controversial "ladder of investment" theory (Cave and Vogelsang, 2003) explain the rationale behind this framework. With the access regulation applied in the EU broadband services the new market competitors were able to provide broadband service for customers by using the incumbents' infrastructure, the prices for which are regulated[21]. Thus, firm performance is, in part, dependent on regulatory decisions. For this reason, in this Chapter, we evaluate the effect of access regulation on firm performance by observing the regulated prices that entrants pay for access to the incumbents' network to provide Internet services to subscribers.

The implementation of regulated rates directly affects, within the access regulation context, firm performance in two ways: it impacts the entrants' production costs through the input prices and it impacts the incumbents' wholesale and retail income. Therefore, to appreciate fully the impact of wholesale access prices

[20] This new regulatory framework is contained in EU Directives 2002/19/EC to 2002/21/EC.

[21] The usage is related to the unbundling network elements (UNEs), which represent the different types of access that the entrants have over the incumbents' network.

on firm performance the approach adopted must include performance information in both the retail and the wholesale market.

The changes to the EU telecommunications sector over the past three decades have meant that in most countries access to Internet services is now provided by a broad range of operators: on the one hand, there are the traditional monopolist telecom operators, i.e., the incumbents and, on the other, there are the new operators (the alternatives to the traditional monopolist telecom operators), i.e., the entrants. Among the incumbents and the entrants there are firms that operate in just one country as well as firms that operate in several EU countries (see Chapter 2). Thus, in any given country, broadband services might be provided by, for instance, a national entrant (with only national operations), a multinational entrant (which might be an entrant in several countries and/or an incumbent in another country), and a national or multinational incumbent.

Differences can be expected in the performances of entrants and incumbents, as well as in those of national and multinational (with varying degrees of internationalization) firms. In addition to the differences between incumbents and entrants from their vertical relation, the local market knowledge of entrants and incumbents is likely to differ. Moreover, the resulting balance between the costs and benefits derived from the firms' internationalization process will impact differently on their performance. As such, these differences should be taken into account when analyzing the performance of EU telecommunications firms.

If we consider that the wholesale access price is a regulatory outcome, then it is subject to a certain degree of discretion, which might ultimately lead to regulatory risk. Moreover, a firm's decision to operate as a multinational can be seen as a diversification strategy aimed at partially reducing some of the country risks. As such, a firm's exposure or sensitivity to the regulated access price might differ depending on whether it operates nationally or internationally. For this reason it is interesting to evaluate possible differences in the regulated price elasticity of performance for national and multinational firms providing telecommunications services within EU.

Thus, using firm, corporate group, and country level information for the European broadband market over the period 2002-2010, we estimate the effects of regulated access prices and firms' multinational status on three measures of firm performance, namely: market share, turnover and productivity. Particular attention is given to differences in the effects on performance measures depending

on whether the firms are market incumbents or entrants. We find that, while access prices exert a negative effect on entrants' market share and turnover, the effect on incumbents' market share, turnover and productivity is positive. Additionally, we find that multinational entrants perform better than national entrants in terms of their market share but worse in terms of their turnover and productivity. The opposite is the case for incumbent multinationals. These perform better than their national counterparts in terms of their turnover and productivity but worse in terms of their market share. Thus, we confirm that firms' multinational status has a significant impact on their performance, and that this impact differs for incumbents and entrants. Finally, when evaluating the price elasticity at the mean performance of national and multinational firms, we find that the effect of access prices on performance is lower for multinational than it is for national firms (both for incumbents and entrants).

This chapter is organized as follows. Section 3.2 summarizes the related literature and develops the empirical hypotheses regarding the effect of regulated access prices and firms' multinational status on firm performance. Section 3.3 outlines our empirical strategy and discusses data issues. Section 3.4 presents the estimations and results of our analysis. Finally, Section 3.5 concludes.

3.2 Related Literature and Empirical Hypotheses

Most of the literature on access regulation has been devoted to analyzing its impact on firms' investment incentives (Valletti, 2003; De Bijl and Peitz, 2005; Hori and Mizuno, 2009). The effects of third-party access in Europe have generated considerable debate, in which one of the leading questions concerns the impact of mandatory unbundling on a firm's investment incentives[22]. Its proponents claim that unbundling serves to encourage broadband deployment and to promote facility-based competition, while its opponents argue that it distorts entrants' make-or-buy decisions, reduces investment incentives and, as such, has been a failure. In a change of focus, a recent article by Nardotto et al. (2013) evaluates the effect of open access on broadband market performance indicators (penetration and quality) in the UK. The authors find that while local loop unbundling entry has not raised total broadband penetration across different local markets, it has substantially increased the quality of the service as measured by

[22] The literature review in Chapter 2 provides more information on this debate.

average broadband speed. In this study, our focus, rather than being on market performance, is placed on firm performance. Despite the relevance of firm performance for overall market dynamics, and for the provision of the service itself, this is a dimension that has attracted little attention in empirical research (Wallsten and Hausladen, 2009; Grajek and Roller, 2012; Cambini and Rondi, 2012, see) when analyzing the effects of access regulation.

Under the current EU regulatory framework, new entrants can access the incumbent's fixed-line infrastructure at the wholesale level with regulated rates and compete with them in the retail market[23]. Since the regulated access rate is the price that an entrant must pay to the incumbent for each subscriber obtaining a service through the incumbent's infrastructure, the access price is a key ingredient of the firms' marginal cost of providing the service. As such, an inverse relation is expected between access prices and entrants' performance.

The expected relation between access prices and the incumbent's performance is not so straightforward. When analyzing a firm's activity in the context of competitive retail markets, special attention must be paid to whether it is an operator that participates in multiple levels of the industry or not. Generally speaking, a firm usually obtains greater profits in a retail market if its rivals' costs increase, since this induces the latter to raise their prices or reduce their output, both of which can increase the revenue of a retail competitor. Thus, it might be thought that since the incumbent and the entrants compete directly for retail costumers, the former will always benefit from its position as an input supplier, given that it can raise the costs of its retail rivals. However, following Armstrong and Sappington (2006) and Sappington (2006), this is not always the case, because while the incumbent's retail income may increase as its rivals' production costs increase, the incumbent's wholesale profits can fall further than the corresponding increase in its retail profits. In this situation, the incumbent's wholesale profits will fall if the quantity of access bought by the entrants falls at a proportionally higher rate than the access price goes up, which depends on elasticities. Therefore, the relation expected between access prices and the incumbent's performance will depend on the effect that prevails, a positive one from the retail market or a negative one from the wholesale market.

[23] Entrants to the DSL market can provide broadband access to customers by four different means: Full ULL (Unbundled Local Loop), line sharing (Shared Access), bitstream access (a technological use of the incumbent's assets), and pure reselling of the incumbent's services. As of 2009, bitstream access and resale lines represented less than 10% of the total DSL retail lines, so we focus only on Full ULL and Shared Access rates.

The relationship between the degree of multinationality and firm performance has attracted enormous scholarly attention over past decades. However, only limited consensus has been established either theoretically or empirically. Studies on the subject have used a diversity of theoretical and empirical approaches, ranging from the finance theory of portfolio diversification (Levy and Sarnat, 1970; Kim et al., 1993), to the resource view (Kotabe et al., 2002), to that of organizational learning theory (Ruigrok and Wagner, 2003). In spite of the large number of theoretical studies, the empirical evidence has not been robust, and the relationship between multinationality and performance has been found to be negative (Denis et al., 2002), insignificant or very weak (Tallman and Li, 1996), positive (Gomes and Ramaswamy, 1999), and concave (Ruigrok and Wagner, 2003).

In the telecommunications sector, empirical analyses of the relationship between the degree of multinationality and firm performance are quite scarce[24]. The studies by Gerpott and Jakopin (2005, 2007) on mobile network operators are the exception, but they do not find any significant results regarding the above mentioned relationship. Gerpott and Jakopin (2005) found no significant evidence of a positive impact of the degree of internationalization on the financial performance of mobile network operators, and Gerpott and Jakopin (2007) found that announcements of internationalization had insignificant effects on the value of expanding operator stock.

Although no conclusive findings about the relationship between the degree of multinationality and the performance of mobile operators have been reported, in the European broadband sector there are a priori reasons to believe that the relationship may be significant. However, to the best of our knowledge the question has not yet been systematically studied. Given that the EU broadband service has experienced large movements of firms within its confines and that many of them operate simultaneously in more than one country, we believe this is an important question that should not be ignored when evaluating firm performance. Moreover, unlike previous studies, here we pay special attention to the differences between entrant and incumbent firms when analyzing the effect of the degree of multinationality on firm performance, and how this relates to the

[24] Jakopin (2008) presents a literature review and describes a research agenda on internationalization in the telecommunications services industry where the majority of contributions are of a descriptive nature and a somewhat limited number of papers (with the exception of econometric studies of international telephony, see Einhorn, 2002 for a review) empirically test their hypotheses.

access pricing problem, which is a more preeminent problem in the broadband than it is in the mobile market.

Multinationals may, on the one hand, gain knowledge as they enter new countries (Ghoshal, 1987) and develop global strategies that affect national markets, albeit that they might not necessarily respond to the conditions of that specific country. They may, moreover, enjoy greater bargaining power when, for instance, purchasing equipment (Sarkar et al., 1999). Yet, on the other hand, multinationals also face certain costs that are inherent to the internationalization process, such as a lack of focus and the overload suffered by their most qualified professionals. The balance between these benefits and costs determines the positive or negative impact of the degree of multinationality on firm performance. A firm's internationalization can be seen as a sequential process during which the costs and benefits can differ depending on the particular stage reached (Johanson and Vahlne, 1977, 2009). Therefore, depending on the degree of multinationality (e.g. the number of countries in which the firm operates), the cost-benefit relation associated with internationalization can vary and, in the same way, its impact on firm performance might differ with varying degrees of multinationality.

At the outset, broadband services in the EU were provided mainly by each country's incumbent operator. With the opening of access to the incumbents' infrastructure, incumbents and entrants alike began expanding in the EU seeking new business opportunities. Here, a firm's position as incumbent or entrant can play a key role in their performance, especially in a market characterized by vertical relations; thus, while incumbents operate at multiple levels of the industry, entrants typically operate at a single level. Moreover, depending on whether the firm is an incumbent or entrant, its market knowledge will differ. As former monopolist operators, incumbents enjoy years of experience and boast valuable accumulated knowledge of their domestic market (customers, regulations, doing business, etc.). Hence, as knowledge represents a potential gain (among others) of the process of internationalization (Ghoshal, 1987), we hypothesize that the balance between the gains and losses associated with the degree of multinationality differs between incumbent and entrant firms. As such, we seek to estimate the impact of a firm's multinational status on its performance by taking into account the differences between entrants and incumbents in the market.

As discussed above, we expect different effects of a regulated access price on the performance of incumbent and entrant firms. One of the outcomes of the regulatory process within the European broadband sector is the wholesale access price (Edwards and Waverman, 2006). As a regulatory outcome, the access price is subject to some degree of discretion which may ultimately lead to regulatory risk (Armstrong and Sappington, 2006; Sidak and Spulber, 1998, see). Moreover, a firm's decision to be a multinational can be seen as forming part of a diversification strategy to reduce in part some of the risks (Levy and Sarnat, 1970; García-Canal and Guillén, 2008). In line with this risk covering mechanism, multinational firms may be less exposed to regulatory risk on the access price than is the case of national (undiversified) firms. The lower degree of exposure to regulatory risk enjoyed by multinationals, both incumbents and entrants, may translate into a lower impact of access prices in performance (i.e., their average performance in the countries in which they operate). Therefore, we can expect the regulated price elasticity of firm performance to be lower for multinational firms than for national firms. Accordingly, when we estimate the impact of the regulated access price on the firm performance of incumbents and entrants, we aim to test whether there are significant differences between national and multinational firms in relation to this impact.

In short, while an inverse relation is expected between access prices and entrants' performance, in the case of the incumbents this relation may depend on the combined effects at both the retail and the wholesale levels. Moreover, in this study we estimate the importance of a firm's multinational status on its performance by considering differences between incumbents and entrants. Finally, we are able to test if there are any significant differences in the impact of access prices on the firm performance of national and multinational firms.

3.3 Data and Empirical Approach

In this section we present the empirical approach and the data used to test the effect of regulation and firms' multinational status on the performance of European telecommunications firms. We first present the general approach adopted in a single equation and explain the variables used and their data sources (Section 3.3.1). Then, once the relevance of incumbency in the context of this study is taken into account, we present the final equation to be estimated (Section 3.3.2).

3.3.1 General Approach and Variables

Eq. (3.1) represents the performance of firm i operating in country j at time t ($Perf_{ijt}$) as a function of the country regulated access price (P_{jt}), the firms group multinational status (MN_{gt}) and other firm and country level characteristics.

$$Perf_{ijt} = \alpha_0 + \alpha_1 P_{jt} + +\alpha_2 MN_{gt} \alpha_3 X_{ijt} + \alpha_4 Z_{jt} + \alpha_5 F_i + \alpha_6 C_j + \alpha_7 Y_t + \epsilon_{ijt} \quad (3.1)$$

Since we are evaluating the effect of country level (P_{jt}) and group level (MN_{gt}) variables on a firm level and time variant variable ($Perf_{ijt}$), particular attention is given to control for other determinants of performance at firm (X_{ijt}) and country (Z_{jt}) levels. We also control for non observable time invariant firm (F_i) and country specific effects (C_j), as well as non observable country invariant time specific effects (Y_t).

Therefore, our database comprises firm, group, and country level information for the EU broadband market over the period 2002-2010. To identify firms offering xDSL services in different countries, we used the data provided by Point Topic's Global Broadband Statistics. As for the number of subscribers in 2009, our database accounts for 98% of the number of DSL subscribers reported by the European Commission's Communication Committee Working Document on "Broadband access in the EU: situation at July 2009". Our database is completed with information from the National Regulatory Agencies and from firms' Annual Reports (from Amadeus Database[25]) to validate the entry date and length of time the firms had been operating in each country. Below we explain the variables included in Eq. (3.1).

3.3.1.1 Firm Performance

Firm performance ($Perf_{ijt}$) is approximated using three different measures. The first measure is a firm's retail market share in each country and period (**Market Share**). While the regulation is introduced at the wholesale level, the effect on consumer welfare is observable at the retail level. Thus, approximating firm performance by their retail market share allows us to observe the firms' activity at a level where most of the policy implications are evaluated.

[25] Bureau van Dijk, Amadeus: http://www.bvdinfo.com

The second proxy of performance is a firm's operative turnover[26] in each country and year **Turnover**). This measure is especially important given the vertically integrated nature of incumbents that not only compete in the retail market but also provide inputs to entrants at the wholesale level. Therefore, a firm's turnover allows us to quantify the effect of regulation on firm performance above and beyond what is simply observable in the retail market through the market share, and to evaluate the prevailing effect on the incumbents' performance.

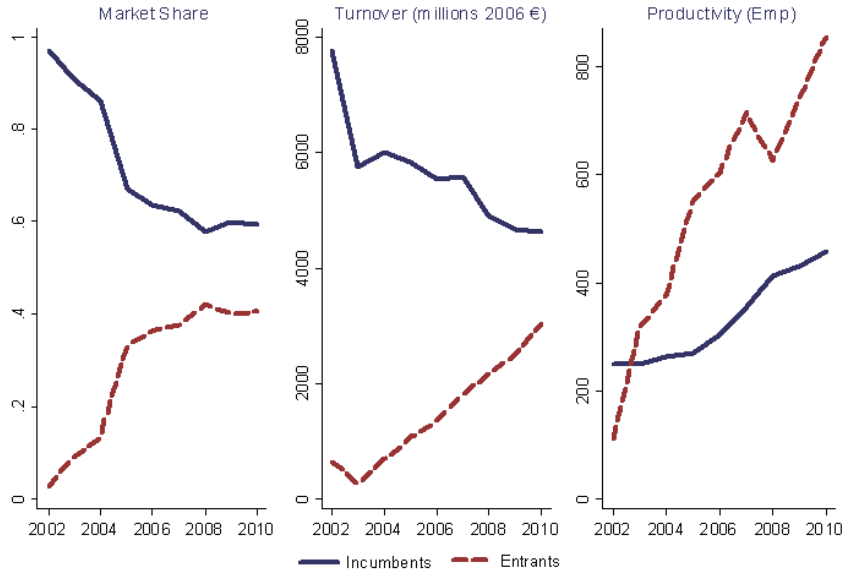
Finally, the third proxy of performance is firm productivity (**Productivity**) measured as the turnover per employee (labor productivity) in each country and year. The wholesale access price represents (part of) the cost of fixed capital inputs for entrants and the return to fixed capital for incumbents. Therefore, by approximating performance with labor productivity we can test if the cost and the return of capital have any relevant impact on the efficiency in the use of labor. The expected effects of access prices on productivity are the following: (i) negative in the case of the entrants (acting over the marginal cost) and (ii) positive in the case of the incumbents (better remunerated assets can be reverted to investment in activities, such as RD activities and, ultimately, improve firm productivity, as emphasized by Sidak and Spulber, 1998).

