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Procompetitive infrastructure sector regulation and diffusion of innovation: the case of broadband networks

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Abstract

The paper assesses the scope for competition inducing infrastructure regulation in furthering the diffusion of innovation. The paper uses data on the adoption of broadband services comprising a global panel of 167 countries. The effects of different regulatory provisions are assessed. The result of this paper allows qualifying different elements of the regulatory debate on the consequences of access requirements, including mandatory unbundling.

First, it suggests that interplatform competition is generally not leading to acceleration in broadband diffusion. Second, with respect to intra-platform competition, this has been analyzed at two different levels: full unbundling and retail competition. In the first case the competitor is investing in network infrastructure to be able to induce some degree of service differentiation. With retail competition the scope for service differentiation is much more limited and hence competition is most likely centered on price. While both lead to faster diffusion, the results consistently show that the effect from retail competition is proportionally about twice as strong compared to unbundling. Moreover, the analysis of the time profile of the effects show that this impact on diffusion first increases until the third or fourth year after introduction, but then dissipates away. Also here one can argue that retail differentiation leads to more intense price competition and therefore faster diffusion. Different robustness checks for the results are provided.

JEL codes: L96, L51, O33
Keywords: Broadband, regulation, innovation, service competition, platform competition, local loop unbundling

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1. Introduction

Until some 20 years ago network utilities were almost exclusively organized by state monopolies. Among the reasons for state monopolies were: the public interest in controlling industries supplying essential services; the better ability of the state in raising the large scale funding required for infrastructure investment; and the perception that a public sector owned monopoly was deemed as politically preferable to a privately owned one. However, during the last quarter of the century, these basic tenets were questioned from a political point of view. Poor performance of state infrastructure monopolies and relative sluggishness in innovation led to institutional reforms under the heading of "liberalization", involving a combination of competitive restructuring, privatization and establishment of new regulatory mechanisms (Armstrong et al., 1994; Newberry, 1999; Kessides, 2004). Attention to appropriate regulatory measures became an essential ingredient for successful liberalization. The conventional wisdom had it that with network utilities economically non-replicable assets should in principle be unbundled, horizontally and vertically, with potentially competitive segments put under separate ownership from natural monopoly components. Regulation could then be confined to the monopoly segment.

The crux of the matter is that successful liberalization needs a very careful weighting of the factors that are influenced by industry specific technology features, firm behavior and regulatory incentives (Armstrong and Sappington, 2006). Regulatory provisions moreover have very important incentives for investment (Guthrie, 2006), which is ultimately necessary to make innovations available for consumers to adopt. Two broad approaches can be identified in restructuring network utilities: vertical separation and competitive access. Both approaches have advantages and disadvantages, which affect significantly the performance, and everything depends very much on the circumstances. Mandating competitive access is less intrusive with respect to ownership, as the incumbent makes bottleneck facilities available on a fair and equal basis, but involves much more demanding regulatory provisions in the context of asymmetric information. Vertical separation on the other hand is perhaps less demanding for regulation, but it leads to a potential loss of coordination of infrastructure provision and economies of scope. However, vertical separation is generally considered as an extreme measure when horizontal measures such as mandating access are considered as insufficient. Hence most of the regulatory activity is focusing on determining the most appropriate conditions for access to network elements. There is relatively little empirical literature that has carefully analyzed the consequences for innovation with respect to the different types of regulatory provisions. Innovation is on the other hand a very important issue with respect to network utilities such as telecommunications, where rapid technological innovation has fundamentally shaken up the industry and where the adoption of innovation has demonstrably profound consequences for productivity growth.

This paper addresses the question of what form of regulatory mechanism is most conducive in advancing innovation in services provided by network utilities, in particular in telecommunications. Telecommunications is one of the sectors where regulatory reform has been considered as being most successful, especially when looking at the retail price of services as benchmarks for success (Winston, 1993). Indeed the real price for telecommunications services has declined dramatically, also aided by technological innovation in the electronic equipment industry. Sector liberalization and competition has also induced very rapid diffusion in innovation. The mobile telecommunications industry is a case in point: within some 20 years it acquired the same number of subscribers as the fixed line industry managed to achieve in 120 years (Gruber, 2005). Broadband communications, which is the most recent major innovation in the telecommunications sector provides an interesting field for empirical research as the there are some technological and regulatory features that make it quite different from the well studied mobile telecommunications industry. Broadband infrastructure has a significant impact on economic growth in industrialized countries

(Czernich et al., 2011) and hence there is a public interest in accelerating diffusion. However, there is substantial heterogeneity in diffusion of broadband across industrialized countries (OECD, 2011) and this has attracted a high level of political attention for identifying factors that promote broadband diffusion. The US government's *National Broadband Plan*[2] and the European Commission's *Digital Agenda for Europe*[3] are examples of these perceived political priorities for the diffusion of broadband infrastructure access and services. The intention of this paper is to identify the factors affecting the diffusion on broadband adoption and to provide some insights for the policy discussion. Using a worldwide sample, we test the significance of three forms of competition that are induced by appropriate access regulation: inter-platform competition; intra-platform competition in the local loop through full unbundling; and competition on service, which could be under the form of bit-stream access or simple reselling. As policy decisions may be endogenous to market performance we additionally use a separate specification with a two-staged approach. Capturing the direct effect of policy interventions in the first stage we then use the fitted values of competition metrics in the diffusion model. Our results suggest that inter-platform competition is an impediment to broadband adoption whereas full and retail unbundling introductions have sparked adoption in quite different ways. These results could have significant implications for regulatory policies for the sector.

This paper is organized as follows: Section 2 includes a review of the relevant literature and some insights on broadband adoption. In Section 3 the methodology and data are presented and discussed. The results are shown in section 4 and a discussion of the outcomes of the paper is presented in Section 5. The conclusions are in Section 6.

