# Chapter 2

# Broadband prices in the European Union: competition and commercial strategies[17]

## 1. Introduction

Over the last decade, millions of people in the European Union have installed broadband in their households[18], thus enabling them to download information and to use sophisticated digital services.[19] Broadband Internet access is an essential component of inclusiveness in the 21st century, and households without broadband access are in risk of becoming marginalised from society and economic opportunity. Several papers have analysed the impact that technological change and regulation have had on the expansion of Internet. However, little attention has been given to how telecommunication operators adapt their pricing and commercial strategies to market evolution and competition. The analysis of the way in which prices are established is essential to orientate regulatory and competition policies in this sector. Moreover, it can help shed light on the significant price and quality differences across EU Member States.

Effective competition plays a key role in expanding broadband access and in ensuring that consumers benefit from lower prices, greater choice and better quality services. However, competition can be affected by several problems, including the lack of investment in new technologies, price discrimination, margin squeeze, or excessive pricing. Competition in the provision of retail broadband services also depends on effective competition at the wholesale level, or, if this does not exist, on its effective regulation. In Europe, telecommunications regulators conduct regular analyses in order to define the

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[18] The European Commission defines broadband Internet access as "an access assuring an always-on service with speeds in excess of 144 kbps. This speed is measured in download terms" (European Commission, 2009 and 2011b).

[19] During the nineties, broadband was delivered over cable and telephone lines. In the years that followed, these technologies were upgraded and some operators began to deploy fibre for home delivery as this would support a higher bandwidth.

relevant broadband market and to determine which firms have significant market power (SMP) and need to be regulated. In this context, price analysis is necessary to examine the conduct of operators and to assess the state of competition.

This paper analyses the factors that determined fixed broadband Internet prices in 15 EU Member States between 2008 and 2011.[20] We employ a rich data set that contains both the commercial and technical characteristics of 2204 plans offered to households by incumbent and entrant operators. By using an instrumental variable approach we estimate a pricing equation using three types of variables: (1) the technical characteristics of the plans; (2) the operators' commercial strategies; and (3) the patterns of competition in the country. To the best of our knowledge, this is the first paper to use information at the level of the operators' commercial plans to examine the influence of competition and regulation on broadband retail prices.

We analyse how operators adjust their prices to the technological characteristics of the plans. First, we show that downstream speed has a positive and significant non-linear impact on price. And second, we explain that cable modem and fibre (FTTx) broadband plans have lower prices per Mbps than xDSL plans. This is an interesting result that questions the interest that operators might have for deploying Next Generation Access Networks (NGAs).

We then examine the importance of several commercial practices typically adopted by operators. We show that flat rate plans are more expensive than metered plans (which limit the downloadable volume), and that plans that bundle broadband Internet access with voice telephony and/or television are also more expensive, especially in the case of triple packages. In the last year there has been an important debate in the literature and among practitioners concerning the motivations of operators' use of bundling. Our paper contributes to this debate by showing the effects of bundling on prices.

The paper also examines how competition and regulation affect operators'

[20] In spite of their growing relevance, mobile broadband services are not included in our analysis. Note that the commercial characteristics of mobile plans differ markedly from those of fixed broadband Internet access. For example, download speed is significantly slower in the case of mobile offers (although new wireless technologies such as LTE can provide speeds similar fixed broadband).

pricing strategies. We show that incumbents set prices that are significantly higher than those of entrants, which might be a consequence of factors such as their wider coverage, reputation, or the incumbents' concerns about the price-squeeze tests set by competition authorities. Moreover, we obtain that the number of plans offered by each operator in a country has a positive effect on their prices. This result suggests that market segmentation and consumer confusion about the economic and technical characteristics of plans might allow firms to set higher prices.

Finally, the main contribution of the paper is to identify the effects of access regulation. We find that prices are higher in countries where entrants make a more intensive21 use of bitstream access, and lower when they rely more heavily on direct access (local loop unbundling, LLU). Despite this, we observe no significant effect on prices when entrant upgrades their own networks, nor do we find a robust effect of inter-platform competition between xDSL, cable and FTTx. These results might be interpreted as a consequence of the application of the "ladder of investment" approach (LOI), whereby in order to promote sector competition regulators initially facilitate the access of entrants to incumbents' network so as to guarantee service-based competition, and subsequently, once these entrants have acquired experience and reputation they create incentives to entrants to invest in their own infra-structure. The objective of this regulation is to reconcile the long-term benefits of facility-based competition with short-term price reductions. In spite of this, the effectiveness of this strategy has been questioned.[22]

The rest of the paper is organised as follows. Section 2 reviews the economic literature, so as to highlight the contributions of this paper, and it also describes the European broadband market. Section 3 outlines our estimation strategy. Section 4 describes the data set. Section 5 presents the empirical strategy and results. Section 6 discusses the main contributions of the paper. Finally, Section 7 concludes.

[22] The "ladder of investment" regulatory model was first identified by Cave (2006). See Cambini and Jiang (2009) for an extensive review of the literature on this topic and Bourreau et al. (2010) for a critical analysis of this regulatory approach.

## 2. Literature review and the European broadband market

### *2.1. Review of the empirical literature on broadband access*

The initial empirical literature on broadband Internet access focused on the determinants of its penetration. For example, Distaso et al. (2006) report the impact of inter-platform competition on broadband penetration in 14 European countries from 2000 to 2004. They find that while inter-platform competition had a positive effect on penetration, intra-platform competition did not play an important role. Other studies, including Höffler (2007), have highlighted the inefficiencies created by the duplication of existing platforms.[23]

More recent papers have analysed the impact of the regulation of wholesale prices on the investment decisions of firms and on the diffusion of the service.[24] Grajek and Röller (2012) examine the effects of access regulation on incentives for investment in 20 countries in the period 1997–2006. They explain that regulation has discouraged the investment of incumbents and individual entrants, and suggest that the European regulatory framework has failed to provide incentives for facility-based competition. They also examine the regulators' response to infrastructure investments, concluding that whereas access regulation has not been affected by the entrants' investments, regulators have toughened access regulation in response to increased investment by incumbents. Bouckaert et al (2010) investigate the influence of competition on broadband penetration in a sample of 20 OECD countries. They consider three entry patterns adopted by broadband operators: (1) inter-platform competition, where the incumbent xDSL operators compete with infra-structure-based operators (e.g. cable modem and FTTx); (2) facility-based intra-platform competition, in which entrants lease some unbundled local loop elements, but have to invest in their own equipment and facilities (e.g. LLU and shared lines); and (3) service-based intra-platform competition, where entrants resell the incumbent's services (bitstream

[23] There is a number of papers that have analysed the diffusion of broadband services. See for example Cava and Alabau (2006), Lee et al. (2011), Andrés et al. (2010) and Czernich et al. (2011).

[24] A detailed review of the theoretical literature on access charges in telecommunications can be found in Laffont and Tirole (2000), Armstrong (2002), and Vogelsang (2003).

access/resale). According to these authors, only infrastructure-based competition increases the penetration of the service, while the other types have little effect. Briglauer et al. (2013) examine the effects of infrastructure and service- based competition on the deployment of Next Generation Access (NGA) networks in a panel data set of the EU 27 Member States. They show that whereas infrastructure-based competition affects NGA deployment in an inverted U-shaped manner, service-based competition negatively affects total NGA investment of both incumbent and entrant operators.

Few papers have undertaken specific country studies. Pereira and Ribeiro (2010) examine the competition between xDSL and cable operators in Portugal. They find that inter-platform competition (mainly between xDSL and cable) increases the diffusion of Internet thanks to both the higher coverage of broadband access and the existence of lower prices. More recently, Nardotto et al. (2012) have analysed the impact of unbundling on broadband penetration in the UK during the period 2005–2010 using micro level information. They find that LLU had little or no effect on broadband penetration, although it increased the quality of the service in terms of average broadband speed. On the other hand, they show that inter-platform competition from cable increased local broadband penetration.

Many of the above results contrast with those reported by Gruber and Koutroumpis (2013) who, using a data set of 167 countries between 2000 and 2010, find that inter-platform competition is an impediment to broadband adoption. They conclude that markets that focus specifically on one type of technology typically present a more rapid adoption process than that experienced in multi-technology markets. This finding can be justified by the fact that full retail unbundling does not require duplication of networks, which reduces costs and, ultimately, prices.