Figure 3.1 shows the evolution of the average firm performance proxies, for both entrants and incumbents operating within European countries. The incumbents' market share in the country of their incumbency has fallen dramatically since new competitors entered the retail market - they have lost on average almost 40% of their DSL costumers in nine years. The market share held by the entrants started at a EU27 mean level of 3%, increased continuously up to 2008 when it reached a maximum of 42%, and then stabilized in the last two periods at around 40% of the total number of subscribers.

Despite this evolution of market share, the evolution of the incumbents' turnover tells a slightly different story. Incumbents faced on average a reduction of 25% in their turnover when new firms first entered; however, their turnover almost immediately stabilized, recording an average loss of only 17% with respect to their pre-competition position. Meanwhile, the evolution of the entrants' turnover presented an upward trend during the period covered in this study. After difficult beginnings, during which the entrants lost on average 40% of their turnover

[26] For the purposes of this study, we could use either sales or operative turnover (their correlation is 0.999). We use operative turnover because the number of observations for turnover is higher in our database.

FIGURE 3.1: Evolution of firm performance: EU27 average



during the second year, they recovered to the point that, in seven periods, they quadrupled their average turnover.

The evolution of firm productivity (measured as the turnover per employee) provides additional information about the performance of European telecommunications firms. The main feature of this variable is that, unlike the other two performance measures, the incumbents' productivity is on average lower than that of the entrants, i.e. on average the entrants are more productive than the incumbents (for all periods but the first). In the case of the incumbents, in spite of their lost turnover and market share, on average their productivity almost doubled during the period covered in this study. In the case of the entrants, average productivity grew dramatically until 2007 when it reached levels seven times higher than those recorded at the beginning of the period. Following periods of decline and subsequent recovery, by 2010 the productivity of the entrants stood at an average level that was eight times higher than that recorded at the beginning of the period.

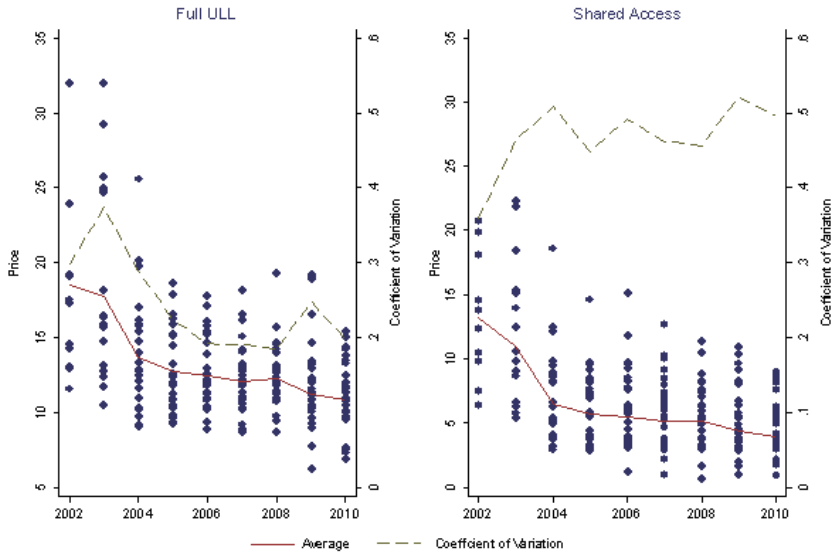
3.3.1.2 Regulation

We use two regulated price measures as proxies of the regulation (P_{jt}) variable. Price data (**Price**) are taken from the European Commission "Report on the

Implementation of the Telecommunications Regulatory Package" for the years 2002 to 2010. The two measures are the prices of Full Unbundled Local Loop (ULL) and Shared Access, which represent the total average cost on a yearly basis including the monthly rental and connection charges per unbundled loop. More precisely, we use European Commission estimates of the total average cost based on the total cost for the first year of access to the loop. The average evolution for EU27 countries in these two prices is shown in Figure 3.2 for the period covered in this study.

The difference in levels between the two prices is due to the use that each type of access makes of the incumbents' infrastructure. While accessing by Full ULL allows the entrant the exclusive use of the incumbent loop and the possibility of a high level of product differentiation, with Shared Access the entrant installs its own transmission equipment to the incumbent infrastructure and the loop is shared by the incumbent (who provides telephony service to the consumer) and the entrant (who provides broadband services through the high frequency channels of the same line).

FIGURE 3.2: Evolution of access prices and the coefficient of variation: by country and EU27 average



Over time both access prices fell (see Figure 3.2). The EU27 average of the Full ULL price fell from 19.73 € in 2002 to 11.33 € in 2010, while Shared Access fell from 14.70 € to 4.76 € in the same period. However, if we analyze price dispersion, major differences emerge. While both prices started with the same

coefficient of variation (around 0.3 in 2002), the Full ULL price dispersion had fallen to 0.2 in 2010, while that of Shared Access had risen to 0.5 by the end of the period[27]. In other words, the total average cost of access to the loop by Full ULL fell over time with a decreasing dispersion, while the total average cost of access to the loop by Shared Access also fell over time but with an increasing dispersion between the EU27 countries.

As Grajek and Roller (2012) point out, regulatory outcomes such as mandatory access prices might be subject to a possible endogeneity problem. For instance, when a regulator's objective is to promote competition so as to benefit the consumer, it might provide cheaper access to stimulate the entry of new players in the market. Hence, the regulated access price might be determined by regulators in response to the performance (such as market share) of the firms operating in the country. To alleviate this possible problem of reverse causality, and given the lack of data for dealing with this problem in a more conventional way, we opt to introduce our main explanatory variable, regulated prices, lagged by one period[28]. This empirical strategy for partly overcoming possible problems of endogeneity is based on the empirical observation that, due perhaps to the consistency of regulatory policies, current prices are very likely to be highly correlated with past values (see Figure 3.2). Moreover, since unlike current regulatory decisions, it is reasonable to assume that past regulatory decisions are not determined by current firm performance, using the lag value of prices might break with the possible reverse causality problem.

3.3.1.3 Multinational Status

The ownership information in the Amadeus Database allows us to identify which firms belong to corporate groups providing broadband services in more than one

[27] We compute the coefficient of variation (standard deviation over mean) of both prices for every year in our sample. See Appendix B for yearly price statistics including the coefficient of variation.

[28] As an alternative approach for dealing with this potential endogeneity problem, exogenous shocks in technology affecting broadband speed could be used as an instrument for access prices. Unfortunately, homogeneous statistics on speed from different sources (such as ITU, EU, OECD, as well as other private data sources) date back only to 2006. Thus, the use of this alternative instrument, although potentially correct from a methodological perspective, would mean neglecting the initial (and important) years after the access regulation policy was implemented (see Figure 3.2), which were characterized by major changes in both firm performance and regulated prices.

country (multinationals) and which firms do not belong to corporate groups (providing services only in the country observed). On average, firms operate in 2.2 countries, with a minimum of one country (national firms) and a maximum of six countries[29]. The national or multinational dimension of firms can be incorporated into the analysis in different ways, each of which allows us to answer different questions about the effect of multinationals on firm performance. The simplest approach is a dummy variable indicating whether the firm is part of a group or not, taking the value 1 if the firm belongs to a multinational group and 0 otherwise. If the variable is defined in this way, it is equivalent to classifying firms between national (when the dummy equals 0) and multinational (when the dummy equals 1), thus evaluating the potentially differentiated performance of national and multinational firms.

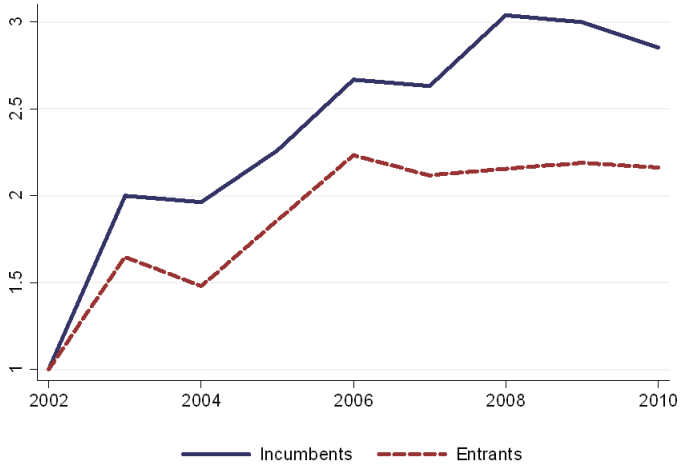
Given that we have firm level information for each country in which the firms operate, instead of the dichotomous variable, we use a counting (discrete) variable capturing multinational status (MN_{gt}) with the number of firms in each group. When a group comprises N firms (because it operates in N countries), the value of the multinational status variable for each of the group's firms will be N. In this context, non-multinational firms are a special case (the base level) where the number of firms in the group (N) equals 1.

Figure 3.3 shows the evolution of the multinational status (MN_{gt})[30] of European DSL providers when considering the EU27 mean values for incumbents and entrants. At the beginning of the period, the service was only provided by national firms. Over time, the number of countries in which the telecom groups operated grew; both incumbents and entrants expanded. While the expansion of entrants stabilized in 2006-2007, with an average of 2.2 firms per group, the expansion process of the incumbents continued reaching a maximum of 3.1 firms per group in 2008, before falling slightly during the last two periods of our sample.

[29] Some of the firms included in our database operate in countries that are not included in our sample of countries (EU27).

[30] The firm's group multinational status (MN_{gt}) variable is equivalent to one of the most frequently used structural measures of internationalization, namely the number of countries in which the group operates (see Dörrenbacher (2000) for a review of measuring internationalization). By introducing this variable into the analysis, we can evaluate the possible differentiated performance of firms depending on the degree of international diversification of their group.

FIGURE 3.3: Evolution of multinational status: EU27 average



3.3.1.4 Firm Level Controls

The set of time variant firm level variables (X_{ijt}) controls for scale and scope economies, as well as technological diversification. Given the traditional monopolistic nature of the infrastructure of telecommunications services, scale is one of the key dimensions to take into consideration when analyzing firm performance. Persistent scale economies allow relatively large providers to supply services at lower average costs per subscriber than the costs incurred by small providers. Therefore, we should expect a positive relationship between the scale and the performance of the firm in the presence of scale economies. To test this relation, a firm's scale is proxied by its number of employees (**N Employees**). If firm performance is approximated by the labor productivity, we control instead for the fixed assets per employee (**F Assets per Emp**)[31].

Scope economies occur when costs are reduced by providing two or more services jointly as opposed to just one. In this case it is more efficient for a single diversified firm to produce outputs than by splitting up the production of each output. In the case of telecommunications providers, the catalogue of services that are most frequently supplied in addition to xDSL broadband are home phone, mobile phone, and IPTV[32]. Thus, to analyze whether the joint provision of services has an effect on provider performance in the context of this study, we

[31] This is for consistency with a production function approach.

[32] While today the joint provision of telecom services is common practice, in the first few years of the period covered in this Chapter this was a potential differentiating factor of a firm's cost structure (e.g. in 2003, 70% of firms on average provided joint services).

proxy scope economies with a dummy variable for service diversification (**Diver Service**) representing whether or not the firm is the provider of any of the aforementioned telecommunication services.

In addition, we also include technological diversification as a firm level determinant of the performance of European broadband providers. Alternative access technologies allow for some degree of product differentiation. For instance, Cable and FTTx allow higher transmission rates, which also have more symmetric download (and upload) capacities than xDSL. Therefore, since technological diversification allows product differentiation, and this can give a firm an advantage over its competitors, a positive relation can be expected between the firms' technological diversification and performance. Here, technological diversification is introduced as a dummy variable (**Diver Tech**) taking a value of 1 if the firm provides broadband services via another technology besides xDSL (such as Cable or FTTx) and 0 otherwise.

Firm level variables are useful as controls, but their sign and significance also provide additional information on performance determinants in the broadband sector. Thus, to the extent that our proxies capture the underlying phenomenon, we can test whether there are scale and scope economies or not, and if technological diversification is relevant to firm performance.

3.3.1.5 Additional Controls

Country level variables (Z_{jt}) include population density, per capita income (**GDPpc**), and broadband penetration. While population density (**Pop Dens**) accounts for differences in the infrastructure costs of providing services, the income and broadband penetration rates (**BB Pen**) help to control for different market potential across countries. The population density and per capita income data come from the Eurostat database, while the data on the broadband penetration rate are taken from the International Telecommunication Union[33]. Time invariant firm (F_i) and country (C_j) controls aim to capture all those effects that are specific to a firm or to a country that we cannot observe, but which might exert some influence on firm performance.

[33] To avoid possible problems of multicollinearity between GDPpc and BB pen, given that previous studies in the literature on economic growth report a positive relationship between these two variables, (Koutroumpis, 2009; Czernich et al., 2011, see), we make use of the broadband penetration rate with one period lag.

3.3.2 Incumbency Interactions

In the context of this study, one of the most important considerations about the firms is their incumbency in the country in which they operate. Differences between the incumbents and entrants can be captured by performing separate estimations for these two broad types of firm. Unfortunately, given the limited number of firms operating in the market, specifically as regards the number of incumbents, if we follow this strategy when estimating the incumbents' performance equation, the number of observations is rather small (141 observations). Moreover, introducing year, country and firm fixed effects further reduces the degrees of freedom of the estimations performed.

Alternatively, we adopt the approach of introducing a dummy variable ($IncD_{ij}$) indicating whether the firm is an entrant or incumbent in the market. $IncD_{ij}$ takes the value of 1 if the firm is the country incumbent and 0 otherwise. Thus, the $IncD_{ij}$ variable controls for firm characteristics that are specific to all incumbents and which distinguish them from entrants independently of the country in which they operate.

As previously discussed, we can expect different effects of access prices (P_{jt-1}) and the multinational status of the firm's group (MN_{gt}) on firm performance depending on the firm's position as market incumbent or entrant. Therefore, we proceed in our analysis in line with Eq. (3.2) in which we introduce both the interaction between the access prices and the firm's position as entrant or incumbent in the country ((P_{jt-1}*$IncD_{ij}$), as well as the interaction between the multinational status of the firm's group and its position as an entrant or incumbent in the country (MN_{gt}*$IncD_{ij}$).

$$\begin{aligned} Perf_{ijt} = {} & \alpha_0 + \alpha_1 X_{ijt} + \alpha_2 IncD_{ij} + \\ & \alpha_3 MN_{gt} + \alpha_4 MN_{gt} * IncD_{ij} + \\ & \alpha_5 P_{jt-1} + \alpha_6 P_{jt-1} * IncD_{ij} + \\ & \alpha_7 Z_{jt} + \alpha_8 F_i + \alpha_9 C_j + \alpha_{10} Y_t + \epsilon_{ijt} \end{aligned} \tag{3.2}$$

Additionally, for consistency and for purposes of interpretation of the estimated results, the multinational degree (MN_{gt}) and the lagged access prices (P_{jt-1}) are also introduced into the analysis. Thus, the impact of the group is captured by two variables: the multinational status (MN_{gt}) and its interaction

with the $IncD_{ij}$ (MN_{gt}*$IncD_{ij}$), while the impact of regulation is captured by two variables: the access prices (P_{jt-1}) and their interaction with the $IncD_{ij}$ (P_{jt-1}*$IncD_{ij}$). It should be highlighted that during the period covered in this study, two of the EU27 incumbents (in Italy and UK) were vertically separated. Since our hypotheses rely on the vertically integrated nature of incumbent firms, the observations of these incumbents were excluded from our estimations for the years after separation. All variables (except for the dummies and ratios) are measured in logarithms, and monetary variables are expressed in thousand constant 2006 €. Table 3.1 shows the summary statistics of the variables.