2. Background on broadband and literature survey

[2] See http://www.broadband.gov

[3] See http://ec.europa.eu/information_society/digital-agenda

The most common networks to provide broadband access are traditional telecommunications access networks using copper pair cable in the local loop and the cable TV networks using different versions of coaxial cables. In most countries, these infrastructures have been built long time ago and hence significant upgrade investments are required to achieve broadband transmission capability in the local access network. In the case of telecommunications infrastructure, this is achieved by the switch to digital subscriber line (DSL) technology. Cable TV infrastructure used to have one way information flow only requires investments that allow also for bi-directional flow of traffic. Broadband infrastructure therefore poses a notable regulatory challenge as broadband services are to a large extent provided by legacy communications infrastructure where the incumbent firm typically has significant market power. An international comparison in the wireline access markets shows that for most OECD countries the market share of the incumbent wireline firm is well above 90 per cent (OECD, 2005). Whereas regulatory reform was fairly successful in introducing competition in the mobile telecommunications market concentration, this was much less so for the fixed, or wireline, network. Regulators are thus loaded with the problem of avoiding that market power with the legacy system can be transferred also to the emerging broadband market. There are in principle two different policy issues at stake: first, the objective of rapid diffusion of broadband access; second, the issue of economic conditions of service provision. Although the two issues are interrelated, for the sake of simplicity let us assume them as separate for the moment. In the political discourse, diffusion is getting the main attention, as countries are typically benchmarked by this parameter. There is a complex relationship between the industry structure and innovation (Armstrong and Sappington, 2006), which is linked to the weighting of the Schumpeterian element of disruptive innovation triggered by monopolies and the fact that under competition the overall market is larger. Though there is evidence for the telecommunications industry generally that competition drives diffusion of innovation, this is not always the case (Bohlin et al., 2010). For broadband adoption this evidence is even more mixed. There are several strains of the empirical literature that have assessed the determinants for broadband adoption, including individual choice determinants (Madden and Simpson, 1997; Rappoport et al., 2003), strategic market considerations (Woroch, 2002) and cost of service factors (Gabel and Kwon, 2000; Kim et al., 2003; Cava-Ferreruela and Alabau-Muñoz, 2006). Also regulatory concerns have been taken into account. Garcia-Murillo (2005) finds that unbundling an incumbent's infrastructure only results in a substantial increase in broadband deployment for middle-income countries, but not for their high-income counterparts. Similarly, Grosso (2006) finds that competition, income, and unbundling increase broadband diffusion. Several studies look also at the role of inter-platform competition vs. intra-platform competition. Lee and Marcu (2007) find that platform competition is a significant driver of cable modem broadband, but not DSL diffusion. These studies typically make reference to OECD countries. But data availability in many cases restricts the analysis to a significantly smaller subset of countries, mostly regions with a coordinating regulatory authority. Distaso et al. (2006) look at 14 European countries for the period 2000-2004 and find that inter-platform competition drives broadband diffusion, but that competition in the DSL market does not play a significant role. They also suggest that lower unbundling prices stimulate broadband uptake. Denni and Gruber (2006) find in the US that both types of competition significantly affect the rate of diffusion, although with different effect. Intra-platform competition has a positive impact only initially on the rate of diffusion but then dissipates. Inter-platform has a longer-term role in driving the rate of diffusion. They also take into account the impact of other variables measuring competition in the telecommunications sector as well.

Competition in broadband can be achieved in two ways: first, through service competition on the same network facility through open access provisions at varying levels of the network infrastructure; second, through facility based competition by means of alternative technology platforms. The former will be referred to as intra-platform competition and the latter as inter-platform competition. Bouckaert et al. (2010) have shown for 19 OECD countries that inter-platform competition has been the main driver for broadband diffusion. Results on intra-platform competition instead are mixed.

Substantial regulatory effort during the last decade has been devoted towards creating the conditions for equal access, in particular through the unbundling of infrastructure elements for local access. The 'ladder of investment' theory (Cave, 2006) postulates that initially new entrants use the facilities of the incumbent for service based competition, and later invest in own infrastructure, i.e. assets with increasing difficulty to replicate. So through unbundling service based intra-platform competition would ultimately develop into facility based inter-platform competition. For providing time consistency to this proposition this would require some form of increasing access price or sunset clauses. The practical adoption of such an approach is however difficult as the case of the Netherlands show, where regulators had difficulties in approving increasing access prices (Rood and te Velde, 2003; Poel, 2006).

Regulators have to trade off the interests of new entrants for low access prices with the interests of the incumbent in terms of long-term incentives for infrastructure investments (Pindyck, 2003). Bourreau and Dogan (2004) show that sufficiently low priced unbundling is actually a substitute for infrastructure investment by new entrants. Hausman and Sidak (2005) discuss how setting cost based prices for unbundled network elements has negative economic effects for innovation and new investment. The success of unbundling measures as device for reducing incumbent's market power turned out as being mixed so far, with regulators in countries such as the U.S. basically giving up on the objective, but with European countries continuing on this path. Inducing facility-based competition seems to be the less controversial one from a regulatory point of view, provided that markets are capable of accommodating alternative infrastructures (Faulhaber and Hagendorn, 2000). See also Cambini and Jiang (2009) for a survey of the relationship between regulation and broadband infrastructure investment.

The novelty of this paper consists in advancing the empirical research in two directions: first, using a dataset with a worldwide coverage of 167 countries covering 11 years: second, using a more refined dataset on regulation to identify inter-platform competition and different degrees of competition on an intra-platform basis.

3. Methodology and Data

3.1. Presentation of dataset

The dataset used in this study comes mainly from two sources. The broadband industry data come from Informa Telecoms & Media's World Broadband Information Service. This is a proprietary database with quarterly data for incumbents and entrants in the broadband market for 167 countries from 2000 until 2010. This is by far the most detailed dataset used in broadband adoption studies together. The demographic data come from the World Bank statistics. We are primarily interested to identify the adoption effects from different levels of mandatory infrastructure sharing that have taken place. However we also look at the platform and firm competition that have taken place at the same periods.

As mentioned, technology adoption has rarely followed a uniform path in different countries. Mainly dependent on income, socio economic and demographic factors, national broadband markets have evolved in quite dissimilar ways. Across regions the net additions of broadband lines and the overall penetration of the technologies are shown in Figure 1. In the Americas and the Middle East, net additions continue to rise throughout the decade 2000-2010; Western Europe and North America have seen a clear drop in net additions after 2005, Eastern Europe net connections started to dwindle a bit later and the rest of the world followed less consistent adoption patterns. Africa and Asia/Pacific have experienced alternating periods of higher and lowed net additions. Perhaps the global scale in Figure 1 is most informative. Broadband penetration has been constantly increasing; however the developed world is already past this phase.

(Figure 1)

These pattern are quite similar to the those analyzed in the numerous empirical and theoretical technology diffusion studies looking at information and communications technologies in the recent past and have identified significant catalysts of adoption and also factors that impede technology penetration. In many cases competition is among the key determinants in driving penetration, but many other explanatory variables appear with mixed results. This is in particular the case with regulatory variables. This suggests a possibly complex process of broadband adoption differs across counties, markets and cultures.

The sample distinguishes DLS lines between fully unbundled lines and retail access. With local loop unbundling the competing firm physically installs equipment in the local exchange of the incumbent firm and connects the subscriber line it. With retail access the incumbent operator keeps the physical access line as it is, and the competitor basically resells the services supplied by the incumbent. This distinction has important implications for service differentiation. In the case of local loop unbundling the firm can supply quite different service than in the case of simple reselling. A large part of regulatory efforts and negotiation has been centered about the issue of unbundling, as this constitutes a much more significant intrusion into the infrastructure than would simple retailing activity. However, unbundling does not lead to inter-platform competition as the final user would still be served by the same subscriber line running from the central office to the home.

In terms of regulatory metrics our broadband subscriber statistics presented in Figure 2 suggest that full and retail unbundling represent a significant part of broadband lines especially in the leading Western economies. In Western Europe, one sixth of all types of broadband connections are retailed by the incumbents and one tenth is fully unbundled. In Northern America and Eastern Europe the retailed part of the connections rises to one third of the total. Inevitably this has a significant effect on the market structure and competition among incumbents and entrants. Nevertheless it is not certain that these clear policy interventions have a beneficial effect for the country level adoption.

(Figure 2)

In our sample most countries adopted some form of unbundling after 2002 until 2010. The dark line in figure 3 shows the change in percent of population additions in the years prior to the full mandatory unbundling for the global sample. In this case a normalized metric has been used (% population added in an annual basis) to allow for cross-country comparisons. Moreover the effects from all countries have been averaged out to provide a single value for each observation. As pointed out in Figure 3, the rate of adoption has undergone a steady increase in the early years of broadband infrastructure introduction (-7 to -4 in the graph) and has flattened out at a constant pace until full unbundling was mandated.