The analysis of broadband prices has received much less attention.[25] Explanations for this include the absence of consistent data, and the fact that broadband services are highly varied and typically offered jointly with voice telephony and television. One major exception is the study conducted by Wallsten and Riso (2010), which examines broadband prices in a group of 30 OECD countries between 2007 and 2009. They find that downstream speed

[25] Galperin (2012) describes the evolution of broadband prices in Latin America.

has a positive effect on prices in the study period; that broadband plans with bit caps are on average offered at lower prices than unlimited plans; and that plans with contracts are typically less expensive than those without. While our paper confirms some of these findings, here, additionally, we examine the effect on the prices of competition and the impact of alternative entry patterns (bitstream, direct access and own networks).

Greenstein and McDevitt (2011) also analyse the economic value created by the diffusion of broadband Internet access provided via xDSL and cable in the United States. They do not have direct information on prices, but create a price index that adjusts prices to the progressive improvement in service quality. Taking this into account, they show that broadband prices in the US fell slightly during the period 2004–2009. They explain that this is a very different evolution to that of the prices of electronic products, including laptops and printers, where the quality-adjusted price falls have been significant.

### *2.2. The European broadband market*

In July 2011, the average penetration level of fixed broadband Internet access in the EU Member States was 27.2%.[26] However, there were significant differences across countries. For example, while the penetration levels in Netherlands, Denmark and France were 39.3%, 38.5% and 33.9%, respectively, in Romania, Bulgaria and Poland they were 14.6%, 15.6% and 16.4%, respectively (Fig. 1).[27]

In recent years, the prices of fixed broadband Internet access have fallen significantly, which is quite remarkable if we consider that operators have improved the quality of their offers. Often operators allow consumers to migrate at no cost to other offers providing higher download speeds. Moreover, many offers bundle broadband access with other services such as fixed voice, TV, and more recently with mobile telephony. Such packages allow operators to attract new consumers (the bundle being cheaper than the

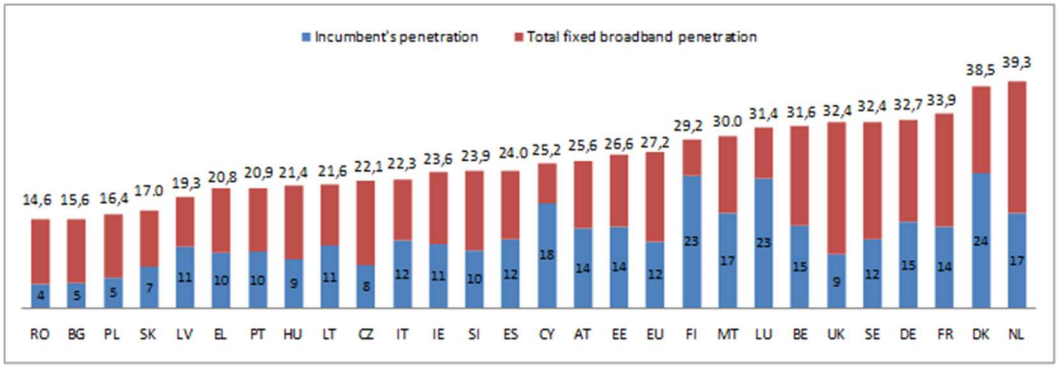
[26] As of the same date, the penetration of large screen mobile broadband subscriptions (using dedicated data cards or USB modems) was 7.5%.

[27] See the European Commission Implementation Reports (European Commission 2011a, b).

sum of the single services) and to gain the loyalty of their subscribers.

This situation has not prevented significant price differences across European countries (Fig. 2).[28] Price differences can be explained by the technical and commercial characteristics of the plans, but they might also reflect differences in the level of competition in national markets. Thus, while in 2011 the incumbent's market shares (according to the number of broadband lines) in Cyprus, Luxemburg and Austria were 73%, 72% and 55% respectively, in the UK and Bulgaria they were 29% and in Romania just 30%. Many EU countries have four or five alternative operators, but other national markets are much more fragmented. For example, in Germany there are around 100 regional entrants, though the incumbent retains a 46% market share.

**Figure 1:** Fixed broadband and incumbent's penetrations in 2011 (%)

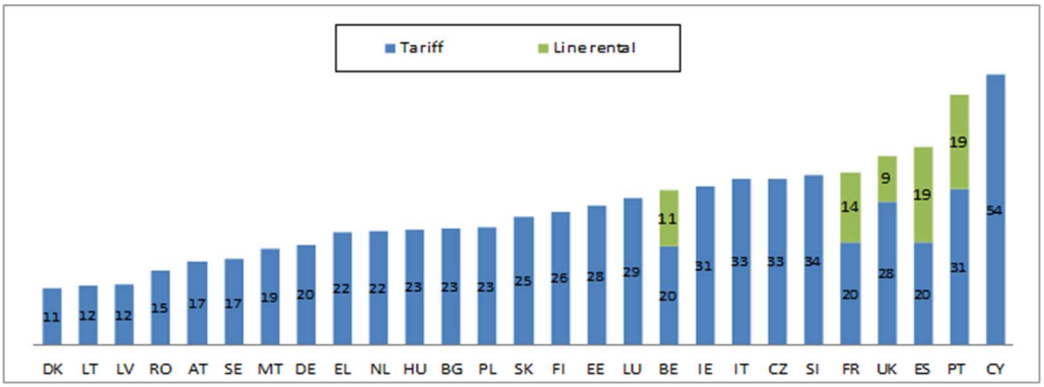



**Source:** European Commission (2011a).

[28] In the EU, retail prices of broadband services are not regulated. However, national regulators periodically assess whether there is a "margin squeeze" that reduces the profitability of entrants. This occurs, for example, when wholesale access prices make it impossible for entrants to match the incumbent's prices.

**Figure 2:** Fixed broadband prices in 2011 (€ PPP)

Least expensive offer (all ISPs): Basket 4096 kbps-8192 kbps, 5GB or 20 hours/month




**Source:** European Commission (2011b).

Broadband access can be provided via several technologies. In the period we study, the most frequently employed system is xDSL followed by cable modem, but some operators use FTTx or wireless technologies such as 3G, WiMAX and satellite. Around 77% of the fixed access lines in European countries use the xDSL technology, which explains why the average speed is still quite low (around 10 Mbps) and why there is more intra than inter-platform competition.

Incumbent fixed telecommunications operators are usually vertically integrated (except in Sweden, the UK and Italy, where different types of vertical separation are found)[29] and use xDSL (although some use cable, which is the case, for example, of Denmark). Most entrants use the incumbent's network to provide their services and have to pay a regulated access fee. Cable operators have built their own infrastructure, but they also need to sign interconnection agreements with incumbent operators because of their limited national coverage.

In the EU, National Regulatory Authorities (NRAs) set access charges in order to guarantee an adequate development of competition. There are two mandatory types of access. Entrants can access the incumbent's network directly (direct access or LLU) or indirectly (bitstream). At the same time, the direct access can be of three types: complete unbundling of the local loop, where entrants pay to use the incumbent's access lines without any restriction;

[29] For an analysis of vertical separation in telecommunications see for example Teppayayon and Bohlin (2010).

shared LLU, where entrants use the high frequencies of the access lines to provide broadband and incumbents use the low frequencies to provide voice telephony; and, shared LLU without voice telephony (naked ADSL), which is similar to the previous service but voice telephony is offered over the Internet (VoIP). The main advantage of unbundling is, therefore, to allow entrants to offer a differentiated service and to develop their own commercial policy.

In the case of indirect access (bitstream), entrants can access the incumbent's network at two levels: at the ATM level (or Gig-ADSL), where there are several geographical interconnections, and at the IP level (or ADSL- IP), which is more expensive and has less interconnection points.

Price regulation of all these access services is inessential instrument for promoting competition and investment. Regulated access prices determine in which part of the incumbent's network the entrants will invest and influence both retail prices and service quality. In the EU, following the "ladder of investment" (LOI) regulatory model, NRAs set the prices of bitstream and direct access (LLU) in order to provide incentives to entrants to invest progressively in their own equipment. In spite of this, the empirical literature is still unclear about the effectiveness of this strategy (Hazlett and Bazelon, 2005; Bourreau and Dögan, 2006; Waverman et al., 2007; Grajek and Röller, 2012; and Bacache et al., 2014). As Bourreau et al. (2010) explain, the main problem of the LOI is that once entrants obtain some profits with bitstream access, their incentives to invest may not be so high, creating a "replacement effect". Moreover, the simultaneous presence of multiple access levels can hinder incentives to access higher rungs on the investment ladder. Our paper contributes to the literature on access regulation by assessing how the use of each type of entry at the country and at the operator level affects retail prices.