Table 3.1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Market Share	488	0.4526	0.4093	0.0003	1
Turnover	476	13.8538	1.6377	9.9512	17.5709
Productivity	463	5.8608	0.8940	2.7464	10.3071
Diver Tech	488	0.2090	0.4070	0	1
Diver Service	466	0.9291	0.2567	0	1
N Employees	466	7.9724	1.6362	3.5263	12.0882
F Assets	479	13.7880	1.9978	6.2996	18.1192
F Assets per Emp	466	5.7971	1.1688	1.0072	9.6673
IncD	488	0.4446	0.4974	0	1
MN	488	2.2397	1.5898	1	6
Price (Full ULL)	466	2.5008	0.2455	1.8324	3.4660
Price (Shared Access)	465	1.5868	0.5659	-0.4403	3.1047
GDPpc	488	9.8963	0.6221	7.9219	11.2104
BB Pen	468	0.15327	0.0805	0.0008	0.3199
Pop Dens	488	4.8174	0.8297	2.8375	7.1701

3.4 Results

In order to analyze the impact of access price and multinational status on firm performance, we use the performance equation (Eq. 3.2) to estimate six models corresponding to the three performance variables and the two access prices described above. We are particularly interested in testing whether the influence of regulated prices and multinational status on firm performance differs between incumbents and entrants. For all the estimations we use firm and country fixed effects to control for time invariant determinants at the firm and country level, as well as time fixed effects to control for any EU-wide time-trend in the data. The analysis of the effects of the access price on the performance of incumbents

and entrants is undertaken by computing the elasticity of performance relative to price[34] while that of the effects of the multinational status is undertaken by computing the marginal effect.

We estimate Eq. (3.2) by means of panel data techniques and report the within estimator results[35] in Table 3.2. Columns (1) and (2) correspond to the results for the determinants of the firms' market share with Full ULL and Shared Access prices respectively. Likewise, columns (3) and (4) correspond to the results for the determinants of the firms' turnover, and columns (5) and (6) refer to the firms' productivity.

3.4.1 Regulated Access Price

Overall, results from estimations of Eq. (3.2) support a significant effect of regulated access prices on firms' performance (see Table 3.2[36]). In the case of the entrants while both prices (Full ULL and Shared Access) exert a negative and significant effect on entrants market share, only the Full ULL price is significant in the case of entrants' turnover, and none of the prices are significant determinants of entrants' productivity. In the case of the incumbents only the Shared Access price has a positive and significant effect on their market share, and the effect of both prices on their turnover and productivity is positive and highly significant.

Table 3.3 reports the price elasticity of firm performance at the sample mean resulting from the estimated models. These results indicate that, when holding other variables at their sample means, a 1% increase in the wholesale price will

[34] Given the introduction of interaction terms, the price elasticity is not directly observable through the simple observation of the estimated coefficients. Following the chain rule, we compute the elasticity at the mean performance (of incumbents and entrants) and at the mean price (also holding other variables at their sample means). When firm performance is approximated in terms of market share, we first calculate the semi-elasticity to account for the semi-log nature of Eq. (3.2), and then we compute the percentage points resulting from the evaluation of the semi-elasticity at the incumbents' and entrants' sample mean.

[35] We address heteroskedasticity with robust standard errors. See Appendix B for the homoskedasticity test and additional diagnostic test results confirming the stationarity of the series.

[36] Given the interactions with the incumbent dummy the significance of the effects from prices (as well as those from multinational status) are not directly observable via the coefficients (see Eq. (3.2)). In the case of the entrants, the significance comes from the lagged price coefficient without the interaction, and in the case of the incumbent from the sum with and without the interaction.

TABLE 3.2: The effects of regulated access price and multinational status on firm performance

	Market Share		Turnover		Productivity	
	(1) Full ULL	(2) Shared A	(3) Full ULL	(4) Shared A	(5) Full ULL	(6) Shared A
IncD	0.394***	0.446***	-1.337**	-0.126	-1.508**	-0.426**
	(0.104)	(0.0674)	(0.649)	(0.271)	(0.594)	(0.198)
Price t-1	-0.0877***	-0.0365**	-0.300*	-0.0271	-0.104	0.122
	(0.0288)	(0.0159)	(0.261)	(0.149)	(0.205)	(0.0921)
Price t-1 x IncD	0.0859**	0.0997***	0.707**	0.356**	0.551**	0.203*
	(0.0384)	(0.0319)	(0.277)	(0.145)	(0.251)	(0.111)
MN N of Countries						
Two	0.00836	0.00677	-0.231**	-0.234**	-0.206*	-0.200*
	(0.0273)	(0.0136)	(0.104)	(0.111)	(0.113)	(0.111)
Three	0.0409*	0.0339**	-0.175	-0.188	-0.128	-0.129
	(0.0237)	(0.0151)	(0.113)	(0.120)	(0.111)	(0.112)
Four	0.118***	0.110***	-0.246	-0.270	-0.169	-0.187
	(0.0380)	(0.0341)	(0.192)	(0.193)	(0.180)	(0.178)
Five	0.116**	0.0965**	0.0885	0.0844	0.145	0.182
	(0.0532)	(0.0453)	(0.350)	(0.345)	(0.317)	(0.312)
Six	0.132**	0.115***	0.184	0.168	0.0751	0.0836
	(0.0537)	(0.0429)	(0.345)	(0.337)	(0.309)	(0.303)
MN N of Countries x IncD						
Two	-0.0412	-0.0265	0.163	0.189	0.187	0.190
	(0.0418)	(0.0314)	(0.115)	(0.120)	(0.128)	(0.129)
Three	-0.169***	-0.171***	0.404**	0.370**	0.445***	0.393**
	(0.0442)	(0.0526)	(0.180)	(0.182)	(0.167)	(0.168)
Four	-0.168***	-0.185***	0.518*	0.533*	0.502**	0.538**
	(0.0500)	(0.0491)	(0.271)	(0.280)	(0.234)	(0.241)
Five	-0.252***	-0.231***	0.369	0.340	0.431	0.346
	(0.0602)	(0.0598)	(0.366)	(0.361)	(0.338)	(0.334)
Six	-0.296***	-0.278***	0.0601	0.0532	0.244	0.208
	(0.0776)	(0.0940)	(0.391)	(0.384)	(0.365)	(0.357)
Diver Tech	0.0112	0.00756	0.147	0.135	-0.109	-0.133
	(0.0176)	(0.0117)	(0.194)	(0.198)	(0.186)	(0.191)
Diver Service	0.0624**	0.0550***	0.00693	-0.00942	-0.186	-0.212
	(0.0277)	(0.0161)	(0.323)	(0.322)	(0.205)	(0.208)
N Employees	0.0337***	0.0307***	0.626***	0.625***		
	(0.00675)	(0.00542)	(0.0905)	(0.0922)		
F Assets per Emp					0.379***	0.381***
					(0.0725)	(0.0722)
GDPpc	-0.0296	0.00692	0.610	0.632	1.259***	1.214***
	(0.0642)	(0.0634)	(0.477)	(0.476)	(0.446)	(0.435)
BB Pen t-1	-0.0632	-0.184	-0.279	-0.355	-0.916	-0.769
	(0.242)	(0.255)	(1.175)	(1.139)	(1.514)	(1.515)
Pop Dens	0.591*	0.595	1.201	0.00299	-0.353	-2.246
	(0.330)	(0.414)	(1.697)	(1.871)	(1.723)	(1.791)
Constant	-3.012	-3.512	-2.841	2.890	-6.129	4.385
	(1.997)	(2.603)	(10.49)	(10.78)	(10.02)	(9.910)
Observations	376	375	374	373	374	373
R-squared	0.983	0.984	0.968	0.967	0.885	0.885

Note: Dependent variables are Market Share, Turnover, and Productivity. All estimations are controlled by firm, country and time fixed effects. Regulated access prices are lagged one period to avoid the possible problem of reverse causality. Robust standard errors in parentheses.

result in a loss of between 2.1 (in the case of Shared Access) and 7.5 (in the case of Full ULL) market share points for the entrant and in a gain of 7.5 market share points for the incumbents (in the case of Shared Access).

Table 3.3: Price elasticity

	Market Share		**Turnover**		**Productivity**	
	(1) Full ULL	**(2) Shared A**	**(3) Full ULL**	**(4) Shared A**	**(5) Full ULL**	**(6) Shared A**
Elast on Entrants	-0.0757***	-0.0211**	-0.0568*	-0.0034	-0.0453	0.0358
Elast on Incumbents	-0.0031	0.0749**	0.0734***	0.0398***	0.1923***	0.0938***

Note: When firm performance is approximated by the market share, the Table shows the market share percentage points resulting from the evaluation of the semi-elasticity at the incumbents and entrants sample mean. As in the main estimations, price elasticities are calculated with regulated access prices lagged one period to avoid the possible problem of reverse causality. See Appendix B for robustness checks on price elasticity with a different number of price lags.

On the one hand, the entrants' turnover is significantly influenced by wholesale prices only in the case of Full ULL. On the other hand, both prices have positive and significant effects on the incumbents' turnover. Thus, while a 1% increase in the Full ULL price translates into a 5.6% loss of entrants' revenues (see Table 3.3) and a 7.3% rise in the incumbents' revenues, with a 1% increase in the Share Access price the entrants lose 0.3% (although this is not significant) and the incumbents gain 3.9% more revenue.

Regulated access prices exert positive and significant effects on the incumbents' productivity and non significant effects on that of the entrants. Thus, holding other variables at their sample means, a 1% increase in the wholesale prices will translate into a productivity improvement of incumbent providers of between 9.3% (in the case of Shared Access) and 19.2% (in the case of Full ULL).

The negative effect that wholesale access prices exert over entrants' market share indicates that, when observing the retail market directly, the empirical hypothesis of an inverse relation between regulated prices and entrants' performance is confirmed. These results are highly consistent with the wholesale access policy developed within the European broadband sector during the period covered by this study, which aimed at increasing entrants' participation at the retail level and at enhancing retail competition by means of cheaper access to the incumbent network.

In general, the difference in the estimated effects of Full ULL and Shared Access prices might be explained by the use that each type of access makes of the

incumbent's infrastructure. Entrants' market shares are more sensitive to Full ULL, because they need to devote more of their resources to access the input (i.e., the access price level is higher) and they need to make greater investments to use this wholesale access product that allows them a higher degree of diversification. Moreover, the significant effect on the entrants' turnover of the Full ULL price might be driven by the impact that this price has on the entrants' market share which, as pointed out above, is relatively high with respect to the Shared Access price.

The counterpart of a declining wholesale access prices policy is the effects that these have on the incumbents' performance. Beyond the desirable effects observed at the retail level, with a decease in the incumbents' market share (given its positive relation with the Full ULL price), there are additional effects associated with the positive relation between the wholesale access prices and the incumbents' turnover and (most importantly) their productivity.

In line with the empirical hypothesis, the expected effect of an increase in wholesale access prices is that the incumbents' wholesale profits will decrease if the quantity of access bought by entrants falls at a proportionally higher rate than the rise in access prices, which depends on elasticities. Estimated wholesale price elasticity on retail entrants' market share seems to confirm that this condition is met. The change in access bought by entrants is proportionally higher than the change in the wholesale price. Therefore, at the wholesale level the estimated relation between the regulated price and incumbent turnover is negative. Nevertheless, the total effect on incumbent turnover is attributable to a combination of both the retail and the wholesale effects. Consequently, the estimated results of a positive and significant wholesale price elasticity of incumbent turnover seem to indicate that the prevailing effect acting over the incumbent turnover is the retail market effect.

The positive and strong estimated effect of regulated prices on incumbents' productivity merits special attention. For incumbents, wholesale access prices represent remuneration for their infrastructure assets. Thus, by reducing these prices their remuneration worsens, a situation that may not be reversed by investments in infrastructure and other activities such as R&D, which ultimately could improve firm productivity.

It should be stressed that while the incumbent market share is not significantly influenced by the Full ULL price, in the case of entrants the negative effect of

the access price is significant (mainly) in terms of their market share. Therefore, policies oriented at promoting competition in the retail market may be effective by altering this price, while they will have a minimum impact on the incumbents' market share. Nevertheless, the incumbents' productivity is significantly and highly sensitive to the wholesale access prices (particularly in the case of Full ULL access). Hence, there is a trade-off between favoring entrants in terms of market share and the performance of incumbents in terms of their turnover and productivity. Consequently, considerable attention should be paid to the effect of policies on other dimensions of the firms, above all those to which the policies are not specifically directed.

3.4.2 Multinational Status

Our results regarding the impact of multinational status on firm performance (see Table 3.4) show that only when the entrant operates in three or more countries does it perform significantly better in terms of its market share than a non-multinational entrant. In addition, a multinational entrant with operations in two countries performs significantly worse in terms of turnover and productivity than a non-multinational entrant. Table 3.4 reports the estimated marginal effects of firms' multinational status on firm performance measures. These are the marginal effects when comparing the base level of non-multinational firms with multinational firms across their different statuses (while holding other variables at their sample means). Thus, in the case of the entrants, the results indicate that when the firm is a multinational operating in three countries, its market share is around 4% higher than when it is a non-multinational firm. Likewise, if the multinational operates in four to six countries its market share is between 9.6 and 13% higher than when it is a non-multinational firm. Multinational entrants with operations in two countries have both a significantly lower turnover and productivity than non-multinationals; the turnover is between 1.7% lower and the productivity is 3.5% lower.

Our results regarding the effects of multinational status on incumbent performance shows, on the one hand, that when the firm operates in three or more countries the performance is significantly worse in terms of its market share than that of non-multinationals (between 5 and 16%). On the other hand, our results show that if the incumbent operates in five countries, its turnover is around 3% higher that if it where a non-multinational. In addition, when the incumbent

TABLE 3.4: Multinational effects (from the base level of one country)

	Market Share		**Turnover**		**Productivity**	
N Countries	**(1) Full ULL**	**(2) Shared A**	**(3) Full ULL**	**(4) Shared A**	**(5) Full ULL**	**(6) Shared A**
Entrants						
2	0.00836	0.00677	-0.0173**	-0.0175**	-0.0357*	-0.0348*
3	0.0409**	0.0339**	-0.0131	-0.0140	-0.0222	-0.0224
4	0.1179***	0.1097***	-0.0184	-0.0203	-0.0293	-0.0325
5	0.1164**	0.0965**	0.0065	0.0062	0.0244	0.0306
6	0.1322***	0.1153***	0.0136	0.0124	0.0127	0.0142
Incumbents						
2	-0.0328	-0.0197	-0.0049	-0.0032	-0.0031	-0.0017
3	-0.1281***	-0.137***	0.0163	0.0130	0.0536**	0.0447*
4	-0.0497	-0.0755**	0.0193	0.0186	0.0562**	0.0592**
5	-0.1359***	-0.1342***	0.0322**	0.0299**	0.0953***	0.0875***
6	-0.1633**	-0.1624**	0.0173	0.0157	0.0540	0.0493

operates in three or more countries it performs significantly better (between 4.5 and 9.5%) in terms of productivity than a non-multinational incumbent. These results support the belief that a firm's multinational status has a significant impact on its performance.

Overall, these results seem to confirm the hypothesis that the balance between the gains and losses of multinational status differ between incumbent and entrants firms. On the one hand, for entrants the positive effect on their market share represents the possible gains from operating in more countries. However, the negative effect on their turnover and productivity seems to indicate that the positive effect on their market share from operating in more countries is outweighed by the costs incurred when expanding their operations, resulting in a negative impact on both turnover and productivity. On the other hand, multinational incumbents perform worse than non-multinational incumbents in terms of their share of the market in which they hold the incumbency. This is possibly a consequence of their becoming active in new markets at the expense of a decrease in interest in their original market. Nevertheless, the better results in terms of turnover and productivity seem to capture the positive effects of international expansion by entering other countries.