This practically means that if a country was, say, at 2% of broadband penetration at point -7, it reached 6.5% at year -4 and 12.5% at year -1. The introduction of unbundling boosted adoption by 50% in the first year and held this pace for another 4 years after initiation. In absolute values this is approximately 4.5% percent population from unbundling only and almost twice the number of subscribers that would have been added if no unbundling was not in place.

In order to provide some further insights on the level of unbundling we continue this exercise with retail unbundling. This is a softer – for the incumbent - version of the infrastructure sharing mandate as the potential entrants do not have full rights on the unbundled local loop but are only allowed to re-sell a range of connections predefined by the incumbent operator and accepted by the local telecommunications regulator.[4]

(Figure 3)

The lightly shaded line in figure 4 shows the percent population subscribing to broadband connections before and after retail unbundling introduction. Contrary to the previous findings, the rate of adoption has held a constant increasing pace for the countries in this sample and there is no clear policy shock after the retail unbundling introduction. This comparison is much clearer when we compared with the other line.

Table (1) presents the countries of the sample. While we used a global dataset with 192 countries, 167 of them had sufficient demographic information to be included in out regressions. Table (2) presents descriptive statistics of the variables in this study.

(Table 1)

(Table 2)

3.2. The technology diffusion model

All potential subscribers do not immediately adopt broadband infrastructure. The adoption decision takes time. Various alternative diffusion models have been used to describe such an adoption process by users. Out of these, the "epidemic" approach resulted to be particularly popular, as it fits remarkably well the diffusion path of many innovations. The adoption of

[4] There are different conventions to describe the levels of retail, ranging from simple retailing of incumbent's lines to the provision of bitstream access. The main idea however is that infrastructure investment by the retailer is very limited.

innovation by the different agents is modeled in a similar way as diseases spread in biology. Griliches (1957) pioneered this approach in agriculture in the study of the diffusion of hybrid corn and has found widespread use in the literature on technology adoption (Geroski, 2000). The model adopted in this study is an appropriately modified version of Gruber and Verboven (2001) and Bohlin et al (2010).

Let y_{ijt} denote the number of agents that have adopted the broadband telecommunications *i* in country *j* at time *t*; let y^*_{jt} denote the total number of broadband telecommunications users in country *j* at time *t*. The fraction of the total number of adopters of technology generation *i* in country *j* that have adopted before time *t* is specified by the logistic distribution function:

$$\frac{y_{ijt}}{y^*_{jt}} = \frac{1}{1+\exp\left(-a_{jt}-b_{jt}t\right)}. \qquad (1)$$

The variable a_{jt} in (1) is a location or "timing" variable. It shifts the diffusion function forwards or backwards, without affecting the shape of the function otherwise. For example, when a_{jt} is very high, we may say that country *j* at time *t* is very "advanced" in its adoption rate. The variable b_{jt} is a measure of the diffusion growth as it equals the growth rate in the number of adopters at time *t*, relative to the fraction of adopters that have not yet adopted at time *t*. Equivalently, this says that the number of new adopters at time *t*, relative to the fraction of adopters that have not yet adopted at time *t*, is a linear function of the total number of consumers that have already adopted at time *t*. This reflects the epidemic character of the logistic diffusion model.

In our econometric analysis we transform equation (1) as follows:

$$\log\left(\frac{y_{ijt}}{y^*_{jt}-y_{ijt}}\right) \equiv z_{ijt} = a_{jt} + b_{jt}t\,. \qquad (2)$$

The dependent variable, z_{ijt}, is the logarithm of total number of adopters relative to the number of potential adopters that have not yet adopted. Equation (2) shows that this measure for the level of adoption evolves linearly through time. Two essential elements determine the diffusion of new generations of broadband telecommunication services: the location variable, a_{jt}; and the growth variable b_{jt}. These, can be specified in a general form as follows:

$$a_{ijt} = \alpha_j^0 + x_{jt}\alpha \qquad (3)$$

$$b_{ijt} = \beta_j^0 + x_{jt}\beta \qquad (4)$$

The parameters α_j^0 and β_j^0 are country-specific location and growth effects. The vector x_{jt} includes variables affecting the location or growth variables, e.g. per capita income.

Substituting into the transformed diffusion equation (2), the following obtains, which also becomes the econometric reference model of the diffusion process:

$$z_{ijt} = \alpha_j^0 + x_{jt}\alpha + \left(\beta_j^0 + x_{jt}\beta\right) t \qquad (5)$$

3.3. The technology diffusion model

Apart from macroeconomic and technology specific variables, we have constructed several metrics to use in the different variants of the models. Each of them captures a different angle of the diffusion path and allows for a closer look at the subsequent effects. The following competition variables are used:

Concentration index of inter-firm competition:

$HH_{inter} = \sum_{i=1}^{m}\left(\frac{C_i}{TC}\right)^2$, with C_i being the number of broadband subscribers of firm i and TC the total number of broadband subscribers. It is the sum of the squared market shares of each firm, which is the classic Herfindahl index computed over the market shares. This index has the range of $\frac{1}{m} \leq HH_{inter} \leq 1$, where m is the total number of firms in the market (the maximum number of firms reported in our sample is 45). The higher the value the more the market is tilted towards monopoly.

Concentration index of inter-platform competition:

$HH_{technology} = \sum_{i=1}^{9} \left(\frac{T_i}{TC} \right)^2$, with T_i being the number of broadband subscribers for each network technology (DSL, FTTH, Cable, Ethernet, Fixed Wireless Broadband, Powerline Communications, WiMAX, Satelite, other). It is the sum of the squared technology shares of each platform, i.e. a sort of Herfindahl index computed over the technology shares. This index has the range of $\frac{1}{9} \leq HH_{technology} \leq 1$. The higher the value the more the market is tilted toward one network technology.

Concentration index of intra-DSL competition:

$HH_{DSL} = \sum_{i=1}^{n} \left(\frac{T_i}{TC} \right)^2$, with T_i being the number of DSL broadband subscribers in each country. It is the sum of the squared DSL operator shares of each platform, that is a sort of Herfindahl index computed over the technology shares. This index is in the range $1/k \leq HH_{DSL} \leq 1$, where k is the total number of DSL based firms in the market. The higher the value the more the market is concentrated.

Concentration index of intra-Cable competition:

$HH_{Cable} = \sum_{i=1}^{n} \left(\frac{T_i}{TC} \right)^2$, with T_i being the number of Cable broadband subscribers in each country. It is the sum of the squared Cable operator shares of each platform, that is a sort of Herfindahl index computed over the technology shares. This index is in the range $1/l \leq HH_{Cable} \leq 1$, where l is the total number of cable firms in the market. The higher the value the more the market is concentrated.

Regulation Metrics:

- *Full Unbundling*: a metric (binary variable) of full unbundling timing introduction for each country. This takes the value 1 once full LLU has been mandated.

- *Retail Unbundling*: a metric (binary variable) of retail unbundling timing introduction for each country. This takes the value 1 once retail LLU has been mandated.

- *Unb_0 – Unb_4*: Binary variables for each year after Full Unbundling introduction. Thus, *Unb_0* is equal to 1 for the first year of full LLU introduction only and 0 elsewhere. Likewise *Unb_1* is equal to 1 one year after full LLU has been mandated. We limit the dummies to 5 years after introduction – representing half of the sample duration – as there is insignificant amount of observations beyond this point.