## 3. Estimation strategy

This section examines the prices of broadband Internet access in 15 European countries in the period 2008-2011. After adjusting for the hedonic features of the operators' plans, we analyse the impact on prices of several commercial strategies frequently used by operators, including bundling and market segmentation. Additionally, we assess the effects of the entry patterns (bitstream, LLU and own network) that are usually found in national markets.

We estimate a model for the prices of broadband residential plans ($p_{moit}$), where m is the offer, 'o' is the operator, 'i' is the country, and 't' is the time period. The explanatory variables that we use in the estimation can be grouped into three blocks: (1) technical characteristics of the service; (2) the operators' commercial strategies and (3) measures of competition and regulation in the country. The price equation also includes the penetration of the service in each country and country and time fixed effects. Specifically, we estimate the following model:

**Pricing Equation (1):**

$$p_{moit} = \underbrace{a_0 + a_1 DownstreamSpeed_{mit} + a_2 UpstreamSpeed_{mit} + a_3 Technology_{mit}}_{\text{Technical characteristics}} + \underbrace{a_4 Bundling_{mit} + a_5 VoIP_{mit} + a_6 UnlimitedVolume_{mit} + a_7 VolumeCap_{mit} + a_8 NOffers_{oit}}_{\text{Commercial characteristics}} + \underbrace{a_9 Incumbent_{it} + a_{10} HHIPlat_{it} + a_{11} Bitstream_{it} + a_{12} Directaccess_{it} + a_{13} Ownnetwork_{it} + a_{14} BitstreamO_{oit} + a_{15} DirectaccessO_{oit}}_{\text{Measures of competition and regulation}} + a_{16} Penetration_{it} + a_{17} Country_i + a_{18} Time_t + e_{moit}$$

The prices of the plans offered by each operator may vary according to the quality of the service and the access technology. In Eq. (1), *DownstreamSpeed* is the downstream speed advertised in the plans' technical details. The speed of the service is one feature usually considered by consumers when they contract a plan because it determines how fast they can view web pages, receive e-mails, or download music, for example. *UpstreamSpeed* is the upstream speed offered in the plan and indicates the speed at which users can upload data to the Internet, which might include, for instance, uploading a file to a server, sending an email message or using peer-to-peer software. Operators usually assign much more downstream than upstream speed.[30] To account for a possible non-linear relationship between *Price* and *DownstreamSpeed* and *UpstreamSpeed* these variables are introduced in the model in logarithms. Technology is the access technology used to provide the service. This might be xDSL, cable modem or fibre (FTTx). We expect each technology to have a different effect on the price since they require different levels of investment and bandwidths, and because consumers might have different "perceptions" about their quality.

The price equation also includes the commercial practices that may be adopted

[30] Symmetric connections, such as Symmetric Digital Subscriber Line (SDSL), offer identical upstream and downstream rates but our data do not include any plan with this feature.

by operators. *Bundling* refers to the practice in which broadband access is provided together with voice telephony and/or television. Our basic estimations consider all the plans commercialized by operators and we include dummy variables to capture when the broadband service is bundled with other services. We have adopted this approach because we believe operators consider stand-alone and bundled broadband services to be partly substitutes when setting their prices. This is also the approach taken by the European Commission when it establishes its principles for analysing the broadband wholesale market.[31] Notice also that bundle subscriptions we assess the effects of the entry patterns (bitstream, LLU and own network) that are usually found in national markets are especially prevalent in the EU. According to DG CONNECT, in 2011 around 75% of all broadband subscriptions in the EU-15 were for bundled broadband plans.[32] In our data set, almost 60% of all plans are broadband packages. In spite of this, it could still be argued that stand-alone and bundled broadband are different services. For this reason, in Section 6 we present separate estimations for each type of plan.

The commercialization of broadband bundled together with other services might represent a cost saving for operators, owing, for example, to the existence of scope economies, but it might also imply additional costs that justify a price increase. For example, to be able to offer television services, operators must first reach agreements with TV channels and pay them a fee. In other cases, bundling may be a marketing strategy used by operators to segment consumers or to increase their switching costs.[33]

The variable *VoIP* reflects the situation in which the broadband service is bundled together with voice telephony but provided over IP, which reduces the operators' costs (naked xDSL).

*UnlimitedVolume* is a dummy variable that shows if the plan offers unlimited broadband volume or if there is a restriction on the user's downloadable

[31] For instance, in its Explanatory Memorandum to the Recommendation on Relevant Product and Service Markets (SEC (2007) 1483/2), the European Commission considers that "In most case the individual services in the bundles are not good demand-side substitutes for each other yet may be considered to be part of the same retail market if there is no more independent demand for individual parts of the bundle".

[32] Specifically, broadband and voice, on the one hand, and broadband, voice and TV, on the other, accounted on average for 49% and 26% of all subscriptions to broadband plans in the EU 15. See http://ec.europa.eu/digital-agenda/en/scoreboard.

[33] Our data set does not allow us to identify if consumers can subscribe separately to each service ("menu à la carte") or if they are forced to contract the bundle (tying).

capacity. *VolumeCap* measures the volume of data that users can download if the plan has a capacity restriction. A priori, we expect capped offers to be cheaper than those with unlimited capacity, and also for the price of the plan to increase with the download limit. In spite of this, in a recent theoretical paper Economides and Hermalin (2013) have shown that operators might impose download limits in order to promote competition among content providers. This can increase consumer surplus and allow them to charge higher prices.

We also examine a group of variables that reflect the level of competition in the national markets. *Incumbent* is a dummy that identifies if incumbents have different pricing policies to those adopted by entrants. Incumbents may enjoy some market power thanks to reputational advantages or to the existence of consumer switching costs. They may also have cost advantages over their rivals. Yet, it is important to recall that European operators may be an incumbent in one country but an entrant in one or more other countries. Hence, operator costs need to be related to their presence in several countries and to their bargaining power with equipment providers. Notice also that incumbents might set higher retail prices in order to avoid the margin squeeze tests implemented by anti-trust authorities. As Carlton (2008) and Sidak (2008) argue, a price squeeze ban can act as an incentive to vertically integrated incumbents to increase their prices and so reduce the risk of antitrust lawsuits being brought by their competitors.[34]

*HHIPlat* is the Herfindahl–Hirschman Index (HHI) of concentration in terms of technology shares. A high *HHIPlat* would mean a high concentration of a particular technology in a given country. As discussed in Section 2, the empirical literature is ambiguous with regard to the effect of inter-platform competition on the diffusion of the service (see, for example, Bouckaert et al., 2010 and Gruber and Koutroumpis, 2013). In the price analysis, a factor that should be considered is that inter-platform competition allows operators to differentiate their services, which might offset price reductions generated with platform competition.

*NOffers* is the number of plans offered by each operator in each country and it is introduced in order to measure the effects of market segmentation on the

[34] Gaudin (2012) describes several recent price squeeze cases concerning regulated incumbent operators in Europe and the US.

prices. When competition is strong, operators can offer a large number of plans to better target specific groups of consumers, but when they have market power they can also segment the market to set higher prices. Hoernig (2001) also suggests that operators can release a large number of plans to generate some confusion among consumers and so as to be able to increase prices.

Finally, a principal objective of this study is to determine how the prevalence of different types of entry in a country (bitstream, direct access or the deployment of the entrant's own network) affects the operators' pricing strategies. *Bitstream, Directaccess*, and *Ownnetwork* are explanatory variables that reflect the relative importance of these entry patterns in each country with respect to the incumbent's number of lines.[35] The inclusion of these variables at the country level shows how different types of competition affect the operators' price decisions. In addition to this, the variables *BitstreamO* and *DirectaccessO* are the number of bitstream and direct access lines that each operator has in the country divided by its total number of lines. These variables should measure how the specific entry strategy adopted by an operator affects its prices. We believe that the use of bitstream and direct access by an operator will depend on the regulation of access charges, but also on other aspects such as the investment required to deploy the network, the operators' perceptions of consumers' willingness to pay for high quality services, or the regulatory institutions in the country.