3.4.3 Regulated Access Price: National vs. Multinational

To extend our analysis of the impact of wholesale prices on firm performance, we compute the effect of regulated access prices on the mean performance of national and multinational firms (both incumbents and entrants). In general, our results show that the performance of multinational firms is less sensitive than that of national firms to changes in wholesale prices: the impact of prices is lower (in absolute value) for multinationals than it is for nationals firms (see Table 3.5). These results, in line with the approach that sees multinationals as a risk diversifying mechanism, might indicate that, via the international diversification of their operations, multinationals are better able than national firms to cover wholesale access price risks.

TABLE 3.5: Price elasticity: differences between national and multinational firms

	Market Share		**Turnover**		**Productivity**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	Full ULL	**Shared A**	**Full ULL**	**Shared A**	**Full ULL**	**Shared A**
Elast on Entrants						
Nationals	-0.0764***	-0.0219**	-0.0586*	-0.0036	-0.0462	0.0374
Multinationals	-0.0748***	-0.0202**	-0.0548*	-0.0032	-0.0442	0.0340
$\|Nat\| - \|MN\|$	0.0016***	0.0017**	0.0038	0.0004	0.0020	0.0026
Elast on Incumbents						
Nationals	-0.0032	0.0779**	0.0765***	0.0425***	0.2021***	0.1007***
Multinationals	-0.0031	0.0721**	0.0701***	0.0369***	0.1818***	0.0863***
$\|Nat\| - \|MN\|$	0.0001	0.0085**	0.0064***	0.0056***	0.0203***	0.0144***
	$\mathcal{E}Nat > \mathcal{E}MN$		$\mathcal{E}Nat > \mathcal{E}MN$		$\mathcal{E}Nat > \mathcal{E}MN$	

Note: Significance of differences between national and multinational firms comes from Wald tests under the null hypothesis that price elasticity is equal for both. As in the main estimations, price elasticities are calculated with regulated access prices lagged one period to avoid possible problem of reverse causality.

The results of the additional firm level control variables (see Table 3.2) confirm that the firms included in this study exhibit significant economies of scale (this result holds for the three performance variables used). Service diversification exerts a significant effect only when firm performance is approximated by their market share. Finally, our results do not confirm the existence of a significant performance enhanced effect from the technological diversification of the firms. This probably responds to the fact that during the period covered by this study this type of diversification was quite low (on average 20% of the firms were diversified).

Our results regarding the economies of scale and service diversification merit special mention. First, economies of scale exert a positive effect on all three performance indicators evaluated. This leads to a discussion as to the preferred composition of the sector: one with few big firms or one with several small firms. Second, service diversification only exerts a significant effect when firm performance is approximated by the firms' market share. Thus, firms that aim to gain a greater stake of the market might be successful if they provide more than one service to their subscribers, that is, by exploiting the scope economies present in the sector.

Finally, our results for the additional country level control variables only show significant effects for income per capita in those cases where firm performance is captured by their turnover and productivity, indicating that firms perform better in countries where the subscribers have a relatively higher purchasing power. The absence of any more significant results for the country level variables is possibly a consequence of the inclusion of both country and firm level fixed effects.

This chapter represents an initial step towards a possible future study of the welfare effects of the regulatory framework on firm performance. EU policy is oriented towards promoting retail competition by stimulating the entry of new agents in the sector. This is being achieved via mandatory access with a falling regulated wholesale price. A lower level of concentration might lead to greater competition, with potentially lower retail prices and gains on consumer surplus. However, as confirmed by our results, the sector is characterized by scale economies and the incumbents' productivity is highly sensitive to the wholesale access prices. Thus, there are also possible negative welfare consequences of the current regulatory framework to be taken into account when designing future regulations of the sector.

3.5 Conclusions

In this Chapter we have empirically tested the effects of regulated access prices and firms' multinational status on firm performance. The analysis has been performed using firm, group and country level information for the European broadband market for the period 2002-2010. Three measures of firm performance have been used, namely: market share, turnover and productivity. Special attention

has been given to differences in the effects on performance measures depending on a firm's position as market incumbent or entrant.

We find a negative effect of access prices on entrants' performance and a positive effect on that of incumbents. Our results indicate that the effect that prevails in the relationship between wholesale access prices and the incumbents' performance is positive. Although the impact of wholesale access prices on the incumbents' performance can be negative at the wholesale level (driven by the negative wholesale price elasticity on the entrants' retail market share), the effect from the retail level is positive (on the incumbents' market share). Hence, the latter seems to be driving the total positive effect on the incumbent's turnover and productivity.

Moreover, in the period covered by this study, a firm's multinational status has a significant impact on its performance, and this impact varies for incumbents and entrants. We find that for multinational entrants, the positive effects on market share derived from their operating in more countries are outweighed by the costs incurred when they expand their operations. This results in a negative impact on both their turnover and productivity. In the case of multinational incumbents, the estimated positive impact of the degree on internationalization on turnover and productivity seems to capture the positive effects of international expansion and entry into other countries, albeit at the cost of a loss of market share in their country of origin. We also found that multinational firms are less sensitive to access prices than are national firms.

As summarized above, important conclusions can be drawn from this Chapter, although certain shortcomings should also be noted. First, given the availability of data, the retail subscriber related to each type of wholesale access is not directly observable; hence, our results only take into account differences between Full ULL and Shared Access prices from the perspective of the wholesale market. Second, more detailed firm-level data on retail prices would enable us to disentangle better the wholesale and retail effects on the performance of incumbents. Nevertheless, this study represents a novel contribution to the analysis of the impact of the regulatory framework on firm performance in an industry characterized by vertical relations, with incumbents and entrants, as well as with firms that present varying degrees of international operations.

4. Retail Price Effects of Feed-in Tariff Regulation

4.1 Introduction

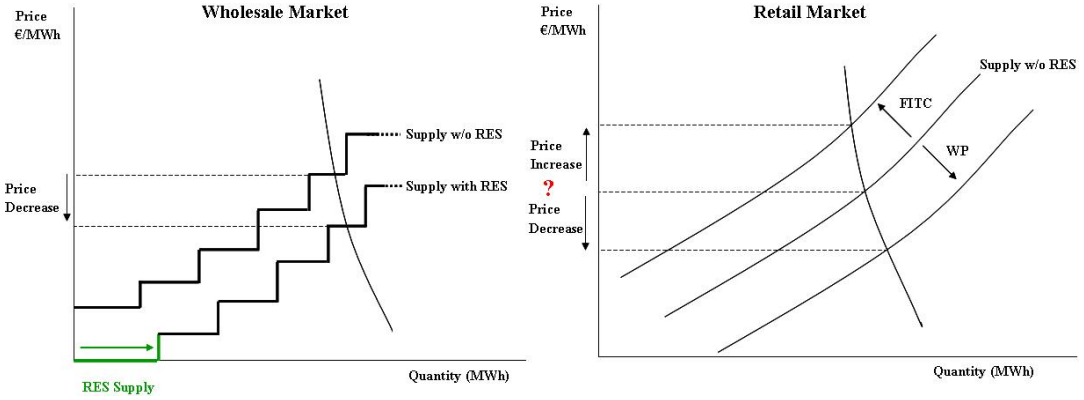
Within the EU 2020 energy strategy, the Third Energy Package aimed to complete the liberalization process, and the Climate and Energy Package implemented the targets for 2020. One of the targets is raising the share of EU energy consumption produced from renewable resources up to 20% (Directive 2009/28/EC). EU countries embraced this target promoting the production of electricity from renewable energy sources (RES), and the feed-in tariff (FIT) regulation is the wider spread promotion scheme used to encourage the take-up and development of generation from RES. Basically, under the FIT regulation a specific price is guaranteed per electricity produced by generators of the targeted technologies.

In most EU countries the costs of resources devoted to promote the production of electricity from RES are borne by final consumers[37]. Recent years' recession has made Europe's governments, industry and consumers worry about high energy prices, and some blame is attributed to climate policies in general and to FIT in particular. In Spain, around 8 Bn Euros a year, on average, have been devoted to promote the production of electricity from renewable energy sources (RES) during the last four years. This amount of resources represents around 12% of the industry GDP. Given that these costs are translated to final consumers through the electricity bill, it is worth thinking over the implications that this policy has on retail prices. Electricity is a highly relevant economic factor, therefore, policy and regulatory decisions affecting its price should be deeply analysed given the direct effect that energy prices have on the production costs of firms and, hence, in terms of welfare. However, there is no empirical assessment of the actual impact that this scheme has over final consumer (retail) prices.

[37] With the exceptions of Finland and The Netherlands where the costs are completely financed by general taxes (CEER, 2013). A detailed explanation is provided in the Section 4.3 below.

Two components of the electricity retail price are expected to be influenced by FIT regulation; the wholesale price of electricity and the incentive to those firms producing electricity from RES. On the one hand, from the characteristics of the electricity wholesale price (WP) formation (merit of order) and the low marginal cost of renewable energy generation, the introduction of RES in the energy mix is expected to exert a downward pressure on the WP of electricity. This effect over the WP is represented on the *Wholesale Market* graph in Figure 4.1. On the other hand, from the regulatory design of the incentive mechanisms the FIT costs (FITC) are translated to the final electricity consumers. Hence, acting over the electricity retail price in opposite directions (see *Retail Market* graph in Figure 4.1), both components are functions of the proportion of renewable sources in the energy mix. Therefore, to assess the overall effect of RES promotion the research question is on the relative intensity that these two components exert over electricity retail prices.

FIGURE 4.1: FIT Regulation effects



To the best of our knowledge, none of the previous work has assessed empirically from a disaggregated perspective the effect from both determinants (FITC and WP) on retail price. For instance, Gelabert et al. (2011) analysed empirically the effect of RES and cogeneration (COG) only on WP, and Burgos-Payan et al. (2013) presents an overview of the policy including both components, but performing only an aggregated cost-benefit analysis. Therefore, this study aims to contribute to the empirical assessment of the effect that the FIT regulation has over the electricity retail price for industrial consumers by quantifying the relative intensity of the FITC and the WP of electricity.

This chapter is organized as follows. Section 4.2 summarizes the related literature. Section 4.3, overviews the FITC and the role played by different technologies. Section 4.4, describes the data and models used to estimate the retail price effects of the feed-in tariff regulation. Section 4.5 presents the estimation and results of our analysis. Finally, section 4.6 discusses, interprets, and contextualizes our findings.

4.2 Related Literature

Previous studies for different countries have analyzed (*ex-ante* and *ex-post*) the additional cost from supporting FIT, estimated the potential benefits from the merit of order effect, and compared aggregated figures of the potential cost savings from higher RES to direct costs of the FIT. Below we describe the main finding of these three closely related branches of the energy economics literature.

Numerous *ex-ante* studies calculate the additional cost from supporting schemes to electricity generated from RES. Ragwitz et al. (2007) predicted that it was necessary a steady rise of the average EU consumer price between 5.0 €/MWh and 7.7 €/MWh over the period 2005-2010 to finance the RES deployment. In the German case, Frondel et al. (2010) calculated (dividing the overall amount of FIT of about 9 Bn €by the overall electricity consumption of 617 Bn kWh) that in 2008 the price mark-up due to the FIT was about 7.5% of the average household electricity price. Using a quantitative electricity market model that accounts for factors such as oligopolistic behavior, emission trading, and restricted cross-border transmission capacities, Traber and Kemfert (2009) also find an upward price effect of the German FIT. Relatively few *ex-post* studies have analyzed the price effects of FIT regulation. Del Rio and Gual (2007) assess the effect of the Spanish FIT between 1999 and 2003 in terms of additional costs paid by consumers for renewables compared to conventional electricity (i.e. the share of RES promotion of the electricity bill). Their study finds that the additional cost for the consumer increased annually by 23% during the period considered.

As previously mentioned, some properties of RES generation could also potentially counteract the upward-price effect associated with FIT regulation. In the wholesale electricity market the supply curve is constructed by ordering the bids of all generators from lowest to highest. These bids should equate the marginal

costs of the generators and, therefore, the supply curve reflects the aggregate marginal cost curve for the market (if no market power exists). The market price is set at the intersection of the supply and demand curves, and all generators with lower marginal costs serve demand receiving this uniform price. The introduction of technologies under the FIT tends to shift the supply curve to the right, due to its low marginal cost of generation, which pushes more expensive marginal plants (e.g. coal, combined cycle, petroleum, etc.) out of the market, and exerts a downward pressure on the wholesale price of electricity (see *Wholesale Market graph* in Figure 4.1). This is called the merit of order effect, a well documented feature of wholesale prices in context of FIT.

Traber and Kemfert (2011), using a mixed complementary program computational model, find that higher wind supply reduces German market prices by more than 5%. Gelabert et al. (2011), using a multivariate regression model of daily average Spanish electricity prices for 2005 to 2009, also find that a marginal increase of 1 GWh of electricity from RES and COG is associated with a reduction of 1.9 €/MWh (3.7%) in wholesale electricity prices. Following a similar methodological approach Würzburg et al. (2013) find that in Germany and Austria electricity price fell by roughly 1 €/MWh (around 2% of the electricity price) for each additional GWh of average daily renewable electricity generation between July 2010 and June 2012.

Finally, there are studies that, in an attempt to account for both effects, compare the potential cost savings from higher RES to direct costs of the FIT with either or both effects considered at an aggregated level. This is the case of the study by Sensfub et al. (2008), which offers a detailed analysis of the price effects of renewable electricity generation on German wholesale prices between 2001 and 2006. When comparing the computed cost savings due to RES feed-in to the total costs of the FIT in 2006 they find that the cost savings outweighed the total costs. Similarly, Saenz de Miera et al. (2008), through a simulation analysis for the Spanish wholesale price, find that when comparing the simulated reduction of the wholesale price of electricity as a result of more wind generation with the total yearly support for wind generation, there are net saving costs for consumers from the FIT scheme. Also for the Spanish case, Burgos-Payan et al. (2013) compared the aggregated cost and benefits from the FIT system over the period 2008-2009 and find that the magnitude of both effects are roughly counterbalanced.

Our research is related with the above literature, more closely related to the last group given that we account for both effects, although from a disaggregated perspective. More precisely, through the estimation of three econometric models, this research contributes to the empirical assessment of the effect that the FIT regulation, promoted following EU targets, has over the industrial retail price of electricity by quantifying its sensibility to the incentives for electricity generation under the FIT and the electricity wholesale price. Especial attention is devoted to technology-specific considerations. In the next section we present an overview of the FITC and the role played by different technologies.

4.3 Feed-in Tariff Cost and Technology

With the exceptions of Finland and The Netherlands where the FITC are completely financed by general taxes, in EU countries the costs of promoting RES are borne by final electricity consumers. Depending on the regulatory design, the FITC might be translated into the electricity prices by two basic ways; non-tax levies and pass down to end users of suppliers costs (CEER, 2013)[38], and in both the FITC are translated to the retail price after the wholesale price is set. Hence, the more common regulatory design is one in which the FITC are borne by final consumers without impacting the wholesale price market formation mechanism. This, along with the data availability for Spain, and the fact that in the EU context Spain is one of the countries with the highest renewable power capacity[39] (with Germany and Italy), wind power generation penetration (with Germany and Denmark), and solar power generation penetration (with Germany), are the main reasons why this study is applied to Spain.