- *Ret_0 – Ret_4*: Binary variables for each year after Retail Unbundling introduction. Thus, *Ret_0* is equal to 1 for the first year of retail LLU introduction only and 0 elsewhere. Likewise *Ret_1* is equal to 1 one year after retail LLU has been mandated. We limit the dummies to 5 years after introduction – representing half of the sample duration – as there is insignificant amount of observations beyond this point.

4. Results

As discussed earlier, all diffusion models include a location specific part and a growth part. The model uses as location variables Population and GDPC. These variables represent the location effects that exist in each country in the sample. Additionally the diffusion 'growth' effects are captured by the concentration indexes of inter-technology and inter-firm competition. These variables are used to assess the growth impact of competition among firms and different network types on broadband adoption. One would expect that inter-firm competition and inter-platform competition to have a positive impact on the diffusion speed. Likewise different forms of unbundling are expected to have a positive impact on diffusion.

In Table 3 the impact of several location and diffusion variables on broadband adoption is estimated. All models include controls for country and year effects for the 167 countries in the sample of the period 2000-2010. Population enters the results tables as an insignificant determinant of adoption speed across all models. GDPC is found to positively affect adoption and is statistically significant at the 1% level. The variables that capture the timing of different levels of regulatory policy introductions are both positive and significant in model (2). One can also notice that the effect from retail unbundling is more that twice as strong as the effect from full unbundling. This may shed an interesting light on the regulatory discussion about the extent to which service competition, achievable for instance by bitstream access, can contribute is furthering the diffusion of broadband access and whether full unbundling is essential. Full unbundling involves higher investments costs and more regulatory efforts. This discussion is particularly vigorous in Europe in the context of the appropriate network architectures of next generation network. For instance, promoters of extensive competition advocate for point-to-point architectures starting from scratch, where it is relatively easy to fully unbundle fiber local loops access. This is more difficult with different forms of overlay networks (e.g. GPON) which are based on the architecture of the incumbent's network and hence provide an intrinsic competitive advantage to the incumbent.

Overlay networks have however a lower roll-out cost, though the size wedge between the two is extensively discussed (see for instance WIK, 2010).

To take into account the lags in unbundling to assess the time path of this effect, the relevant variables interact with year dummies in model (3) to check for the immediate effect of each policy introduction and how it unfolds over time. Y_t indicates the year t after unbundling was introduced in the country. We have already seen in figures 3 and 4 that the effects are not uniform. This is confirmed in the econometric results. We find that the direct impact of a mandate of full access to the local loop has a smaller effect on broadband adoption immediately after introduction. This effect increases during the second and third year of the policy adoption, decreases slightly in the forth year and then dissipates in subsequent years. Retail unbundling has no direct effect of introduction during the first year for the countries included in the sample. After one year the retail offerings become significant determinants of broadband diffusion, reaching a peak level at the second year and then dissipate in the subsequent years. These results therefore suggest that there is a relatively strong but temporary effect of intra-platform competition after two years of introduction, but then this dissipates. This finding would shed some light on the appropriateness of introducing incentives for entrants to climb up the ladder of investment by introducing sunset clauses for unbundling.

(Table 3)

In terms of the growth variables, we test the effect of competition among all firms in each market and inter-platform competition. Since the Hirschman-Herfindahl indexes are used, a smaller value implies a more fragmented market and a higher value a monopoly market. Therefore a negative sign suggests that higher competition in the broadband market triggers quicker diffusion of the broadband technologies. Inter-firm competition enters all regressions with a negative and highly significant value, translating into a positive effect on diffusion. To the contrary, inter-platform competition has negative effects, thus impeding diffusion in the sample. This suggests a slower adoption speed in countries with more than one broadband infrastructure, while quicker adoption in single-platform markets. This runs against findings in other studies already mentioned on a more restricted sample, where platform competition increases diffusion (e.g. Denni and Gruber, 2007; Bouckaert, 2010). One explanation could be that such competitive settings require elements of network duplication, which ultimately leads to higher costs to be borne by the customers (Höffler, 2007). Platform competition may also reduce the need for regulation, but it could well occur at a higher cost base for providing services to customers.

These findings lead us to some conclusions on the adoption determinants: The first refers to regulatory provisions, in particular on unbundling of local access in the existing incumbent network that have taken place during the last decade in several countries. The effects of introduction and subsequent year-effects are always positive and significant catalysts of broadband diffusion. However the effects reach a peak in year 3 and then abate.

The second conclusion suggests that intra-platform competition among firms has a direct effect on the markets offerings, prices, innovativeness and reach. Inter-firm competition has been found to critically affect diffusion in across all models.

The third conclusion relates to platform competition from multiple technology offerings and the distribution of connections among them. It has been found that markets tilted towards a single technology usually have a quicker adoption process compared to multi-technology markets.

Finally, we tested the macroeconomic parameters that have frequently been found to contribute to the consumption propensity for new products and services. In this case it has been shonw that income has a positive effect on diffusion speed. But as issues of endogeneity and reverse causality might exist in this case, these are further analyzed.

Before moving there, we address the issue of competition within platforms. The primary interest is on DSL that represents the most widely used access technology; however we further control for cable access too. The remaining technologies are rarely non monopolistic on a country basis and add very little to the explanatory value of the subject. From the results shown in Table 4, it becomes clear that across all specifications intra-platform competition among DSL operators has a significant effect of quicker adoption. Evidently equipment sharing further affects the infrastructure sharing and adds to intra-DSL competition. On the contrary, competition among cable operators is found to be insignificant. This perhaps suggests that the lack of extensive infrastructure sharing in cable platforms does not foster or even impedes competition and subsequently broadband adoption.

(Table 4)

Reverse causality and robustness checks

Broadband should be considered as an example of network infrastructure and appropriate methodological concerns should be taken into account when assessing its economic impact. The economic literature on the effect of infrastructure on growth provides some guidance, by considering possible reverse causality in the link from income to infrastructure diffusion as well (Munnell, 1992). Indeed, there is robust empirical evidence that the diffusion of telecommunications infrastructure has direct and indirect effects on economic growth (Roeller and Waverman, 2001; Koutroumpis, 2009; Gruber and Koutroumpis, 2011). Therefore our specification may not adequately control for the effects that derive from the adoption of broadband technology itself and affect the GDP and subsequently the per capita metrics. Increased income leads to higher consumption propensity for technologies as Comin and Hobijn (2004) showed, suggesting that advanced economies are almost always the early adopters. Given the significant impact of income on technology adoption, we have devised two different ways to control for this effect. First, one can adequately capture the effect of comparative – not actual - income by using different income clusters instead of the actual figures. This appears to be a valid proposition to include an alternative income metric while avoiding the effect of reverse causality, assuming that a country would not migrate to a higher income band *due to* broadband adoption. In our case we break the sample into four equally populated clusters: high, medium, medium-low and low. Table 5 reproduces the same models as in table 3, with the difference that income variable as been substituted by a country cluster. Model (1) shows that the diffusion impact increases with income level; this effect is particularly strong passing from low to medium levels. Intra-platform competition has a positive impact on diffusion. The inter-platform competition parameter is not any more significant. However, population is now significant, but has a negative sign, suggesting that large countries have greater difficulties in diffusion of broadband. Models (2) and (3) show that the diffusion impact is bell-shaped with respect to income, peaking at the middle income level. Intra-platform competition again has a positive impact on diffusion, but the size of the impact is much smaller. Inter-platform competition parameter is not any more significant. Model (2) confirms the previous result of retail unbundling having a stronger impact than full unbundling. With respect to the time lags in model (3), also here the peak of the impact on diffusion speed is reached in year 3 and then declines strongly.