In most European countries, broadband services are mainly provided by the legacy communication infrastructure, where the incumbent operator maintains significant market power. Taking this into account, we seek to examine the response of prices to different entry patterns. The variables *Bitstream, Directaccess*, and *Ownnetwork* are defined at the country level and should reflect the responses of operators to the type of competition in the country. By contrast, *BitstreamO* and *DirectaccessO* are defined at the operator level and should capture the influence of their cost structure.

[35] Notice the differences between *Ownnetwork* and *HHIPlat*. While the former identifies an entrant that bypasses the incumbent's network (implying the duplication of networks), the latter reflects the presence of different technologies in the country, though not necessarily the duplication of networks. An example of market segmentation by technology is Belgium where the broadband lines in Flanders are usually cable, while in Wallonia there is a more intensive use of xDSL.

Unfortunately, our data set does not contain any information about the number of subscribers to each plan. Yet, the variable *Penetration* offers details of the number of subscribers in each country for five different speed ranges. In the presence of economies of scale, we expect operators to set lower prices as they have a larger penetration and more subscribers to their plans. However, this effect may be moderated when the increase in penetration is achieved as a result of extending service coverage to high cost or low density areas.

**Table 1: Descriptive Statistics. Period 2008-2011**

| Variable | Observations | Mean | Standard Deviation | Minimum Values | Maximum Values |
|---|---|---|---|---|---|
| **Price (euros)** | 2204 | 35.8 | 14.8 | 7.1 | 138.5 |
| **Price Single Broadband (euros)** | 909 | 30.3 | 12.3 | 7.3 | 82.5 |
| **Price Broadband and Voice (euros)** | 699 | 35.9 | 12.9 | 7.1 | 107.7 |
| **Price Broadband and TV (euros)** | 116 | 39.7 | 12.9 | 15.1 | 72.2 |
| **Price Broadband, Voice and TV (euros)** | 479 | 45.2 | 16.8 | 13.8 | 138.5 |
| **Price Metered Offers (euros)** | 410 | 36.7 | 14.7 | 7.1 | 79.8 |
| **Volume Cap (Gb)** | 410 | 64.0 | 135.9 | 0.4 | 1000 |
| **Download Speed (Mbps)** | 2204 | 23.8 | 32.6 | 0.1 | 500 |
| **Upstream Speed (Kbps)** | 2204 | 784.9 | 3444 | 0.1 | 60000 |
| **HHI Inter-platform** | 2204 | 63.6 | 17.2 | 38.0 | 100.0 |
| **Bitstream Access Index** | 2204 | 4.2 | 8.3 | 0.0 | 48.27 |
| **Direct Access Index** | 2204 | 32.1 | 44.7 | 0.2 | 171.7 |
| **Own Network access Index** | 2204 | 52.1 | 76.5 | 0.0 | 405.9 |

Source: Quantum Web-Ltd

## 4. The data

We use a panel data set of residential retail broadband offers in 15 European Member States for the period 2008 to 2011. The 15 countries considered group more than 80% of the total broadband access lines offered in the EU-27 during this period. On average, the data set contains around 550 offers per year and an overall total of 2204 observations (Table 1). The sample includes the operators' plans that group more than 90% of the broadband subscribers in each country. Most of our data are drawn from Quantum-Web Ltd. Data for the countries' broadband penetration rates and socio-economic variables are provided by the European Commission Directorate General for Communications Networks, Content & Technology (DG-CONNECT), Eurostat, and the OECD.

The units of the dependent variable *Price* are euros adjusted by the country's

purchasing power parity (PPP). Information about the prices and the technical characteristics of the plans is obtained primarily from the operators' web sites by Quantum-Web. The prices announced by operators might differ in some cases from those offered by operators via other sales channels (e.g.: operators' retail shops). Likewise, operators may offer discounts to retain their subscribers or to attract consumers away from their rivals.[36]

We have separate information about the monthly prices announced on the operators' websites and the landline rental. The sum of these two components is the monthly price of the Internet service considered in our estimations. Notice that xDSL operators usually present the monthly price and the landline rental separately in their offers, but cable modem and FTTx operators charge a single price.

Quantum-Web also offers information about non-recurring charges associated with the service (installation costs, routers, antennas, etc.). Customers usually pay these charges as a lump-sum payment at the beginning of the contract. Operators might use these costs strategically in order to attract consumers. Indeed, they may hide the information about the costs of some devices, such as routers, or some services, such as roaming. In practice, broadband consumers may not learn all the details of the price structure until after they have contracted the service.[37]

The inclusion of non-recurring costs in the price requires the use of some assumptions. On the one hand, we consider that all consumers incur these non-recurring costs, even those that are already subscribers to the operator. On the other hand, we assume an amortization period of 26 months for these costs, which is the average duration of the contracts in the EU according to the European Commission, 2011b.[38] Taking into account the effect that these assumptions might have on the interpretation of our results, we present separate estimations of the model with and without the non-recurring costs.

[36] The prices do not include the additional charges that consumers with metered plans have to pay when they exceed their capacity limits.
[37] The relevance of this problem is studied in Gabaix and Laibson (2006).
[38] We have also estimated the model considering an amortization period of non-recurring costs of 24, 36 and 48 months, obtaining similar results for our key variables. The results of these estimations can be obtained from the authors upon request.

The variables representing the downstream and upstream speeds are in logarithms. *DowsntreamSpeed* is measured in Mbps. The minimum speed in our sample is 0.128 Mbps and the maximum is 500 Mbps. However, a significant number of plans have a quality between 10 and 30 Mbps (Table 2). *UpstreamSpeed* is measured in Kbps. In our sample it ranges from 0.1 Kbps to 60,000 Kbps. The difference between downstream and upstream speeds is usually great, although it is smaller in FTTx and cable modem plans. On the other hand, note that in some cases the speeds promoted by operators might differ greatly from the actual speeds obtained by households. These differences can depend on various aspects such as the distance of the household from the operator's cabinet. Our data set only contains the information included on the operators' web sites and unfortunately we are unable to analyse whether these speeds and those actually offered by operators differ significantly.

The model also considers the technology used by the operators to provide the service. The variables *xDSL, Cable* and *FTTx* are dummy variables that take the value 1 when operators use these technologies to offer the service and 0 otherwise. It should be stressed that the downstream speed is related to the type of technology used to provide the service. Thus, xDSL cannot provide more than 30 Mbps, with the sole exception of VDSL which can reach 50 Mbps. By contrast, cable supports speeds of up to 100 Mbps (DOCSIS3.0) and FTTx can attain download speeds of 1 Gbps. The possibility of bundling the broadband access with other services also depends on the technology. While xDSL is usually bundled with voice telephony, cable modem and FTTx are able to support high quality TV services.

**Table 2: Residential Broadband Plans. Characteristics by Country in 2011**

| | Observa-tions | Number of Operators | Average Price (euros) | Average Download Speed (Mbps) | Average Upstream Speed (Mbps) | Bundling (% bundled plans) | Metered Offers (%) | Average Volume Cap (Gb) | Bitstream market share (%) | ULL market share (%) | Own Network market share (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Austria** | 71 | 7 | 39.6 | 29.9 | 2.1 | 58% | 20% | 58.4 | 1.9% | 12.9% | 24.7% |
| **Belgium** | 32 | 5 | 42.6 | 20.2 | 2.1 | 34% | 56% | 25.5 | 4.7% | 3.7% | 37% |
| **Denmark** | 12 | 3 | 25.9 | 27.3 | 2.7 | 58% | 42% | 208.3 | 7.1% | 9.6% | 21.7% |
| **Finland** | 26 | 4 | 26.4 | 27.5 | 1.5 | 0% | 4% | 0.1 | 2.8% | 1.9% | 63.1% |
| **France** | 46 | 5 | 34.3 | 52.9 | 4.9 | 93% | - | - | 7.6% | 43.2% | 7% |
| **Germany** | 55 | 10 | 26.6 | 28.2 | 1.4 | 65% | 2% | 1.8 | 6.8% | 35.7% | 12.4% |
| **Greece** | 33 | 5 | 40.3 | 18.6 | 0.9 | 61% | - | - | 1.9% | 55.7% | 0% |
| **Ireland** | 38 | 4 | 38.1 | 17.3 | 1.2 | 55% | 63% | 29.2 | 19.6% | 5.1% | 25.8% |
| **Italy** | 26 | 6 | 29.1 | 10.6 | 0.6 | 42% | 15% | 0.1 | 14.0% | 29.5% | 3.8% |
| **Luxembourg** | 19 | 3 | 36.3 | 18.6 | 0.6 | 32% | 16% | 1.4 | 0.0% | 11.2% | 19.0% |
| **Netherlands** | 60 | 9 | 39.3 | 29.6 | 3.0 | 53% | - | - | 1.8% | 13.1% | 39.5% |
| **Portugal** | 33 | 5 | 53.1 | 69.4 | 5.2 | 88% | 39% | 18.2 | 2.2% | 9.4% | 40.1% |
| **Spain** | 47 | 7 | 56.9 | 20.9 | 1.1 | 89% | 2% | 0.0 | 5.7% | 24.1% | 17.6% |
| **Sweden** | 53 | 5 | 28.7 | 36.9 | 9.6 | 32% | - | - | 4.0% | 13.7% | 38.8% |
| **UK** | 39 | 6 | 30.7 | 23.4 | 1.5 | 67% | 31% | 7.0 | 10.7% | 37.7% | 21.4% |