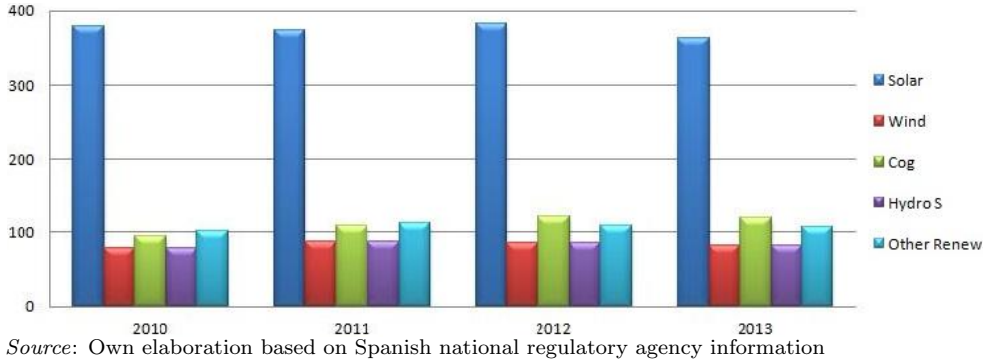
In order to stimulate the development of certain technologies, the basic feature of FIT is to guarantee generators of the targeted technologies a specific price per electricity produced. In Spain the FIT is granted to generation from RES and cogeneration plants with an installed capacity below 50MW (this is the so called Special Regime -SR). To take into account that different technologies have different levels of development and generation costs, the supports are technology-specific granted. Figure 4.2 shows the yearly average FITC (in €/MWh) in Spain

[38] To be more precise, while the non-tax levies are used in Austria, Belgium, France, Ireland, Italy, Lithuania, Luxembourg, Slovenia, and Spain, the pass down to end users of suppliers costs is used in Belgium, Czech Republic, Germany, Greece, Hungary, Norway, Poland, Portugal, Romania, Sweden, and UK.

[39] Excluding hydropower.

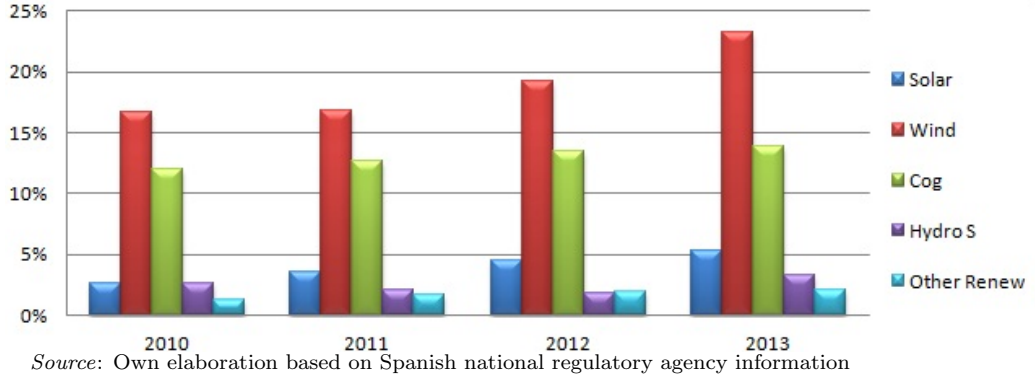
by technology during the last four years. While solar technology was granted with an average of 375 €/MWh produced, in the case of wind and small hydro was an average of 83 €/MWh, for cogeneration (COG) and other renewable the average FIT was 110 €/MWh.

FIGURE 4.2: Yearly average FITC (in €/MWh)



Source: Own elaboration based on Spanish national regulatory agency information

FIGURE 4.3: Yearly average % of Load



Source: Own elaboration based on Spanish national regulatory agency information

It is also important to highlight that wind and solar technologies make different contributions of electricity to the system during the day, which are characterized by different demand profiles. While wind power contribution is in relative terms higher during off-peak hours, the opposite happens with solar power which is generated during daylight (peak hours). Moreover, the technologies within the FIT scheme provide different contributions to the energy consumed (see Figure 4.3); while during the last years wind covered on average around 20% of the total load, solar covered 5% in the best case, small hydro only 3% or less, other renewable 2% or less, and COG (non-renewable) covered about 13% of the load. Hence, technology specific considerations are important not only from the FITC perspective but also on the WP perspective, and this is carefully taken into

account in the empirical study presented in this Chapter. Next, we present the empirical approach and the data used to perform the analysis of the effects that the FIT regulation has on Spanish electricity retail prices for industrial consumers.

4.4 Data and methods

The empirical assessment of the effect that the FIT regulation has over electricity retail price (RP) has been developed through the estimation of a RP equation which allows us to quantify the relative intensity of the effects from both the feed-in tariff cost (FITC) and the wholesale price (WP) of electricity. This assessment is performed in a two-step strategy using weekly data. In a first step, we estimate an inverse supply equation Eq.(4.1) where WP as function of the energy supply mix and the load (equilibrium quantity), and a FITC equation Eq.(4.2) capturing the effect that the electricity production by RES and COG has on the cost per unit of electricity consumption. In a second step, we introduce the estimates of WP and FITC (along with additional controls) into the RP equation Eq.(4.3) to evaluate the relative intensity of both components. Below we describe the models and data used to estimate the retail price effects of the FIT regulation.

$$\begin{aligned}\Delta WP_t = {} & \beta_0 + \beta_1 \Delta WP_{t-1} + \beta_2 \Delta Load_t + \beta_3 \Delta Mix_t \\ & + \Delta\beta_4 Y_t + \Delta\beta_5 Q_t + \Delta\beta_6 M_t + \Delta\beta_7 W_t + \epsilon_{1t}\end{aligned} \tag{4.1}$$

$$\sigma^2_{1t} = \delta_0 + \delta_1 \epsilon^2_{1t} \tag{4.1.1}$$

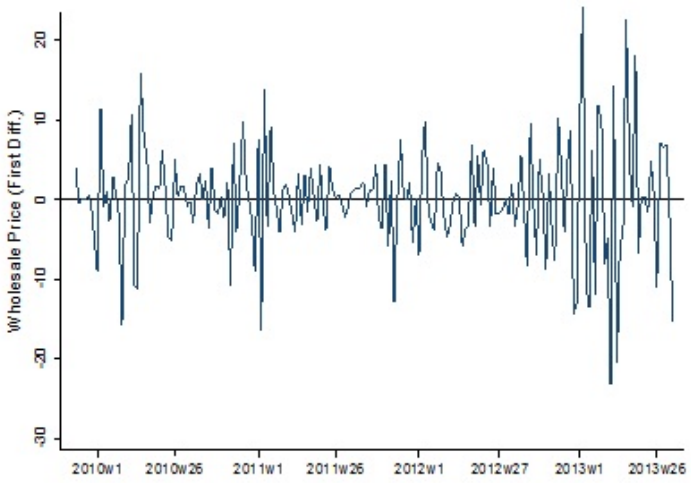
$$\begin{aligned}\Delta FITC_t = {} & \lambda_0 + \lambda_1 \Delta FITC_{t-1} + \lambda_2 \Delta Mix_t \\ & + \lambda_3 \Delta Y_t + \lambda_4 \Delta Q_t + \lambda_5 \Delta M_t + \lambda_6 \Delta W_t + \lambda_7 \epsilon_{2t-1} + \epsilon_{2t}\end{aligned} \tag{4.2}$$

$$\begin{aligned}\Delta RP_t = {} & \alpha_0 + \alpha_1 \Delta RP_{t-1} + \alpha_2 \Delta \widehat{WP}_t + \alpha_3 \Delta \widehat{FITC}_t \\ & + \alpha_4 \Delta Y_t + \alpha_5 \Delta Q_t + \alpha_6 \Delta M_t + \alpha_7 \Delta W_t + \epsilon_{3t}\end{aligned} \tag{4.3}$$

We analyze the FIT regulation effect on the wholesale market price (WP_t) in Eq. (4.1) following the empirical strategy of estimation in differences as Gelabert et al. (2011) and Würzburg et al. (2013). In addition to the load ($\Delta Load_t$) and the electricity generation by energy source (ΔMix_t which includes wind, solar, other renewable, cogeneration, combined cycle, nuclear, coal and hydro), we introduce an autoregressive component (ΔWP_{t-1}) to capture dynamic effects, and an ARCH variance to account for the volatility effects that are observable increasing in the first difference of the WP_t series (see Figure 4.4).

The residuals in Eq. (4.1) are defined as an autoregressive process where all ϵ_{1t} are of the form $\epsilon_{1t} = Z_t\ \sigma_{1t}^2$ with Z_{tv} (0,1), and D_v (0,1) is the probability density function of the residuals with zero mean and unit variance. Eq. (4.1.1) represents the variance equation of the ARCH process. The wholesale price data were obtained from the Spanish market operator (OMEL) and data on electricity generation by energy source were obtained from the Spanish transmission system operator (REE).

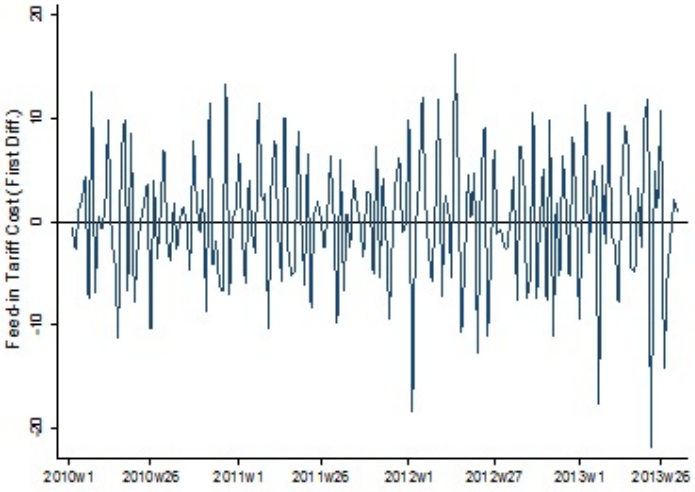
FIGURE 4.4: Wholesale price (first differences)



Following the same empirical strategy as in the WP_t model, for the analysis of the $FITC_t$ the estimation is performed in differences with a lag dependent variable ($\Delta FITC_{t-1}$). Eq. (4.2) represents the change in the cost of the FIT per unit of electricity consumption ($\Delta FITC_t$) capturing the effect from change in the composition of electricity production by different sources (wind, solar,

small hydro, other renewable, and cogeneration) covered through the FIT system (ΔMix_t). Unlike in the case of ΔWP_t, the $\Delta FITC_t$ variance does not follow an ARCH process (see Figure 4.5). However, the $\Delta FITC_t$ series does follows a moving-average process of first order, for this reason we introduce ϵ_{2t-1} component.

FIGURE 4.5: Feed-in Tariff Cost (first differences)



To obtain the weekly $FITC_t$ the following procedure is used. First, in the same line as Burgos-Payán et al. (2013), from Spanish national regulatory agency (National Commission of Markets and Communications, by its acronym in Spanish CNMC, previously named National Commission of Energy, CNE) statistics on FIT payments[40] we take the yearly amount of Euros by technology devoted to the incentives of firms producing electricity from RES and COG. Second, the yearly amount of Euros per technology is weighted by the daily proportion of their yearly production (Prod-day / Prod-year) and added to obtain the daily cost of FIT. Third, to account for volume differences, we compute the cost of the FITs per unit of electricity consumption (load). Finally, we compute the weekly average.

The period covered for the estimation of the ΔWP_t and the $\Delta FITC_t$ equations is from November 2009 to July 2013 (195 weeks). The selection of this period is motivated by regulatory stability and data reliability: up to October 2009 the distribution companies were in charge of handling the FIT payments to the

[40] *"Informacion Estadistica sobre las Ventas de Energia del Regimen Especial"*, available at www.cne.es

Special Regime (SR) producers. Since November 2009 the CNMC is responsible for the FIT payments, providing public and reliable information on those payments[41].

The analysis of effect that the FIT regulation has over electricity retail price for industrial consumers (RP_t) is performed using weekly data through the estimation of Eq. (4.3), which quantifies the retail price change as a function of changes from both the cost of the incentive to electricity generation under the FIT and the wholesale price of electricity. To capture dynamic effects an autoregressive term (RP_{t-1}) was introduced in the model. $\widehat{WP}_t$ is the estimated weekly average of the (day-ahead) spot market price capturing the effect from the composition of electricity production by energy sources (Eq. (4.1)). $\widehat{FITC}_t$ is the estimated weekly FIT cost per unit of electricity consumption capturing the effect from the electricity production by RES and COG (Eq. (4.2)).

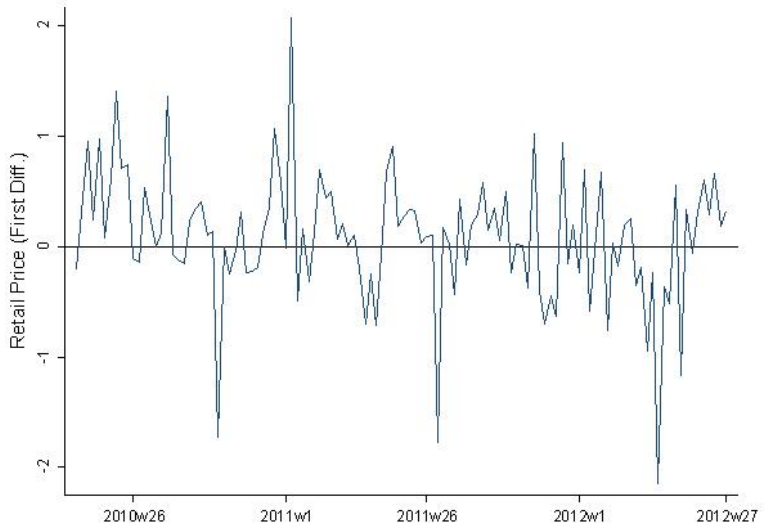
According to the Spanish price design, the industrial retal price (RP, excluding taxes) is the result of adding the Access Tariff (AT), the Net Retail Margins (NRM) and the Wholesale Cost (WC). The AT data comes from the CNMC reports on monitoring the retail market[42]. The NRM, obtained from the same source, were computed quarterly by the CNMC based on two forward purchasing strategies by retailers (see CNE, 2013). We follow the same methodology for one forward purchasing strategy to approach their WC on rolling basis; using weekly, monthly and quarterly contracts (see Appendix C for additional details on the RP proxy)[43]. In order to develop comprehensive empirical estimations weekly data for the period between April 2010 and June 2012 is used (116 weeks). The selection of this period is motivated by data availability. Figure 4.6 shows the industrial retail price in first differences.

[41] In practice it is possible to obtain the payments by both as a direct tariff or as a premium over the market price, here we use the total resources (the FITC) because captures the overall cost of the policy.

[42] *"Informe de Supervision del Mercado Minorista de Electricidad Julio 2011 - Junio 2012"*, (CNE, 2013). More precisely we used the CNMC access tariff for the average industrial consumer according to the RD 110/2007 consumers' classification.

[43] As pointed out in CNE (2013) and Ofgem (2008), firms can employ a range of hedging strategies and these may change over time. For practical purposes we used one of the two purchasing strategies employed by the CNMC for industrial consumers. In the dynamic strategy we use, the supplier buys during remaining time before the rolling period ends to cover the delivery, while in the other strategy the portfolio length is uniformly distributed through the products within the rolling period. Given that our model is in first differences and capture long-term effects, results are expected to be consistent to the use of different strategies.

FIGURE 4.6: Retail price (first differences)



Finally, it is important to highlight that in all three equations the seasonality is controlled using fourth set of dummies variables: yearly (ΔY_t), quarterly (ΔQ_t), monthly (ΔM_t), and weekly (ΔW_t) dummies. Table 4.1 shows the summary statistics of the data used. While all prices and cost (RP, WP and FITC) are measured in €/MWh, all electricity volumes are measured in GWh.