(Table 5)

Another way to tackle potential reverse causality is to use lagged values of GDPC. This is actually a simple way to tackle the effect of reverse causality in principle: we expect that broadband adoption has an impact on future GDP *after having been adopted*, not before.

Using one year lags of personal income we manage to both measure the effect of income on technology adoption and at the same time isolate the reverse effect. The estimates in table 6 derive again from the same models as before but revenue per capita is lagged by one year. All models show that income has a positive impact on diffusion. Inter-firm competition again has a positive impact on diffusion, while inter-platform competition parameter has a negative impact. Model (2) shows again that the effect from retail unbundling is more that twice as strong as the effect from full unbundling. The lags in unbundling suggest that there is an increasing effect of intra-platform competition until three years after introduction, but then this dissipates.

(Table 6)

To provide an additional check for the robustness of the results, we modify our technology adoption model. We relax the assumption imposed on the dependent variable with the use of S-shaped curves for broadband adoption and we simply regress the same set of variables against *net additions* of broadband subscribers (Table 7) or alternatively the net increase of broadband penetration (Table 8). Clearly the size of the parameter estimates change as a result, but in most cases the sign and significance levels of previous results are confirmed. The major exception appears to be in model (3) with respect to the time profile of the impact of retail unbundling. Though the effect is positive, it is indeed delayed in time.

(Table 7)

(Table 8)

Last, there is still a possibility that the timing of policy introduction has an effect on competition measurements. A regulator or government in certain cases might view the lack of competition in the market as an opportunity to impose local loop sharing. Therefore competition will increase *because of* the mandate and its timing and not through exogenous factors, like the launch of a new or re-use of existing platforms. This means that there might be some form of endogeneity between the full and retail unbundling dummies and the Herfindahl index of inter-firm competition. One possible way to account for this is to introduce a two-staged model, where the first stage measures the effect of policy intervention on competition, as indicated in equation 6. One would expect that both the time elapsed since full unbundling and retail unbundling would be positive, i.e. the parameter estimates would be negative. This is confirmed by the results in table 9).

$$HH\_Competition_{ijt} = c_j^0 + Unb\_timing_{ijt} + Retail\_timing_{ijt} \qquad (6)$$

(Table 9)

Then the fitted values of inter-firm competition are used as an independent variable in the diffusion model. Results are shown in table 10. In the second stage of the regression the results essentially confirm again the previous results, in particular with displaying the importance of inter-firm competition.

(Table 10)

5. Discussion

The results related to the regulatory instruments that can be interpreted in the light of the discussion on the role of regulation in promoting broadband diffusion, which in many countries is a declared policy goal (OECD, 2008). The role of competition has ambivalent role in this debate. On one hand competition is considered as a key driver for broadband diffusion, but on the other hand it is rarely clearly spelt out what elements of the networks should become amenable to competition. Inter-platform competition is considered as the ideal setting for competitive forces to unfold, but it implies full duplication of access networks, an objective which may be difficult to achieve in the market and which may lead to higher costs to users. Intra-platform competition in the sense of giving selective access to network elements is a solution that takes account of the difficulties in achieving the goal of inter-platform competition, or at least in the interim period if one follows the ladder of investment argument. The result of this paper allows qualifying the different elements of the debate.

First, it suggests that inter-platform competition is generally not leading to acceleration in broadband diffusion. This result may be surprising as it goes against the general belief that platform competition leads to faster broadband roll out. But one has to bear in mind that there are two different aspects in this debate. One is the roll out of broadband access in general. The second is the roll out of high speed access networks, or NGAs. The results of the paper relate to the first aspect. It may however well be that intra-platform competition leads to faster diffusion of NGA, but on top of existing broadband access. More empirical work on this is needed.

Second, with respect to intra-platform competition, this has been analyzed at two different levels: full unbundling and retail competition. In the first case the competitor is investing in network infrastructure to be able to induce some degree of service differentiation. With retail competition the scope for service differentiation is much more limited and hence competition is most likely centered on price. While both lead to faster diffusion, the results consistently show that the effect from retail competition is proportionally about twice as strong compared to unbundling. Moreover, the analysis of the time profile of the effects show that this impact on diffusion first increases until the third or fourth year after introduction, but then dissipates away. Also here one can argue that retail differentiation leads to more intense price competition and therefore faster diffusion. As already indicated, this may lead to interesting conclusions with respect to the regulatory requirements for full unbundling. This is a measure that is very often opposed by incumbent firms as this measure is considered intrusive with respect to the network architecture and requires additional investments. Another argument brought forward by incumbents is that full unbundling has negative effects on the incentives to invest for new infrastructure. This debate has reached an apex in Europe in the context of the ambitious broadband rollout targets provided by the European Commission's *Digital Agenda for Europe*, which aims at providing universal service type of high speed broadband access by the year 2020. A substantial part of this is not achievable without public subsidies, as investment costs are too high. With constrained public funds available, this objective has to be achieved to as much as possible by market forces. This raises interesting question on the conditions under which financial markets will perceive regulatory conditions as conducive for investment.

6. Conclusion

This study has investigated into the effects of regulatory provisions in furthering diffusion of broadband as an innovation in the telecommunications sector using for the first time a worldwide dataset. The purpose was to get new insights on theoretical propositions in the regulatory debate with respect to the introduction of elements of competition in an infrastructure business that has various forms of natural monopoly. The expected result should shed light into the debate when extensive unbundling provisions broaden the market and improve the economic and consumer welfare. The results show that regulatory efforts in reducing market power of incumbents by introducing elements for competition through unbundling of selected networks elements do increase the speed of diffusion. The results show that inter-firm competition in general and intra-platform competition on the incumbent's

DSL platform in particular accelerate adoption of broadband, whereas there is little evidence that inter-platform over different access technologies in general and cable TV platforms in particular have such effects. Retail competition has about a twice as strong effect than local loop unbundling in furthering diffusion. The effect deriving from service competition is more powerful than the effect of regulatory provisions that should supposedly induce competitors in investing. At the extreme, platform competition does not seem to have an effect in furthering diffusion. The diffusion enhancing effect from regulatory access provisions however dissipates after 3-4 years. These results are robust under different hypotheses of reverse causality and taking into account regulatory metrics and variable endogeneity.

This study has not made any distinction between different performance levels of broadband access. The policy discussion in the context of building next generation networks is based on the notion that this not only involved the primary diffusion of broadband, but also its upgrade to higher speed access. To achieve the latter substantial investment in infrastructure is needed. For this new investment it may not be necessarily the case that more competition will bring more investment, or in other words, with inter-platform competition there not are not necessarily reduced incentives to invest in more advanced infrastructure. The network duplication cost may be outweighed by the strategic consideration to invest in a new market. Addressing this question will be on the agenda for further work as a richer dataset will be required that takes into account the performance of the broadband access paths.

