Access regulation, competition, and broadband penetration: an international study

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Abstract:

The evolution of broadband penetration has shown substantial differences between OECD countries. This paper empirically investigates to what extent different forms of regulated competition explain these international differences. It distinguishes three modes of competition between broadband internet access providers that result from regulatory policies: (1) inter-platform competition; (2) facilities-based intra-platform competition; and (3) service-based intra-platform competition. In most countries these forms of competition co-exist although their intensity varies from country to country. Intra-platform competition may differ among countries depending on the degree of mandatory access obligations imposed by the regulator on the dominant network firm. Based on a sample of OECD countries the analysis finds that inter-platform competition has been a main driver of broadband penetration. The two types of intra-platform competition have a considerably smaller effect on broadband penetration. Linking these findings back to access regulation suggests that the "stepping stone" or "ladder of investment" theories might not provide the justification to impose extensive mandatory access obligations on DSL incumbents.

Keywords: broadband penetration, access regulation, OECD-countries.

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1 Introduction

The evolution of broadband penetration has shown substantial differences between OECD countries. In countries such as Denmark and the Netherlands, broadband penetration has been fast and high, whereas in countries such as the United Kingdom and France broadband has taken up more modestly. This paper presents an empirical analysis of the determinants of broadband penetration, based on its evolution in twenty OECD countries during 2003-2008. It is particularly interesting to analyse the extent to which regulatory policy choices across comparable countries aiming to enhance competition, explain differences in international penetration patterns.

Since the start of liberalisation of telecommunications services in the eighties, there has been a debate on whether or not incumbent network operators should be obliged to provide entrants access to their networks. Proponents of access regulation put forward that mandatory access creates retail competition in the short term, and provides a "stepping stone" for entrants to invest in own infrastructure. Opponents argue that mandatory access comes at the cost of reduced investment incentives, both for the incumbent and entrants.

Whereas in the early years this debate was related to fixed telephony services, the ongoing debate is primarily with respect to broadband internet access services. One of the main questions in this debate is whether or not mandatory access to Digital Subscriber Line (DSL) networks encourages broadband penetration. In the event of mandatory access, the subsequent question arises what type of access should be imposed. Should access merely enable entrants to resell the incumbent's services or should entrants be required to invest in infrastructure themselves? These questions are answered by estimating the impact of different forms of competition, as encouraged by different regulatory policies, on broadband penetration.

The empirical analysis distinguishes three forms of competition between broadband internet access providers. First, inter-platform competition, which is not dependent on access regulation but instead results from rivalry between multiple infrastructures in a country (often DSL and cable networks). Second, facilities-based intra-platform competition, as encouraged by mandatory access, whereby access seekers lease bare unbundled local loop elements and have to invest in own equipment and facilities. The third form is service-based intra-platform competition, which depends on mandatory access through bitstream access, and where

entrants incur lower levels of investment, or merely resell the incumbent's broadband services.

Since both forms of intra-platform competition clearly depend on access regulation, it is possible to indirectly analyse the relationship between access regulation and broadband penetration. In most EU countries regulators have imposed both unbundled local loop access *and* bitstream access obligations on incumbent DSL networks. Incorporating the actual degree of facilities-based and service-based intra-platform competition allows an analysis of the efficacy of both forms of access regulation, including the technical access conditions and regulated access prices, in encouraging broadband penetration in a country.

Empirical research on the relationship between different forms of access regulation and broadband penetration to date has been incomplete. Some studies make a distinction within intra-platform competition, but do not take inter-platform competition into account. Wallsten (2006), for example, looks at the relationship between DSL-broadband penetration and different forms of broadband regulation without consideration of cable platforms. Wallsten finds that the more extensive subloop unbundling is negatively related to broadband penetration, whilst local loop unbundling has no significant effect on broadband penetration. Other studies distinguish between inter-platform and intra-platform competition, without making a further distinction between facilities- and services-based intra-platform competition. For example, Denni & Gruber (2006) and Distaso, Lupi & Manenti (2006) study the effects of intra-platform competition (incumbent vs. entrants) and inter-platform competition on broadband penetration. Their analysis, however, does not distinguish between facilities-based and service-based intra-platform competition. Denni & Gruber show that intra-platform competition has a positive impact on the rate of diffusion only at an initial stage, to disappear at a later stage. Both studies find that, for the longer term, inter-platform competition has a much more important role in broadband diffusion.[1]

The novelty of the current analysis is to simultaneously consider the role of inter-platform competition and both facilities- and service-based intra-platform competition. By doing so, the analysis assesses to what extent these differing degrees of unbundling regulatory policy choices explain international patterns in broadband penetration. Inter-platform competition is

[1] See also Aron & Burnstein (2003) and Höffler (2005), which find a positive relationship between inter-platform competition and broadband penetration.

found to have been a main driver of broadband penetration. Facilities-based intra-platform competition, on the contrary, is found to have an insignificant impact on broadband penetration, whilst service-based intra-platform competition has even a negative impact. To disentangle these various effects this study uses a new data set covering broadband penetration at a more detailed level than in previous studies.

This article is organised as follows. Section 2 describes the different broadband platforms and the modes of competition in broadband access services as implied by the different regulatory choices. Section 3 gives an overview of the theoretical arguments for access regulation, including the "ladder of investment" or "stepping stone" theory. Section 4 presents the set-up and results of the empirical analysis. Section 5 considers the case of Belgium, to assess to which extent the determinants of differences in cross-country broadband penetration can also explain regional differences within a country. Finally, section 6 concludes with policy implications.

2 The market for broadband services

2.1 Broadband platforms

There are several physical networks over which broadband services can be offered to end users. Digital Subscriber Line (DSL) is the platform for broadband access technology via the upgraded traditional fixed telephone network, the Public Switched Telephone Network (PSTN).