**Source: Quantum Web-Ltd**

Broadband access can be bundled with other services and commercialized at a single price. To identify the effect of this commercial strategy on the price we have created four dummy variables: *Stand-alone* broadband represents single broadband plans, Internet and voice indicates when broadband is offered together with voice telephony; Internet and tv when it is offered with television; and Internet, voice and tv when broadband is bundled with both voice and television.[39]

*UnlimitedVolume* is a dummy variable that takes a value of 1 for plans that offer unlimited downstream volume, and 0 for plans that have a volume cap. For metered plans, the variable *VolumeCap* measures the maximum number of GBs that can be consumed without paying an extra charge. Consumers pay an 'overage charge' when their consumption exceeds this limit, but as explained before we do not consider this charge in our analysis.[40]

Competition and regulation are essential factors in understanding the operators' pricing policy. Our data set contains information about the number

[39] In contrast with Wallsten and Riso (2010), we have no information about the number of channels in triple play packages.

[40] Metered plans charge for the additional capacity consumed. The extra charges are usually paid per GB or per a discrete number of extra GB, but some plans establish charges per day, hour or minute above the cap limit. In some cases, operators do not charge an extra fee but the service experiences a sharp reduction in download speed once the cap has been exceeded (bandwidth throttling).

of lines per operator in each country, classified according to technology and type of access. Moreover, the European Commission provides data about the different types of access at an aggregated country level. We use this information to construct the variables that measure the entry patterns at the country and at the operator levels. *Bitstream* is the entrants' number of bitstream lines (Gig-ADSL or ADSL-IP) in the country divided by the incumbent's number of lines. Direct access is the entrants' number of direct access lines divided by the incumbent's number of lines. *Ownnetwork* is the entrants' number of own lines divided by the incumbent's number of lines. As such, these indexes show the relevance of alternative entry patterns in relation to incumbent size. On the other hand, *BitstreamO* is the operator's number of bitstream lines divided by its total number of lines, and *DirectaccessO* is the operator's number of direct access divided by its total number of lines.

We use other variables to measure the level of competition in each country. Incumbent is a dummy variable that takes a value of 1 when the operator is the incumbent in the country and 0 otherwise. *HHIPlat* is the Herfindahl–Hirschman Index for each country, which is estimated by adding the sum of the squares of market shares by technology xDSL, cable, FTTx). On the other hand, *NOffers* is the number of offers commercialised by each operator in each country and in each year.

*Penetration* is defined as the number of broadband subscriptions per 100 inhabitants in a country. For this variable we use EU information for five downstream speed ranges: (1) below 2 Mbps, (2) 2–9.99 Mbps, (3) 10–29.99 Mbps, (4) 30–99.99 Mbps, and (5) above 100 Mbps (ultrafast speed). The last two ranges are usually provided by cable or FTTx, although the VDSL can also support speeds up to 50 Mbps.

Finally, the pricing equation includes country-fixed effects and year dummies, to account for the unobserved heterogeneity in each national market and to control for the evolution of prices during the period studied.

For illustrative purposes, Table 2 shows some characteristics of the broadband plans for each country in 2011. The table highlights across-country differences in terms of price and downloads speed. Direct observation of these statistics suggests that price differences may be explained by differences in the download speeds, but also by other factors such as bundling and volume caps.

The econometric analysis conducted in the next section seeks to identify the main factors determining the operators' prices.

## 5. Empirical strategy and results

This section presents an econometric multivariate analysis of the factors influencing broadband Internet access prices. We estimated the pricing equation using two procedures: ordinary least squares (OLS) and two-stage least squares (2SLS-IV).[41]

### *5.1. Methodology*

The estimation of our model using OLS can result in a problem of endogeneity because a country's broadband prices can influence the number of subscribers. Indeed, we verified that the Hausman test for the exogeneity of the variable Penetration is rejected at the 1% significance level (Table 3). In such a case, the OLS coefficients of *Penetration* could be biased downwards, and so we might erroneously conclude that penetration has a smaller effect on price than it actually does. In order to solve this problem we used instrumental variable techniques and we examined different socio-economic variables as potential instruments for *Penetration*. The instruments should be variables that are correlated with the penetration of the broadband service but uncorrelated with the error term in Eq.(1). We considered using the following variables as instruments: *GDPpc* – the gross domestic product per capita; *Unemployment* – the percentage of people unemployed in the country; *Density* – the number of inhabitants in the country divided by its area in square kilometers; *Digitalskills* – the proportion of the population having at least low digital skills;[42] and *PC* – the percentage of personal computers per household. We also considered using the lags of the variable *Penetration* as instruments. Data for *GDP, Unemployment* and *Density* were obtained from Eurostat, *Digitalskills* from the Digital Agenda Scoreboard (DG-CONNECT) and PC penetration from the OECD

[41] Our model includes country fixed effects. We have ruled out the use of a random effects model because the unobserved heterogeneity (the unobserved firm or country characteristics) is correlated with the explanatory variables in the pricing equation.

[42] The European Commission defines digital skills as "the confident analytical use of information society technology (IST) for work, leisure, learning and communication".

broadband statistics.

We expect *GDPpc, Density, Digitalskills* and *PC* to have a positive effect on the adoption of Internet and *Unemployment* to have a negative effect. *GDPpc* should be a good instrument because it affects Internet penetration but it should not influence the operators' pricing strategy. In addition, both *Price* and *GDPpc* were adjusted by the country's PPP so as to account for differences in the cost of living across EU countries. *Density* should be related to the historical deployment of telecommunications networks and should affect the coverage of Internet. However, we do not expect the prices set by operators to be affected by the density at the national level. As for *Digitalskills*, we expect the percentage of the population with some knowledge in the use of ICTs to be related to Internet penetration, but digital skills in the country should not be related to the operators' pricing policies. Similarly, *PC* should have a positive effect on the adoption of Internet but we do not expect an impact of PC on broadband prices since computers have other uses aside from accessing the Internet and because there are other devices such as laptops, notebooks, tablets and mobile phones that can be used to access the Internet.

Table 3 presents the econometric tests that examine the suitability of our panel of candidates for instruments. All the specifications considered passed Hansen's J test for over-identifying restrictions. Moreover, we applied the instrument suitability tests (the F-statistic in the first stage regression of the variable *Penetration*) to verify that the instruments are strong. In spite of this, notice that Hansen's J test has a lower p-value when we consider the *GDPpc*. Taking this into account, we eventually chose as instruments *Unemployment, Density, Digitalskills* and PC in order to maintain the efficiency of the model.

Likewise, it should be noted that the competition and regulatory variables might also be affected by an endogeneity problem since the entrants' entry patterns could be determined simultaneously with prices. Yet, a high value for *Bitstream, Directaccess* and *Ownnetwork* might also reflect the greater efficiency of entrants, or the fact that consumers consider that entrants offer a better service. To account for this situation, the model includes country fixed effects to capture the unobserved characteristics that influence the efficiency of operators and, eventually, the retail prices. Examples of these unobserved effects include investments, administrative constraints, and state aid plans that are specific to each country.