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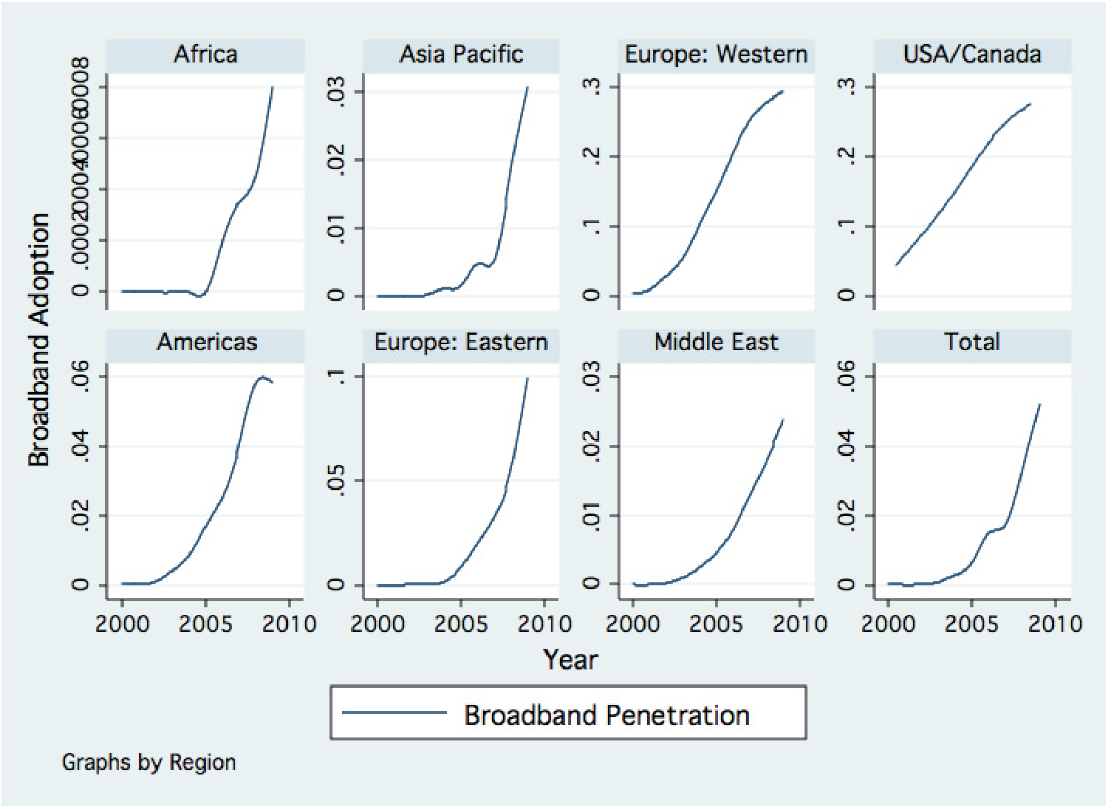