The other main platform for broadband services is cable modem technology, which provides broadband access over cable television networks. In order to provide broadband services, these cable television networks need to be upgraded to make two-way traffic (uploading and downloading) possible.

Besides DSL and cable, there are newer platforms able to provide broadband access. These upcoming platforms include optical fibre and wireless technologies, such as third-generation (3G) mobile telecommunications or WiMax. In practice, however, they still play a relatively minor role in most countries.

2.2 Modes of competition and access in broadband services

Regulatory policy gives rise to three modes of competition in broadband services, as presented in Figure 1. Without mandatory access to the incumbent's DSL network,

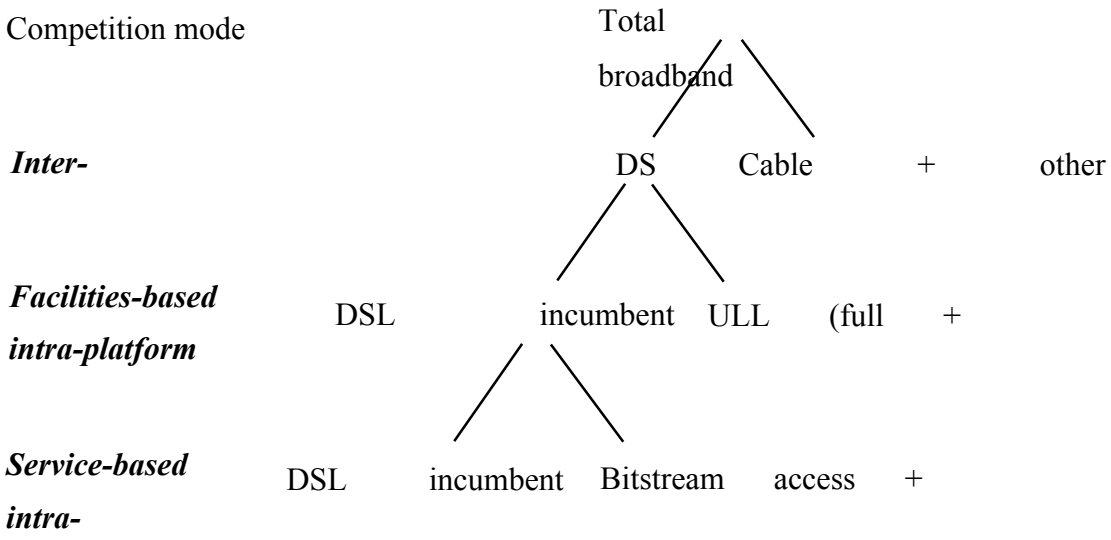
competition in broadband services takes the form of *inter-platform competition* (top layer in Figure 1). Inter-platform competition refers to rivalry *between* the incumbent DSL operator and infrastructure-based operators on other platforms, most notably cable, but possibly also fibre-to-the-home and wireless.

When the regulator imposes access to the incumbent's network, competition takes the form of intra-platform competition. Intra-platform competition thus refers to rivalry between different DSL operators on the incumbent's network through regulated access. Mandatory access to DSL networks can take various forms, ranging from full local loop unbundling (ULL) to reselling the DSL incumbent's services. These various forms of access differ with respect to the investments in own equipment that entrants/access service buyers are required to make. This paper distinguishes between two main form of intra-platform competition: facilities-based and service- based.

Under facilities-based intra-platform competition (second layer in Figure 1), entrants lease bare unbundled local loop elements, but have to invest in own equipment and facilities. Two access modes can be distinguished (Gruber, 2007). First, with full ULL, the new entrant has to install its own transmission equipment and network elements necessary for backhauling traffic. This form of access requires the highest level of investment in own facilities by the new entrant. Second, with shared access, the copper pairs are shared by the incumbent and entrants. The incumbent continues to provide fixed-telephony services to the consumer, whilst the new entrant uses the high frequency channels of the same line to provide broadband services. The new entrant has to install its own transmission equipment.

Under service-based competition (third layer in Figure 1), entrants are merely reselling the incumbent's services and therefore incur few investments themselves. Also here, two modes of access can be distinguished (Gruber, 2007). First, with bitstream access, the wholesale product of the DSL incumbent consists of transmission capacity which allows new entrants to offer their own services to their customers. Bitstream access may also include "backhaul" services to carry traffic to higher layers in the DSL network where the entrant already has a point of presence. Second, the entrant may make use of resale services offered by the incumbent. That is, the new entrant essentially retails the DSL product which it buys from the incumbent at a wholesale price. Little investment in own facilities by the entrant is required for this form of access.

Figure 1 – Three modes of competition in broadband services



Notice that these forms of competition can co-exist. Inter-platform competition may occur simultaneously with facilities-based intra-platform competition and service-based intra-platform competition. Various players can compete in the market for broadband internet access services whereby the basis for their presence can be either own infrastructure, ULL access or bitstream access to the incumbent's network. The degree of these different forms of competition varies from country to country, depending on factors such as the presence of alternative infrastructures, the regulated contractual access service conditions (such as service levels and service times) and the level of regulated access prices. The next section discusses how countries have put different emphasis on the different types of regulation, and how this is reflected in different forms of competition across countries.

3 Access regulation: motives for mandatory access

3.1 Why force an incumbent to give access?

Since the liberalization of the telecommunications sector, a debate exists on how to promote competition in the best interest of end-users. The creation of good competitive conditions is seen as an efficient way to promote high penetration levels of communications services. Regulating the incumbent's bottleneck by mandatory local loop unbundling and cost-based open access provision has been the cornerstone of the regulatory framework in most European countries. The regulation of network elements of the incumbent has been regarded

as an effective way to make monopolistic pricing disappear and achieve an efficient supply of communications services to end users. Access regulation thus leads to competition between downstream service providers within one network.

