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ABSTRACT: We empirically estimate the effects of regulated access prices and firms' multinational status on firm performance by using firm, corporate group, and country level information for the European broadband market between 2002 and 2010. Three measures of firm performance are used, namely: market share, turnover and productivity. 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. We find that while 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 their 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 their market share. This confirms 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 firms.

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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 these operators. More recently, in 2002, the EU promoted the mandatory unbundling (third-party access) regulation aimed at ensuring the entrance of new agents in the sector[1]. 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. The rationale behind this framework was that local loop[2] access products would allow entrants to provide services with minimum direct investment while relying on the incumbent's existing network; however, after this first stage, entrants were expected to increase their investments as they developed their own infrastructure in a process captured by the "ladder of investment" theory (Cave and Vogelsang, 2003).

Within the telecommunications sector, one of the markets affected by changes in the European regulatory framework is the broadband service. The main access technology to broadband services (providing high-speed Internet access) in Europe is the xDSL (Digital Subscriber Lines), which by July 2009 accounted for 80% of broadband retail lines[3]. With the mandatory unbundling regulation, new market competitors were able to provide broadband access for customers by using the incumbents' infrastructure, the prices for which are regulated[4]. Thus, firm performance is, in part, dependent on regulatory decisions. For this reason, in this study, 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 mandatory unbundled 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 on firm performance the approach adopted must include performance information in both the retail and the wholesale market.

The changes to the European 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 European countries. 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.

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[1] This new regulatory framework is contained in EU Directives 2002/19/EC to 2002/21/EC.
[2] The local loop is the wire used by a telecommunications company to connect each consumer to the service provider's network and from there to the rest of the word.
[3] Own estimation based on EC report (2009).
[4] The usage is related to the unbundling network elements (UNEs), which represent the different types of access that the entrants have over the incumbent's network.

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 Europe's 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 Europe.

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 article is organized as follows. Section 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 outlines our empirical strategy and discusses data issues. Section 4 presents the estimations and results of our analysis. Finally, Section 5 concludes.

2. Related Literature and Empirical Hypotheses

Most of the recent 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[5]. Its proponents claim that unbundling serves to encourage broadband deployment

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[5] The literature review on broadband and investment regulation in Cambini and Jiang (2009) provides extensive coverage of this debate.

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. (2012) 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 average broadband speed. In this paper, 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 (see Wallsten and Hausladen, 2009; Grajek and Roller, 2012; Cambini and Rondi, 2012) when analyzing the effects of access regulation.

Under the current European 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[6]. 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.

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

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[6] 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 (own estimation based on EC, 2009), so we have discarded them from our analysis and focus only on Full ULL and Shared Access rates.

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[7]. 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 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 European 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 and one 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 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; Johanson and Vahlne, 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 Europe seeking new business opportunities. Here, a firm's position as incumbent or entrant plays 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

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[7] 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.

(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 (see Armstrong and Sappington, 2006; Sidak and Spulber, 1998). 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. Data and Empirical Strategy

In this section we present the empirical strategy 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 3.1). 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 3.2).

3.1. General Approach and Variables

Eq. (1) represents the performance of firm i operating in country j at time t ($Perf_{ijt}$) as a function of the country's regulated access price (P_{jt}), the firm's group multinational status (MN_{gt}) and other firm and country level characteristics.

$$Perf_{ijt} = \alpha_1 P_{jt} + \alpha_2 MN_{gt} + \alpha_3 X_{ijt} + \alpha_4 Z_{jt} + \alpha_5 F_i + \alpha_6 C_j + \alpha_7 Y_t + \varepsilon_{ijt} \qquad (1)$$

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 firm 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 European 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[8]) to validate the entry date and length of time the firms had been operating in each country. Below we explain the variables used to estimate Eq. (1).

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.

The second proxy of performance is a firm's operative turnover[9] 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 R&D activities and, ultimately, improve firm productivity, as emphasized by Sidak and Spulber, 1998).

Fig. 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.

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[8] Bureau van Dijk, Amadeus http://www.bvdinfo.com/Products/Company-Information/International Amadeus

[9] 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.

<INSERT FIG. 1 AROUND HERE>

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, as above where market share was a proxy of performance, 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 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.

3.1.2. 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 Fig. 2 for the period covered in this study.

<INSERT FIG. 2 AROUND HERE>

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).