*5.2. Estimation results*

Table 4 reports the OLS and 2SLS estimates of the pricing equation. We present three specifications for the OLS regression: Specification 1 considers the technical characteristics of the offers and the commercial strategies of the operators; Specification 2 also includes the competition and regulatory variables at the country level and *Penetration*,[43] and Specification 3 adds the access variables at the operator level. We also show three specifications of the model estimated with 2SLS. Specification 4 considers all the variables except the access variables at the operator level, Specification 5 considers all variables, and Specification 6 considers all variables when prices include the non-recurring costs. All specifications include country fixed effects and year dummy variables.

The estimates of the pricing equation are robust to the alternative specifications considered. Moreover, most of the coefficients in the regressions are significant and their signs are in line with our predictions. In the case of *Penetration* we find that the coefficient is negative and significant, except in Specification 4 when we do not include the access variables at the operator level.[44] Observe also that the *Penetration* coefficient is larger, in absolute terms, when we apply 2SLS-IV (Specifications 4 to 6) than in the OLS regression (Specifications 1 to 3), which suggests that the OLS *Penetration* coefficient is biased downwards ($\tilde{\beta}_{\text{Penetration-OLS}}$= -0.008 compared to $\tilde{\beta}_{\text{Penetration-2SLS}}$=-0.011). The 2SLS Penetration coefficient shows that a one percentage point increase in the penetration level is followed by a 1.1% fall in price.[45]

[43] Since the dependent variable Price is included in logs, Penetration is interpreted as a semi-elasticity.

[44] The computed standard errors are robust to any bias from heteroskedasticity and they are also clustered according to observations from the same country. We tested for multicollinearity using the *variance inflator factor* (*VIF*) obtaining values below 3.

[45] We also estimated the model using the lagged *Penetration* variable as our instrument. We found that this instrument mitigates the endogeneity problem although not completely. Nevertheless, it confirms that the simultaneity bias of the *Penetration* coefficient is downwards.

**Table 3: Endogeneity test for *Penetration***

| Hausman endogeneity test. Ho: *Penetration* exogenous | p-value= 0.0000 | | | |
|---|---|---|---|---|
| **Instruments for *Penetration*** | *GDPpc, Unemployment, Density, Digitalskills, PC* | *GDPpc, Density, Digitalskills, PC* | *Unemployment, Density, Digitalskills, PC* | *Density, Digitalskills, PC* |
| **Test** | **Test Result 1** | **Test Result 2** | **Test Result 3** | **Test Result 4** |
| Hansen J test. Ho: instruments exogenou | p-value=0.1079 | p-value=0.0578 | p-value=0.9263 | p-value=0.4993 |
| Validity of Instruments Ho: weak instrun | p-value=0.0000 | p-value=0.0000 | p-value= 0.0000 | p-value=0.0001 |

**Table 4: Estimation Results (OLS and 2SLS): All Broadband Plans**

| **Dependent variable** | **Specification 1** | **Specification 2** | **Specification 3** | **Specification 4** | **Specification 5** | **Specification 6** |
|---|---|---|---|---|---|---|
| Log Price (*Price*) | **OLS** | **OLS** | **OLS** | **2SLS-IV** | **2SLS-IV** | **2SLS-IV** |
| **Independent variables** | **Coefficient** | **Coefficient** | **Coefficient** | **Coefficient** | **Coefficient** | **Coefficient** |
| Penetration | - | **-0.006**** | **-0.008***** | **-0.008** | **-0.011**** | **-0.011**** |
| | | (0.010) | (0.001) | (0.138) | (0.03) | (0.023) |
| Log Speed (DownstreamSpeed) | **0.145***** | **0.135***** | **0.134***** | **0.132***** | **0.127***** | **0.122***** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Log Upstream (UpstreamSpeed) | **0.006** | **0.001** | **-0.004** | **-0.001** | **-0.008** | **-0.006** |
| | (0.759) | (0.973) | (0.857) | (0.962) | (0.724) | (0.776) |
| Technology dummy (reference: xDSL) | | | | | | |
| Cable | **-0.091** | **-0.111**** | **-0.098** | **-0.118***** | **-0.108** | **-0.087** |
| | (0.117) | (0.046) | (0.266) | (0.01) | (0.166) | (0.27) |
| FTTx | **-0.045** | **-0.066** | **-0.074** | **-0.072**** | **-0.085**** | **-0.073*** |
| | (0.263) | (0.128) | (0.128) | (0.044) | (0.032) | (0.071) |
| UnlimitedVolume | **0.133*** | **0.143**** | **0.148**** | **0.144**** | **0.150**** | **0.140**** |
| | (0.073) | (0.045) | (0.036) | (0.019) | (0.013) | (0.017) |
| VolumeCap | **0.0005**** | **0.0005**** | **0.0005*** | **0.0005**** | **0.0005**** | **0.0004**** |
| | (0.047) | (0.034) | (0.053) | (0.016) | (0.028) | (0.047) |
| Bundling (reference: stand-alone broadband | | | | | | |
| Internet and voice | **0.115***** | **0.111***** | **0.116***** | **0.112***** | **0.118***** | **0.118***** |
| | (0.000) | (0.001) | (0.001) | (0.000) | (0.000) | (0.000) |
| Internet and tv | **0.164***** | **0.164***** | **0.164***** | **0.166***** | **0.169***** | **0.173***** |
| | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) |
| Internet, voice and tv | **0.323***** | **0.304***** | **0.310***** | **0.304***** | **0.310***** | **0.313***** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| VoIP | **-0.014** | **-0.038** | **-0.060*** | **-0.038** | **-0.060*** | **-0.068**** |
| | (0.727) | (0.245) | (0.086) | (-0.200) | (0.046) | (0.032) |
| Incumbent | **0.145***** | **0.120***** | **0.138*** | **0.118***** | **0.136**** | **0.154**** |
| | (0.001) | (0.004) | (0.071) | (0.000) | (0.042) | (0.023) |
| HHIPlat | - | **0.007** | **0.004** | **0.007** | **0.004** | **0.004** |
| | | (0.195) | (0.373) | (0.158) | (0.343) | (0.339) |
| Bitstream | - | **0.482**** | **0.535**** | **0.479***** | **0.526***** | **0.420**** |
| | | (0.011) | (0.013) | (0.003) | (0.003) | (0.013) |
| Directaccess | - | **-0.212**** | **-0.301***** | **-0.204***** | **-0.288***** | **-0.260***** |
| | | (0.011) | (0.006) | (0.004) | (0.001) | (0.002) |
| Ownnetwork | - | **0.093** | **-0.089** | **0.089** | **-0.107** | **-0.055** |
| | | (0.736) | (0.768) | (0.735) | (0.708) | (0.836) |
| BitstreamO | - | - | **0.067** | - | **0.066** | **0.075** |
| | | | (0.254) | | (0.224) | (0.188) |
| DirectaccessO | - | - | **-0.014** | - | **-0.010** | **0.014** |
| | | | (0.874) | | (0.900) | (0.861) |
| NOffers | - | **0.012**** | **0.014**** | **0.012***** | **0.015***** | **0.015***** |
| | | (0.033) | (0.015) | (0.009) | (0.001) | (0.001) |
| Constant | **3.283***** | **2.855***** | **3.142***** | **2.882***** | **3.200***** | **3.195***** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $R^2$ | *0.556* | *0.570* | *0.593* | *0.569* | *0.591* | *0.591* |
| *Number of observations (N)* | *2204* | *2204* | *2003* | *2204* | *2003* | *2003* |

**Note:** All specifications include country and year dummies which are not reported for brevity. Year dummies are not statistically significant. Standard errors are robust to heteroskedasticity and are clustered by country. P-values are in parenthesis. Significance at * 10%, ** 5%, *** 1% level.

As expected, *DownstreamSpeed* increases broadband prices. Specifically, a 10% increase in speed raises broadband prices by around 1.3%. On the other hand, the coefficient of *UpstreamSpeed* is not significant.

As for technologies, xDSL appears to be more expensive than cable modem and FTTx, although the coefficient of cable is not significant in Specifications 5 and 6. Fibre and cable modem technologies can provide higher speeds and better quality than xDSL, but this might not be sufficient to enable operators to charge higher prices per Mbps. Such a situation might reduce the operators' incentives to invest in New Generation Access Networks (NGAs) and constitutes an obstacle to the authorities' objective of promoting the extension of broadband networks. One explanation for this finding is that xDSL is often the only available technology in many locations. Operators using xDSL can set a higher price per Mbps because they only face competition from cable modem and fibre in specific locations, whereas cable modem and fibre operators are usually present in densely populated areas where there are several competitors. A complementary explanation is that cable and fibre operators commercialize plans with a higher downstream speed and cannot establish a proportional increase in prices.