There are two basic theoretical underpinnings for imposing mandatory access to an incumbent's network. The first is that encouraging intra-platform retail competition for the incumbent increases static efficiency. The second is that mandatory access provides a "stepping stone" for entrants to enter the market, build a customer base and consequently invest in own infrastructure. This improves dynamic efficiency.

The first motive for mandatory access, static efficiency, relates to the fear for the competitive problem of foreclosure. By refusing wholesale access to its network, an incumbent could foreclose the retail market for entrants and thus reduce retail competition, leading to higher retail prices. Although the risk of foreclosure does not always occur, post-Chicago theories explain why an incumbent monopoly may have an incentive to foreclose by not providing access to entrants (see Rey & Tirole, 2007). In the absence of voluntary access, imposing mandatory cost-based access takes away the risk of foreclosure, and thus creates retail competition.

The common criticism against mandatory access is that there is a trade-off between static and dynamic efficiency. While mandatory access may stimulate competition in the short-run at the retail level, it may reduce the incentives to invest in infrastructure, both by the incumbent, who is forced to share its network, and potential entrants, who can free-ride on the incumbent's network.

This leads to the second motivation for mandatory access: the stepping stone or ladder of investment theory. This theory is dynamic in the sense that it assumes that mandatory access is only needed in the short run. According to this theory, in the longer run the entrant is able to invest in its own network, and the experience from early entry at the retail level helps in building up a competing network (Cave, 2006).[2] According to the "stepping stone" or "ladder of investment" theory, mandatory access does therefore not imply a trade-off between static

[2] There is clear similarity between the stepping stone or ladder of investment theory in access regulation on the one hand, and the infant industry consideration in international economics on the other hand. In both cases a temporary government intervention or subsidy is justified with reference to positive effects in the longer term without continued intervention or subsidy.

and dynamic efficiency. It does not necessarily reduce – and even actually promotes – the entrants' investments in infrastructure in the longer run. Intra-platform competition would in the longer run lead to inter-platform competition.

Whether or not the stepping stone or ladder of investment theory holds is an empirical question, on which the empirical analysis below aims to shed light.

3.2 The downside of too low regulated access prices

When mandatory access is imposed, access prices are often regulated as well because otherwise the incumbent may set very high access prices, and thus effectively still refuse access. The effects of mandatory access on static efficiency and investment incentives therefore depend to a large extent on how access prices are regulated.

There is broad agreement in the economic literature that an access price equal to marginal cost is not appropriate (see Laffont & Tirole, 2000). Two basic approaches to set access prices have been suggested in the economic literature, which are both cost-based. The first is an access price based on long-run incremental costs. The second approach that is advocated by some economists is based on the opportunity costs of the incumbent: the "efficient component pricing rule" (Baumol & Sidak, 1994). This rule essentially states that an incumbent should also be compensated for the revenues it is foregoing by providing access to an entrant rather than selling the service on the retail market itself.

A number of theoretical arguments have been put forward to say that cost-based access prices, including prices based on long-run incremental costs or the efficient component pricing rule, often fail to take into account certain cost components. The result would be that the incumbent does not receive an appropriate compensation for providing access to its network. This leads to underinvestment by the incumbent.

First, access regulation directly discourages investments by the incumbent because it limits the future profit stream of an incumbent (Pindyck, 2004). Second, mandatory access provides a risk-free option for an entrant to arbitrage between wholesale and retail prices. Entrants are therefore less likely to invest in their own infrastructure in order to exploit the arbitrage opportunity (Valletti, 2003). Third, due to a shift of the burden of risk from the entrant to the incumbent, the cost of capital for the incumbent increases (Jorde, Sidak & Teece, 2000). Entrants are less likely to invest in their own infrastructure and more likely to buy access services in times of low demand/recession. In times of high demand there is less uncertainty and entrants are prepared to invest more. This creates an asymmetry in entrants' investment

behaviour. More importantly, since the incumbent has an access obligation, it faces higher investment risks. This exposure to higher risks should be reflected in higher access prices. Failure to take account of this asymmetry implies fewer investments by the incumbent.

3.3 Bias in favour of access regulation in Europe?

The previous sections have described the trade-off between static and dynamic efficient which results from mandatory access. According to the stepping stone or ladder of investment theory this trade-off partially disappears because according to these theories mandatory access improves rather than weakens the incentive to invest for entrant. The trade-off is also affected by the level of access prices, and there are signs that access prices have been too low, thus discouraging investments by both incumbents and entrants. This section draws attention to the bias towards imposing mandatory access which seems to exist in regulation in Europe. The European Commission in a way encourages mandatory access in Member States by lowering the burden of proof for national regulators. It seems that the stepping stone or ladder of investment theory has played an important role in the Commission's policy.

Broadband services in Europe are regulated according to the principles laid down in the European Regulatory Framework by the European Commission. The European Regulatory Framework for the Electronic Communication Services has been established in 2003 under Framework Directive 2002/21/EC.[3] The framework requires one or more undertakings to have significant market power, in accordance with the concept of dominant undertakings as defined by the European Court of Justice, before access regulation can be imposed.

Recent market developments have resulted in a new Recommendation published by the Commission in 2007 to identify new product market boundaries in accordance with the principles of competition law.[4] The 2007 Recommendation has listed seven relevant markets that show characteristics justifying the imposition of *ex ante* regulatory obligations. Two of

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[3] In addition to the Framework Directive, four other Directives accompany the ECS regulatory framework: the Access Directive 2002/19/EC; the Authorisation Directive 2002/20/EC; the Universal Service Directive 2002/22/EC and the Data Protection Directive 2002/58/EC.