Over time both access prices fell (see Fig. 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.[10] 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 unbundling policies and 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 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,[11] we opt to introduce our main explanatory variable, regulated prices, lagged by one period. 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 Fig. 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.

3.1.3. Multinational Status

The ownership information in the Amadeus Database allowed us to identify which firms belong to corporate groups providing broadband services in more than one 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[12]. 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

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

[11] 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. First, if regulated access prices were set by examining the cost of providing the access, a shock in technology (e.g. a new technology that increases the network speed) would have to be translated as a change in regulated prices. Second, the shock is exogenous to firm performance if all firms in the market provide the service at the new speed at the same time, because there is no room for firms to behave strategically. 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 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 2), which were characterized by major changes in both firm performance and regulated prices.

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

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.

Fig. 3 shows the evolution of the multinational status (MN_{gt})[13] 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.

<INSERT FIG. 3 AROUND HERE>

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 (***Nº Employees***). If firm performance is approximated by the labor productivity, we control instead for the fixed assets per employee (***F Assets per Emp***)[14].

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[15]. Thus, to analyze whether the joint provision of services has an effect on provider performance in the context of this study, we 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

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[13] 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 Dörrenbächer, 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.

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

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

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.

3.1.5. 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.[16] 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.

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 quite small (just 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***) 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. (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 ($MN_{gt}*IncD_{ij}$).

$$Perf_{ijt} = \quad \alpha_1 X_{ijt} \; + \; \alpha_2 IncD_{ij}$$

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[16] 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, (see Koutroumpis, 2009; Czernich et al., 2011), we make use of the broadband penetration rate with one period lag.

$$+ \ \alpha_3 MN_{gt} + \ \alpha_4 \, MN_{gt} {}^* IncD_{ij} \qquad\qquad\qquad\qquad\qquad (2)$$

$$+ \ \alpha_5 \ P_{jt-1} \ + \ \alpha_6 \, P_{jt-1} {}^* IncD_{ij}$$

$$+ \ \alpha_7 \ Z_{jt} \ + \ \alpha_8 \, F_i + \ \alpha_9 \, C_j + \ \alpha_{10} Y_t + \ \varepsilon_{ijt}$$

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 the 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 1 shows the summary statistics of the variables.

<INSERT TABLE 1 AROUND HERE>

4. Results

In order to analyze the impact of access price and multinational status on firm performance, we use the performance equation (Eq. 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[17] while that of the effects of the multinational status is undertaken by computing the marginal effect.

We estimate Eq. (2) by means of panel data techniques and report the within estimator results[18] in Table 2. Columns (1) and (2) correspond to the results for the determinant of the firms' market share with Full ULL and Shared Access prices respectively. Likewise, columns (3) and (4) correspond to the results for the determinant of the firms' turnover, and columns (5) and (6) refer to the firms' productivity.

<INSERT TABLE 2 AROUND HERE>

4.1. Regulated Access Price

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[17] 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. (2), and then we compute the percentage points resulting from the evaluation of the semi-elasticity at the incumbents' and entrants' sample mean.

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

Overall, results from estimations of Eq. (2) support a significant effect of access prices (lagged one period to avoid the possible problem of reverse causality) on firms' performance (see Table 2[19]). 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 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 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).

<center><INSERT TABLE 3 AROUND HERE></center>

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) 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.

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[19] 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. (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.

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.

4.2. Multinational Status

Our results regarding the impact of multinational status on firm performance (see Table 2) 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 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.

<center><INSERT TABLE 4 AROUND HERE></center>

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 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.

4.3. Regulated Access Price: National vs. Multinational

To extend our analysis of the impact of wholesale prices on firm performance, we computed 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 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.

<center><INSERT TABLE 5 AROUND HERE></center>

The results of the additional firm level control variables (see Table 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 paper represents an initial step towards a possible future study of the welfare effects of the regulatory framework on firm performance. European policy is oriented toward 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 result, 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.

5. Conclusions

In this study 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.

Although a number of valuable conclusions can be drawn from this study, 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.