Figure 1: Broadband adoption by region

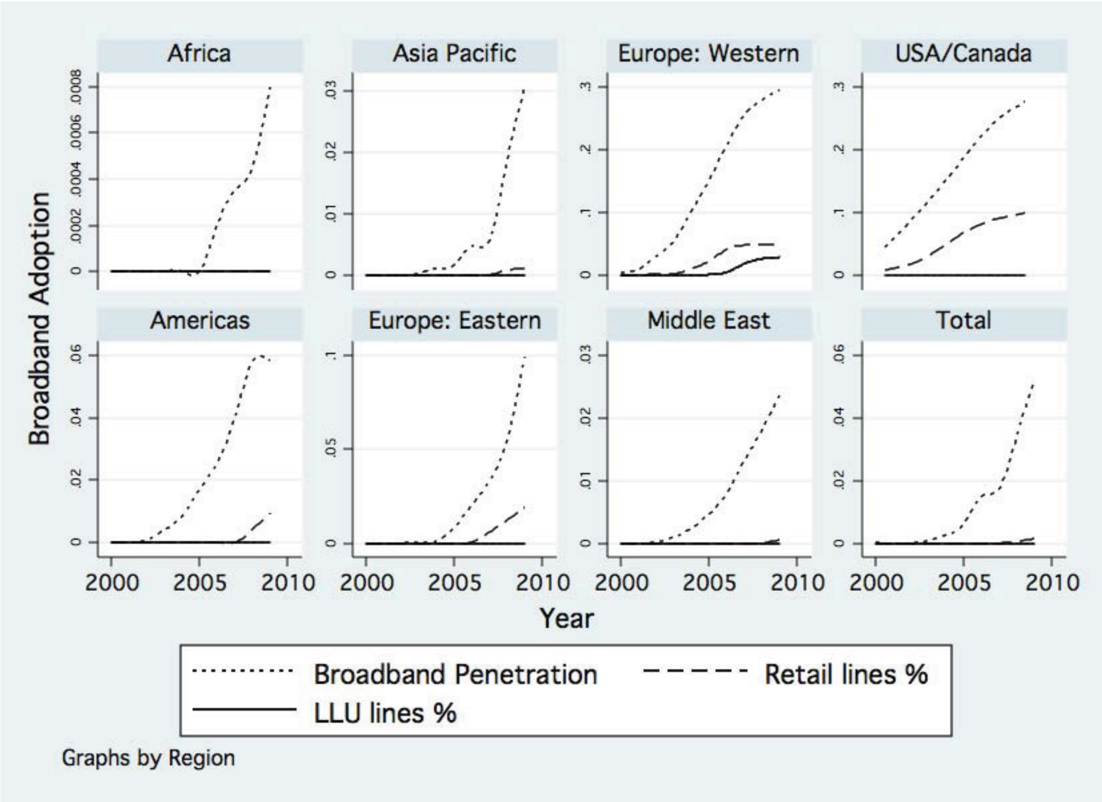

Figure 2: Broadband penetration full and retail local loop unbundling

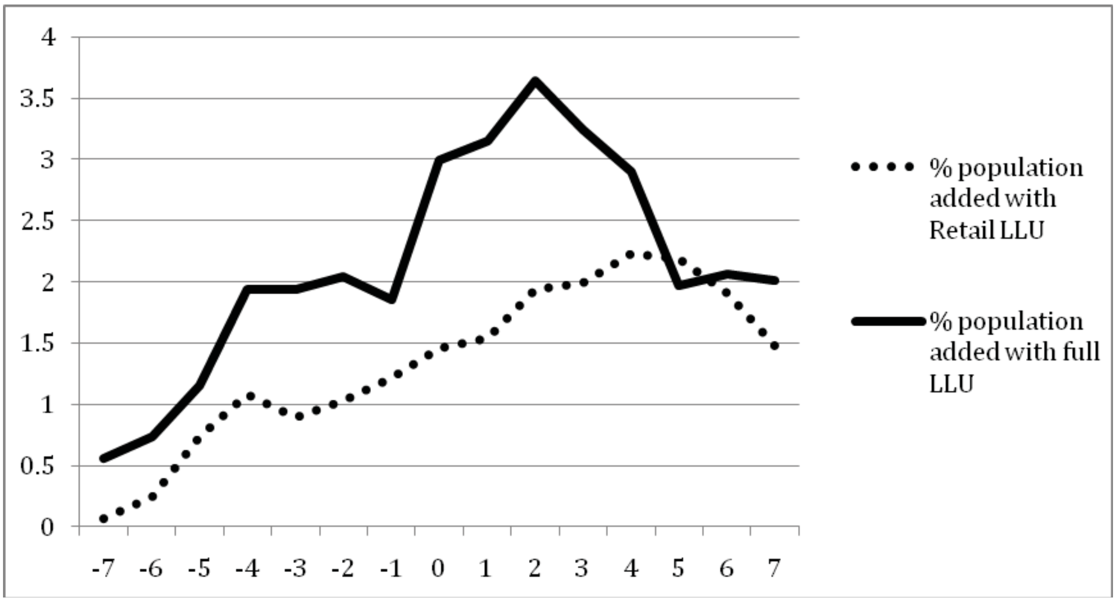

Figure 3: Comparison between Full LLU and Retail LLU

Table 1: Countries in the sample

Albania	Djibouti	Kyrgyzstan	Portugal
Algeria	Dominica	Laos	Qatar
Andorra	Dominican Republic	Latvia	Romania
Angola	Ecuador	Lebanon	Russia
Argentina	Egypt	Libya	Rwanda
Armenia	El Salvador	Liechtenstein	Saint Kitts And Nevis
Australia	Eritrea	Lithuania	Samoa
Austria	Estonia	Luxembourg	Saudi Arabia
Azerbaijan	Ethiopia	Macao	Senegal
Bahamas	Faroe Islands	Macedonia	Serbia
Bahrain	Federated States of Micronesia	Madagascar	Singapore
Bangladesh	Fiji	Malaysia	Slovakia
Barbados	Finland	Maldives	Slovenia
Belarus	France	Mali	Solomon Islands
Belgium	Gabon	Malta	South Africa
Belize	Georgia	Marshall Islands	Spain
Benin	Germany	Mauritania	Sri Lanka
Bhutan	Ghana	Mauritius	St Lucia
Bolivia	Greece	Mexico	St Vincent And The Grenadines
Bosnia And Herzegovina	Greenland	Moldova	Sudan
Botswana	Grenada	Monaco	Sweden
Brazil	Guinea-Bissau	Mongolia	Switzerland
Brunei	Hong Kong	Montenegro	Syria
Bulgaria	Hungary	Morocco	Tanzania
Burkina Faso	Iceland	Mozambique	Thailand
Cambodia	India	Namibia	Trinidad And Tobago
Cameroon	Indonesia	Nepal	Tunisia
Canada	Iran	Netherlands	Turkey
Cape Verde	Iraq	New Zealand	Turkmenistan
Chad	Ireland	Nicaragua	UAE
Chile	Isle Of Man	Niger	UK
China	Israel	Nigeria	USA
Colombia	Italy	Norway	Uganda
Comoros	Jamaica	Oman	Ukraine
Congo	Japan	Pakistan	Uruguay
The Democratic Republic Of The	Jordan	Palau	Uzbekistan
Costa Rica	Kazakhstan	Panama	Vanuatu
Cote D'ivoire	Kenya	Papua New Guinea	Venezuela
Croatia	Kiribati	Paraguay	Viet Nam

Cyprus	Korea	Peru	Yemen
Czech Republic	Kosovo	Philippines	Zambia
Denmark	Kuwait	Poland	

Table 2: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Demographics					
Broadband subscribers	1340	1948631	7892375	0	1.22E+08
Income per capita (constant $)	1691	11131.21	18788.27	0	211500.6
Mobpen	1809	4.897	20.1089	0	287.7712
Population (thousands)	1777	3.50E+07	1.31E+08	18867	1.33E+09
Technologies (subscribers)					
xdsl	1280	1324988	5439001	0	9.87E+07
fttx	349	688745.2	2454048	0	2.06E+07
cable	679	895794.3	3784145	57	4.41E+07
ethernet	65	526722.3	735520.1	100	3300000
fwb	364	57678.47	140373.4	0	790000
plc	25	13622.4	25388.23	250	90000
wimax	230	22593.85	45537.97	0	301000
other	11	6437.909	6576.22	1048	16400
sat	87	69197.99	222902.2	30	1214000
Platform Competition	1339	0.7499676	0.2353633	0.2607653	1
Regulation					
incumbent retail lines	2101	658184.4	4411587	0	1.19E+08
full llu lines	2101	102771.3	736032.3	0	9594000
retail lines	2101	372356.5	2269423	0	4.35E+07
other networks retail lines	2101	109330.3	594117	0	1.09E+07
Technology Competition (all modes)	1344	0.7100564	0.2524548	0.2757439	1
Firm Competition	1337	0.6135482	0.3034396	0.0553515	1

Table 3: Broadband Diffusion results

Broadband Adoption (VA 40%)	(1)	(2)	(3)
Location Variables			
Population	-1.206	-1.347	-1.277
	(0.939)	(0.933)	(0.913)
GDPC	0.814***	0.728***	0.680***
	(0.151)	(0.148)	(0.149)
Full Unbundling		0.253**	
		(0.115)	
Retail Unbundling		0.555***	
		(-1.11)	
Full_Y0			0.422***
			(0.129)
Full_Y1			0.458***
			(0.132)
Full_Y2			0.465***
			(0.140)
Full_Y3			0.407***
			(0.150)
Full_Y4			0.259
			(0.171)
Ret_Y0			-0.005
			(0.090)
Ret_Y1			0.313***
			(0.091)
Ret_Y2			0.453***
			(0.098)
Ret_Y3			0.431***
			(0.108)
Ret_Y4			0.348***
			(0.118)
Growth Variables			
HHI Competition	-0.186***	-0.137***	-0.148***
	(0.035)	(0.035)	(0.035)
HHI Technology	0.091**	0.082**	0.072**
	(0.038)	(0.038)	(0.037)
Constant	6.705	13.717	13.163
	(17.671)	(17.608)	(17.247)
Country effects	Yes	Yes	Yes
Year effects	Yes	Yes	Yes
R^2	0.93	0.94	0.94
F-test/ Wald	85.58	93.43	91.68
Obs	1028	1028	1028

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively

Table 4: Broadband Diffusion results with intra-platform effects

Broadband Adoption (VA 40%)	(1)	(2)	(3)
Location Variables			
Population	-1.152	-1.442	-1.358
	(0.969)	(0.950)	(0.945)
GDPC	0.716***	0.625***	0.627***
	(0.157)	(0.153)	(0.155)
Full Unbundling		0.250**	
		(0.119)	
Retail Unbundling		0.591***	
		(0.090)	
Full_Y0			0.418***
			(0.134)
Full_Y1			0.481***
			(0.146)
Full_Y2			0.455***
			(0.156)
Full_Y3			0.275
			(0.171)
Full_Y4			0.158
			(0.174)
Ret_Y0			0.080
			(0.092)
Ret_Y1			0.312***
			(0.097)
Ret_Y2			0.441***
			(0.107)
Ret_Y3			0.351***
			(0.121)
Ret_Y4			0.332**
			(0.130)
Growth Variables			
HHI Competition	-0.141***	-0.098***	-0.120***
	(0.038)	(0.037)	(0.037)
HHI Technology	0.097**	0.098**	0.087**
	(0.041)	(0.040)	(0.040)
HHI DSL	-0.030**	-0.034***	-0.026**
	(0.012)	(0.012)	(0.013)
HHI Cable	0.003	0.007	0.001
	(0.018)	(0.018)	(0.018)
Constant	7.957	6.951	12.114
	(17.660)	(17.751)	(17.219)
Country effects	Yes	Yes	Yes
Year effects	Yes	Yes	Yes
R^2	0.95	0.95	0.95
F-test/ Wald	90.30	95.55	91.04
Obs	899	899	899