[4] Commission Recommendation (2007/879/EC) of 17 December 2007 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services.

these relevant markets are: (i) "wholesale (physical) network infrastructure access (including shared or fully unbundled access at a fixed location)" (market 4) and (ii) "wholesale broadband access" (also known as "bitstream access") (market 5).[5] These two relevant markets reflect two types of wholesale access in the current analysis. First, access by third-parties that requires more investment in own facilities and leads to "facilities-based" intra-platform competition. Second, access that is merely reselling of the incumbent's services, which requires much less investment by entrants, and resulting in "service-based" intra-platform competition.

For relevant markets that are not listed in the Recommendation, it is up to National Regulatory Authorities (NRA's) to show that the market circumstances are such that regulation is warranted. NRA's have the right to deviate from the Recommendation be it to impose remedies in markets off the list, or not to impose remedies in markets on the list. However, they have to justify deviations based on the Framework's principles. The burden of proof to deviate is thus up to the NRA.

In broadband, almost all European Union (EU) countries have decided to impose various forms of mandatory access and access price regulation on the DSL network of the incumbent. In fact, a recent overview of the European Commission with notifications of proposed regulation from NRA's in EU countries shows that 25 out of 27 EU countries are planning or have imposed ex ante regulation in market 4, unbundled access.[6] The two remaining countries (Bulgaria and Romania) have either withdrawn their notifications or the proposed regulation was vetoed by the Commission. With respect to market 5, bitstream access, 22 out of 27 EU countries are imposing ex ante regulation. The remaining five countries either do not impose access regulation (Malta) at all, or impose only partial regulation (Portugal and the United Kingdom), or have withdrawn their notification (Bulgaria and Romania). Section 4 discusses this in further detail.

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[5] This is done according to the "three-criteria test" which defines three cumulative criteria to determine whether a particular market justifies ex ante regulation: (i) high, non-transitory (structural or regulatory) barriers to entry; (ii) effective competition will not be established within the relevant time horizon; and (iii) competition law is not effective in competition problems.

[6] http://ec.europa.eu/information_society/policy/ecomm/doc/implementation_enforcement/eu_consultation_procedures/Market_overview_29_01_2010.pdf

4 Empirical analysis

This section provides an empirical analysis of the determinants of broadband penetration in 20 OECD countries. It is particularly interesting to understand the role of the three forms of competition implied by access regulations: inter-platform competition, facilities-based intra-platform competition, and service-based intra-platform competition. At the same time, the analysis should control for other factors that may affect broadband penetration.

4.1 Dataset

The dataset used here is a panel dataset for 20 OECD countries covering December 2003 to March 2008.[7] The main part of this dataset is from Analysys-Mason and includes the number of broadband connections per quarter and per country. The connections are broken down in several categories, following Figure 1. First, broadband connections are broken down by type of platform (DSL, cable and other). Furthermore, DSL connections are broken down in incumbent wholesale connections and in unbundled connections (ULL). Finally, incumbent wholesale connections are in turn broken in DSL incumbent retail and bitstream/resale. In addition to this main data set several other variables were collected from various sources, in particular OECD broadband statistics.

The dependent variable in the linear regression model is total broadband penetration, *TOTPEN*. This is the total number of broadband connections per quarter/country as a share of the total number of households, and expressed as a percentage. An alternative definition of broadband penetration, namely as a share of total population instead of total households, has been used as well, and this gave similar empirical results.

The explanatory variables consist of three categories: competition variables, broadband service variables and market demographics. A quadratic time trend is also included. These three categories of variables are now discussed in turn.

Competition variables. The main focus is on the competition variables. Following the earlier discussion as summarized in Figure 1, three different variables are constructed . First, for the

[7] These 20 countries are: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. For these 20 countries the data are complete, except for Spain where there are no data on broadband prices and speed.

degree of inter-platform competition the Herfindahl concentration index, *H-INTER,* is used (scaled between 0 and 100). This is the squared DSL market share plus the squared non-DSL market share, which mainly refers to cable, but may also include wireless and fibre. A higher Herfindahl index reflects a more asymmetric market structure and implies a lower degree of inter-platform competition. Second, for the degree of facilities-based intra-platform competition we use the Herfindahl index, *H-INTRAFAC*. This is defined as the squared market share of the DSL incumbent at the wholesale level (including the incumbent's retail DSL, resale and bitstream access), plus the squared market share of alternative DSL providers that are active on the basis of ULL and shared access.[8] Finally, for the degree of "service-based" intra-platform competition the Herfindahl index *H-INTRASERV* is used. This variable is defined as the squared retail market share of the DSL incumbent plus the squared retail market share of alternative DSL providers that are active on the basis of reselling and bitstream access ("*H-INTRASERV*").

Both intra-platform competition variables aim to reflect the strength of access obligations imposed on the incumbent network, including the regulated access charges. For example, facilities-based intra-platform competition is expected to be relatively weak, resulting in a higher Herfindahl index (*H-INTRAFAC*), if a regulator imposed unbundled access obligations but set relatively high access charges. Similarly, if a regulator set a relatively low access charge for bitstream access, this is expected to result in more service-based intra-platform competition and thus a lower Herfindahl index (*H-INTRASERV*).

Figure 2 illustrates that the competition variables indeed reflect the strength of the underlying access regulation. It is based on the European Commission (2009) which reports the ULL access prices (both full unbundled and shared) for most EU countries in 2008. Figure 2 shows that fully unbundled access prices are indeed positively correlated with the facilities-based intra-platform competition proxy (*H-INTRAFAC*). The correlation coefficient is 0.64, showing that countries with high access prices are indeed characterized by weaker facilities-

[8] Note that only variables for competition on the DSL platform are included, and not for competition on the cable platform. While there are multiple cable providers in some countries, these typically operate in mutually exclusive service areas and therefore are not competing with each other. Moreover, there appears to be no country in which mandatory access for broadband services is being imposed on cable operators. Finally, in some countries (e.g. Greece and Italy) there is no broadband cable at all.