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Fig. 1 Evolution of firm performance: EU27 average.
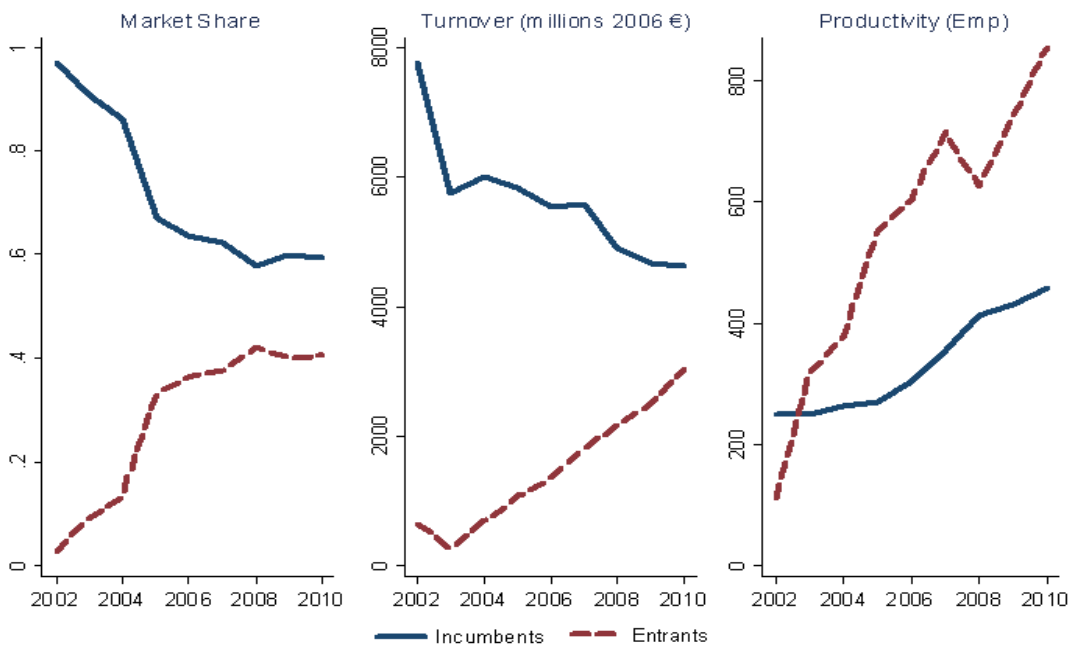
Fig. 2 Evolution of access prices and the coefficient of variation: by country and EU27 average.
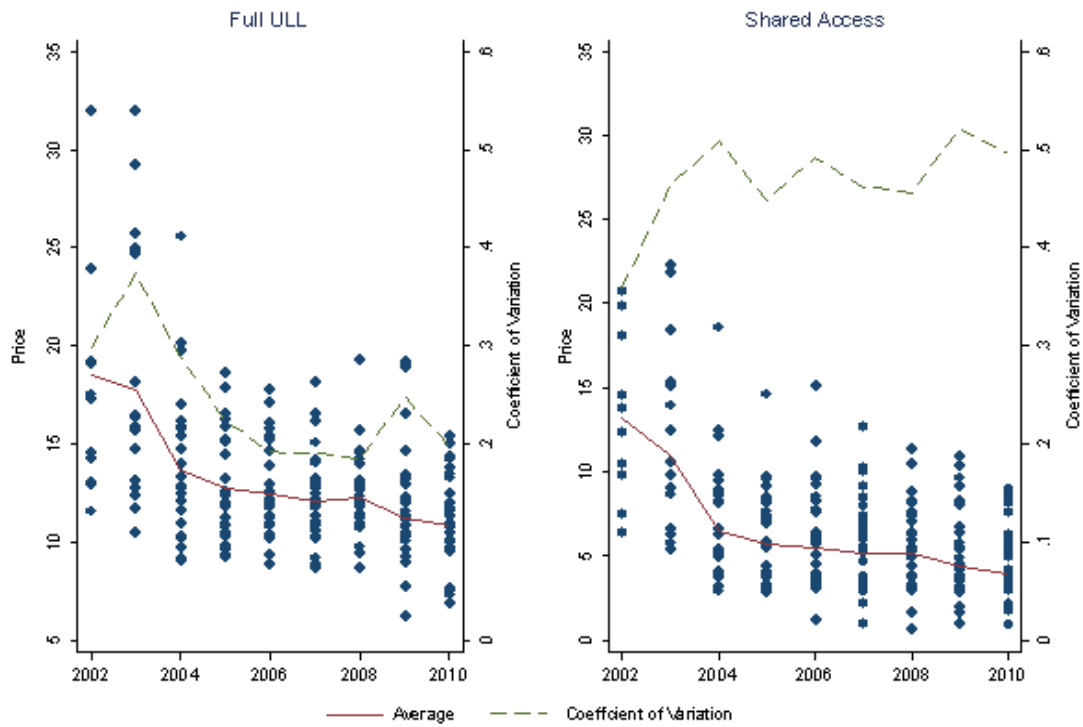
Fig. 3 Evolution of multinational status: EU27 average.
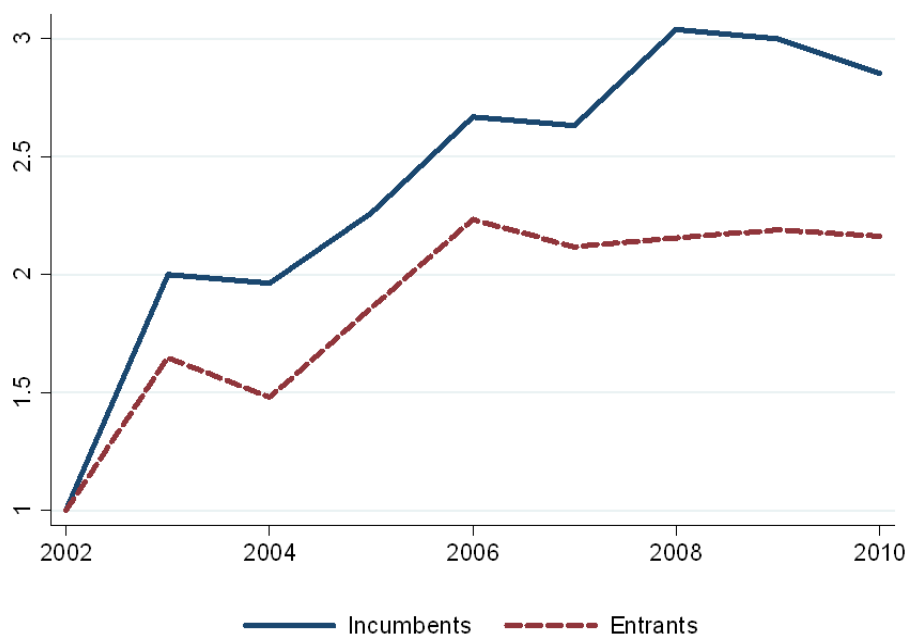
Table 1 Summary Statistics