As for the operators' commercial strategies, plans with unlimited download capacity have prices that are around 15% higher than those with download restrictions. In the case of metered plans, the coefficient of the variable *VolumeCap* is positive and significant but very small. Indeed, one additional GB increases the price of the metered plan by 0.05%. We also find that bundles of broadband and other services are more expensive than stand-alone broadband plans. Plans combining broadband with voice and broadband with TV are 13% and 18% more expensive than standalone plans, respectively.[46] On the other hand, plans that combine broadband, voice telephony and television are 36% more expensive. By contrast, plans that include broadband and voice over IP are about 6% cheaper.

Competition variables also offer interesting results. Incumbents' plans are around 15% more expensive than entrants' plans, which might be explained by the formers' dominant position in the market and/or by the existence of an "umbrella effect". As explained above, when the regulatory authorities ban price squeezes, vertically integrated incumbents might raise their retail prices and generate "price umbrellas" for their competitors. *Noffers* exhibit a positive effect on prices, suggesting that firms can set higher prices when they are

[46] The coefficients of dummy variables in semi-logarithms models are interpreted as the percentage difference of 100 exponential [(coefficient)-1] with respect to the reference (Halvorsen and Palmquist, 1980).

better able to screen consumers. We also find that technological concentration, measured with the variable *HHIPlat*, has a positive sign but it is not significant in any specification.

Specifications 2-6 show that country entry patterns are a factor that explains broadband prices. In particular, we find that the intensity in the use of *Bitstream* at the country level has a positive effect on broadband prices and that the use of *Directaccess* (LLU) reduces prices. On the other hand, the estimations reveal that *Ownetwork* does not have a significant statistical effect. It is also interesting to highlight that the coefficient associated with *Bitstream* almost doubles that associated with *Directaccess*. Indeed, with an increase of 0.1 units in the *Bitstream* index there is an increase of 5% in the price of the plan, whereas with the same increase in the *Directaccess* index there is a reduction of 3% in the price. This implies that with an equivalent change in these variables there will be a greater price reaction with *Bitstream*. One explanation is that LLU allows operators to differentiate their products and to develop their own commercial strategies, which may imply smaller price reductions for equivalent levels of entry. Finally, the coefficients of *BitstreamO* and *DirectaccessO* have the expected sign, but they are very small and are not significant. All in all, these results imply that the operators' pricing policies are influenced by the entry patterns present in the country, but that they do not respond to their own network configuration.

## 6. Discussion

Our analysis in the previous section shows that two key factors – operators' bundling strategies and their entry patterns in a country – are essential for understanding the way in which operators set their prices. Below we discuss them in more detail.

### *6.1. Bundling strategies*

A commercial policy widely adopted by telecom operators is that of bundling several services together in the same offer. Our estimations in the previous section considered all the plans offered to consumers and we included several dummy variables in the pricing equation to identify the effects of bundling

(Table 4). In spite of this, it could be considered that operators use different commercial strategies when setting the prices of standalone and bundled plans. For example, they could set the prices taking into account that each type of plan is addressed to consumers with different quality preferences or different willingness to pay. They could also use different technologies in each type of service. In order to analyse this situation, we have re-estimated the model in Eq. (1) separating standalone and bundled plans. Below we explain that the main results obtained in Table 4 are robust to this alternative estimation strategy.[47]

Table 5 shows the estimates of the pricing equation when we separate standalone broadband and bundles of broadband and voice telephony. In the 2SLS-IV estimations, Penetration is instrumented by the same group of socio-demographic variables as before, but now we obtain that the coefficient is only significant for the case of stand-alone broadband.[48] By contrast, the coefficient of *HHIPlat* is now significant for standalone plans, indicating that a higher concentration of one technological platform (i.e., less inter-platform competition) raises prices per Mbps.

As for the variables that reflect the operators' entry patterns, we obtain similar results to those in Table 4. The coefficients associated with *Bitstream* and *Directaccess* maintain the same sign for both OLS and 2SLS-IV estimations, although *Directaccess* is now not significant for bundled offers. Notice also that the variable *DirectaccessO* is negative and significant for broadband plans, which implies that operators that make an intensive use of this type of entry set lower prices.

At this point, it is interesting to discuss the factors that might serve as incentives to operators to commercialize bundles. The economic literature reports that bundling enables operators to price discriminate between customers and it allows them to extract a larger part of the consumer surplus.[49] Bundling can also generate cost savings due to the presence of economies of scale and scope in the production of the services. Finally,

[47] Wallsten and Riso (2010) adopt a similar approach when analysing bundling.

[48] The penetration information we use is based on the whole sample given that it is not possible to distinguish between penetration rates that depend on bundled plans, on the one hand, and those that depend on unbundled plans, on the other.

[49] See for example Adams and Yellen (1976), Evans and Salinger (2005), McAfee, McMillan and Whinston (1989), Nalebuff (2004), and Prince and Greenstein (2014).

bundling acts as a "lock-in" strategy that increase the operators' market power. From the consumers' perspective, bundles can also be attractive because they might mean lower prices and they might reduce nuisance (i.e., consumers receive a single bill and have a unique customer helpline).

In our data set, stand-alone offers represent 41% of all the plans, bundles that combine broadband and voice account for 32% of the plans, and bundles of broadband and TV represent only 5% of all the plans, and are mainly sold by cable operators or xDSL incumbents. Triple packages (broadband, voice and TV) represent 22% of the plans and are the preferred combination of cable operators. It would be very useful to know the number of subscribers to each type of plan, but as pointed out above, this information is not available.

The lack of information about the consumption patterns of Internet users in each country and about the operators' costs prevents us from studying the bundling decisions of operators in more detail. In spite of this, Table 6 illustrates the differences in the bundling strategies of incumbents and entrants in the 15 countries studied. Direct inspection of the table shows that incumbents use xDSL in 92% of their plans, and that 39% of these are standalone plans. By contrast, entrants use xDSL in 50% of their plans, cable modem in 37% and fibre in the remaining 13%. Interestingly, regardless of the technology, around 40% of the entrants' plans are standalone plans. This implies that on aggregate terms incumbents and entrants differ in the type of technology offered, but both of them use a similar mix of bundled and unbundled plans.

Finally, we ran different regressions that consider the effect of competition and the entry patterns on the percentage of bundled plans offered by firms.[50] While we can certainly not interpret the coefficients of these simple cross-sectional regressions as causal, we have found that bundling is positively related with the intensity in the use of direct access at the operator and country level, and this result is robust to different model specifications. This result is in line with the intuition that LLU enables entrants to use innovative and diversified commercial practices.

[50] These estimations are restricted to xDSL plans and are available from the authors. First, we analysed a linear model that examines the proportion of bundled broadband plans offered by each operator and, then, we estimated a logistic model to analyse the factors influencing the operators´ decisions to offer bundles.

*6.2. Entry pattern*

One of the main results that emerges from our analysis is that broadband prices are higher in countries where entrants make greater use of bitstream entry and lower in countries where they make a more intensive use of direct access. Moreover, each entry pattern has a different effect on broadband prices. Thus, for example, in Specification 5 of Table 4, we found that $\tilde{\beta}_{Bitstream}$=0.526 and $\tilde{\beta}_{Directaccess}$=-0.288, which illustrates the greater sensitivity of prices to bitstream access. This result can be accounted for by the fact that direct access requires entrants to make major investments and because it allows operators to differentiate their products (Nardotto, Valletti and Verboven, 2012). Thus, for an equivalent increase in the use of these access mechanisms, the prices show a greater reaction to the increase in *Bitstream*.

In recent years, access-charge regulations in the EU Member States have been designed to acts an incentive to the progressive increase in the investments made by entrants, but very little is known about how this regulatory strategy affects retail prices. Most NRAs have followed the LOI approach, which involves setting higher access prices for bitstream so as to induce entrants to use direct access (Cave, 2006; Höffler, 2007; Bourreau et al., 2010). This measure has been effective in forcing the migration from bitstream access lines to LLU, but it has not been sufficient to encourage entrants to deploy their own networks (Bacache et al., 2014). Our paper shows that the application of the LOI has also had important implications for broadband prices. The LOI implies higher costs for the operators using bitstream, but even operators that have a small dependence of the incumbents' networks can set high prices if they observe that in the country there is a high prevalence of bitstream access and consider that this weakens competition. This finding should be taken into account by the authorities when they regulate the wholesale broadband market.