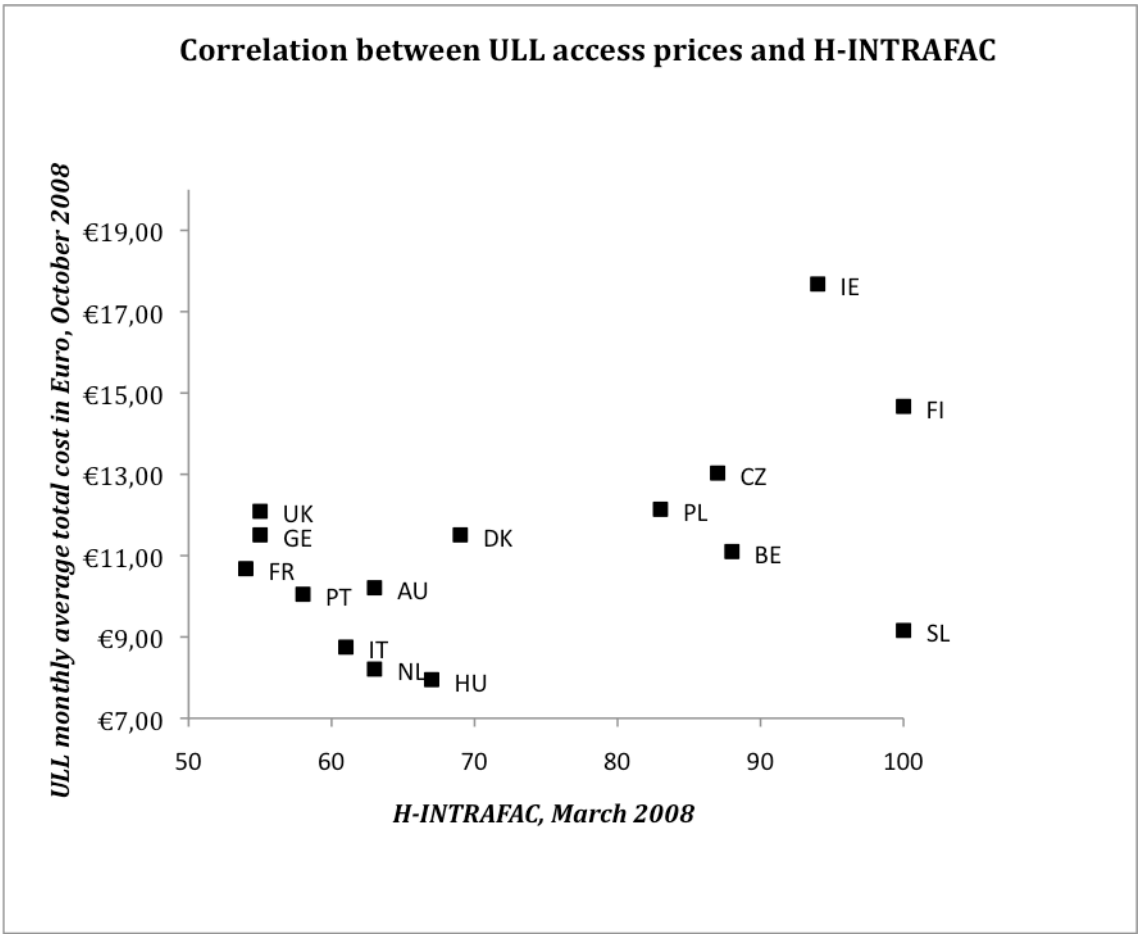
based competition according to the Herfindahl index proxy.[9] To illustrate, in Ireland there is a high ULL access price of €17.68, which is reflected in a high concentration index *H-INTRAFAC* of 94. In contrast, in Austria there is a low access price of €10.21 as reflected in a low concentration index *H-INTRAFAC* of 63. To summarize, this discussion implies that the competition variables are a reasonable indicator for the strength of the underlying access regulation.

Broadband service variables. The second category of variables consists of the broadband service variables. These include the average speed of a broadband connection in megabyte per second (Mb/s), *SPEED*, and the average price of a broadband connection in Euro, *PRICE*. It is expected that speed, as a quality indicator, has a positive impact on broadband penetration, and price has a negative impact. Both variables are direct but imperfect measures for the extent of competition within the country. Furthermore, for some countries the variables are only observed at one point in time.[10] Therefore both a specification that includes the variables *PRICE* and *SPEED* and a specification that excludes these variables, are considered.

[9] Figure 2 plots H-INTRAFAC against the total costs of fully-unbundled ULL access because in most European countries fully-unbundled ULL access is the primary service. However, the same picture emerges if H-INTRAFAC is plotted against the total costs of shared ULL access, with a positive correlation coefficient of 0.59.

[10] Price and Speed were not available for Spain. For the remaining 19 countries different sources had to be combined. For 12 of the 19 remaining OECD countries the price and speed data were only available for one quarter (from OECD Broadband Statistics), while for 7 there were data for all quarters between December 2003 and March 2008 (from Analysys). The fact that price and speed data come from different sources should not by itself affect the conclusions since the analysis will separately control for country effects.

Figure 2



Source: ULL charges taken from http://ec.europa.eu/information_society/policy/ecomm/library/communications_reports/annualreports/14th/index_en.htm, page 118.

Market demographics. The final category of variables is market demographics. The variable *POPDENS* is population density as measured by the number of individuals per squared kilometre; *POPDISP* is population dispersion as measured by the indexed share of total population on 50% of the country's landmass. Both demographic variables account for the cost of investment in broadband coverage. One may expect that it is less costly to invest in broadband infrastructure in countries with a higher population density or a lower population dispersion, implying a higher broadband penetration. In addition to these investment cost proxies demand side variables are included. *GDP* is gross domestic product per capita in a country, measured in 1,000 US dollars in 2006 purchasing parity. *PC-PEN* is PC-penetration as a fraction of the number of households. Both variables are at an annual frequency. Income is expected to be positively correlated with the demand for broadband internet access

services. Also, PC-penetration is expected to encourage broadband take-up, because a PC is required to make use of broadband services.