TABLE 4.1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
RP Industrial	116	79.8259	3.2661	69.7313	84.1047
WP	195	43.298	10.4807	3.25	63.6914
FITC	195	47.8293	10.1541	28.0443	82.564
Load	195	28.7619	2.0537	23.9702	34.1131
SR	195	11.2848	2.1422	7.0179	17.75
RES	195	7.5922	2.0167	3.994	13.6012
COG	195	3.693	0.2784	2.6667	4.2143
Wind	195	5.3534	1.969	1.9167	11.6012
Solar	195	1.073	0.5014	0.2396	2.4762
Hydro S	195	0.6869	0.2516	0.2083	1.1786
Hydro B	195	3.4741	1.677	1.3571	8.6905
Hydro T	195	4.161	1.8973	1.6667	9.7738
Other Renew	195	0.4788	0.0931	0.3155	0.6667
Nuclear	195	6.7936	0.8035	4.0833	7.8869
Coal	195	4.3477	2.1268	0.3036	9.1607
Comb Cycle	195	5.4349	2.2302	1.3452	11.5238

Once described the equations to be estimated and the data used, we present the stationarity analysis of the series. We perform two test, first, the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) under the null hypothesis of a unit root and, second, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests (Kwiatkowski et al., 1992) under the null hypothesis of stationarity. While results of ADF test (see Table 4.2) in levels indicate that, we cannot reject the null hypothesis of a unit root in WP, FITC or RP at any reasonable level of significance, results in first differences indicate that we can reject the null hypothesis of a unit root for all three series. In addition, KPSS results in levels indicate that we can reject the null hypothesis of stationarity in WP, FITC and RP in any case, and in first difference that we cannot reject the null hypothesis of stationarity at 1% level of significance. Both tests confirm that WP, FITC and RP weekly series are stationary in first differences so we estimate the models in first differences[44].

TABLE 4.2: Augmented Dickey-Fuller and Kwiatkowski-Phillips-Schmidt-Shin test

	ADF test		**KPSS test**	
	Levels	**First differences**	**Levels**	**First differences**
Wholesale Price (WP)	-3.061	-9.005***	1.060***	0.038
Feed-in Tariff Cost ($FITC$)	-3.247	-9.751***	3.090***	0.054
Retail Price (RP)	-2.606	-4.695***	2.350***	0.541

Note: Test results are statistics. Lag length is determined by the Modified Akaike Information Criterion. The trend is not significant in any case, hence, it is excluded. ADF null hypothesis of unit root. KPSS null hypothesis of stationarity. *** Significant at 1%.

4.5 Results

Given that the effects from FIT regulation come through the proportion and type of renewable sources in the energy mix, three set of estimations are perform for each equation with different aggregations of the electricity mix. While in Set 1 a single variable captures the electricity generated under the FIT system (SR), in Set 2 we distinguish between renewable (RES) and cogeneration (COG) under the FIT system, and in Set 3 the renewable sources are disaggregated in Wind, Solar, Small Hydro, and Other Renewable. In addition to electricity generated

[44] Furthermore, estimations results with absolute value of autoregressive coefficients lower than one confirms the stationarity of the series.

under the FIT system, other main technologies of the energy mix are introduced in the WP equation (Combined Cycle, Nuclear, Coal and Hydro[45]). Table 4.3 and Table 4.4 shows the results of the three maximum likelihood estimations with robust standard errors for the ΔWP_t (Eq. (4.1)) and $\Delta FITC_t$ (Eq. (4.2)), respectively. We first present results from all estimations with the short-run analysis. This is followed by a summary and comparison between short-run and long-run implications.

In general, results from the WP equation are consistent with those of previous studies; the introduction of RES exerts a downward pressure on the wholesale price of electricity. At an aggregated level (Set 1), results indicates that in the short-run one additional GWh of electricity generated under the FIT system (SR) decrease the WP (Table 4.3) in the magnitude of 1.13 €/MWh (-2.61%) and increase the FITC (Table 4.4) on 2.08 €/MWh (4.35%). When separating renewable from cogeneration (Set 2) results for renewable are very similar to the aggregated FIT system, showing that an additional GWh of renewable production decrease the WP in 1.09 €/MWh (-2.53%) and an increase in 2.07 €/MWh of the FITC (4.33%).

The renewable sources are disaggregated in the last group of estimations (Set 3). Results shows that one additional GWh of wind production decrease the WP in the magnitude of 1.11 €/MWh (-2.56%) and increase the FITC in 2.22 €/MWh (4.66%). In the case of solar production, an additional GWh decrease the WP 2.51 €/MWh (-5.80%) and increase 9.94 €/MWh the FITC (20.79%). Finally, cogeneration results shows that one additional GWh of its production decrease the WP around 2.64 €/MWh (-6.12%) and increases 4.62 €/MWh the FITC (9.67%).

The other coefficients of the remaining explanatory variables are very similar across specifications. Besides, as measure of the statistical estimate's reliability Table 4.3 and Table 4.4 shows the relative standard deviation (RSD) and the standard deviation (SD) of residuals, respectively. Decreasing value of both indicators with higher disaggregation of the electricity mix (from Set 1 to Set 3), confirms the adequacy and relevance of technology consideration in the context

[45] Given that small hydro generation is part of the RES under the FIT system, to avoid double imputation of small hydro in the mix, only big hydro generation was introduced as additional control in the first two estimations of the WP. Furthermore, to avoid multicolineality problems coming from the high correlation between small and big hydro, total hydro was introduce in the third estimation of the WP.

TABLE 4.3: Wholesale price

ΔWP_t	(1)	(2)	(3)
ΔWP_{t-1}	-0.287***	-0.284***	-0.238***
	(0.044)	(0.044)	(0.047)
$\Delta Load$	0.814***	0.821***	0.844***
	(0.219)	(0.203)	(0.264)
ΔSR	-1.128***		
	(0.179)		
ΔRES		-1.095***	
		(0.167)	
ΔCOG		-2.330**	-2.648***
		(0.907)	(1.002)
$\Delta Wind$			-1.109***
			(0.210)
$\Delta Solar$			-2.512***
			(0.758)
$\Delta OtherRenew$			7.312
			(5.361)
$\Delta CombCycle$	0.322	0.365*	0.280
	(0.210)	(0.200)	(0.258)
$\Delta Nuclear$	-0.248	-0.267	-0.426
	(0.270)	(0.279)	(0.370)
$\Delta Coal$	0.951***	0.953***	0.939***
	(0.201)	(0.193)	(0.243)
$\Delta HydroB$	-3.169***	-3.180***	
	(0.240)	(0.235)	
$\Delta HydroT$			-2.836***
			(0.242)
Constant	0.145	0.134	0.0379
	(0.094)	(0.090)	(0.102)
δ_1	0.870***	0.752***	0.728***
	(0.367)	(0.367)	(0.339)
δ_0	1.200**	1.083**	0.949***
	(0.470)	(0.457)	(0.360)
Seasonality			
Year	Y	Y	Y
Quarter	Y	Y	Y
Month	Y	Y	Y
Week	N	N	N
Observations	194	194	194
RSD of residuals	46.620	43.033	25.049

Note: Robust standard errors are in parentheses. * Significant at 10%, ** Significant at 5%, *** Significant at 1%. The 51 weekly dummies were excluded from the wholesale price seasonality to allow the optimization of the ARCH process.

TABLE 4.4: Feed-in tariff cost

$\Delta FITC_t$	(1)	(2)	(3)
$\Delta FITC_{t-1}$	-0.231**	-0.256**	-0.344***
	(0.102)	(0.099)	(0.104)
ΔSR	2.081***		
	(0.203)		
ΔRES		2.072***	
		(0.198)	
ΔCOG		6.034**	4.625*
		(2.974)	(2.535)
$\Delta Wind$			2.227***
			(0.189)
$\Delta Solar$			9.944***
			(1.331)
$\Delta HydroS$			1.671
			(1.908)
$\Delta OtherRenew$			-9.837
			(8.006)
Constant	0.081	0.076	0.061***
	(0.057)	(0.062)	(0.016)
ϵ_{t-1}	2.170***	2.203***	2.168***
	(0.367)	(0.367)	(0.339)
Seasonality			
Year	Y	Y	Y
Quarter	Y	Y	Y
Month	Y	Y	Y
Week	Y	Y	Y
Observations	194	194	194
SD of residuals	46.620	43.033	25.049

Note: Robust standard errors are in parentheses. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

of this study. Furthermore, the goodness of fit of the estimates are very high as can be seen in Figure 4.7 and Figure 4.8 showing the observed and predicted values from Eq.(4.1) and Eq.(4.2), respectively[46].

Once considered the effect of electricity produced under the FIT regulation over the WP and FITC, the overall impact of the FIT regulation on retail price will ultimately depend on the relative intensities of the effects exerted through WP

[46] As a robustness check, when re-estimating the WP model including the gas price as an additional control, the effect is positive but not significant, and the rest of estimated coefficients remain unchanged. This not significant result might comes from the fact that gas price effect it is captured, at least partially, by the combined cycle contribution into the electricity mix.

and FITC. This analysis is performed through the estimation of the Eq. (4.3) for industrial consumers using the predicted values of WP and FITC resulting from previous estimations.

FIGURE 4.7: Goodness of fit Eq. (1)

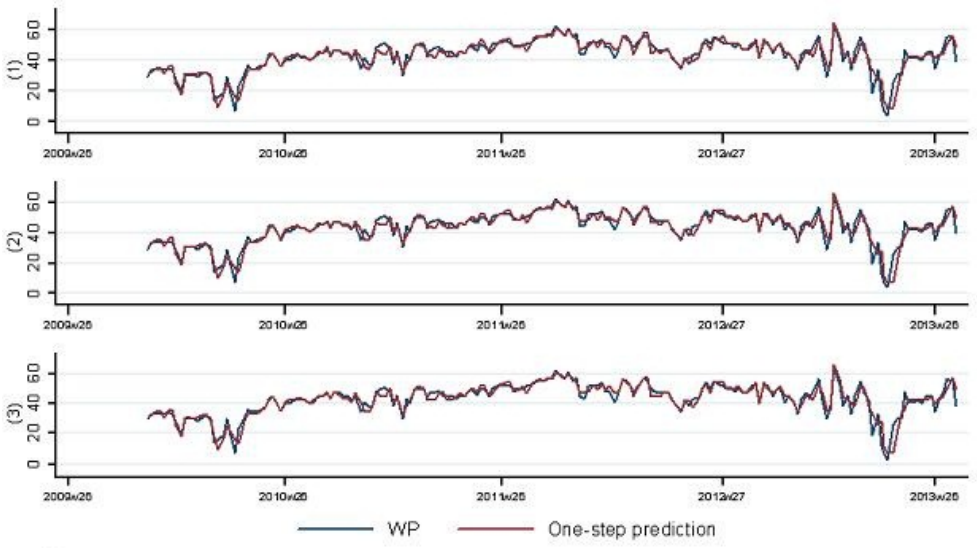
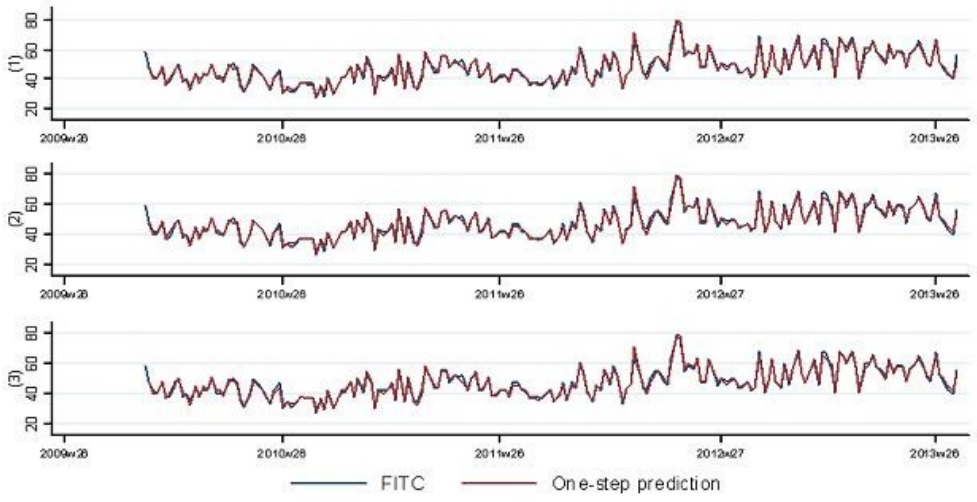


FIGURE 4.8: Goodness of fit Eq. (2)



Given that $\widehat{WP}_t$ and $\widehat{FITC}_t$ are both function of the energy mix some worries might arise on effect over the retail price equation from the potentially high correlation between them. Nonetheless, the correlation between the two estimated variables is -0.131 for results in Set1, -0.132 in the Set2, and -0.150 in the Set3. Results from estimations of Eq. (4.3) are presented in Table 4.5.

TABLE 4.5: Retail price industrial

ΔRP_t	(1)	(2)	(3)
ΔRP_{t-1}	0.154**	0.155**	0.178**
	(0.073)	(0.072)	(0.076)
$\Delta\widehat{WP}_t$	0.034***	0.030***	0.037***
	(0.011)	(0.011)	(0.011)
$\Delta\widehat{FITC}_t$	0.034***	0.028***	0.037***
	(0.009)	(0.009)	(0.009)
Constant	0.059	0.060	0.057
	(0.037)	(0.037)	(0.037)
Seasonality			
Year	Y	Y	Y
Quarter	Y	Y	Y
Month	Y	Y	Y
Week	Y	Y	Y
Observations	116	116	116
SD of residuals	0.337	0.335	0.330

Note: Robust standard errors are in parentheses. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

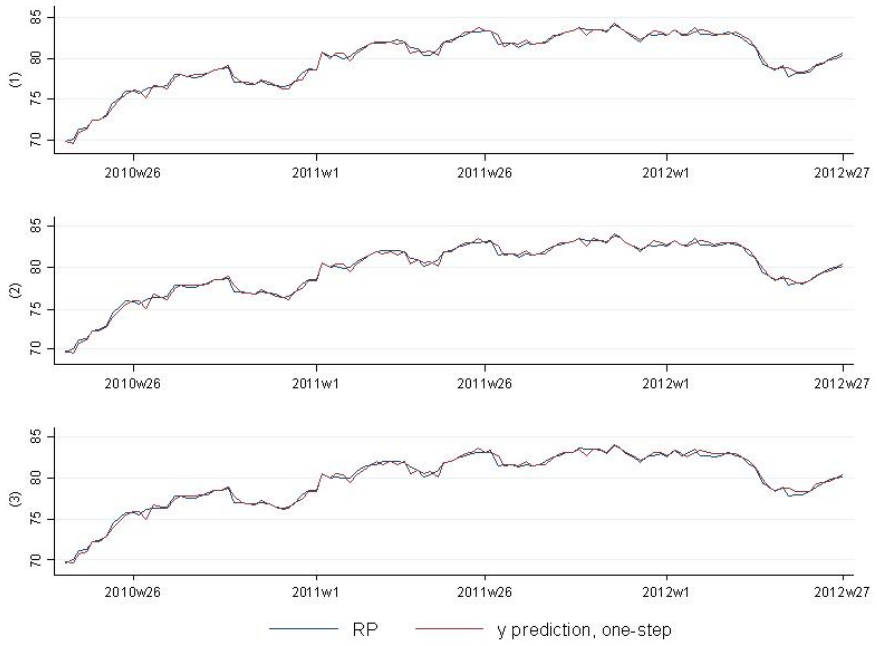
In general, all estimations indicate that the short-run effects from changes in WP and FITC on the industrial RP change are small and similar. At an aggregated level (Set 1), results shows that an increase of 1 €/MWh in the WP and the FITC leads to increase the RP in 0.034 €/MWh. Combining the estimated effects from Eq.(1) and Eq.(2) over the WP and the FITC with these retail price effects[47] we obtain that, from one additional GWh of production under the FIT system (9% more) the RP increase in 0.042%. When separating renewable from cogeneration (Set 2), results are very similar showing that increase of 1 €/MWh in the WP and the FITC leads to increase the RP in 0.030 €/MWh and 0.028 €/MWh respectively. Hence, an extra GWh of renewable production (13.2% more) increase the RP in the short-run in 0.031%.

Finally, when renewable sources are disaggregated (Set 3), results shows that an increase of 1 €/MWh in the WP and the FITC increases the RP in 0.037 €/MWh. Therefore, short-run one additional GWh in the case of wind (18.7% more) increase the RP in 0.053%, and in the case of solar (93.2% more) increase the RP in 0.349%.

[47] The final short-run effect on the RP from one additional GWh of production is calculated as follows:
α_2 * [β_3 / $\overline{WP}$] + α_3 * [$\lambda_2/\overline{FITC}$]

As in previous models, using the standard deviation (SD) of residuals (see Table 4.4) as measure of the statistical estimate's reliability, we observe that it has decreasing value with higher disaggregation of the electricity mix (from Set 1 to Set 3). Besides, the goodness of fit of the retail price equation is very high as can be seen in Figure 4.9 showing the observed and predicted values from the retail price equation.