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively

Table 5: Broadband Diffusion results with income clusters

Broadband Adoption (VA 40%)	(1)	(2)	(3)
Location Variables			
Population	-2.205**	-2.290**	-2.296**
	(0.914)	(0.905)	(0.890)
Income_high	1.110***	1.057***	0.882***
	(0.258)	(0.251)	(0.251)
Income_medium	1.084***	1.147***	0.974***
	(0.199)	(0.194)	(0.193)
Income_med-low	0.559***	0.565***	0.505***
	(0.145)	(0.141)	(0.140)
Full Unbundling		0.398***	
		(0.114)	
Retail Unbundling		0.538***	
		(0.087)	
Full_Y0			0.450***
			(0.128)
Full_Y1			0.531***
			(0.130)
Full_Y2			0.550***
			(0.137)
Full_Y3			0.491***
			(0.145)
Full_Y4			0.326*
			(0.170)
Ret_Y0			0.014
			(0.085)
Ret_Y1			0.306***
			(0.088)
Ret_Y2			0.408***
			(0.094)
Ret_Y3			0.371***
			(0.104)
Ret_Y4			0.307***
			(0.113)
Growth Variables			
HHI Competition	-0.151***	-0.095***	-0.119***
	(0.033)	(0.033)	(0.033)
HHI Technology	0.057	0.039	0.041
	(0.037)	(0.037)	(0.036)
Constant	17.011**	22.295**	18.073**
	(9.441)	(9.398)	(9.179)
Country effects	Yes	Yes	Yes
Year effects	Yes	Yes	Yes
R^2	0.95	0.95	0.95
F-test/ Wald	93.08	97.88	97.88
Obs	1087	1087	1087

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively

Table 6: Broadband Diffusion results with lagged GDPC

Broadband Adoption (VA 40%)	(1)	(2)	(3)
Location Variables			
Population	-0.950	-1.088	-1.014
	(0.937)	(0.937)	(0.913)
$GDPC_{t-1}$	1.080***	0.991***	0.951***
	(0.152)	(0.151)	(0.150)
Full Unbundling		0.215*	
		(0.120)	
Retail Unbundling		0.424***	
		(0.091)	
Full_Y0			0.424***
			(0.125)
Full_Y1			0.453***
			(0.135)
Full_Y2			0.452***
			(0.135)
Full_Y3			0.324**
			(0.143)
Full_Y4			0.183
			(0.166)
Ret_Y0			-0.048
			(0.086)
Ret_Y1			0.252***
			(0.088)
Ret_Y2			0.373***
			(0.094)
Ret_Y3			0.397***
			(0.103)
Ret_Y4			0.277**
			(0.113)
Growth Variables			
HHI Competition	-0.194***	-0.154***	-0.165***
	(0.034)	(0.035)	(0.034)
HHI Technology	0.112***	0.101***	0.098***
	(0.038)	(0.038)	(0.037)
Constant	4.288	6.951	6.175
	(17.779)	(17.751)	(17.309)
Country effects	Yes	Yes	Yes
Year effects	Yes	Yes	Yes
R^2	0.95	0.96	0.96
F-test/ Wald	96.81	98.85	98.40
Obs	1004	1004	1004

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively

Table 7: Delta Broadband Adoption results

Delta Broadband Adoption	(1)	(2)	(3)
Location Variables			
Population	0.007	0.017	0.012
	(0.019)	(0.019)	(0.019)
GDPC	0.015***	0.014***	0.013***
	(0.003)	(0.003)	(0.003)
Full Unbundling		0.009**	
		(0.002)	
Retail Unbundling		0.004**	
		(0.001)	
Full_Y0			0.005**
			(0.002)
Full_Y1			0.006**
			(0.002)
Full_Y2			0.009***
			(0.002)
Full_Y3			0.010***
			(0.003)
Full_Y4			0.008***
			(0.003)
Ret_Y0			0.001
			(0.002)
Ret_Y1			0.001
			(0.002)
Ret_Y2			0.002
			(0.002)
Ret_Y3			0.004*
			(0.002)
Ret_Y4			0.005**
			(0.002)
HHI Competition	-0.021***	-0.012**	-0.013***
	(0.005)	(0.005)	(0.005)
HHI Technology	0.109*	0.006	0.007
	(0.006)	(0.006)	(0.006)
Constant	-0.237	0.420	-0.319
	(0.353)	(0.352)	(0.349)
R^2	0.57	0.58	0.58
F-test/ Wald	7.48	7.77	7.53
Obs	865	865	865

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively

Table 8: Delta Broadband Subscribers results

Delta Subscribers	(1)	(2)	(3)
Location Variables			

Population	0.020	0.031*	0.025
	(2.787)	(0.018)	(0.018)
GDPC	0.015***	0.014***	0.013***
	(0.003)	(0.003)	(0.003)
Full Unbundling		0.010**	
		(0.002)	
Retail Unbundling		0.003**	
		(0.002)	
Full_Y0			0.005*
			(0.002)
Full_Y1			0.006**
			(0.002)
Full_Y2			0.009***
			(0.002)
Full_Y3			0.010***
			(0.003)
Full_Y4			0.008***
			(0.003)
Ret_Y0			0.001
			(0.002)
Ret_Y1			0.001
			(0.002)
Ret_Y2			0.002
			(0.002)
Ret_Y3			0.003*
			(0.002)
Ret_Y4			0.005**
			(0.002)
HHI Competition	-0.205***	-0.012**	-0.013***
	(0.005)	(0.005)	(0.005)
HHI Technology	0.011**	0.006	0.007
	(0.006)	(0.006)	(0.006)
Constant	-0.476	-0.673	-0.562
	(0.349)	(0.348)	(0.347)
R^2	0.59	0.60	0.61
F-test/ Wald	8.12	8.47	8.17
Obs	865	865	865

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively

Table 9: First stage results on HHI competition

HHI Competition First Stage Results **Location Variables**	
Full Unbundling	-0.538*** (0.158)
Retail Unbundling	-0.969*** (0.122)
Constant	7.180 (1.083)
Country effects	Yes
Year effects	Yes
R^2	0.88
F-test/ Wald	42.08
Obs	1337

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively
[1]The predicted values – from the first stage - and not the actual are used here

Table 10: Second stage results with fitted values

Broadband Adoption Second Stage Results (VA 40%)	
Location Variables	
Population	-1.691*
	(0.920)
$GDPC_{t-1}$	0.953***
	(0.152)
Diffusion Variables	
HHI Competition[1]	-0.505***
	(0.081)
HHI Technology	0.015
	(0.026)
Constant	16.840
	(15.856)
Country effects	Yes
Year effects	Yes
R^2	0.95
F-test/ Wald	95.57
Obs	1005

Standard errors reported in parentheses
***, **, * 1%, 5% and 10% level, respectively
[1]The predicted values – from the first stage - and not the actual are used here