Table 1 presents some summary statistics of the available dataset. Columns two and three offer the average values of the used variables at the start and the end of the time period considered (December 2003 and March 2008, respectively). The last column offers the average values across all periods. Average broadband penetration has more than doubled from 21% to 49% in the period covered. The Herfindahl index for inter-platform competition has remained stable around 65%. In contrast, there is a decrease in the concentration index regarding facilities-based intra-platform competition from 85% to 72% and a slight increase in the concentration index for service-based intra-platform competition. The last variable worth mentioning is PC-penetration that increased from 44% to 62% during the covered period.

Table 1
Summary statistics data (average based on 19 OECD countries)

	Dec. 03	**Mar. 08**	**All periods**
Broadband penetration (“*TOTPEN*”)	21%	49%	32%
Herfindahl index inter-platform competition (“*H-INTER*”)	65	64	65
Herfindahl index facility-based competition (*H-INTRAFAC*”)	85	72	80
Herfindahl index service-based competition (*H-INTRASERV*”)	68	73	70
Average price (“*PRICE*”)		46.5	
Average speed (“*SPEED*”)		10299	
Population dispersion (“*POPDISP*”)	23%	23%	23%
Population density (“*POPDENS*”)	143	143	145
National income (“*GDP*”)	26 355	30 759	29 135
PC-penetration (“*PC-PEN*”)	44%	62%	53%

4.2 Results

A linear regression model is estimated based on a panel of 20 OECD countries during December 2003-March 2008. To control for unobserved heterogeneity between countries the regression model includes random effects. Similar results were obtained using fixed effects per country. Since in this case the time-invariant population density and dispersion variables are not identified, only the results from the random-effects model are presented. There is a potential endogeneity issue regarding the Herfindahl indices of concentration. A concentrated market means that there is little competition, so it is interesting to see whether a high concentration leads to low market penetration because of a lack of competition. However, a concentrated market may be the result of one very efficient firm, which would imply a high market penetration. Because of the endogeneity problem, an OLS regression would tend underestimate the effect of the Herfindahl concentration index on market penetration (coefficient biased towards zero). Including fixed or random effects partly mitigates this issue since unobserved country-specific factors are filtered out (for example a persistently efficient firm). Nevertheless, the results should be interpreted with caution. In particular, the main interest is in a relative comparison of the coefficients of the three different Herfindahl indices, rather than in interpreting the magnitude of each individual coefficient.

Table 2 provides an overview of the results of three different specifications. The first specification excludes the variables *PRICE* and *SPEED* for two reasons. First, the data for price and speed were not as complete as the other variables. Second, these variables are rather imperfect competition proxies, adding to the main Herfindahl proxies, which aim to distinguish between the effects of different types of competition. The second specification includes the variables *PRICE* and *SPEED*. Finally, the third specification incorporates dynamics by including a lagged dependent variable ("*TOTPEN(-1)*"). This variable captures the extent of persistence in penetration over time.

The total number of observations is 344 in the first specification (with all countries) and 326 in the second and third specification (which excludes Spain because of missing price information).[11] So an average of about 17 quarters per country in both specifications is

[11] The number of observations is not reduced when the lagged dependent variable is included, since the available data for that variable go back in time longer than the other variables.

observed. In all three specifications the hypothesis of zero random effects can be rejected at a very high significance level (p-value<1%). The overall R^2 of the regressions varies from 0.81 in the first specification to 0.99 in the third specification.

In all specifications, the time trend is positive and significant, and the squared time trend is significant and negative, showing that broadband penetration is growing over time, but at a decreasing rate. Market demographics contribute to explaining differences in broadband penetration across countries. They have the expected effects and are mostly statistically significant. First consider the demand side variables. National income per capita has the expected, positive effect on penetration and is statistically significant at the 1% level. A $1000 increase in GDP per capita tends to raise the broadband penetration rate by an amount of almost 1% (0.8% in the first and 0.9% in the second specification).[12] PC-penetration has the expected positive effect on broadband penetration, and is also highly significant. A 10% increase in PC-penetration is associated with an increase in broadband penetration of approximately 2%.

Now consider the investment cost proxies. Population density has a positive effect on penetration and population dispersion has a negative effect. This is consistent with expectations, since investment costs tend to be lower in countries with a high population density and a low population dispersion. For example, a cross-country difference in population density of 100 inhabitants/km^2 tends to increase broadband penetration by 3%. Both parameters are significant at the 10% level. Since *POPDENS* and *POPDISP* do not vary across years, their effect is identified from cross-country variation. Stronger statistical significance might be obtained if more countries were available.

Coming to the broadband service variables (in the second specification), a higher average price is associated with a significantly lower broadband penetration, whereas a higher speed

[12] The long-run effect of GDP/capita is also of a similar order of magnitude, though slightly higher, in the third specification. To compute this effect, one should divide the coefficient of GDP/capita by (1—coefficient lagged dependent variable). This gives 0.048/(1-0.966)=1.412, implying a $1000 increase in GDP/capita would raise penetration by 1.4% in long-run.

is associated with a higher broadband penetration (*P*-value of 6%). While these results are in line with expectations, they should be interpreted with caution, since both variables are only imperfect measures. Yet it is reassuring that the other results are robust as to whether the two variables are included or excluded.[13]

[13] There is a potential problem of multicollinearity with the variables *PRICE* and *SPEED*. However, both variables show only limited multicollinearity in the dataset. Furthermore, as a sensitivity check the model was estimated separately with only *PRICE* or only *SPEED* and obtained very similar results for each variable.