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
Nº 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

Table 2: The effects of regulated access price and multinational status on firm performance

	Market Share		Turnover		Productivity	
	(1)	(2)	(3)	(4)	(5)	(6)
	Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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)
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)
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)
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)
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.

Table 3 Price Elasticity

	Market Share		Turnover		Productivity	
	Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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 III for robustness checks on price elasticity with a different number of price lags.

Table 4 Multinational Effects (from the base level of one country)

Nº Countries		Market Share		Turnover		Productivity	
		Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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

Table 5 Price Elasticity: Differences between national and multinational firms

	Market Share		Turnover		Productivity	
	Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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***
	$\varepsilon_{Nat} > \varepsilon_{MN}$		$\varepsilon_{Nat} > \varepsilon_{MN}$		$\varepsilon_{Nat} > \varepsilon_{MN}$	

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.

Appendix I: Yearly Access Price Statistics with Coefficients of Variation (CV)

Table AI.1: Full ULL Price Summary Statistics

Year	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 AI.2: Shared Access Price Summary Statistics

Year	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

Appendix II: Diagnostic test results

To be confident of our estimation results, we performed several diagnostic tests. We were 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 were estimated with robust standard errors.

Table AII.1: Breusch-Pagan/Cook-Weisberg Homoskedasticity test

	Market Share		Turnover		Productivity	
	Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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

H_0: Homoskedasticity, the error variances are all equal.

In addition, to rule out possible spurious regression problems arising from nonstationarity of the series we performed 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 AII.2: 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: H_0: The panels contain a unit root. To mitigate the impact of cross-sectional dependence we follow the procedure suggested by Levin et al. (2002), by introducing the mean test option.