Our results also suggest that, during the period analysed, intra-platform facility-based-competition was more effective in reducing prices than was intra-platform service-based-competition. On the other hand, only when we analysed stand-alone broadband plans separately did we observe that inter-platform competition generated lower prices (see the coefficient of *HHIPlat* in Table 5).

Cable modem and FTTx plans involve lower prices per Mbps than those charged by xDSL plans, but these technologies also offer more downstream speed and additional services such as TV, which increase the final price paid by consumers. A further aspect that should be considered when interpreting our results is that although we introduced the *HHIPlat* index at the national level to measure the relevance of the inter-platform competition, cable modem and fibre are usually only present in certain regions or locations of a country. As a consequence, even if the *HHIPlat* index is low in the country there might be little competition between technologies.

**Table 5: Estimation Results (OLS and 2SLS): Stand-alone Broadband and Bundles**

| **Dependent variable** | **Stand-alone Broadband** | | **Broadband + Fixed Voice** | |
|---|---|---|---|---|
| Log Price (Price) | **OLS** | **2SLS-IV** | **OLS** | **2SLS-IV** |
| **Independent variables** | **Coefficient** | **Coefficient** | **Coefficient** | **Coefficient** |
| Penetration | **-0.007*** ** | **-0.024*** | **-0.006*** ** | **-0.001** |
| | (0.001) | (0.081) | (0.006) | (0.894) |
| Log Speed (DownloadSpeed) | **0.131*** ** | **0.116*** ** | **0.132*** ** | **0.142*** ** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Log Upstream (UpstreamSpeed) | **0.027** | **0.005** | **-0.038** | **-0.033** |
| | (0.383) | (0.843) | (0.267) | (0.259) |
| Technology dummy (reference: xDSL) | | | | |
| Cable | **-0.071** | **-0.123** | **-0.157** ** | **-0.146** ** |
| | (0.617) | (0.341) | (0.022) | (0.015) |
| FTTx | **-0.122*** | **-0.185** ** | **-0.049** | **-0.039** |
| | (0.068) | (0.028) | (0.45) | (0.499) |
| UnlimitedVolume | **0.110** | **0.115*** | **0.219*** | **0.221** ** |
| | (0.113) | (0.096) | (0.062) | (0.031) |
| VolumeCap | **0.0002** | **0.0002** | **0.0006** ** | **0.0007*** ** |
| | (0.512) | (0.585) | (0.015) | (0.003) |
| VoIP | **-** | **-** | **-0.091*** | **-0.090** ** |
| | | | (0.071) | (0.044) |
| Incumbent | **0.185** | **0.164** | **0.088** | **0.087** |
| | (0.150) | (0.133) | (0.218) | (0.174) |
| HHIPlat | **0.010*** | **0.010** ** | **0.005** | **0.005** |
| | (0.094) | (0.018) | (0.429) | (0.454) |
| Bitstream | **0.727** ** | **0.697** ** | **0.404** ** | **0.396*** ** |
| | (0.036) | (0.014) | (0.017) | (0.008) |
| Directaccess | **-0.618*** ** | **-0.537*** ** | **-0.111** | **-0.117** |
| | (0.008) | (0.004) | (0.423) | (0.396) |
| Ownnetwork | **-0.749** | **-0.753** | **0.303** | **0.354** |
| | (0.185) | (0.131) | (0.479) | (0.389) |
| BitstreamO | **0.199** | **0.190** | **-0.071** | **-0.077** |
| | (0.156) | (0.141) | (0.403) | (0.321) |
| DirectaccessO | **0.078** | **0.078** | **-0.122*** | **-0.129** ** |
| | (0.565) | (0.545) | (0.051) | (0.017) |
| NOffers | **0.004** | **0.004** | **0.002** | **0.002** |
| | (0.000) | (0.000) | (0.696) | (0.651) |
| Constant | **2.854*** ** | **3.087*** ** | **3.224*** ** | **3.175*** ** |
| | (0.5527) | (0.5099) | (0.5361) | (0.484) |
| $R^2$ | *0.512* | *0.440* | *0.608* | *0.603* |
| *Number of observations (N)* | *796* | *796* | *631* | *631* |

**Note:** All specifications include country and year dummies which are not reported for brevity. Year dummies are not statistically significant. Standard errors are robust to heteroskedasticity and are clustered by country. P-values are in parenthesis. Significance at * 10%, ** 5%, *** 1% level.

**Table 6: Number of Plans (Percentanges) by type of Bundle across Technologies and Incumbent and Entrants (I/E)**

| Bundling (Incumbent/Entrant) | xDSL | Cable Modem | FTTx | Total plans (I/E) |
|---|---|---|---|---|
| **Single Broadband (I/E) *** | 204 (39%) / 352 (43%) | 0/ 257 (42%) | 16 (40%) /80 (37%) | 220 (39%) / 689 (42%) |
| **Broadband & Voice (I/E) *** | 148 (28%) / 350 (43%) | 0 / 125 (20%) | 12 (30%) / 64 (30%) | 160 (28%) / 539 (33%) |
| **Broadband and TV (I/E) *** | 41 (8%) / 6 (1%) | 4 (100%) / 46 (8%) | 4 (10%) / 19 (9%) | 49 (9%) / 67 (4%) |
| **Broadband, Voice and TV (I/E) *** | 130 (25%) / 105 (13%) | 0 / 184 (30%) | 8 (20%)/ 53 (25%) | 138 (24%) / 342 (21%) |
| **Total Plans (I/E) ^** | 523 (92%) / 813 (50%) | 4 (1%)/ 608 (37%) | 40 (7%) / 216 (13%) | 567 (100%) / 1637 (100%) |

* The percentages in brackets for bundles are measured with respect to the number of plans for each technology.

^ The percentages in brackets of all plans by technology are calculated with respect to the total number of plans.

## 7. Conclusions

This paper has analysed the determinants of the prices of broadband Internet access in 15 countries of the EU between 2008 and 2011. Our econometric model focused on three types of variables: (1) the technical characteristics of the plans; (2) the operators' commercial strategies; and (3) the regulation and competition in the country. Besides, we controlled for the potential endogeneity of broadband penetration by using the instrumental variable approach (2SLS-IV) and employed as instruments a group of socio- economic variables.

Our analysis reveals that downstream speed is a significant driver of the price in broadband plans: a 10% increase in the download speed causes prices to rise by around 1.3%. Additionally, the price per Mbps of cable modem and fibre technologies is lower than that of xDSL, although the plans that use these technologies usually offer higher download speeds and bundle broadband access with voice telephony and/or television. In this context, an important policy question that emerges is whether consumer willingness to pay for cable modem and fibre plans is sufficiently high to encourage operators to invest in NGAs.

The operators' marketing strategies also play an important role in determining the prices. When the broadband service is bundled with voice telephony, the price increases by more than 10% and when it is bundled with both voice telephony and television it increases by around 36%. By contrast, when consumers contract the voice service through VoIP they obtain some price reductions. An interesting question for future research would be to examine the factors that act as an incentive to operators to offer bundled services and

to analyse the effects of these practices on the level of competition.

The paper has also contributed to the literature that analyses the effects of access regulation in the broadband market. We show that broadband prices are higher in countries where entrants make greater use of bitstream access and lower in countries making greater use of LLU. We find little evidence that inter-platform competition and stand-alone entry (the last rung on the "ladder of investment" approach) reduce prices. Operators that rely mainly on their own networks might be offering high quality products that are more expensive or that experience less competition. All in all, our results confirm the benefits of facilitating the migration from bitstream to LLU entry, but they are less conclusive regarding the relevance of inter-platform competition for prices.

One limitation of our study is that we have not considered mobile broadband plans offered via smartphones or dongles. Mobile broadband demand is booming and future research should consider its impact on the prices of fixed and mobile broadband plans. For example, a rising number of operators are currently offering packages of mobile and fixed broadband services and this might modify the pricing strategies of operators and competition.

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