Table 2

Regressions for total broadband penetration ("TOTPEN")[1]

Independent variable	Coefficient (Standard error)	Coefficient (Standard error)	Coefficient[3] (Standard error)
Herfindahl index inter-platform competition ("*H-INTER*")[2]	-0.166** (0.052)	-0.195** (0.051)	-0.021** (0.006)
Herfindahl index facility-based competition (*H-INTRAFAC*")[2]	0.024 (0.029)	-0.020 (0.029)	-0.012** (0.005)
Herfindahl index service-based competition (*H-INTRASERV*")[2]	0.059** (0.026)	0.086** (0.027)	-0.015** (0.006)
Average price ("*PRICE*")	-	-0.051** (0.017)	-0.002 (0.003)
Average speed ("*SPEED*")	-	0.175* (0.093)	0.024 (0.021)
Population dispersion ("*POPDISP*")	-0.418* (0.229)	-0.336 (0.230)	-0.025 (0.162)
Population density ("*POPDENS*")	0.030* (0.018)	0.031* (0.017)	0.001* (0.001)
National income ("*GDP*")	0.809** (0.128)	0.889** (0.126)	0.048** (0.019)
PC-penetration ("*PC-PEN*")	0.214** (0.036)	0.180** (0.037)	0.004 (0.005)
Time trend	2.107** (0.150)	2.134** (0.150)	0.176** (0.043)
Time trend squared	-0.018** (0.006)	-0.021** (0.006)	-0.007** (0.002)
Lagged total penetration ("*TOTPEN(-1)*")	-	-	0.966** (0.011)
Regression fit (R^2)	0.81	0.85	0.99
Number of observations	344	326	326

A "" indicates significance at the 10% level, a "**" indicates significance at the 1% level.*

[1] Regression without price and speed includes 20 OECD countries; regression with price and speed includes 19 OECD countries (not Spain)

[2] A low Herfindahl index points at a high degree of competition and a high Herfindahl index points at a low degree competition. Therefore, a negative (positive) sign for the parameter of the Herfindahl index points at a positive (negative) relationship between competition and broadband penetration

[3] *In order to compare the magnitude of the coefficients from this regression with the lagged variable with the coefficients from the other two regressions, it is necessary to divide the coefficients by (1- coefficient lagged variable), i.e. by (1 – 0.966).*

The discussion now turns to the various competition variables, as induced by the various kinds of access regulation. It starts with the results from the static model, specifications 1 and 2. First, inter-platform competition has a significant, positive effect on broadband penetration. A more equal division of the market between cable and DSL (i.e. a lower value of *H-INTER*) leads to a higher level of broadband penetration. For example, broadband penetration will tend to be about 12% higher in a country where DSL and cable have equal market shares, compared to a country without a cable operator.[14] This result confirms what has been found in several other empirical studies, namely that inter-platform competition is important for the diffusion of broadband services.

Second, facilities-based intra-platform competition (*H-INTRAFAC*) has an insignificant effect on broadband penetration. Hence, mandatory ULL or shared access regulations designed to promote such competition have no significant impact on broadband penetration.

Third, service-based intra-platform competition has a significant, negative effect on broadband penetration: a more important market share of service-based competitors on the DSL platform (i.e. a lower *H-INTRASERV)* is associated with lower rates of broadband penetration. The negative effect of service-based intra-platform competition is therefore in contrast with the positive effect of inter-platform competition on broadband penetration. But the magnitude of the effect is less important than that of inter-platform competition. This result strengthens what has been found in other empirical studies, namely that service-based competition forms an impediment for the diffusion of broadband services.

These results suggest that policies that promote access to the incumbent's DSL network may negatively affect the firms' incentives to invest in network development, in particular if these policies are limited to promoting service-based intra-platform competition. To further explore this hypothesis a dynamic version of the model was estimated, the third specification, which includes the lagged dependent variable. This specification confirms that inter-platform

[14] In a country with 50% market shares for DSL and cable, *H-INTER* (scaled between 0 and 100) is 25, in a country with 100% market share for DSL, *H-INTER* is 100. Hence, the change in penetration is (100-25)*0.166=12.45.

competition has a significant, positive effect on broadband penetration. In fact, the magnitude of the long-term coefficient becomes about four times larger than in the static model, i.e. it becomes -0.628 instead of -0.166. At the same time, intra-platform coefficient now tends to have a significant positive effect on broadband penetration. However, the coefficients are only half the size of the coefficient for inter-platform competition..

In sum, the dynamic specification confirms that inter-platform competition is considerably more important in facilitating broadband penetration than intra-platform competition. The effects of inter-platform competition are even more important than suggested by the static model, but the effects of intra-platform competition may no longer be neutral or negative.

Several reasons may be behind the finding that inter-platform competition is more important than intra-platform competition in facilitating broadband penetration. Firstly, the incumbent DSL operator finds it less profitable to invest in its DSL network if the resulting investment also benefits rivals who pay below market rates for access. Secondly, having access to the DSL network at advantageous terms cannot increase the entrants' incentives to invest in their own facilities. Thirdly, advantageous access rates lead to further DSL entry than would otherwise arise. This increased competition is likely to reduce the returns from investing in an alternative platform such as cable or wireless.

Differences in regulatory policies seem therefore to have played a crucial role in different broadband penetration patterns. Countries that promoted competition between different platforms have done significantly better. In contrast, countries that mainly promoted service-based intra-platform competition on the incumbent's network have on average done worse.

This is consistent with the view that service-based competition does not provide sufficient investment incentives to new entrants and discourages investment of the incumbent operator. The results indicate that the "stepping stone" or "ladder of investment" theories motivating access regulation might not provide good guidance for regulatory policy. Rather than facilitating, access regulation might even slow down the diffusion of broadband services.