FIGURE 4.9: Goodness of fit Eq. (3)



Estimated coefficients from lagged dependent variables were used compute the long-run effects[48]. A summary of the short-run and long-run effects FIT regulation in the average WP, FITC and RP are presented in Table 4.6. In the case of the long-run effects it is interesting to highlight that they decrease for WP and FITC with respect to those in the short-run, the effect of one additional GWh of production under the FIT system over the WP and the FITC is stronger in the short than in the long-run (β_1 and λ_1 are negative). The opposite happens for the RP, in the long-run the effect of additional production under the FIT system increases with respect to those observed in the short-run (α_1 is positive).

[48] In each case, the long-run effects are calculated as follows:
WP: $[\beta_3 \ / \ 1\text{-}\ \beta_1] \ / \ \overline{WP}$
FITC: $[\lambda_2 \ / \ 1\text{-}\ \lambda_1] \ / \ \overline{FITC}$
RP: $\alpha_2 * [\beta_3 \ / \ 1\text{-}\ \beta_1] \ / \ \overline{WP}/[1\text{-}\alpha_1\ ] + \alpha_3 * [\lambda_2 \ / \ 1\text{-}\ \lambda_1] \ / \ \overline{FITC}/[1\text{-}\alpha_1\ ]$

TABLE 4.6: Effects from one additional GWh of production

Short-Run	SR	RES	Wind	Solar
WP	-2.61%	-2.53%	-2.56%	-5.80%
FITC	4.35%	4.33%	4.66%	20.79%
RP	0.042%	0.031%	0.053%	0.349%
Long-Run	**SR**	**RES**	**Wind**	**Solar**
WP	-2.02%	-1.97%	-2.07%	-4.69%
FITC	3.54%	3.45%	3.47%	15.47%
RP	0.06%	0.04%	0.07%	0.49%

Note: 1 GWh represents 9%, 13.2%, 18.7% 93.2% and 27.1% of the average generation for SR, RES, Wind, Solar, and COG, respectively.

4.6 Discussion and Conclusions

In this study we have analyzed the effects that FIT regulation has on Spanish electricity retail price for industrial consumers. This analysis is performed by quantifying the relative effects of the cost of the incentives for electricity generation under the FIT and the electricity wholesale price on the industrial retail price.

At an aggregated level, results confirms that in the short-run an increase of about 9% of the total production under the FIT system leads to a decrease of 2.61% of the WP and an increase of 4.35% of the FIT cost (FITC). Regarding final industrial consumers, the previous mentioned effects over WP and FITC are translated into a 0.042% increase of the average retail price. These results, although illustrative, must be carefully interpreted because do not take into account the effect from different technologies.

One interesting finding from this study is that the effects from one additional GWh of solar production on the WP and on the FITC is stronger than the effects from wind. In the case of the WP this seems to be the confirmation of the differentiated effect from the fact that both technologies make different contributions of electricity to the system during the day, characterized by different demand profiles. Even though solar contribution to the energy mix is relatively small (less than 5% in average), given that it is available during peak hours, the downward pressure that exerts over the WP is stronger than the one from wind with a higher penetration (around 20%) but relatively stronger during off-peak

hours. Nevertheless, this would need a further evaluation using hourly data. In the case of FITC the stronger effect from solar it is much more straightforward, it is capturing the extremely high FIT incentive in terms of €/MWh devoted to this technology.

Regarding the final impact on industrial retail price from previous mentioned results, the effect of one additional GWh solar production is 6.6 higher that the effect coming from wind in the short-run and 7.6 higher in the long-run. When looking at these effects, it is important to highlight that one additional GWh of solar would imply increasing 93.2% its average generation while in the case of wind it would represent only an 18.7%. To place these results into perspective, we compute the effects from a 1% increase of the average production from both technologies on the average retail price. Result indicates that in the long-run a 1% increase of solar generation leads to an increase in the retail price which it is actually only 1.5 higher that the effect coming from 1% more wind.

With respect to the small magnitude of the retail price effects, it has been recently pointed out by the European Commission that, in an open and competitive retail market the pricing signals should provide a strong link between the retail and wholesale market, and the final consumers would then be able to adapt their economic decisions in line with the supply and demand fundamentals. These conditions are rarely met in today's retail markets in the EU (EC, 2014). From our analysis we conclude that there is not a strong link between the retail and wholesale market for Spanish industrial consumers. This is possible the consequence of a variety of factors and barriers that are limiting the retail market competition.

5. Conclusion

The assessment of the impact of EU regulation is important when involves industries that, acting as input providers for other industries, have a key role in the economy. This dissertation has examined the impact of EU regulation in network industries centering the analysis on two specific regulations promoting the entrants access to the incumbent network in telecommunications sector (analyzed in Chapter 2 and Chapter 3) and the generation of electricity from renewable energy sources (studied in Chapter 4). This final chapter summarizes the main conclusions drawn from the three empirical studies presented in previous chapters.

The study presented in Chapter 2 analyzes the role of EU regulation and firm internationalization as drivers of infrastructure investment in telecommunications from a country-level perspective. We have classified firms holding operations in the EU broadband market according to the degree of internationalization of their operations and their position as incumbent or entrant in the markets to create what we called the "typology of firms" characterizing each country. We evaluate the impact of this classification and that of the access regulation on broadband infrastructure investment.

Findings from this research suggest that regulation has not had a significant, direct impact on aggregate infrastructure investment, and on the contrary, the "typology of firms" capturing the firm's internationalization and position in the markets is a significant driver of investment. Specifically, regarding firms' internationalization and market position, we find that, for the firms holding operations in the EU broadband market, the evidence support the view of firms investing internationally as part of an efficiency-seeking process and/or to exploit their scale economies

Given that lower level of concentration might lead to greater competition, the finding of a positive impact of intra-facility concentration on investment indicate that the increase in competition has not been accompanied by infrastructure investment, but rather by subscribers switching from incumbents to entrants. This, along with the possibility that the markets subject to access regulation are

currently at a stage in which the relationship between competition and investment is negative, put forward some concerns on the effectiveness of regulations (like access regulation) promoting competition within a single infrastructure, and their possible long-term effects on infrastructure development and quality.

In short, it can be concluded from Chapter 2 that, although regulation has not a direct effect on aggregated infrastructure investment it does have an effect (negative) through the competition promoted within the regulated infrastructure, which might have negative consequences over the future broadband infrastructure. Besides, under the current regulatory framework, firms that choose to invest more in infrastructure are those that have more international experience in the sector. As such, firm's position in the markets plays an important role in telecommunication sector.

Furthering our examination of EU access regulation in the telecommunications sector and expanding from the empirical analysis presented in Chapter 2, namely the use of country-level data, in Chapter 3 detailed firm-level data is incorporated to facilitate a better understanding of how the firms' internationalization and firms' position as incumbent or entrant in the markets are related to each other within the EU broadband markets. More precisely, in Chapter 3 the effects of regulated access prices and firms' multinational status on firm performance are analyzed using firm, group, and country level information. The three measures of firm performance that have been used are: market share, turnover and productivity.

With the empirical hypotheses based on the vertical and horizontal relations between incumbents and entrants, we estimate the impact of regulated wholesale access prices on firm performance. The main finding from Chapter 3 is that access prices exert a negative effect on entrants' performance and a positive effect on that of incumbents. Since the regulated access rate is the price that an entrant must pay to the incumbent for each subscriber obtaining a service through the incumbent's infrastructure, the access price is a key ingredient of the firms' marginal cost of providing the service. As such, the inverse relation between access prices and entrants' performance find is according to expectations.

The effect that prevails in the relationship between wholesale access prices and the incumbents' performance is positive. Unlike above mentioned in the case of the entrants, the relation between access prices and the incumbent's performance is less straightforward. On the one hand, the impact of wholesale access prices

on the incumbents' performance can be negative at the wholesale level as a consequence of the negative wholesale price elasticity on the entrants' retail market share. On the other hand, the wholesale access prices have a positive impact on the incumbents' market share, which implies a positive effect at the retail level. Hence, we conclude that the positive effect at the retail level is driving the total positive effect on the incumbent's turnover and productivity.

Other relevant conclusions from the analysis presented in Chapter 3 are those regarding the international dimension of firms and the differences from their position as incumbent or entrant in the markets. We find that for multinational entrants, the positive effects on market share derived from their operating in more countries are outweighed by the costs incurred when they expand their operations. This results in a negative impact on both their turnover and productivity. In the case of multinational incumbents, the estimated positive impact of the degree on internationalization on turnover and productivity seems to capture the positive effects of international expansion and entry into other countries, albeit at the cost of a loss of market share in their country of origin. This confirms that the firms' multinational status has a significant impact on its performance, and this impact varies for incumbents and entrants.

The regulated wholesale access price is considered a regulatory outcome, and as a such is subject to some degree of discretion which may ultimately lead to regulatory risk. We find that the performance of multinational firms is less sensitive than that of national firms to changes in wholesale prices. Hence, in line with the approach that sees multinationals as a risk diversifying mechanism, we conclude that, via the international diversification of their operations, multinationals are better able than national firms to cover wholesale access price risks.

Finally, in the study presented in Chapter 4 we examine the impact of promoting the production of electricity from renewable energy sources following the 20-20-20 target established under EU regulations governing the energy sector. More specifically, we have analyzed the effects that feed-in tariff regulation has on Spanish electricity retail price for industrial consumers. This analysis is performed by quantifying the relative effects of the cost of the incentives for electricity generation under the feed-in tariff and the electricity wholesale price on the industrial retail price.

Findings from Chapter 4 confirms that an increase of the production of electricity generated under the feed-in tariff system leads to a decrease of the wholesale price and an increase of the feed-in tariff cost. The later is always stronger than the former, the increase of costs exceeds the decrease of prices. This is true for all estimations with different aggregations and technologies, as well as in the short- and long-run. From these results is apparent that, at wholesale (producer) level, the cost of renewable promotion through the feed-in tariff regulation overcomes the potential gains from merit of order effect. Nevertheless, regarding final industrial consumers, the previous mentioned effects over wholesale price and feed-in tariff cost are only partially translated into the retail price.

An interesting finding from Chapter 4 is that the effects from one additional GWh of solar production on the wholesale price and on the feed-in tariff cost are stronger than the effects from wind. In the case of the wholesale price this seems to be the confirmation of the differentiated effect from the fact that both technologies make different contributions of electricity to the system during the day, characterized by different demand profiles. Even though solar contribution to the energy mix is relatively small, given that it is available during peak hours, the downward pressure that exerts over the wholesale price is stronger than the one from wind with a higher penetration but relatively stronger during off-peak hours. In the case of feed-in tariff cost the stronger effect from solar it is much more straightforward, it is capturing the extremely high feed-in tariff incentive devoted to this technology.

Regarding the final impact on industrial retail price from previous mentioned results, the effect of one additional GWh solar production is between 6 and 8 times higher that the effect coming from wind. When this is place into perspective, given the different average generation of both technologies, it is observable that in the long-run a 1% increase of solar generation leads to an increase in the retail price of electricity for industrial consumers which it is actually only 1.5 higher that the effect coming from 1% more wind.

While under the current regulatory design the economic incentives are technology-specific granted according to the level of development and the generation costs, when implementing the regulation, the technology-specific effects from the wholesale and retail markets perspective has not been taken into account. From the above findings is clear that regulations oriented to promote the generation of

electricity from renewable sources, as the fee-in tariff, should consider the overall markets effects as well as those coming from the differences among promoted technologies.

In an open and competitive retail market the pricing signals should provide a strong link between the retail and wholesale market, and the final consumers would then be able to adapt their economic decisions in line with the supply and demand fundamentals. It has been recently pointed out by the European Commission that these conditions are rarely met in today's retail markets of energy in the EU. On this regard, from the small magnitude of the retail price effects find in our analysis we conclude that there is not a strong link between the retail and wholesale market of electricity for Spanish industrial consumers, and that this is possible the consequence of a variety of factors and barriers that are limiting the retail market competition.

Through the consideration of both wholesale and retail dimensions in the assessments include in this dissertation, we obtained important information on the potential welfare effects of regulation. While in the case of telecommunications the regulated access price at the wholesale level was found to have strongly significant effects at the retail level, in the case of electricity a significant, albeit not strong, link was identified between the retail and wholesale market prices for industrial consumers. The later is preventing final consumers from experiencing the potential welfare effects resulting from both the competitive wholesale market, in which the feed-in tariff regulation exerts a price suppressing effect, and the cost of financing this mechanism promoting renewable sources of energy.

The stimulation of retail competition from the implementation EU regulation in the telecommunications sector is being achieved via mandatory access and a falling regulated wholesale price. Potentially lower retail prices and gains in consumer surplus may arise from the lower levels of concentration. Nevertheless, the negative impact of competition on investment indicates that decrease of concentration have not been accompanied by investment in infrastructure. This have possible long-term effects on telecommunications infrastructure. Moreover, given that the sector is characterized by scale economies and the productivity of incumbents is highly sensitive to wholesale access prices, there are also possible negative welfare consequences of the current EU regulatory framework.

From the above discussion it is noteworthy that introducing EU regulations in network industries has implications beyond the specific goals they were designed

to achieve. These implications are partially attributable to the context in which they are implemented. Hence, in the same way that the differences between Member States are considered when designed and implemented supranational EU regulations in network industries, special attention need to be devoted by those responsible for introducing regulations when evaluating these implications so as to anticipate their potentially negative welfare effects.

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A. Appendix Chapter 2

Estimates including access regulation AR_{it-1} individual components

TABLE A.1: Results with access regulation individual components

	Panel	**Panel IV**
Typology of Firm		
TF_{it}	0.648*	0.660**
	(0.370)	(0.347)
Access Regulation AR_{it-1}		
$Bitstream_{it-1}$	-0.279	-0.328
	(0.267)	(0.246)
$Share_{it-1}$	0.0104	0.0374
	(0.201)	(0.187)
ULL_{it-1}	0.0834	0.0285
	(0.130)	(0.150)
Competition		
$HHIinter_{it}$	2.133	2.489*
	(1.344)	(1.451)
$HHIintra_{it}$	1.373**	1.327**
	(0.632)	(0.548)
Income		
Ln$GDPpc_{it}$	-0.291	0.885
	(1.315)	(1.681)
Constant		-1.072
		(4.327)
Observations	161	161
R-squared	0.453	0.449
Nº Countries	27	27
F-statistic		26.44

Note:Dependent variable TF_{it}. All estimations are control by country and time fixed effects. Robust standard errors in parenthesis.

Alternative valuation scores of V_{itf}

From arguments drawn on International Business Theory and Management Theory, it is clear that some differentiated investment behaviour can be expected depending on firms internationalization and position in the markets, meaning that an entrant or an incumbent (or an entrant in several countries) cannot be treated as equals when analysing their investments. This is the reason why we rank firms according to these characteristics. Despite knowing the ranking (the

order), we do not know how much one firm should be valued higher than another. However, since we have to assign values to quantify the effect of firms internationalization and position in the markets, we propose a linear scale of relation between the scores in the rank. Thus, within the linear scale, when a firm changes its position in the rank (see Table 2.2) to an adjacent one, the change in the score is always the same independently if it happens at the top or the bottom of the rank. With this scale we computed the variable TF_{it} in the main text (for comparison purposes, here we call it the linear TF_{it}). As an alternative to the linear scale, and as a robustness check, we also constructed two other scales; one convex and one concave (see Table A.2).

With these scales we computed two new versions of the variable TF_{it} (see Figure A.1 for a selection of countries). In each country the three versions of TF_{it} have the same pattern, but each one captures changes in the composition of the countries-firms differently. Thus, within the same country, while changes for the linear version are constant, for the convex one they are smoother, and for the concave one sharper. As expected, the correlations between the TF_{it} presented in Chapter 2 and the convex and concave cases are very high (0.9521 and 0.8386 respectively).