Appendix III: Robustness Checks on Price Elasticity

Table AIII.1: Price Elasticity without lags

	Market Share		Turnover		Productivity	
	Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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 AIII.2: Price Elasticity with one lag

	Market Share		Turnover		Productivity	
	Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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 AIII.3: Price Elasticity with two lags

	Market Share		Turnover		Productivity	
	Full ULL	Shared Access	Full ULL	Shared Access	Full ULL	Shared Access
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***

2011

2011/1, Oppedisano, V; Turati, G.: "What are the causes of educational inequalities and of their evolution over time in Europe? Evidence from PISA"

2011/2, Dahlberg, M; Edmark, K; Lundqvist, H.: "Ethnic diversity and preferences for redistribution "

2011/3, Canova, L.; Vaglio, A.: "Why do educated mothers matter? A model of parental help"

2011/4, Delgado, F.J.; Lago-Peñas, S.; Mayor, M.: "On the determinants of local tax rates: new evidence from Spain"

2011/5, Piolatto, A.; Schuett, F.: "A model of music piracy with popularity-dependent copying costs"

2011/6, Duch, N.; García-Estévez, J.; Parellada, M.: "Universities and regional economic growth in Spanish regions"

2011/7, Duch, N.; García-Estévez, J.: "Do universities affect firms' location decisions? Evidence from Spain"

2011/8, Dahlberg, M.; Mörk, E.: "Is there an election cycle in public employment? Separating time effects from election year effects"

2011/9, Costas-Pérez, E.; Solé-Ollé, A.; Sorribas-Navarro, P.: "Corruption scandals, press reporting, and accountability. Evidence from Spanish mayors"

2011/10, Choi, A.; Calero, J.; Escardíbul, J.O.: "Hell to touch the sky? private tutoring and academic achievement in Korea"

2011/11, Mira Godinho, M.; Cartaxo, R.: "University patenting, licensing and technology transfer: how organizational context and available resources determine performance"

2011/12, Duch-Brown, N.; García-Quevedo, J.; Montolio, D.: "The link between public support and private R&D effort: What is the optimal subsidy?"

2011/13, Breuillé, M.L.; Duran-Vigneron, P.; Samson, A.L.: "To assemble to resemble? A study of tax disparities among French municipalities"

2011/14, McCann, P.; Ortega-Argilés, R.: "Smart specialisation, regional growth and applications to EU cohesion policy"

2011/15, Montolio, D.; Trillas, F.: "Regulatory federalism and industrial policy in broadband telecommunications"

2011/16, Pelegrín, A.; Bolancé, C.: "Offshoring and company characteristics: some evidence from the analysis of Spanish firm data"

2011/17, Lin, C.: "Give me your wired and your highly skilled: measuring the impact of immigration policy on employers and shareholders"

2011/18, Bianchini, L.; Revelli, F.: "Green polities: urban environmental performance and government popularity"

2011/19, López Real, J.: "Family reunification or point-based immigration system? The case of the U.S. and Mexico"

2011/20, Bogliacino, F.; Piva, M.; Vivarelli, M.: "The impact of R&D on employment in Europe: a firm-level analysis"

2011/21, Tonello, M.: "Mechanisms of peer interactions between native and non-native students: rejection or integration?"

2011/22, García-Quevedo, J.; Mas-Verdú, F.; Montolio, D.: "What type of innovative firms acquire knowledge intensive services and from which suppliers?"

2011/23, Banal-Estañol, A.; Macho-Stadler, I.; Pérez-Castrillo, D.: "Research output from university-industry collaborative projects"

2011/24, Ligthart, J.E.; Van Oudheusden, P.: "In government we trust: the role of fiscal decentralization"

2011/25, Mongrain, S.; Wilson, J.D.: "Tax competition with heterogeneous capital mobility"

2011/26, Caruso, R.; Costa, J.; Ricciuti, R.: "The probability of military rule in Africa, 1970-2007"

2011/27, Solé-Ollé, A.; Viladecans-Marsal, E.: "Local spending and the housing boom"

2011/28, Simón, H.; Ramos, R.; Sanromá, E.: "Occupational mobility of immigrants in a low skilled economy. The Spanish case"

2011/29, Piolatto, A.; Trotin, G.: "Optimal tax enforcement under prospect theory"

2011/30, Montolio, D; Piolatto, A.: "Financing public education when altruistic agents have retirement concerns"

2011/31, García-Quevedo, J.; Pellegrino, G.; Vivarelli, M.: "The determinants of YICs' R&D activity"