5 Regional differences within countries: the case of Belgium

So far the focused has been on explaining the evolution of differences in broadband performance across countries. However, the factors which were found to be significant in explaining international penetration differences, can also be important in explaining regional

differences within a country. To assess to which extent this is true the case of Belgium is considered.

Belgium was a frontrunner in terms of broadband penetration in the early years, but has recently slowed down and now belongs to the intermediate group of OECD countries with a household penetration level of 59% in 2007. Behind this national number there are large regional differences: in Flanders (northern part) penetration reached 63% in 2007, compared with 60% in Brussels and only 52% in Wallonia (southern part); see Table 3.

Table 3
Regional differences within Belgium: Flanders, Brussels and Wallonia (2007)

Variable	Belgium	Flanders	Brussels	Wallonia
Broadband penetration (fraction of households)	59%	63%	60%	52%
Competition variables				
Market share cable	39%	55%	33%	28%
Market share DSL incumbent	46%	36%	49%	53%
Market share other licensed operators (OLOs)	13%	7%	9%	17%
- of which unbundled local loop	*2%*	*2%*	*6%*	*3%*
- of which bitstream access	*11%*	*6%*	*3%*	*14%*
Market share others	2%	1%	10%	1%
Control variables				
Net taxable income/capita (€, fiscal year 2006)	13 655	14 483	11 550	12 807
PC-penetration (2007)	67%	72%	64%	61%
Population density (pop./km^2, 2007)	345	448	6601	202

**: Belgian market shares are taken from* 13th EU Implementation Report *(2007); regional market shares are estimates based on 2008 market survey by Belgacom; split of OLOs between unbundled local loop and bitstream access is based on estimates by Belgacom.*

Table 3 shows that Flanders had a higher income per capita, a higher PC-penetration and a higher population density, which are all conducive to broadband penetration. Assuming the parameter estimates from the sample of OECD countries are also representative for explaining regional differences within Belgium, the importance of the market demographics can be quantified as follows. First, the different population density accounts for 7% or more than half of the 12% gap between Flanders and Wallonia. Second, the difference in GDP per capita accounts for 3% or about a quarter of the gap. Finally, differences in PC penetration account for 1% of the gap.[15] In sum, the cross-country results suggest that the demographic factors (demand and investment cost determinants) account for the largest part (11% out of 12%) of the regional differences in broadband penetration in Belgium.

However, the difference in broadband performance is also in part due to differences in competition modes. Investment in cable broadband was actively promoted in Flanders from the start, which resulted in a strong degree of inter-platform competition. In Brussels and especially in Wallonia the promotion of inter-platform competition did not take place, and instead there was more emphasis on service-based intra-platform competition (bitstream access). Table 2 indeed confirms that in 2007 cable broadband had reached a market share of 55% in Flanders, compared to only 33% in Brussels and 28% in Wallonia. Conversely, bitstream operators had reached a 14% market share in Wallonia versus only 6% and 3% in Flanders and Brussels. The stronger inter-platform competition in Flanders is responsible for 1.3% points of the gap with Wallonia, whereas the weaker (and detrimental) service-based intra-platform competition is responsible for another 0.4%.[16]

In sum, the promotion of inter-platform competition in Flanders was more appropriate than the focus on service-based intra-platform competition with adverse investment incentives in Wallonia. Nevertheless, the role of demographic factors was quantitatively more important in explaining regional differences within Belgium. This conclusion is based on the cross-country results, in combination with the observed aggregate differences between the two

[15] To obtain these numbers the difference between Flanders and Wallonia for each market demographic were multiplied by the corresponding parameter estimate in Table 3.

[16] Adding up the effects of all factors, the predicted difference between Flanders and Wallonia is 12.8%, which is close to the actual difference of 12%. This suggests the cross-country model does quite well in explaining regional differences, at least for this specific case study.

regions. In future research, it would be of great interest to collect more detailed data at the local level to further assess the validity of this conclusion.

6 Conclusion and policy recommendations

This study has focused on the determinants of broadband penetration using a large panel data set of OECD countries. Market demographics, in particular demand and investment cost variables, were found to in part explain differences in penetration levels between countries. At the same time different modes of competition, as implied by different regulatory choices by policy makers, are also responsible for differences in performance: inter-platform competition encourages broadband penetration, whereas service-based intra-platform competition forms an impediment to penetration. The model performs well for explaining large regional differences in penetration within Belgium, although the role of competition is quantitatively less important in this case.

Based on this analysis the following policy recommendations can be made on how access regulation can improve broadband penetration:

1. Policy-makers should develop a long-term vision and promote inter-platform competition. The "ladder of investment" theory argues that it is good to promote intra-platform competition as a stepping stone for new entrants to induce them to invest. The current study indicates there may not be empirical support for this theory, and that to the contrary intra-platform competition may even give adverse investment incentives. To improve broadband penetration, the promotion of inter-platform competition is likely to be a more effective policy.

2. Policy-makers should gradually phase out bitstream access regulation. The results of this study suggest that service-based intra-platform competition may be worse than facilities-based intra-platform competition, which is neutral in this respect (it neither encourages nor discourages penetration). Therefore a recommendation would be to as a first priority phase out bitstream access regulation, for example by gradually increasing regulated bitstream access prices relative to ULL prices, or by not imposing mandatory bitstream access on new optical fibre networks, where substantial investments are still need to be made.

3. Policy-makers should pay attention to regional differences that affect broadband penetration. The case study for Belgium shows that external conditions may explain large regional differences, but policy is also partly responsible. In regions that are lagging behind, policy makers should assess whether the right regulatory and investment policies are followed and focus sufficiently on inter-platform competition to preserve the right investment incentives.

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