FIGURE A.1: Typology of Firms (Linear, Convex and Concave)

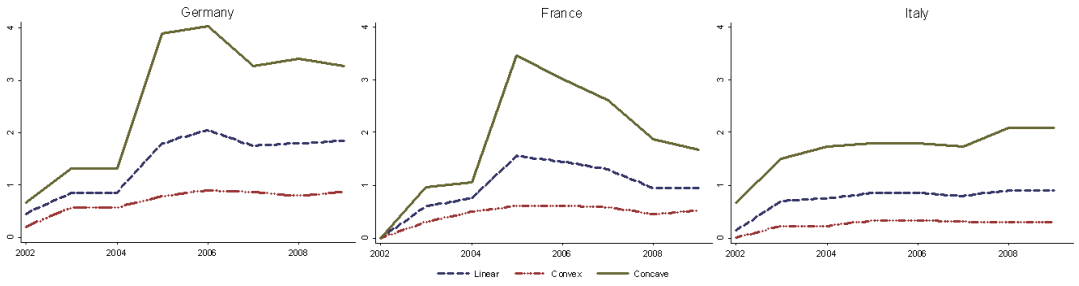


Table A.2: Alternative valuation of Firms' Internationalization and Position

Internationalization-Position	Valuation	
	Conv X^2	Conc X^.5
Entrant in country i	0.0025	0.2236
Entrant in country i and one other country	0.0100	0.3162
Entrant in country i and two other countries	0.0225	0.3873
Entrant in country i and incumbent in another country	0.0400	0.4472
Entrant in country i and in another country and incumbent in another country	0.0625	0.5000
Entrant in country i and incumbent in two other countries	0.0900	0.5477
Entrant in country i and in another country and incumbent in two other countries	0.1225	0.5916
Entrant in country i and incumbent in more than two other countries	0.1600	0.6325
Incumbent in country i	0.2025	0.6708
Incumbent in country i and entrant in another country	0.2500	0.7071
Incumbent in country i and entrant in two other countries	0.3025	0.7416
Incumbent in country i and in another country	0.3600	0.7746
Incumbent in country i and in another country and entrant in another country	0.4225	0.8062
Incumbent in country i and in another country and entrant in two other countries	0.4900	0.8367
Incumbent in country i and in more than two other countries	0.5625	0.8660
Incumbent in country i and in more than two other countries and entrant in another country	0.6400	0.8944

B. Appendix Chapter 3

Yearly access price statistics

TABLE B.1: Full ULL price

Variable	Mean	Std. Dev.	CV	Min	Max
2002	19.7304	5.8808	0.2981	11.5676	31.9871
2003	18.5322	6.9260	0.3737	10.5270	32.0093
2004	14.0449	4.0582	0.2889	9.0954	25.5840
2005	12.8240	2.8617	0.2232	9.3000	18.6000
2006	12.5174	2.4001	0.1917	8.8842	17.7451
2007	12.2166	2.3182	0.1898	8.6635	18.1738
2008	12.2534	2.2546	0.1840	8.6648	19.2535
2009	11.8460	2.9358	0.2478	6.2493	19.1559
2010	11.3308	2.2185	0.1958	6.9129	15.4465

TABLE B.2: Shared access price

Variable	Mean	Std. Dev.	CV	Min	Max
2002	14.7066	5.2709	0.3584	6.4001	21.7495
2003	12.1091	5.6145	0.4637	5.3876	22.3037
2004	7.4623	3.7907	0.5080	2.9063	18.6074
2005	6.3644	2.8522	0.4481	2.8500	14.6300
2006	6.2669	3.0781	0.4912	1.1893	15.1386
2007	5.9198	2.7331	0.4617	1.0326	12.6758
2008	5.6271	2.5669	0.4562	0.6438	11.4323
2009	5.3064	2.7677	0.5216	1.0124	10.9323
2010	4.7656	2.3598	0.4952	0.8927	8.9607

Diagnostic test results

To be confident of our estimation results, we perform several diagnostic tests. We are particularly concerned by the possibility of heteroskedasticity as well as by that of the nonstationarity of the dependent variables and the main variable of interest as they are all likely to be trending variables that can lead to a spurious regression problem. We test for heteroskedasticity using the Breusch-Pagan/Cook-Weisberg test under the null hypothesis that the error variances are all equal versus the alternative that the error variances are a multiplicative function of one or more variables. The results reported in the table below indicate that heteroskedasticity may be a problem in our estimations. Hence,

to address this problem the results in the main text are estimated with robust standard errors.

TABLE B.3: Breusch-Pagan/Cook-Weisberg Homoskedasticity test

	Market Share		Turnover		Productivity	
	(1) Full ULL	(2) Shared A	(3) Full ULL	(4) Shared A	(5) Full ULL	(6) Shared A
Chi2(1)	5.34	8.20	3.40	3.45	11.47	11.54
$Prob > chi2$	0.0208	0.0042	0.0651	0.0634	0.0007	0.0007

Note: H0: Homoskedasticity, the error variances are all equal.

In addition, to rule out possible spurious regression problems arising from non-stationarity of the series we perform a Fisher-type test (see Choi, 2001) on the performance variables and on the main variable of interest (regulated prices and multinational status). This test is based on the Augmented Dickey-Fuller tests under the null hypothesis that the panel data structure of each variable contains a unit root. From the results presented in the table below, we can reject the null hypothesis that the variables show a unit root. Note that in the table we present two of the statistics reported by the test, and the results are consistent for both statistics; thus, we can rule out any possible spurious regression problems arising from the nonstationarity of the series.

TABLE B.4: Fisher test on stationarity of panel variables

	Inverse chi-squared		Modified inv. chi-squared	
	Statistic	p-value	Statistic	p-value
Market Share	499.1269	0.0000	22.3037	0.0000
Turnover	293.9337	0.0000	10.1667	0.0000
Productivity	196.0799	0.0000	4.7425	0.0000
Price (Full ULL)	158.5974	0.0000	10.0649	0.0000
Price (Shared Access)	81.2472	0.0097	2.6219	0.0044
MN	320.3204	0.0000	11.3813	0.0000

Note: H0: The panels contain a unit root. To mitigate the impact of cross-sectional dependence we follow the procedure suggested by Levin et al. (2002).

Robustness checks on price elasticity

TABLE B.5: Price elasticity without lags

	Market Share		Turnover		Productivity	
	(1) Full ULL	(2) Shared A	(3) Full ULL	(4) Shared A	(5) Full ULL	(6) Shared A
Elast on Entrants	-0.0499*	-0.0180**	-0.0461*	-0.0144	-0.0660	-0.0080
Elast on Incumbents	-0.0276	-0.0102	0.0973***	0.0335***	0.1861***	0.0660***

TABLE B.6: Price elasticity with one lag

	Market Share		Turnover		Productivity	
	(1) Full ULL	(2) Shared A	(3) Full ULL	(4) Shared A	(5) Full ULL	(6) Shared A
Elast on Entrants	-0.0757***	-0.0211**	-0.0568*	-0.0034	-0.0453	0.0358
Elast on Incumbents	-0.0031	0.0749**	0.0734***	0.0398***	0.1923***	0.0938***

TABLE B.7: Price elasticity with two lags

	Market Share		Turnover		Productivity	
	(1) Full ULL	(2) Shared A	(3) Full ULL	(4) Shared A	(5) Full ULL	(6) Shared A
Elast on Entrants	-0.0705**	-0.0194**	-0.0357	-0.0040	0.0414	0.0562
Elast on Incumbents	-0.0045	0.0681**	0.0588**	0.0312**	0.1776**	0.0858***

C. Appendix Chapter 4

Eq.(C0) represents the weekly Retail Price (RP) proxy as the result of adding the Access Tariff (AT), Net Retail Margins (NRM) and the Wholesale Cost (WC).

$$RP = AT + NRM + WC \tag{C0}$$

The AT data comes from Spanish national regulatory agency (CNMC, previously named CNE) reports on monitoring the retail market[49][50]. The NRM, obtained from the same source, were compute quarterly by the CNMC based on two forward purchasing strategies by retailers (see CNE (2013)). We follow the same methodology for one the forward purchasing strategy to approach their WC on rolling basis, but with weekly frequency. Below we explain first the actual dynamics of the Spanish future market products we used (weekly, monthly and quarterly), and second, the suppliers forward purchasing strategy used to compute the WC.

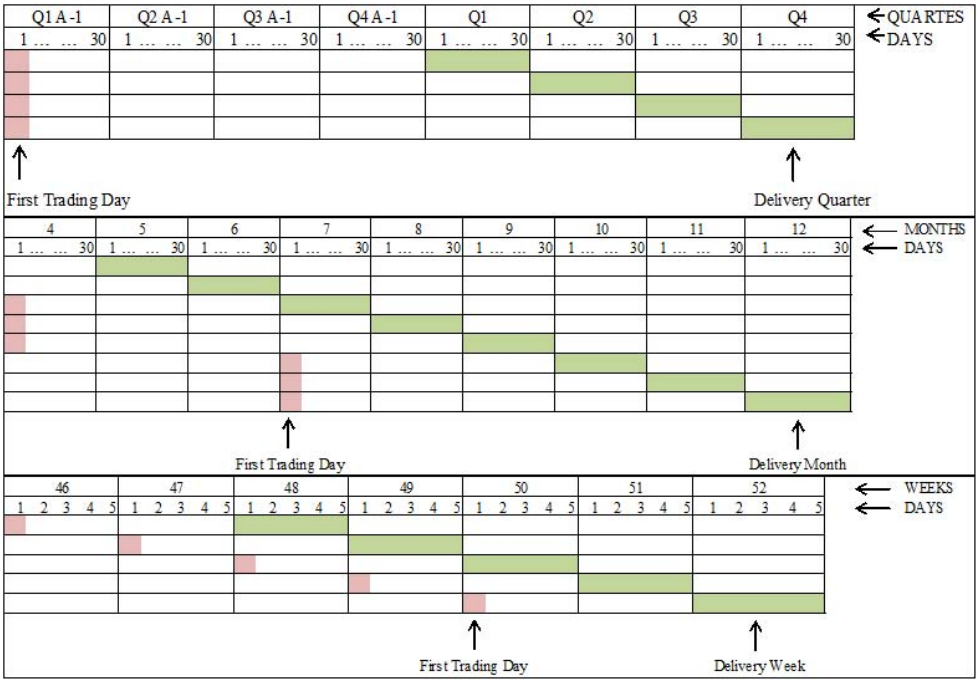
Spanish future market products

There are three products from the Spanish future market that we use to compute the WC based on the suppliers forward purchasing strategies; quarterly, monthly and weekly base load forward contracts. Each contract name corresponds to the delivery period, for instance Q4 is a contract delivered during the fourth quarter of the year (M1 is delivered during the first month, and W2 is delivered during the second week). The three products not only differed on the length of delivery, but also on the time between their first trading day and delivery period. As shown in Figure C.1, while the first trading day of quarterly products starts one year before the delivery of the first quarter, for monthly products the first trading day is the first day one quarter before the quarter holding the month, and for weekly products is the first day three weeks before the delivery week.

[49] *"Informe de Supervision del Mercado Minorista de Electricidad Julio 2011 - Junio 2012"*, (CNE (2013)) More precisely we used the CNMC access tariff for the average industrial consumer according to the RD 110/2007 consumers classification.

[50] The AT includes the cost of transmission and distribution networks, market system interruptibility, extra-peninsular cost, special regime, and a portion of previous years imbalance between regulated income and costs, among others. In Spain, systematically the AT do not cover all the regulated costs.

FIGURE C.1: Future market products



Suppliers forward purchasing strategy

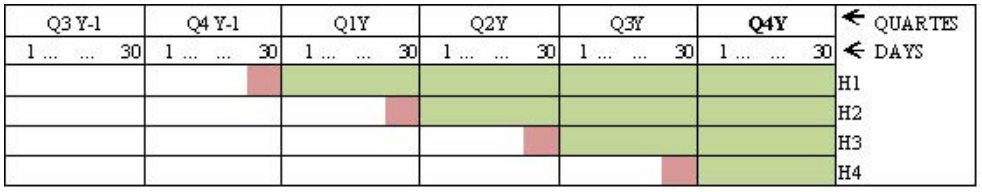
We use the same methodology as CNMC for the forward purchasing strategy, consisting on combining products with different lengths. To obtain higher frequency for the WC, in addition to the monthly and quarterly contracts used by the CNMC, we also take into consideration the weekly contracts. The strategy is a combination of weekly, monthly and quarterly products bought on rolling bases. Therefore, after computing the price for the three alternative products, we combined them to obtain the weekly WC by taking the average price of the three products during each week.

In this dynamic and rolling base strategy, the supplier buys during remaining time before the rolling period ends to cover the delivery. Hence, the price for each product is the resulting from covering one week ahead the delivery for each of the time horizons within the rolling period, weighted by the number of horizons remaining before the rolling period ends.

In the case of quarterly products, the price with this purchasing strategy is the resulting from covering one week ahead the delivery for each of the four quarter within the rolling year, weighted by the number of quarter remaining before the

rolling year ends. Figure C.2 provides the example of the purchasing strategy for Q4. The price of the coverage corresponding to Q4 is represented in Eq.(C1).

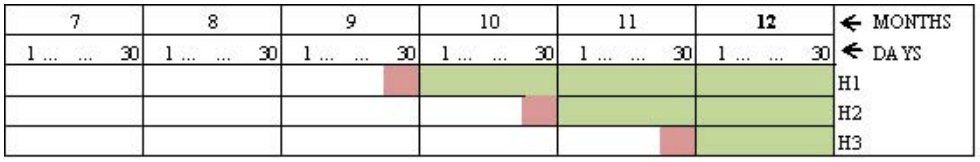
FIGURE C.2: Strategy for quarterly products (Q4 example)



$$P(Q4Y) = P1W(Q1Y) * 4 + P1W(Q2Y) * 3 + P1W(Q3Y) * 2 + P1W(Q4Y)/10 \qquad \text{(C1)}$$

With monthly products, as in the case explained before, the price is the resulting from covering one week ahead the delivery for each of the three months within the rolling quarter, weighted by the number of month remaining before the rolling quarter ends. Figure C.3 provides the example of the purchasing strategy for M12, and the price of the coverage corresponding to that month is represented in Eq.(C2).

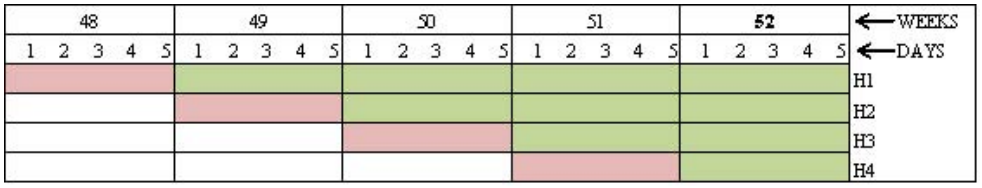
FIGURE C.3: Strategy for monthly products (M12 example)



$$P(M12) = P1W(M10) * 3 + P1W(M11) * 2 + P1W(M12)/6 \qquad \text{(C2)}$$

In the case of weekly contracts (see Figure C.4) there are four weeks to be cover within each rolling month. Hence, following this strategy, the price corresponding the week 52 will be as represented in Eq.(C3).

FIGURE C.4: Strategy for weekly products (W52 example)



$$P(W52) = P1W(W49) * 4 + P1W(W50) * 3 + P1W(W51) * 2 + P1W(W52)/10 \quad \text{(C3)}$$

After computing the price for the three alternative products that can be buy by retailers to cover their supply each week, we combined them to obtain the WC by taking the average price for each week during the sample period. The WC corresponding to the example explained above as represented in Eq.(C4).

$$WC(W52) = P(Q4Y) + P(M12) + P(W52)/3 \quad \text{(C4)}$$

Finally, we combined the WC with the corresponding Net Retail Margins (NRM) (under the same purchasing strategy and time period), and the Access Tariff (AT) to compute the weekly Retail Price (RP). Eq. (C5) represents the retail price for the example week explained above:

$$RP(W52) = AT(Q4) + NRM(Q4) + WC(W52) \quad \text{(C5)}$$