2011/32, Goodspeed, T.J.: "Corruption, accountability, and decentralization: theory and evidence from Mexico"

2011/33, Pedraja, F.; Cordero, J.M.: "Analysis of alternative proposals to reform the Spanish intergovernmental transfer system for municipalities"

2011/34, Jofre-Monseny, J.; Sorribas-Navarro, P.; Vázquez-Grenno, J.: "Welfare spending and ethnic heterogeneity: evidence from a massive immigration wave"

2011/35, Lyytikäinen, T.: "Tax competition among local governments: evidence from a property tax reform in Finland"

2011/36, Brülhart, M.; Schmidheiny, K.: "Estimating the Rivalness of State-Level Inward FDI"

2011/37, García-Pérez, J.I.; Hidalgo-Hidalgo, M.; Robles-Zurita, J.A.: "Does grade retention affect achievement? Some evidence from Pisa"

2011/38, Boffa, f.; Panzar. J.: "Bottleneck co-ownership as a regulatory alternative"

2011/39, González-Val, R.; Olmo, J.: "Growth in a cross-section of cities: location, increasing returns or random growth?"
2011/40, Anesi, V.; De Donder, P.: "Voting under the threat of secession: accommodation vs. repression"
2011/41, Di Pietro, G.; Mora, T.: "The effect of the l'Aquila earthquake on labour market outcomes"
2011/42, Brueckner, J.K.; Neumark, D.: "Beaches, sunshine, and public-sector pay: theory and evidence on amenities and rent extraction by government workers"
2011/43, Cortés, D.: "Decentralization of government and contracting with the private sector"
2011/44, Turati, G.; Montolio, D.; Piacenza, M.: "Fiscal decentralisation, private school funding, and students' achievements. A tale from two Roman catholic countries"

2012

2012/1, Montolio, D.; Trujillo, E.: "What drives investment in telecommunications? The role of regulation, firms' internationalization and market knowledge"
2012/2, Giesen, K.; Suedekum, J.: "The size distribution across all "cities": a unifying approach"
2012/3, Foremny, D.; Riedel, N.: "Business taxes and the electoral cycle"
2012/4, García-Estévez, J.; Duch-Brown, N.: "Student graduation: to what extent does university expenditure matter?"
2012/5, Durán-Cabré, J.M.; Esteller-Moré, A.; Salvadori, L.: "Empirical evidence on horizontal competition in tax enforcement"
2012/6, Pickering, A.C.; Rockey, J.: "Ideology and the growth of US state government"
2012/7, Vergolini, L.; Zanini, N.: "How does aid matter? The effect of financial aid on university enrolment decisions"
2012/8, Backus, P.: "Gibrat's law and legacy for non-profit organisations: a non-parametric analysis"
2012/9, Jofre-Monseny, J.; Marín-López, R.; Viladecans-Marsal, E.: "What underlies localization and urbanization economies? Evidence from the location of new firms"
2012/10, Mantovani, A.; Vandekerckhove, J.: "The strategic interplay between bundling and merging in complementary markets"
2012/11, Garcia-López, M.A.: "Urban spatial structure, suburbanization and transportation in Barcelona"
2012/12, Revelli, F.: "Business taxation and economic performance in hierarchical government structures"
2012/13, Arqué-Castells, P.; Mohnen, P.: "Sunk costs, extensive R&D subsidies and permanent inducement effects"
2012/14, Boffa, F.; Piolatto, A.; Ponzetto, G.: "Centralization and accountability: theory and evidence from the Clean Air Act"
2012/15, Cheshire, P.C.; Hilber, C.A.L.; Kaplanis, I.: "Land use regulation and productivity – land matters: evidence from a UK supermarket chain"
2012/16, Choi, A.; Calero, J.: "The contribution of the disabled to the attainment of the Europe 2020 strategy headline targets"
2012/17, Silva, J.I.; Vázquez-Grenno, J.: "The ins and outs of unemployment in a two-tier labor market"
2012/18, González-Val, R.; Lanaspa, L.; Sanz, F.: "New evidence on Gibrat's law for cities"
2012/19, Vázquez-Grenno, J.: "Job search methods in times of crisis: native and immigrant strategies in Spain"
2012/20, Lessmann, C.: "Regional inequality and decentralization – an empirical analysis"
2012/21, Nuevo-Chiquero, A.: "Trends in shotgun marriages: the pill, the will or the cost?"
2012/22, Piil Damm, A.: "Neighborhood quality and labor market outcomes: evidence from quasi-random neighborhood assignment of immigrants"
2012/23, Ploeckl, F.: "Space, settlements, towns: the influence of geography and market access on settlement distribution and urbanization"
2012/24, Algan, Y.; Hémet, C.; Laitin, D.: "Diversity and local public goods: a natural experiment with exogenous residential allocation"
2012/25, Martinez, D.; Sjögren, T.: "Vertical externalities with lump-sum taxes: how much difference does unemployment make?"
2012/26, Cubel, M.; Sanchez-Pages, S.: "The effect of within-group inequality in a conflict against a unitary threat"
2012/27, Andini, M.; De Blasio, G.; Duranton, G.; Strange, W.C.: "Marshallian labor market pooling: evidence from Italy"
2012/28, Solé-Ollé, A.; Viladecans-Marsal, E.: "Do political parties matter for local land use policies?"
2012/29, Buonanno, P.; Durante, R.; Prarolo, G.; Vanin, P.: "Poor institutions, rich mines: resource curse and the origins of the Sicilian mafia"
2012/30, Anghel, B.; Cabrales, A.; Carro, J.M.: "Evaluating a bilingual education program in Spain: the impact beyond foreign language learning"
2012/31, Curto-Grau, M.; Solé-Ollé, A.; Sorribas-Navarro, P.: "Partisan targeting of inter-governmental transfers & state interference in local elections: evidence from Spain"

2012/32, Kappeler, A.; Solé-Ollé, A.; Stephan, A.; Välilä, T.: "Does fiscal decentralization foster regional investment in productive infrastructure?"

2012/33, Rizzo, L.; Zanardi, A.: "Single vs double ballot and party coalitions: the impact on fiscal policy. Evidence from Italy"

2012/34, Ramachandran, R.: "Language use in education and primary schooling attainment: evidence from a natural experiment in Ethiopia"

2012/35, Rothstein, J.: "Teacher quality policy when supply matters"

2012/36, Ahlfeldt, G.M.: "The hidden dimensions of urbanity"

2012/37, Mora, T.; Gil, J.; Sicras-Mainar, A.: "The influence of BMI, obesity and overweight on medical costs: a panel data approach"

2012/38, Pelegrín, A.; García-Quevedo, J.: "Which firms are involved in foreign vertical integration?"

2012/39, Agasisti, T.; Longobardi, S.: "Inequality in education: can Italian disadvantaged students close the gap? A focus on resilience in the Italian school system"

2013

2013/1, Sánchez-Vidal, M.; González-Val, R.; Viladecans-Marsal, E.: "Sequential city growth in the US: does age matter?"

2013/2, Hortas Rico, M.: "Sprawl, blight and the role of urban containment policies. Evidence from US cities"

2013/3, Lampón, J.F.; Cabanelas-Lorenzo, P-; Lago-Peñas, S.: "Why firms relocate their production overseas? The answer lies inside: corporate, logistic and technological determinants"

2013/4, Montolio, D.; Planells, S.: "Does tourism boost criminal activity? Evidence from a top touristic country"

2013/5, Garcia-López, M.A.; Holl, A.; Viladecans-Marsal, E.: "Suburbanization and highways: when the Romans, the Bourbons and the first cars still shape Spanish cities"

2013/6, Bosch, N.; Espasa, M.; Montolio, D.: "Should large Spanish municipalities be financially compensated? Costs and benefits of being a capital/central municipality"

2013/7, Escardíbul, J.O.; Mora, T.: "Teacher gender and student performance in mathematics. Evidence from Catalonia"

2013/8, Arqué-Castells, P.; Viladecans-Marsal, E.: "Banking towards development: evidence from the Spanish banking expansion plan"

2013/9, Asensio, J.; Gómez-Lobo, A.; Matas, A.: "How effective are policies to reduce gasoline consumption? Evaluating a quasi-natural experiment in Spain"

2013/10, Jofre-Monseny, J.: "The effects of unemployment benefits on migration in lagging regions"

2013/11, Segarra, A.; García-Quevedo, J.; Teruel, M.: "Financial constraints and the failure of innovation projects"

2013/12, Jerrim, J.; Choi, A.: "The mathematics skills of school children: How does England compare to the high performing East Asian jurisdictions?"

2013/13, González-Val, R.; Tirado-Fabregat, D.A.; Viladecans-Marsal, E.: "Market potential and city growth: Spain 1860-1960"

2013/14, Lundqvist, H.: "Is it worth it? On the returns to holding political office"

2013/15, Ahlfeldt, G.M.; Maennig, W.: "Homevoters vs. leasevoters: a spatial analysis of airport effects"

2013/16, Lampón, J.F.; Lago-Peñas, S.: "Factors behind international relocation and changes in production geography in the European automobile components industry"

2013/17, Guío, J.M.; Choi, A.: "Evolution of the school failure risk during the 2000 decade in Spain: analysis of Pisa results with a two-level logistic mode"

2013/18, Dahlby, B.; Rodden, J.: "A political economy model of the vertical fiscal gap and vertical fiscal imbalances in a federation"

2013/19, Acacia, F.; Cubel, M.: "Strategic voting and happiness"

2013/20, Hellerstein, J.K.; Kutzbach, M.J.; Neumark, D.: "Do labor market networks have an important spatial dimension?"

2013/21, Pellegrino, G.; Savona, M.: "Is money all? Financing versus knowledge and demand constraints to innovation"

2013/22, Lin, J.: "Regional resilience"

2013/23, Costa-Campi, M.T.; Duch-Brown, N.; García-Quevedo, J.: "R&D drivers and obstacles to innovation in the energy industry"

2013/24, Huisman, R.; Stradnic, V.; Westgaard, S.: "Renewable energy and electricity prices: indirect empirical evidence from hydro power"

2013/25, Dargaud, E.; Mantovani, A.; Reggiani, C.: "The fight against cartels: a transatlantic perspective"

2013/26, Lambertini, L.; Mantovani, A.: "Feedback equilibria in a dynamic renewable resource oligopoly: pre-emption, voracity and exhaustion"

2013/27, Feld, L.P.; Kalb, A.; Moessinger, M.D.; Osterloh, S.: "Sovereign bond market reactions to fiscal rules and no-bailout clauses – the Swiss experience"

2013/28, Hilber, C.A.L.; Vermeulen, W.: "The impact of supply constraints on house prices in England"

2013/29, Revelli, F.: "Tax limits and local democracy"

2013/30, Wang, R.; Wang, W.: "Dress-up contest: a dark side of fiscal decentralization"

2013/31, Dargaud, E.; Mantovani, A.; Reggiani, C.: "The fight against cartels: a transatlantic perspective"

2013/32, Saarimaa, T.; Tukiainen, J.: "Local representation and strategic voting: evidence from electoral boundary reforms"

2013/33, Agasisti, T.; Murtinu, S.: "Are we wasting public money? No! The effects of grants on Italian university students' performances"

2013/34, Flacher, D.; Harari-Kermadec, H.; Moulin, L.: "Financing higher education: a contributory scheme"

2013/35, Carozzi, F.; Repetto, L.: "Sending the pork home: birth town bias in transfers to Italian municipalities"

2013/36, Coad, A.; Frankish, J.S.; Roberts, R.G.; Storey, D.J.: "New venture survival and growth: Does the fog lift?"

2013/37, Giulietti, M.; Grossi, L.; Waterson, M.: "Revenues from storage in a competitive electricity market: Empirical evidence from Great Britain"

2014

2014/1, Montolio, D.; Planells-Struse, S.: "When police patrols matter. The effect of police proximity on citizens' crime risk perception"

2014/2, Garcia-López, M.A.; Solé-Ollé, A.; Viladecans-Marsal, E.: "Do land use policies follow road construction?"

2014/3, Piolatto, A.; Rablen, M.D.: "Prospect theory and tax evasion: a reconsideration of the Yitzhaki puzzle"

2014/4, Cuberes, D.; González-Val, R.: "The effect of the Spanish Reconquest on Iberian Cities"

2014/5, Durán-Cabré, J.M.; Esteller-Moré, E.: "Tax professionals' view of the Spanish tax system: efficiency, equity and tax planning"

2014/6, Cubel, M.; Sanchez-Pages, S.: "Difference-form group contests"

2014/7, Del Rey, E.; Racionero, M.: "Choosing the type of income-contingent loan: risk-sharing versus risk-pooling"

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